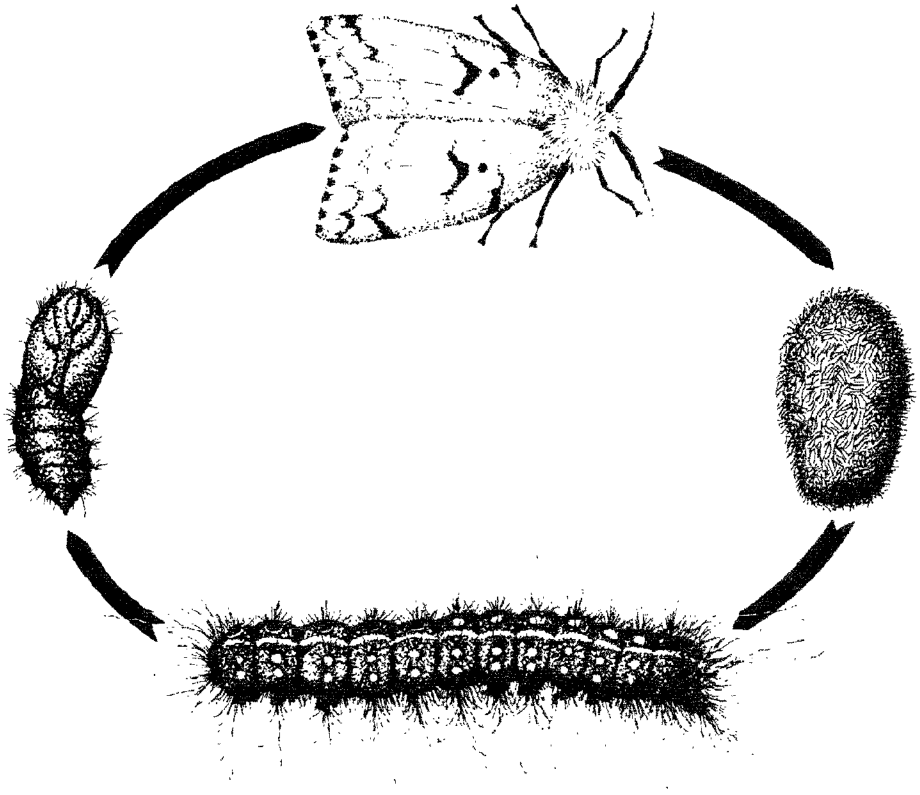
ODC 453–145.7 X 18.77 *Lymantria dispar* (L.) (048.1)

POPULATION DYNAMICS OF THE GYPSY MOTH:

AN ANNOTATED BIBLIOGRAPHY



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NOTE

POPULATION DYNAMICS OF THE GYPSY MOTH: AN ANNOTATED BIBLIOGRAPHY

BY ROBERT W. CAMPBELL
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Abstract

This annotated bibliography contains 592 references, each dealing with some aspect of the population dynamics of the gypsy moth, *Lymantria dispar* (L.).

INTRODUCTION

THIS BIBLIOGRAPHY contains 592 references selected from the world literature on the gypsy moth, *Lymantria dispar* (L.) and related subjects. Either directly or indirectly, each of these references deals with some aspect of the dynamics of this population system.

Although scattered and fragmented, a stupendous world literature deals in some direct way with the gypsy moth. For example, we scanned the titles of at least 6000 gypsy moth related documents during our search for specific papers on its population dynamics. Although we undoubtedly failed to include many publications containing significant information, these references probably represent most of the knowledge that had accumulated about the dynamics of this life system through about 1974. Many of these references, together with a substantial number of more recent papers, have recently been reviewed.[1]

Because the total literature base on this insect is so enormous, we sought to acquire only documents that appeared relevant from their titles alone. Ultimately, we acquired nearly all of the documents we requested; primarily through the splendid efforts of the research librarians at the National Agricultural Library. For many papers in foreign languages we are able to quote from the author's English language summary or abstract. Such material is enclosed in quotation marks. However, we were unable to provide any abstract for 144 of the references. Although nomenclature in all groups has changed considerably, we made no attempt to update synonomy. Rather, we recorded names as they had appeared in the original papers.

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[1] Campbell, R. W. 1979. Population dynamics: Historical review. *In* The gypsy moth: Research toward integrated pest management (M. Sommerville, Ed.) U.S. Dep. Agric. Tech. Bull. 1584. In press.

All references are cited in alphabetical order and each has been assigned a number. For example, references wherein V. I. Benkevich is the senior author are numbered 27-35.

Each reference followed by an abstract concludes with a set of key words and numbers. These key symbols, together with the number of abstracts wherein each one appears, are defined below:

Key word or number (meaning)	*Number of abstracts*
Generation	160
Eggs	107
Instars I-III	56
Instars IV-VI	34
Larvae	164
Prepupae	13
Pupae	87
Adults	43
Sex ratio	14
Fecundity	21
Oak stands	56
Non-oak stands	29
All stands	49
1 Behavior	93
2 Gradation	121
3 Invertebrate predators	51
4 Parasites	162
5 Bacteria	23
6 Disease	22
7 Virus	61
8 Other infectious agents	14
9 Birds	27
10 Mammals	17
11 Other vertebrates	1
12 Environmental influence	119
13 Miscellaneous	54
15 Defoliation, gypsy moth	97
16 Defoliation and secondary organisms	13
17 Defoliation and other insects	5
18 Defoliation and environment	12
19 Stand dynamics and defoliation potential	21
20 Stand dynamics and species composition	17
21 Stand dynamics and crown structure	6
22 Stand dynamics and basal area	4
23 Tree physiology	13
24 Tree condition	19
25 Tree mortality of oak	23
26 Tree mortality of other species	8
27 Tree mortality of oak vs. other	8
28 Normal tree mortality	7
Subject matter review	9
Bibliography	6

Together, key words and numbers provide an aid in locating relevant literature on many relatively specific subjects within the broad heading "population dynamics." For example, reference no. 139, a paper by C. C. Doane, concludes with "Larvae:7." Thus, we categorized this paper as dealing primarily with virus among the larvae. An index to all key word pairs follows.

Guide to References by Subject

Subject	*Reference Numbers*
Generation	
Behavior	55, 58, 59, 68, 69, 81, 92, 107, 117, 201, 225, 226, 241, 300, 302, 366, 372 399, 403, 428, 493, 536, 586.
Gradation	8, 28, 29, 30, 31, 35, 45, 49, 51, 55, 58, 69, 79, 81, 82, 89, 90, 92, 94, 95 105, 107, 116, 117, 120, 126, 137, 149, 154, 171, 173, 175, 179, 187, 188 190, 192, 193, 207, 213, 226, 236, 237, 239, 241, 242, 254, 257, 258, 259 260, 268, 269, 271, 280, 299, 303, 333, 340, 341, 342, 343, 344, 345, 368 433, 436, 439, 468, 478, 480, 494, 495, 523, 537, 538, 541, 545, 546, 547 551, 553, 557, 558, 559, 560, 588.
Invertebrate predators	18, 116, 167, 176, 193, 257, 315, 403, 521, 525, 545.
Parasites	18, 40, 62, 69, 105, 116, 123, 154, 170, 171, 174, 177, 193, 230, 239, 257 258, 260, 271, 333, 372, 400, 401, 402, 403, 414, 444, 446, 465, 478, 481 495, 511, 519, 521, 523, 525, 545, 549, 550, 556.
Bacteria	105, 143, 459, 556.
Diseases	260, 269, 481, 556.
Viruses	99, 105, 271, 279, 399, 428, 459, 496, 545, 556, 558, 560, 561, 570.
Other infectious agents	105, 428, 459, 556, 575, 576.
Birds	49, 50, 69, 119, 176, 372, 523, 532.
Mammals	49, 176.
Environmental influence	10, 28, 29, 30, 31, 32, 33, 34, 35, 37, 82, 90, 94, 98, 107, 137, 149, 169, 171 175, 176, 179, 190, 201, 234, 235, 236, 239, 242, 245, 257, 258, 259, 262 271, 280, 283, 299, 300, 303, 310, 333, 335, 338, 342, 343, 389, 424, 428 429, 433, 493, 495, 496, 541, 545, 547, 558, 588.
Miscellaneous	159, 162, 201, 245, 299, 302, 303, 424, 430, 446, 521.
Eggs	
Behavior	370.
Gradation	37, 70, 73, 82, 90, 129, 191, 236, 237, 239, 317, 334, 336, 343, 349, 363, 545 589.
Invertebrate predators	52, 176, 445.
Parasites	17, 37, 39, 40, 41, 44, 57, 63, 64, 68, 124, 128, 129, 141, 155, 157, 169, 190 192, 211, 227, 228, 229, 264, 269, 289, 344, 345, 355, 371, 375, 376, 393 394, 395, 396, 397, 398, 399, 426, 436, 445, 455, 458, 459, 468, 469, 475 497, 499, 508, 512, 513, 517, 538, 550, 577, 578, 579.
Virus	99, 101, 143, 557, 563.
Other infectious agents	157, 332.
Birds	149, 175, 273.
Mammals	175, 495.
Environmental influence	37, 42, 68, 83, 90, 129, 141, 176, 212, 227, 228, 273, 311, 335, 337, 338, 339 352, 354, 425, 461, 509, 552, 589.
Miscellaneous	129, 194, 306, 310, 317, 327, 349, 354, 425, 527, 552, 589.

Other infectious agents	332, 419, 438, 450, 458, 463.
Birds	3, 68, 91, 149, 175, 186, 187 188, 217, 436, 496, 522, 523, 531.
Mammals	68, 175, 436, 460.
Other vertebrates	176.
Environmental influence	37, 91, 141, 151, 152, 163, 175, 212, 228, 235, 249, 252, 306, 307, 309, 335, 338, 339, 365, 381, 455, 476, 542, 555, 572, 587.
Miscellaneous	67, 141, 161, 164, 176, 194, 201, 221, 249, 280, 283, 296, 304, 306, 309, 310, 338, 380, 413, 476, 527, 572.
Prepupae	
Behavior	298, 363.
Invertebrate predators	69, 236.
Parasites	69, 72, 176, 488, 490, 491, 548.
Diseases	69, 70, 71.
Miscellaneous	249, 488.
Pupae	
Behavior	36, 68, 87, 88, 91, 176, 545.
Gradation	37, 51, 76, 92, 191, 204, 317, 369, 545, 564.
Invertebrate predators	17, 36, 37, 44, 52, 53, 56, 61, 63, 64, 69, 112, 176, 207, 236, 393, 394, 395, 397, 399, 410, 436, 458, 497, 499, 554, 580.
Parasites	36, 64, 66, 68, 69, 71, 72, 74, 75, 76, 91, 93, 147, 153, 169, 176, 191, 211, 215, 228, 269, 295, 297, 308, 356, 386, 393, 395, 396, 397, 399, 430, 436, 445, 455, 458, 459, 488, 490, 491, 497, 498, 515, 548, 550, 578.
Diseases	69, 71, 76, 77, 191.
Viruses	215, 297, 308, 557.
Other infectious agents	332.
Birds	175, 496.
Mammals	36, 37, 51, 68, 69, 75, 91, 92, 93, 94, 176, 460, 496.
Environmental influence	36, 88, 91, 93, 94, 147, 228, 261, 297, 339, 485, 587.
Miscellaneous	194, 249, 261, 296, 317, 327, 485, 488, 527.
Adults	
Behavior	27, 68, 97, 114, 142, 148, 176, 201, 204, 221, 223, 252, 265, 266, 267, 273, 340, 341, 363, 365, 452, 453, 454, 471, 553, 577, 578.
Gradation	37, 88 ,173, 221, 267, 336, 340, 341.
Invertebrate predators	176, 242, 580.
Viruses	140, 557.
Birds	44, 175, 176, 212.
Mammals	176.
Other vetebrates	176.

Tree mortality of other species	80, 95.
Tree mortality of oak vs. other	80, 95, 253, 255, 404.
Normal tree mortality	95, 253, 254, 255.
Non-oak stands	
Defoliation and gypsy moth	20, 46, 106, 149, 163, 187, 191, 205, 214, 236, 249, 252, 258, 259, 2 311, 323, 344, 345, 427, 444, 470, 484, 495, 534.
Defoliation and environment	252.
Stand dynamics and defoliation potential	214.
Tree physiology	67, 542.
Tree condition	118, 534.
Tree mortality of other species	214, 534.
All stands	
Defoliation and gypsy moth	19, 23, 25, 45, 55, 59, 60, 68, 69, 95, 106, 107, 120, 154, 161, 171, 1 238, 257, 286, 322, 361, 363, 366, 377, 381, 399, 400, 401, 403, 48 500, 506, 507, 541.
Defoliation and secondary organisms	20, 95, 208.
Defoliation and other insects	208.
Defoliation and environment	120, 149, 322, 496, 500.
Stand dynamics and defoliation potential	23, 24, 25, 37, 95, 171, 203, 259, 322, 388, 500, 507.
Stand dynamics and species composition	24, 25, 69, 95, 107, 118, 172, 203, 322, 500, 541.
Stand dynamics and crown structure	95, 500.

1. Abdullaev, E.
   1966. **Egg parasites of the gypsy moth *(Lymantria dispar L.)* in Samarkand** [in Russian, Uzbek summary]. Uzb. Biol. Zh. 1966 (4): 57-60.

2. Abdullaev, E.
   1967. **Parasites of eggs of the gypsy moth *(Lymantria dispar L.)* (Orgyidae; Lepidoptera) according to findings from Samarkand Region** [in Russian]. Pages 25-29 *in* Academiya Nauk. Uzbebskoi SSR institut zoologii i Barazitologii. Poleznye i Vrednye bespozvonochnye Zhivotnye, Uzbekistan.

3. Allen, A.A.
   1917. **The warblers.** Am. For. 23: 221-225

Warblers are primarily woodland birds. They arrive in the early spring when gypsy moth eggs are hatching, and they practically rid the trees of insect pests. Warblers do not like the large, full-grown, hairy larvae, but "they destroy them while they are small in great numbers."
Larvae: 9

4. Allen, H.W.
   1916. **Notes on the relation of insects to the spread of the wilt disease.** J. Econ. Entomol. 9: 233-235.

Scavengers of gypsy moth larvae were examined for the presence of polyhedral inclusion bodies. Sarcophagid adults and *Calosoma sycophanta* larvae were found to carry polyhedra. It is evident that wilt is not primarily a windborne disease. The insects that frequent the foliage of trees "carry polyhedra, after contact with the wilt, which indicates that they may assist in spreading the infection."
Larvae: 3,7

5. Amirkhanova, S.N.
   1962. **Nutrient substances in the leaves of healthy and weakened food plants for the gypsy moth** [in Russian]. Pages 81-95 *in* Issledovaniya ochagov vreditelei lesa Bashkirii, UFA Vol. II.

Studies were made of the chemical composition of oak leaves from trees that were healthy, diseased, or weakened by root banding. The leaves were fed to gypsy moth caterpillars. At first there was an increase in dry matter, oil, soluble sugars, starch, and cellulose, and a decrease in the relative content of protein and phosphorus. During the summer when the leaves were fully developed, all the basic substances kept at a constant level, except for starch, which tended to decrease. Warm, moist vegetative periods caused increases in the foliar content of oil, soluble sugars, and starch. The sugar content increased in warmer, drier years. Banding the trunk and cutting slits in the roots caused increases in the foliar content of proteins, soluble sugars, and starch, which are the same changes that usually occur in the development of oak leaves in arid years.
Oak stands: 15,23

6. Anasiewicz, A.
   1964. **Observations on the appearance of *Lymantria dispar L.* on the currant bushes *Ribes nigrum L.* and *Ribes rubrum L.*** [in Polish, Russian and French summaries]. An. Univ. Mariae Curie-Sklodowska Sec. C. 19(7): 111-118.

7. Anderson, J.F., and S.W. Gould
   1974. **Defoliation in Connecticut, 1969-1974: tabulated by use of the geo-code.** Conn. Agric. Exp. Stn. Bull. 749. 25 p.

"High tree mortality, particularly among oaks, may occur in several areas where severe defoliation has occurred for two or more successive years on sites with shallow, rocky soils."
Oak stands: 15,17,18,25

8. Anon.
   1890. **The imported gipsy moth *(Ocneria dispar L.)*.** Insect Life 2: 208-211.

The gypsy moth was present in restricted areas in Massachusetts from 1870 to 1890, but it was not a pest until 1889 and was not recorded in collections or checklists. It was generally held in check in Europe by natural enemies but occasionally was very destructive: for example, in 1817 on the cork oak in southern France, in 1878 on the plane trees of the public promenade in Lyons, and in 1889 at the Berlin zoo.
Generation: 2

9. Aratake, Y. and T. Kayamura.
   1972. **Cross transmission of polyhedrosis viruses of the gypsy moth, *Lymantria dispar japonica* Motschulsky, to the silkworm, *Bombyx mori L.*, and other lepidopterous insects** [in Japanese, English summary]. Proc. Assoc. Plant Prot. Kyushu 18:17-20.

"A nuclear polyhedrosis virus (NPV) of the gypsy moth, *Lymantria dispar japonica*, was not infectious to the silkworm, *Bombyx mori*, and other seven species of lepidopterous insects, but [was] infectious to three species: *Euproctis similis, Dendrolimus spectabilis,* and *Clostera anastomosis.* On the other hand, a cytoplasmic polyhedrosis virus (CPV) of *L. dispar* showed a wider host range compared with the *Lymantria* NPV, infecting *B. mori, E. similis, D. spectabilis, C. anastomosis, Malacosoma neustria testacea, Lymantria mathura aurora, Philosamia cynthia pryeri, Dictyoploca japonica, Scopelodes contracta,* and *Arcte coerulea.* A *Lymantria* CPV retained the infectivity to *B. mori* after a passage through the alternate hosts: *E. similis, P. cynthia pryeri, S. contracta, C. anastomosis, M. neustria testacea,* and *L. mathura aurora.* A *Lymantria* CPV was still infectious to the original host after several passages through *B mori*, but it took a longer incubation period of lethal infection than the original *Lymantria* CPV."
Larvae: 7

10. Ashworth, J.T., and R.B. Friend
1944. **Gypsy moth control**. Pages 253–256 *in* Conn. State Entomol., 1943, 43rd rep. Conn. Agric. Exp. Stn. Bull. 481.

The low gypsy moth populations in the winters of 1940–41 and 1942–43 are attributed to low temperatures (down to -23°F). "In the winter of 1939–40 the number of egg masses per acre in eight one-acre plots varied from 299 to 1403. In the winter of 1940–41 the number on seven adjacent one-acre plots varied from three to nine per acre; in the winter of 1942–43, on the same seven plots, from zero to seven per acre; and in the winter of 1943–44, from zero to three per acre."
Generation: 12

11. Atger, P.
1963. **The diseases of *Lymantria dispar* and the possibilities of microbiological control against this insect** [in French, German summary]. Rev. Pathol. Veg. Entomol. Agric. Fr. 42(1): 47–51.

12. Aulló, M.
1922. **Acclimatization of parasitic insects** [in Spanish]. Rev. Montes 46: 519–521.

13. Aulló, M.
1926. **Organization of campaigns to eradicate *Lymantria dispar* L. outbreaks** [in Spanish]. Rev. Fitopatol. 2–3: 5–12.

14. Aulló y Costilla, M.
1929. **Study of an outbreak of *Lymantria dispar* L. in the oaks of Pedroches Valley (Cordoba)** [in Spanish]. Rev. Fitopatol. 4–6(6): 3–5.

15. Baer, W.
1920. **Tachinids as parasites of injurious insects: their life history, economic importance, and systematic characters** [in German]. Z. Angew. Entomol. 6(2): 185–246.

16. Baeta Neves, C.M.
1942–1943. **The distinction between *Lymantria dispar* L. and other pests that attack cork oak** [in Portuguese]. Bol. Junta Nac. çortica (Lisbon) 50–51: 49–53, 97–101.

17. Baeta Neves, C.M., and F. Azevedo E. Silva.
1944. **Notes on the application of biological control in the campaign against *Lymantria*** [in Portuguese]. Bol. Junta Nac. Çortica (Lisbon) 63: 101–103.

The gypsy moth in Portugal is reviewed, including information on introduced parasites there and in the United States. A list of parasites and predators in Portugal is given. Invertebrate predators are *Calosoma inquisitor*, L., *C. sycophanta*, L., and *Dermestes lardarius*, L. Larval parasites are *Apanteles melanoscelus* Ratz., *A. porthetriae* Mues., *Brachymeria intermedia* Nees, *Compsilura concinnata* Meigen, *Sturmia scutellata* Robineau-Desvoidy, *Tachina larvarum* L. and *Tricholyga segregata* Rondani. *Schedius (Ooencyrtus) kuvanae* Howard is an egg parasite.
Eggs: 4; Larvae: 3,4; Pupae: 3

18. Baeta Neves, C.M.
1947. **The principal insects that attack the cork oak in Portugal** [in Spanish]. Montes 3: 140–147.

The place of the cork oak (alcornoque) in the ecology and economy of Portugal is discussed. Because of the economic value of cork and acorns, they are cultivated, pruned, and treated like fruit trees. This has made the tree dominant over wide areas, which it would not be under natural conditions. In this monoculture the gypsy moth can

flourish for many years. The attacked area is a region between the Sado and the Sorraia, extending through a zone of almost 100,000 hectares of woodland. The gypsy moth was first identified in Portugal in 1886 in Obidos (Estremadora). The following are indiginous parasites and predators: *Calosoma sycophanta, Dermestes lardarius* L., *Compsilura concinnata* Meigen, *Sturmia scutellata* Rob. Des., *Brachymeria intermedia* Nees, and *Apanteles* sp. Although *Schedius kuwanae* was introduced and released, it did not control the infestation. This failure is blamed on insufficient release.
Oak stands: 15; Generation: 3,4

19. Baker, W.L., and A.C. Cline.
1936. **A study of the gypsy moth in the town of Petersham, Mass., in 1935.** J. For. 34: 759–765.
"Complete defoliation was not observed in any instance where favored food trees constituted less than 50 percent of the stand. In 56 out of 81 defoliated areas, oak, gray birch, and poplar comprised more than 75 percent of the stand . . ."
All stands: 15

20. Baker, W.L.
1941. **Effect of gypsy moth defoliation on certain forest trees.** J. For. 39: 1017–1022.
"To determine economic injury by the gypsy moth to forest trees in the New England States, records of defoliation, death of trees, and loss of diameter increment were collected from trees in a wide series of plots from 1912 to 1921. Data from the oaks and white pine (species suffering greatest economic injury) show that an increase in average defoliation was associated in general with an increase in mortality. Growth and defoliation data of four species of oaks and white pine show a direct correlation between percentage of defoliation and decline in radial increment. Diameter growth of black, white, and scarlet oaks was found to fluctuate inversely with percent[age] of defoliation the same year defoliation occurred. In young white pines defoliated only once, there was direct correlation between percent[age] of defoliation and percent[age] of trees dying during the following 9-year period. . . . . This killing may not be entirely a result of defoliation but may be associated with the development of secondary agencies in the weakened trees. From 1912 to 1915 an outbreak of two-lined chestnut borer (*Agrilus bilineatus* (Web.)), developed in the oaks in eastern New England and may have hastened the death of great numbers of trees weakened by heavy defoliation and drought. The shoe-string fungus (*Armillaria mellea* (Vahl.) Quil.) may also have attacked and hastened the death of weakened trees."
Oak stands: 15,25; All stands: 16,27; Non-oak stands: 15

21. Barnes, D.F., and S.F. Potts.
1929. **A disease differing from wilt observed in gipsy moth larvae.** J. Econ. Entomol. 22: 423.
Toxicity tests with lead arsenate were conducted on gypsy moth larvae. When the larvae reached the third instar, a heavy mortality occurred which could not be attributed either to the poison or to polyhedral disease. *Streptococcus disparis* was suspected as the cause of death.
Instars I-III: 5,6

22. Barsacq, J.
1913. **The gypsy moth (*Lymantria (Ocneria) dispar* L.)** [in French]. Rev. Phytopathol. Appl. 1(5): 70–73.

23. Behre, C. E. A.C. Cline, and W.L. Baker.
1936. **Silvicultural control of the gypsy moth.** Mass. For. Park Assoc. Bull. 157. 16 p.
"The forest types which present most favorable conditions for gypsy moth attack are the direct result of a transient agriculture and the destructive lumbering practices of the past." The gypsy moth prefers light-demanding weed species which come in after clearcutting has taken place or farmland has been abandoned. Forest types in the Northeast are discussed in relation to susceptibility to the gypsy moth. The Northern Hardwood Forest is resistant primarily as the result of climate. The Central Hardwood Region of southern New England is composed largely of favored species, yet epidemics have been prevented by some factor other than food. The Cape Cod Region, with sandy soils and an equable climate, bears pitch pine and scrub oak and has been subject to frequent severe outbreaks. The White Pine Region has been the most severely hit area. Its forests are dominated by white pine only on light, sandy soils; otherwise trees of the Central Hardwood Region predominate, making it a transition forest zone.
All stands: 15,19

24. Behre, C. E.
1939. **The opportunity for forestry practice in the control of gypsy moth in Massachusetts woodlands.** J. For. 37: 546-551.

Surveys were made that assigned almost 100,000 acres of Massachusetts forests to one of five categories with respect to resistance to gypsy moth attack. Differentiation was based on percentage of favored food species in the stand. In western Massachusetts 75 percent of the plots were classified as fully or dominantly resistant. In the pine-oak region about half the forested area was entirely or dominantly occupied by highly favored food species. Selected cutting of favored food species is recommended, and partial cutting is advocated in place of clearcutting.

All stands: 19,20; Oak stands: 19,20

25. Behre, C. E., and L. H. Reineke.
1943. **The opportunity for silvicultural control of gypsy moth in southwestern Maine.** J. For. 41:811-815.

A list of forest types in southwestern Maine is given with their relative susceptibility to gypsy moth infestation. Priorities are listed with reference to desirability of silvicultural treatment, based on economic value, damage, susceptibility, and treatments required. The main method of control is the establishment of resistant species of trees by cutting and pruning the preferred food class species.

All stands: 15, 19, 20

26. Bei-Bienko, G.
1924. **Notes on the biology of *Lymantria dispar* L. on the Altai mountains** [in Russian]. Proc. Sib. Agric. Acad. 3: 155-160.

27. Benkevich, V. I.
1958. **Various tree species and their age groups as a substrate for oviposition of the gypsy moth *(Porthetria dispar*,** [in Russian]. Nauchn. Dokl. Vyssh. Shk. Biol. Naŭk. 4: 26-30.

A survey was made in the forests near Moscow of tree species, age classes, and amount of gypsy moth oviposition. Trunks of old oak and spruce and young birch, linden, larch, and pine were preferred by the gypsy moth, especially those trees with a southern or eastern exposure in a sparse, parklike planting. Spruce, birch, larch, pine, and linden (in ascending order) were the most vulnerable to gypsy moth infestation. The lower the humidity of the soil under these species, the more they are infested. Underbrush and grass stands, however, lower the degree of infestation.

Adults: 1,12

28. Benkevich, V. I.
1961. **Data on the prediction of the mass emergence of the gypsy moth, *Porthetria dispar*. Communication I. The mass emergence of the gypsy moth and its prediction in Moscow region** [in Russian]. Pages 22-29 *in* Works on animal ecology and taxonomy of the Orekhovo-Zuevskogo Teachers Institute, vol. 2.

Gypsy moth outbreak was preceded by several years of severe, dry winters. For 3 years before the population eruption, the weather in May and June, when the larvae fed, was hot and dry.

Generation: 2,12

29. Benkevich, V. I.
1961. **Data on the prediction of the mass emergence of the gypsy moth *Porthetria dispar*. II. The mass emergence of the gypsy moth and its prediction in the lower Volga River Valley.** [in Russian]. Pages 38-40 *in* Works on animal ecology and taxonomy of the Orekhovo-Zuevskogo Teachers Institute, vol. 2.

Gypsy moth outbreak is preceded for a period of 4 to 5 years by special meteorological conditions: (1) for 3 or 4 years before the outbreak, the index of severity of the winter is almost always higher than the mean perennial values, while the mean temperature of the coldest month is very low; (2) for 3 years before the outbreak the hydrothermal index for May and June is usually much lower than the mean perennial values; and (3) severe winters and dry, hot weather in May and June are repeated for not less than 2 successive years during the preliminary period. Deviations of meteorological factors from the norm do not cause a mass emergence of the gypsy moth.

Generation: 2,12

30. Benkevich, V. I.
1961. **Materials towards forecasting outbreaks of *Ocneria dispar* L. III. Outbreaks of *O. dispar* L. and their forecast in the Ul'yanovskaya oblast' and the Bashkir Autonomous SSR (Studies in ecology and classification of animals)** [in Russian]. Orekhovo-Zuevskogo Pedagog. Inst. Moskva 2: 45-59.

Typically, winters in the Ul'yanovskaya region and the Bashkir Autonomous SSR are mild. However, the 3 or 4 winters preceding gypsy moth outbreak are severe, with a low mean temperature during the coldest month. Up to 3 years prior to an outbreak, larval development proceeds under normal conditions, or perhaps with a dry May and June. Two years before the outbreak, the humidity in May and June is typically higher and near normal.

Generation: 2,12

31. Benkevich, V. I.
1962. **Forecasting the mass emergence of the gypsy moth, *Ocneria dispar* L. (Lepidoptera, Liparidae). IV. Forecasting emergences of the moth in eastern Siberia.** Entomol. Rev. (English transl. Entomol. Obozr.) 41: 22–27.

Meteorological data from four provinces of eastern Siberia (Chita, Irkutsk, Buryat SSSR, and Ruva ASSR) were analyzed to determine the conditions that initiate a mass outbreak of the gypsy moth. Tables are given comparing the environmental conditions that prevailed in the 5–, 4–, and 3–year intervals between mass outbreaks. The gypsy moth population was not affected positively by separate ecological factors but by these factors in combination. The hydrothermal conditions over a period of 5 successive years were very important. It appears that a 5-year preparatory period is required before such outbreaks can occur, during which time the pest population grows.

Generation: 2,12

32. Benkevich, V. I.
1963. **Data on forecasting the large-scale appearance of *Ocneria dispar* (Lepidoptera: Liparidae). V. Forecasts of the large-scale appearances of *Ocneria dispar* in Voronezh** [in Russian]. Nauchn. Dokl. Vyssh. Shk. Biol. Nauk. 1: 17–22.

Outbreaks of *O. dispar* depend on a number of ecological factors. Meteorological conditions (mainly water and heat balance) for 5 successive years were the most important: (a) drought in May and June for 3 years before outbreaks; (b) very severe winters for 3 or 4 years before outbreaks; and (c) low values of the "hydrothermal coefficient." This includes the average temperature of the coldest month plus high (rarely close to normal) values of coefficients of severity of the entire winter (and of the first half of the winter) for not less than 2 successive years of the total 5-year period preceding a large-scale outbreak.

Generation: 12

33. Benkevich, V. I., and I. A. Nazarov.
1964. **Information on the forecast of the widespread appearance of *Ocneria dispar* (Lepidoptera, Liparidae). VI. Widespread appearance of *Ocneria dispar* and its forecast in Ryazan Oblast.** [in Russian]. Orekhovo-Zuevskogo. Inst. 3: 28–66.

Studies of the hydrothermal regime and the population dynamics of the gypsy moth revealed diminished or minimal solar activity for 5 years before the outbreak. For 3 years there were hot, dry summers with a low hydrothermal coefficient in May and June. Low values of the hydrothermal coefficient, average temperatures of the coldest month, and high severity coefficients in the preparatory period were observed for not less than 2 successive years. A very cold May for 2 years before drought may eliminate the possibility of the widespread appearance of *O. dispar*. An entire complex of ecological conditions affects the population size of *O. dispar*, but meteorological factors in the period preceding their emergence are the most important determinants. A bibliography with 36 references is included.

Generation: 12

34. Benkevich, V.I.
1964. **Information on the forecast of the widespread appearance of *Ocneria dispar* (Lepidoptera, Liparidae). VII. Widespread appearance of *Ocneria dispar* and their forecast in the forest of the Crimea** [in Russian]. Tr. Orekhovo-Zuevskogo Pedagog Inst. 3: 67–82.

For 3 or 4 years prior to gypsy moth outbreak there had been relatively cold winters, with one very cold month; for 3 years there had been dry weather from May to August; and for 1 year, even the year when the insects appeared on a large scale, there had always been a decline in solar activity. A bibliography with 51 references is included.

Generation: 12

35. Benkevich, V. I.
1964. **Information on the forecast of the widespread appearance of *Ocneria dispar* (Lepidoptera, Liparidae). VIII. The widespread appearance of *Ocneria dispar* and their forecast in the**

forests of Altai Krai in eastern Kazakhstan [in Russian]. Tr. Orekhovo-Zuevskogo Pedagog. Inst. 3: 83-95.

Studies were made of the hydrothermal regime preceding outbreak of *Ocneria dispar*. For 3 or 4 years prior to the outbreak there had been cold, severe winters, and for 3 years before the outbreak there had been droughts in May and June.

Generation: 2, 12

36. Bess, H. A.

1947. **I. Relation of forest and site to gypsy moth abundance.** Pages 7-26 in H. A. Bess, S. H. Spurr, and E. W. Littlefield. Forest site conditions, Forest site conditions and the gypsy moth. Harv. For. Bull. 22. Petersham, Mass.

This is a summary of ecological studies on the gypsy moth initiated in 1937 by the U.S. Department of Agriculture, Division of Forest Insect Investigation of the Bureau of Entomology and Plant Quarantine. The information obtained indicates that gypsy moth abundance is strongly influenced by forest and site conditions. Larval behavior differs under different site conditions, with survival lower and defoliation slight where large larvae are found in the litter during the daytime. Larvae tend to remain in the tree under xerophytic site conditions and to rest in the litter under mesophytic conditions. To find out if small mammals (whose populations are highest in dense forest stands with moist, deep ground cover) are responsible for mortality of larvae on the ground, tests were run using cages that excluded them. The results indicated strongly that they are a major mortality factor. The short-tailed shrew and the deer mouse, both voracious insect eaters, were the most abundant small mammals in a good hardwood stand in Petersham, Mass., where no defoliation occurred during the period of census trapping, although larvae were observed.

To determine if predators could cope with large numbers of larvae, different quantities of larvae were released under equivalent site conditions. There was some evidence that survival was higher with larger liberations. Prolonged hot, dry weather during larval and pupal periods helps to maintain a high population level. The same conditions brought about by drought are created by land abuse, e.g., clearcutting, forest fires, and woodlot grazing. Late spring drought in one season followed by early spring drought the next brings about a great increase in population. In a 2-year period these conditions were encountered twice, in 1935-1936 and 1943-1944, which were the only times of heavy defoliation in Petersham. Gypsy moth survival is high in partially defoliated stands where large larvae are likely to stay up in the trees, while litter-inhabiting predators are likely to be driven out or to decrease in number owing to the hot, dry condition of the forest floor. Thus, in its epidemic state the moth creates conditions favorable to its own survival.

Instars IV-VI: 1, 2, 3, 4, 10, 12. Pupae: 1, 3, 4, 10, 12; Oak stands: 15

37. Bess, H. A.

1961. **Population ecology of the gypsy moth *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae).** Conn. Agric. Exp. Stn. Bull. 646. 43 p.

This is an analysis of studies conducted between 1937 and 1945 in a wide range of woodland conditions in Massachusetts, Connecticut, and eastern New York. Primary plots were in Petersham in central Massachusetts, where there was a 30-year endemic population, and in Freetown in southeastern Massachusetts, where there had been widespread defoliation for 20 years.

Behavior and mortality factors are discussed. Among abiotic mortality factors, low temperatures in fall and spring are generally more consequential than in midwinter, although in the course of the study subzero midwinter weather caused the only extensive egg mortality. At temperatures slightly below zero, relative elevation and air drainage are important—there is a higher mortality in low frost pockets. At low temperatures, the mortality of parasitic larvae overwintering in gypsy moth eggs is higher than that of gypsy moth larvae. Heavy spring rains may wash away eggs and young larvae.

Inherent weaknesses in the species cause mortality: about 5 percent of embryos fail to develop; blockages develop in the larval alimentary canal, and larvae fail to complete molt. Additional hazards include those associated with spin-down of small larvae, larvae dropping in areas without food, larvae dropping from trees owing to wind, larvae breaking diapause too early and dying from cold or starvation, and larvae hatching in the fall. The behavioral pattern of large larvae spending the day in the litter, which abounds with predators, also contributes to mortality.

Egg mortality was 30 to 40 percent in Freetown between 1938 and 1942 and 20 percent in Petersham (except for 1938 when it was 7 to 8 percent). Except for high localized mortality in the spring of 1943, mortality was always less than 50 percent. *Anastatus disparis* Ruschka is a relatively hardy parasite, abundant in Freetown but varying greatly in numbers in Petersham and colder regions. *Ooencyrtus kuwanae* (Howard) is widely distributed but less coldhardy. Together they parasitized between 17 and 37 percent in Freetown, except in the year after extreme winter kill (7 percent). The following year, 30 percent were parasitized. Productivity of egg parasites was directly related to the number of host eggs, but there was no relationship between percentage of parasitism and host egg population density. Where the gypsy moth population was at a low level for 3 years and parasites developed primarily on the gypsy moth, egg parasitism was at its highest level.

Larvae rest in concealed places and molt there. In early instars, suitable resting places are found under loose bark on twigs and on the underside of leaves. In good mesophytic hardwoods, large larvae descend from trees at dawn and rest in litter, but they will also rest in suitable places above the forest floor. Also, in open, dry woodlands without litter or where litter is exposed to hot sun, larvae will stay up in the trees, generally on foliage. In Petersham in 1937, larvae feeding on aspen (*Populus grandidentata* and *P. tremuloides*) were more heavily infected with wilt than those feeding on oak. Epizootics of wilt were inconsequential where food was plentiful.

There are many casual predators of the gypsy moth. *Calosoma sycophanta* and *C. frigidum* will consume gypsy moth even under low population densities when larvae congregate in litter. Thus, large larvae are very vulnerable when scarce. *Calosoma* are not found in light, sandy soils because their burrowing tunnels collapse. There is mammalian predation by the short-tail shrew (*Blarina brevicauda brevicauda* (Say)) and the deer mouse (*Peromyscus leucopus noveboracensis* (Fischer)) which are more abundant in mesophytic woodlands around Petersham than in Freetown. Gypsy moth is more abundant in Freetown; therefore, the general abundance of predators is not directly related to the general abundance of moths. When larvae are kept on tree boles and mammals are excluded, mortality decreases.

Major larval parasites are *Apanteles melanoscelus* Ratzeburg, found in more than 50 percent of gypsy moth larvae on June 29, 1938 in Freetown; *Sturmia scutellata* Robineau-Desvoidy, widespread but not in xerophytic areas; and *Compsilura concinnata* Meigen, more abundant in mesophytic forests where it has parasitized a maximum of 80 percent. The first two are almost exclusively parasites of gypsy moth, while *Compsilura* has many hosts. *Theronia fulvescens* Cresson is native and has parasitized 18 percent in one plot, but neither this nor the other species is important in control.

The percentage of larvae parasitized in an area varies widely from year to year. Instars V and VI are the most hazardous stages. Mortality correlates inversely with adult and egg populations produced; no correlation with other stages was found. Parasites do not seem as important as predators. Pupal mortality is lower in percentage and number than larval, and adult female mortality is very low prior to oviposition. All egg masses were fertile, indicating that there were sufficient males. However, sex ratio varied widely from 3:1 to 1:6 as determined from pupae (female:male). High crown density and deep litter within forests are conducive to a rich fauna, including predators.

Adults: 2; All stands: 19; Eggs: 2, 4, 12; Generation: 12; Instars I-III: 1; Instars IV-VI: 1, 2, 3, 10; Larvae: 4, 7, 12; Pupae: 2, 3, 10; Sex ratio: 2

38. Bialaszewicz, K.

1933. **Research on the chemical metabolism and energy in the course of insect development. I. Thermogenesis during the period of larval growth and metamorphosis of *Lymantria dispar* L.** [in French]. Arch. Int. Physiol. 37(1): 1-15.

39. Bjegović, P.

1963. **Contribution to the knowledge of competitory relations between *Ooencyrtus kuwanae* How. and *Anastatus disparis* R.** [in Serbo-Croatian, English summary]. Zast. Bilja 14: 543-552.

Laboratory experiments conducted at a constant 25°C during the winter and spring of 1962–63 show the interaction between two egg parasites of the gypsy moth, *O. kuwanae* and *A. disparis*. As long as *A. disparis* larvae are in diapause, they cannot be hosts of *O. kuwanae*. However, *O. kuwanae* develops successfully as the parasite of larvae of *A. disparis* that have interrupted diapause. It can also parasitize their pupae. It is a comparatively frequent phenomenon (14 percent) that two *O. kuwanae* develop in a single gypsy

moth egg to the adult stage and that both specimens emerge from the chorion through the same opening. By examining the contents of a deserted chorion, it can be easily established whether *O. kuwanae* developed in it as a parasite or as a hyperparasite. If it developed as a hyperparasite, two types of excrement are found in the chorion as well as a respiratory funnel, and there are no remains of the gypsy moth embryo. These experiments show the possibility of utilizing activated larvae and pupae of *A. disparis* by *O. kuwanae* to maintain the parasite in its critical period.
Eggs: 4

40. Bjegović, P.
1964. **The influence of low temperatures on the last stage of *Anastatus disparis* Ruschka larvae** [in Serbo-Croation, English summary]. Zast. Bilja 15(77): 3-12.
Parasitized eggs of the gypsy moth were kept at 0 °C. At this temperature, mature larvae of *Anastatus disparis* can remain latent for about 27 months. By delaying development of the parasite, it is possible to obtain adults of *A. disparis* for investigation in any season. Adults of the parasite can reproduce after being kept for 2 years in a cool place. Although deep-freezing at −34 °C for a brief period can be tolerated by diapausing *A. disparis* larvae, the same temperature is lethal to gypsy moth larvae. At −34 °C, part of the *A. disparis* population remains in diapause for nearly 2 years. However, a temperature of −45 °C is lethal for the last stage of *A. disparis* larvae.
Eggs: 4; Generation: 4

41. Bjegović, P.
1964. **The sex ratio dependence of *Anastatus disparis* Ruschka according to the embryo stage of gypsy moth (*Lymantria dispar* L.)** [in Serbo-Croation, English summary]. Zast. Bilja 15: 569-576.
"Experiments and observations were carried out in order to establish the possibility [of] *Anastatus disparis* R. development in different embryo stage[s] of gypsy moth. The experiments pointed out that *A. disparis* can develop as a parasite in every embryo stage of gypsy moth. This property makes it possible to have two generations per year in Yugoslav mild-climate regions. The development of [the] parasite in fresh-laid eggs of gypsy moth is very successful. In this case the sexual index is very convenient and come[s] to 0.583. If the parasitism take[s] place in the late embryo stage of the gypsy moth, the development of *A. disparis* is less successful. Then the sexual index of the parasite is not so convenient and come[s] to 0.093."
Eggs: 4; Sex ratio: 4

42. Bogach, A. V., I. M. Zolotoverkhaya, and O. I. Kyrychenko.
1966. **Significance of light and temperature in the reproduction of *Porthetria dispar* L. and *Bombyx mori* L.** [in Ukrainian, Russian, and English summaries]. Dopov. Akad. Nauk. Ukr. Res. 6: 825-827.
"Experiments on the effect of light and temperature on the copulation, fecundation, and oviposition of eggs in *Porthetria dispar* and two varieties of *Bombyx mori* showed that light, as an independent factor and in conjunction with temperature, affects the yield and dynamics of flight of the moths, fecundation, and oviposition. The photoperiodic effect is most distinctly manifested [at] low temperatures. Twenty-four hours of lighting per day has an unfavorable effect on oviposition and the viability of the eggs. However, a study of the effects of light and temperature acting jointly on copulation, fecundation, and oviposition showed that the important factor is the temperature."
Eggs: 12; Fecundity: 12

43. Bolivar y Pieltain, C.
1923. **Studies on chalcids of the family *Eupelmidae*. III. Spanish species of *Anastatus*** [in Spanish]. Rev. Fitopatol. 1(4): 114-122.

44. Bowditch, F. C.
1922. **Notes on the gipsy moth in my unsprayed woods at East Marion, Mass. 1922.** Psyche J. Entomol. 29: 213-216.
From 1920 to 1922 the gypsy moth population increased in the pure oak and mixed oak-white pine stands under observation. Larvae were abundant by mid-June, and the "trees began to look thin." Green *Calosoma* were running on the trees but were not seen to attack as they had in previous years. By the end of June, in preparation for pupation, the larvae had bunched together on tree trunks or under branches. They were attacked by voracious *Calosoma* larvae which preferred the already torpid prepupae to the more active larvae. Various dipterans were observed around the larval bunches, but only a large grayish fly was observed

to larviposit. Wilt disease killed many larvae after they had bunched up. By the first week in July most of the larvae had spun a slight web and pupated in a loose mass or in groups of 10 to 12 curled up in leaves at the ends of branches. Most of the *Calosoma* had disappeared, although some of the larger preyed on pupae until the moths emerged on July 10. At the time of adult emergence, birds arrived, staying for the 2 to 3 days of the major emergence. Male moths were attacked more than females. Robins, kingbirds, vireos, chickadees, sparrows, blackbirds, and a variety of smaller birds were present. Gypsy moth females began to lay eggs almost immediately. All the clusters examined were parasitized by an insect imported from Japan whose imago emerges in the fall.
Adults: 9; Eggs: 4; Larvae: 1, 3, 4, 7; Pupae: 3; Oak stands: 15

45. Britton, W. E.
1935. **The gypsy moth.** Conn. Agric. Exp. Stn. Bull. 375: 625-647.
This bulletin deals with the distribution of the gypsy moth in the United States and abroad, with specific information on Connecticut, where the insect was first discovered in 1905. In 1913 it was found in 10 towns along the Rhode Island border, most likely having been dispersed there by wind. Windspread carried the moth further, so that by 1923, when the barrier zone was established, 100 Connecticut towns were infested. The bulletin also reviews favored food plants, life history and behavior of the moth, and its natural enemies. It includes defoliation statistics as well as information on the barrier zone, the Federal quarantine, and control measures.
Generation: 2; Instars I-III: 1; All stands: 15

46. Brown, G. S.
1967. **The gypsy moth, *Porthetria dispar* L., a threat to Ontario horticulture and forestry.** Proc. Entomol. Soc. Ont. 98: 12-15.
Birch and elm are the main hosts of the gypsy moth because they are the most prevalent trees in the area. "Maples are attacked to a lesser degree. Oak appears to be resistant, apparently owing to its delay in leafing out in the spring."
Oak stands: 15; Non-oak stands: 15

47. Brown, R. C., and R. A. Sheals.
1944. **The present outlook on the gypsy moth problem.** J. For. 42: 393-407.
This is a history of the gypsy moth in the United States with a detailed record of defoliation in New England. Also given are summaries of control measures and their effects.
Review

48. Bryantzev. B.
1928. **Some observations on the migration of the larvae of the gypsy moth from forests to fields and orchards in Kursk in 1927** [in Russian]. Zashch. Rast. (Leningrad) 5(3-4): 370-371.

49. Buckner, C. H.
1967. **Avian and mammalian predators of forest insects.** Entomophaga 12: 491-501.
Birds and mammals are homoiothermic, needing prodigious amounts of energy to maintain their body temperature and life processes. As a result, they have a high attack potential but one that is rarely satisfied by exclusive consumption of a specific food source. Thus, with vertebrate predators, more than with other parasites or predators, one must study the entire ecosystem of the pest because buffer species and alternative prey are of great potential importance. The functional and numerical responses of vertebrate predators to prey density are discussed in detail.
Generation: 2, 9, 10

50. Buckner, C. H.
1967. **The estimation of energy flow through the populations of birds.** Pages 163-178 *in* K. Petrusewicz, ed. Secondary productivity of terrestrial ecosystems. Working meeting of IBP Committee, 1966, Warsaw.
"The impact of birds on their food resources is obviously of importance in productivity relationships. Early authors tended to stress the regulatory nature of birds on their food supplies, especially birds as destroyers of noxious insects, but their opinions were more frequently colored by their emotions than by sound ecological data. Recent attempts to relate the regulatory action of birds on their food supply has produced conflicting results. Based upon regression types of analysis, several authors claim strong regulatory action, especially at low to moderate food densities, whereas others indicate only slight regulatory action or no regulation at all. Several authors stress the importance of birds in reducing residual populations of food reserves."
Generation: 9

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Adults: 9; Eggs: 4; Larvae: 1, 3, 4, 7; Pupae: 3; Oak stands: 15

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Generation: 2; Instars I–III: 1; All stands: 15

46. Brown, G. S.
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Birch and elm are the main hosts of the gypsy moth because they are the most prevalent trees in the area. "Maples are attacked to a lesser degree. Oak appears to be resistant, apparently owing to its delay in leafing out in the spring."
Oak stands: 15; Non-oak stands: 15

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Generation: 2, 9, 10

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Generation: 9

51. Buckner, C. H.

1974. **Coactions of small mammals and larch sawflies.** Entomophaga Mem. H. S. 7: 71-81.

"The interrelationships of the larch sawfly and its small mammalian predators have been the subject of intensive investigation for many years. Small mammals usually destroy a large percentage of the cocoon population—at times over 90 percent. Mammal predation is a key factor in the population dynamics of the sawfly at low and moderate prey densities but not at high cocoon populations, although predation may at times act in a catastrophic manner to reduce the density of the pest insect. Two species of predators exhibited a weak numerical response to prey densities, but as prey numbers increased the relationship became less clear. Confounding factors tended to mask this relationship. All predator species exhibited marked functional responses to the density of the prey insect, a fact that greatly enhanced the regulatory value of the predators."

Generation: 2; Pupae: 2, 10

52. Burgess, A. F.

1897. **Notes on certain Coleoptera known to attack the gypsy moth.** Mass. State Bd. Agric. Annu. Rep. 44: 412-431.

The most important predaceous beetles known to attack the gypsy moth are in the genera *Calosoma* and *Harpalus*, family Carabidae. Prior to 1896 the following species were known to attack the gypsy moth in the field: *Ptinus brunneus* Duft. attacked eggs; *Calosoma calidum* (Fab.), *C. frigidum* Kirby, *C. scrutator* (Fab.), *Cicindela 6- guttata* Fab., *Harpalus caliginosus* Say., and *H. pennsylvanicus* (DeG.) attacked larvae; *Dermestes lardarius* L. and *Platynus limbatus* (Say.) attacked pupae. The number of gypsy moth larvae killed on the trees depends on the size and agility of the beetles; *Calosoma* is ranked, in descending order, *frigidum, calidum,* and *scrutator,* with *frigidum* also the most common. Its feeding activity increases with temperature, but it also feeds at night when gypsy moth larvae are active. Details on the rearing method and life history are given for *C. frigidum* and *C. calidum.* Despite their ability to eject a fine mist of pungent-smelling, caustic liquid, they are preyed on by insectivorous birds, toads, and skunks. *C. calidum* is parasitized by the dipteran *Pseudotraetocera calosomae* Coq.

Eggs: 3; Larvae: 3; Pupae: 3

53. Burgess, A. F.

1911. ***Calosoma sycophanta:* its life history, behavior, and successful colonization in New England.** U. S. Dep. Agric. Bull. 101. 94 p.

Calosoma sycophanta in its adult form is a beautiful green beetle, 1 inch long with long legs. It closely resembles the native *C. scrutator* Fab. and *C. wilcoxi* Lec. *C. scrutator* is more common in the central and southern United States, rarely occurring in the north. It is larger than *C. sycophanta* and can be distinguished by the purplish band on the green elytra and the shiny copper-colored margin on the thorax. *C. willcoxi* is also a southern species found occasionally in the north. It is smaller than *C. sycophanta* and has color markings similar to *C. scrutator.* This bulletin covers in detail methods of rearing, transporting, and colonizing the beetle, a report on colonies in Massachusetts, the economic importance of *C. sycophanta* in controlling the gypsy moth, and extensive morphological and ecological data.

Larvae: 3; Pupae: 3

54. Burgess, A. F.

1913. **The dispersion of the gipsy moth.** U. S. Dep. Agric. Bull. 119. 62 p.

Gypsy moth control work ceased in 1900, and when it was resumed in 1905 the infested area was found to be 6 times greater than it had been 5 years earlier. The automobile and electric trolley together with people and their parcels dispersed larvae and egg clusters. Automobile traffic between urban and rural areas was very heavy in June when the gypsy moth was most likely to be spread in its larval stage. Despite assertions to the contrary, the author did not believe that birds were responsible for dispersion into areas not reached by the automobile. Larvae carried by birds were usually injured in flight; eggs were rarely eaten by birds and when they were did not often pass through the alimentary tract unharmed. Local dispersion, however, could have been caused by egg clusters attached to nesting materials.

In 1909, E. D. Sanderson suggested that first-instar larvae were carried aloft by the wind by their aerostatic hairs, which disappear in later instars. Experiments to test larval dispersion by the wind, showed that larvae could not be induced to spin silk at temperatures below 65 °F and that higher temperatures were preferable. Dispersion was more likely to be away from heavily infested areas where food was limited. The direction of the pre-

vailing wind on days in April and May when the temperature was greater than 70°F was correlated with the direction of spread of the gypsy moth. The wind was southwesterly 51 percent of the days when wind spread was possible, and expansion of the infested area was to the north, northwest, and northeast.
Instars I-III: 1, 3, 12

55. Burgess, A. F.
1914. **The gipsy moth and the brown-tail moth, with suggestions for their control.** U. S. Dep. Agric. Farmer's Bull. 564. 24 p.
A general statement covering the history of the gypsy moth in America, its life history, and favored food plants. Methods of control for both by laymen and in state control work are discussed.
Generation: 1, 2; All stands: 15

56. Burgess, A. F., and C. W. Collins.
1915. **The calosoma beetle (*Calosoma sycophanta*) in New England.** U. S. Dep. Agric. Bull. 251. 40 p.
Several species of *Calosoma* and *Carabus* (Coleoptera: Carabidae) were imported from Europe, but only *Calosoma sycophanta* became well established and abundant. The egg is 5.2 × 2.4 mm, elliptical and tapering at one end, and white with a faint yellow tinge. Eggs are deposited in the ground and hatch in 3 to 10 days, depending on temperature. The larva is nearly white upon hatching but remains in the egg cavity until it becomes jet black, then making its way to the soil surface to search for food. It attacks lepidopterous larvae and pupae without regard to size, approaching larvae from the lateral or ventral side and penetrating between segments of hairy larvae. Pupae are also attacked between segments, which leaves an irregular hole that can be easily distinguished from parasite exit holes. The *Calosoma* larvae feed day and night; can climb rough-barked trees; are more active with higher temperatures; are not affected by wilt; and can kill an average of 41 full-grown gypsy moth larvae. They are found in the field roughly from the end of June through August. They molt twice, attaining a full-grown size of 25.8 × 5.7 mm. A pupal chamber is constructed in the soil above the frost line. The prepupal stage is 10 days and the pupal stage 13 days, after which the adult emerges but stays in the pupal cavity over winter until it surfaces June 1. Adult beetles live 2 to 4 or more years. Older adults also surface June 1, having been in an underground cavity since mid-July of the previous year. Adults feed in trees, seizing larvae in the middle of the back and cutting through the body wall. They feed on liquids and fatty material of the prey, injuring more than they devour. *Calosoma* beetles can fly freely to migrate in the spring, can swim, and can live submerged in water for at least 4 days. They copulate a few days after emerging and feeding. The female must mate several times in the season; otherwise, she will lay many infertile eggs. Older beetles lay more eggs, an average of 100 per season. *C. sycophanta* is preyed upon by birds (including crows and hairy woodpeckers) and by raccoons, foxes, and skunks, the last of which will upturn soil in the search. The adult is attacked by the tachinid *Viviania georgiae*, and adults and larvae are attacked in captivity by the mite *Tyroglyphus armipes*. Rearing methods are also described in this bulletin. It is concluded that the life cycle of *C. sycophanta* makes it a predator well suited to the gypsy moth.
Larvae: 3; Pupae: 3

57. Burgess, A. F.
1915. **Parasite work.** The State Forester. Publ. Doc. 73: 84-88, Massachusetts.
Examination of egg clusters from northern Massachusetts and New Hampshire showed that parasitism by *Anastatus bifasciatus* was often 25 percent and sometimes as high as 43 percent.
Eggs: 4

58. Burgess, A. F.
1915. **Report on the gipsy moth work in New England.** U. S. Dep. Agric. Bull. 204. 32 p.
Report on field and experimental work pertaining to the gypsy moth done by the U. S. Department of Agriculture Bureau of Entomology in Boston under the direction of the author.
Generation: 1, 2

59. Burgess, A. F.
1916. **Suppression of the gipsy and brown-tailed moths and its value to states not infested.** U. S. Dep. Agric., Yearb. Agric., 1916.
The history of the gypsy moth and brown-tail moth in the United States is given, and a distinction is drawn between the nuisance value of the former and the problem of poisonous larval hairs

of the latter. Conclusions from earlier experimental work of the author and his colleagues are given. The author emphasizes the cost of control operations to local governments, pointing out that other areas of the country are benefiting as a result.
Generation: 1; All stands: 15

60. Burgess, A. F.
1917. **The gipsy moth and the brown-tail moth and their control.** U. S. Dep. Agric. Farmer's Bull. 845. 28 p.
This is a public information bulletin, giving the life history and the natural and artificial controls of the gypsy and browntail moths.
Larvae: 1; All stands: 15

61. Burgess, A. F., and C. W. Collins.
1917. **The genus *Calosoma*: including studies of seasonal histories, habits, and economic importance of American species north of Mexico and of several introduced species.** U. S. Dep. Agric. Bull. 417. 124 p.
Included in this paper are keys to the species of *Calosoma* larvae and adults and their original description as well as the distribution, ecology, and references for each of the species considered. *Calosoma* and *Carabus* were originally grouped together but were separated into two genera in 1801. The various *Calosoma* species have similar habits and life histories. Also covered are natural enemies of *Calosoma* and methods for transporting and rearing them.
Larvae: 3; Pupae: 3

62. Burgess, A. F.
1924. **The value of natural enemies of injurious insects.** Annu. Rep. Entomol. Soc. Ont. 54: 30-36.
Parasites and predators are necessary to control the population levels of injurious insects, and natural enemies in the native area of the pest species should be utilized. Population fluctuations in the native area should be studied. A table is given listing the numbers of imported gypsy moth parasites released in New England.
Generation: 4

63. Burgess, A. F.
1926. **The present status of the control of the gipsy moth and the brown-tail moth by means of parasites.** J. Econ. Entomol. 19: 289-294.
The results of the introduction of the parasites of the gypsy moth, *Porthetria dispar,* and brown-tail moth, *Euproctis chrysorrhoea* are described. Up to the time of publication, 60 species of parasites and predaceous beetles had been imported from Europe and Japan, 16 of which became established in New England. The species that were well established and abundant by 1914 were *Calosoma sycophanta* L., a predaceous beetle attacking larvae and pupae; *Compsilura concinnata* Meig., a tachinid parasite of larvae; and *Anastatus bifasciatus* Fonsc., an encyrtid egg parasite. In 1916, *Schedius kuvanae* How., another encyrtid egg parasite, *Blepharipa scutellata* R. D., a tachinid attacking larvae, and *Apanteles melanoscelus,* a braconid attacking larvae, were found in considerable numbers. Beginning in 1915, the area of defoliation by the gypsy moth began to decrease gradually, owing to a reduction of favored food, nonhatch of egg clusters, and wilt disease as well as to the increase in parasitism. The average parasitism by all species combined gradually increased and reached a maximum in 1923.
Eggs: 4; Larvae: 3, 4; Pupae: 3

64. Burgess, A. F., and S. S. Crossman.
1929. **Imported insect enemies of the gipsy moth and the brown-tail moth.** U. S. Dep. Agric., Tech. Bull. 86. 147 p.
Life histories of the gypsy moth and the browntail moth are given. Also included are their introduction and spread in the United States and the efforts of the Bureau of Entomology, beginning in 1905 and again in 1922, to introduce natural enemies from Europe and Japan. Detailed information is given about the 1922 project. Over 93 million parasites and predators of the two pests were liberated from 47 species, 15 of which were positively established and 9 or 10 of which became important in New England. The report contains detailed information on imported parasites and invertebrate predators encountered in investigations; earlier work is covered by Howard and Fiske (1911).
Eggs: 4; Instars I-III: 4; Larvae: 3, 4; Pupae: 3, 4.

65. Burgess, A. F.
1944. **The gypsy moth and brown-tail moth: a history of the work for prevention of spread and extermination of these insects in North**

America. U. S. Dep. Agric., Agric. Res. Admin., Bur. Entomol. Plant Quar., Div. of Gypsy Moth and Brown-Tail Moth Control. Greenfield Mass. 334 p.

This report covers work on the gypsy moth from 1890 and on the brown-tail moth from 1897 in the United States. It deals with the efforts of each of the involved states and of the Federal Government, synthesizing the literature published on the subject over the years.

Review

66. Burks, B. D.

1960. **A revision of the genus *Brachymeria* Westwood in American north of Mexico (Hymenoptera: Chalcididae).** Trans. Am. Entomol. Soc. (Philadelphia) 86: 225-273.

All species of *Brachymeria* look alike, but they differ widely in their habits. *Brachymeria intermedia* (Nees) = *Chalcis intermedia* Nees = *Chalcis flavipes.* Type locality is in Sickershausen, Germany, and it is distributed in Europe, the Mediterranean region, Asia Minor, the Middle East, Iraq, Iran, Turkeman, the USSR, and perhaps Massachusetts. It was introduced to New England between 1905 and 1933 but is thought not to have become established, although in 1942 a female was reared from a native *Cacoecia* pupa. It is a primary parasite of 10 families of Lepidoptera pupae and will also parasitize muscoid puparia.

Pupae: 4

67. Buttner, H.

1961. **The influence of fertilizers on the mortality and development of insect pests of forests exerted through their food plants** [in German, English summary]. Schr. Reihe Landesforstverwalt Baden-Württemberg 11(69).

Laboratory experiments on the effect of fertilizers on the mortality of lepidopterous larvae feeding on trees are reported. There is an increase in mortality of "pre-imaginal stages of *Lymantria monacha* (L.), *L. dispar* (L.), and *Pristiphora abietina* on young spruce trees, the results varying with the proportions of the elements in the fertilizers." The effect of the fertilizers on the development of the survivors could not be determined accurately owing to interfering factors. "In field tests in an area long infested with *P. abietina,* the use of calcium ammonium nitrate . . . resulted in 50 percent mortality of the larvae. The way in which mortality is brought about is not known. A correlation was demonstrated between insect mortality and the nitrogen content of their food. Amino acids may be of importance."

Larvae: 13; Non-oak stands: 23

68. Campbell, R. W.

1959. **The development of environmental resistance tables for gypsy moth, *Porthetria dispar* (L.).** M. S. thesis., Univ. Mich., Ann Arbor.

This evaluation of environmental resistance to the gypsy moth is based on observations of a 13.6-acre infested woodlot in Glenville, N. Y. Behavior of larger larvae and pupae differed in each of four environmental subsites differentiated by the depth of the water table. Efficacy of biotic control agents also varied with the site. For example, in a moderately moist site—the "transition site"—large larvae descended to the leaf litter during the day and exposed themselves to both small mammal predation and to a habitat favorable to the virus disease. As a consequence, the transition site was the only one of the four not susceptible to gypsy moth outbreak. Dispersal, exposure, drowning, *Calosoma* predation, small mammals, tachinid parasites, and disease all played a primary role in the environmental resistance complex. Tables are given showing the effects of these factors on survival in each of the sites.

Adults: 1; All stands: 15; Eggs: 4, 12; Generation: 1; Instars I-III: 1, 12; Instars IV-VI: 1, 12; Larvae: 3, 4, 7, 9, 10; Pupae: 1, 4, 10

69. Campbell, R. W.

1961. **Population dynamics of the gypsy moth.** Ph.D. thesis, Univ. Mich., Ann Arbor.

This comprehensive study of the effects of natural factors on gypsy moth populations under various field conditions drew the following conclusions: (1) Sparse populations are probably controlled largely by vertebrates, especially small mammals. (2) Intermediate populations are sometimes damped in their tendency to increase by birds and tachinid parasites. This damping influence may occasionally prolong gypsy moth outbreaks. (3) Dense populations collapse primarily because of the combined effects of disease, desiccation, and ichneumonids. (4) Dry weather may produce conditions on mesophytic sites that will cause an otherwise sparse larval population to stay in the trees, and this in turn may trigger an outbreak. Additional information is given on the parasites, predators, scavengers, disease, and mortality of the gypsy moth. The thesis lists 57 references.

Generation 1, 2, 4, 9; Instars I-III: 1, 9; Instars IV-VI: 1, 3, 4, 6, 7, 9, 10; Prepupae: 3, 4, 6; Pupae: 3, 4, 6, 10; Sex ratio: 4, 6; Fecundity: 12; All stands: 15, 20

70. Campbell, R. W.
1963. **The role of disease and desiccation in the population dynamics of the gypsy moth *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae).** Can. Entomol. 95: 426-434.

"The population dynamics of the gypsy moth, *Porthetria dispar* (L.), are being studied on 10 sites in the Town of Glenville, N. Y. This paper discusses the role of disease and a condition here termed desiccation in the dynamics of these populations during a four-year period, 1958-1961 inclusive. The term desiccation refers to dead prepupae that appeared shriveled, were stiff to the touch, and had a solid mass of food in their gut. The incidence of desiccation among prepupae was closely related to the number of eggs per egg mass produced at the end of the generation (a measure of relative insect density). Disease incidence among larval gypsy moth populations was directly related to insect density. Disease incidence was also related to site conditions, with higher mortality occurring in wet sites. When larval populations reached high densities, they always declined from the dense level within a few generations. These declines ranged from a sudden drastic reduction to a much more gradual decline. The former was preceded by virtual food exhaustion, while the latter was not usually preceded by exhaustion of the food supply. Disease and desiccation were primary factors in producing the sudden type of population reduction noted above. Pathogens may also play an important part in the more gradual type of decline, but this point remains to be clarified.

Eggs: 2; Instars IV-VI: 6, 12; Prepupae: 6

71. Campbell, R. W.
1963. **Some factors that distort the sex ratio of the gypsy moth *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae).** Can. Entomol. 95: 465-474.

"During a study on the population dynamics of the gypsy moth, *Porthetria dispar* (L.), conducted in the Town of Glenville, N. Y. some factors were found to affect the sexes differentially. The importance of this differential mortality is indicated by the fact that 78 percent of the variation in the logarithm of an index of population trend (the ratio of population density from year to year) was associated with the logarithm of adult sex ratio. Disease and desiccation during instars IV to VI and among prepupae were strongly selective against the female insects. This differential mortality caused a change in the pupal sex ratio from about 70 percent females where no disease occurred to less than 25 percent female pupae following on epizootic. Ichneumonids, on the other hand, usually killed more male pupae than females, except when host size was reduced by excessive larval density and competition. The net result from this series of factors that distort the sex ratio has been to produce adult sex ratios varying from more than 80 percent female moths to only 2 percent females. In this host species, as in most other animals, it seems that the population consequences of a mortality factor that kills the host sexes in different proportions should be evaluated in terms of the more critical (female) sex destroyed."

Instars IV-VI: 6; Prepupae: 6; Pupae: 4, 6,; Sex ratio: 2, 4, 6

72. Campbell, R. W.
1963. **Some ichneumonid-sarcophagid interactions in the gypsy moth *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae).** Can. Entomol. 95: 337-345.

"Four ichneumonid species, *Itoplectis conquisitor* (Say), *Pimpla pedalis* Cress., *Theronia atalantae* (Poda), and *Theronia hilaris* (Say), were seen attacking the gypsy moth, *Porthetria dispar* (L.), in the Town of Glenville, Schenectady County, N. Y. These species stung and killed many more host pupae than they successfully parasitized (success here being measured by the development of an ichneumonid offspring within the host). The ratio between the total number of hosts stung by ichneumonids and the number of ichneumonid offspring emerging was different for each of the three primary ichneumonids studied, ranging from 4 to 1 for *T. atalantae* to more than 200 to 1 for *I. conquisitor*. The sarcophagids associated with the gypsy moth, although apparently parasitic, are largely scavengers. Their attacks almost always follow those of ichneumonids. Since the sting of an ichneumonid kills the host but is not always discernible, the number of pupae containing sarcophagid larvae has been used to indicate the true effects of ichneumonids on the host population."

In one study, 925 pupae and prepupae that were known to have been stung by ichneumonids were subsequently examined. Only 18 of these produced adult gypsy moths, and only 8 produced ichneumonid offspring. The 84 prepupae known to have been stung by ichneumonids failed to produce a single ichneumonid. Of an additional 4522 dead prepupae examined in the field, not one contained an ichneumonid offspring.

Prepupae: 4; Pupae: 4

73. Campbell, R. W.
1966. **Gypsy moth egg-mass density and subsequent defoliation.** U.S. Dept. Agric. For. Serv. Res. Note NE-44. 6 p.

"Percentage defoliation of oak by the gypsy moth . . . [was found to be] directly related to egg-mass density at the start of each year, and inversely related to the trend in egg-mass density from the preceding year . . . These relationships were not close enough to provide a useful predictive equation, . . . [but] clear-cut expectations of given defoliation levels can be calculated when broad categories are used."

Oak stands: 15, 19; Eggs: 2

74. Campbell, R. W.
1967. **Studies on the sex ratio of the gypsy moth.** For. Sci. 13: 19-22.

"The sex ratio among gypsy moth (*Porthetria dispar* (L.)) embryos and newly hatched larvae approximated 50:50. By the time the insects reached instar II, however, the sex ratio had changed so that there were more female than male insects in the population. The sex ratio among both instar III and instar IV larvae continued to be distorted in favor of the females and averaged about 66:34 at the start of instar IV. These findings complete the quantitative basis required for the explicit analysis of the female component of gypsy moth populations." Changes in the adult sex ratio were caused primarily by certain types of mortality, as shown in earlier studies. These agents included disease in instars IV to VI and larval and pupal parasitism by ichneumonids.

Instars IV-VI: 6; Pupae: 4; Sex ratio: 4, 6

75. Campbell, R. W.
1967. **Measuring age-specific mortality factors of the gypsy moth.** Proc. North Cent. Branch Entomol. Soc. Am. 22: 53-56.

Methods are discussed for "estimating each of three different sorts of mortality factors: first, mortality caused by ichneumonids among dense populations of pupae; second, predation by vertebrates among sparse populations of instar IV through VI larvae and pupae; and third, components of disease among dense populations of the large larvae."

Instars: IV-VI: 1, 5, 6, 7, 10; Pupae: 4, 10

76. Campbell, R. W.
1967. **The analysis of numerical change in gypsy moth populations.** For. Sci. Monogr. 15. 33 p.

"A study of gypsy moth, *Porthetria dispar* (L.), population dynamics was carried out over a 7-year period in several areas in northeastern New York. The data were summarized in life tables, stratified by density and sex, and then analyzed by mathematical models. Variation in the survival rates of the instar IV to VI female larvae and the female pupae was the greatest source of variation in density among dense populations. Variation in the survival rates of both instar I to III and IV to VI female larvae was most important among sparse populations. Disease was the primary determinant of variation in the survival rate of dense populations of instar IV to VI larvae, while agents other than disease or parasites were most important at this stage among sparse populations. The survival rate of dense populations of the female pupae varied primarily in response to parasites and disease. Variation in the survival rate of the instar I to III larvae was probably primarily a function of variation in the dispersion rate of the newly hatched larvae. A generation model was developed that describes density at the start of a second generation as a function of the environmental variables associated with the above mortality-causing factors. It was tested against an independent body of data with some success."

Instar IV-VI: 2, 6; Larvae: 1, 3, 4; Pupae: 2, 4, 6

77. Campbell, R. W.
1969. **Studies on gypsy moth population dynamics.** Pages 29-34 *in* Forest Insect Population Dynamics. U.S. Dept. Agric. For. Serv. Res. Pap. NE-125.

The survival rate of later instar female larvae and pupae represented the greatest source of density variation in dense populations. Variation in survival rate of all larval stages (female) was most important in sparse populations. Disease was the primary cause of variation in survival rate in dense populations of instar IV to VI female larvae, while agents other than disease or parasites were most important in sparse populations. Female pupal survival rate varied primarily in response to ichneumonids and disease. Instars I to III probably varied in survival rate as a function of variation in the dispersion rate of the newly hatched larvae. "An index of disease incidence among instar IV to VI larvae was a curvilenear function of insect density, a linear function of precipitation during June, a linear function of the percent of swamp white oak in the overstory, and a function of an interaction between density and precipitation."
Instars IV–VI: 6; Pupae: 6

78. Campbell, R. W., and J. D. Podgwaite.
1971. **The disease complex of the gypsy moth. I. Major components.** J. Invertebr. Pathol. 18: 101–107.
"A study was undertaken to elucidate the impact of the various components of disease on natural populations of the gypsy moth, *Porthetria dispar*. Diseased larvae from both sparse and dense populations were examined and categorized on the basis of etiologic and nonetiologic mortality factors. Results indicated a significantly higher incidence of parasite involvement—but virtual nonexistence of polyhedral viruses—in the relatively stable sparse populations. Nuclear polyhedrosis probably represented the primary mortality factor in the dense populations. Many insects examined from both population types revealed no infectious agent or overt cause of disease, a fact that may indicate a major regulatory role of noninfectious disease in natural populations. Variation in the disease complex within the populations that have been studied indicates that minor causes of disease in one may well predominate in others. Thus, to fully understand this complex, it must be studied across a number of years within a series of populations from different geographical areas."
Larvae: 5, 6, 7

79. Campbell, R. W.
1971. **Developing a pest population management system.** Pages 9–20 *in* Proc. Tall Timbers Conf. Ecol. Anim. Control Habitat Manage.
Development of a program designed to achieve reasonable control of the gypsy moth without degrading the environment is discussed. It has four interlocking parts—prediction, understanding, control, and integration.
Generation: 2

80. Campbell, R. W. , and H. T. Valentine.
1972. **Tree condition and mortality following defoliation by the gypsy moth.** U.S. Dep. Agric. For. Serv. Res. Pap. NE-236. 331 p.
"The objective of [this] work is to present a basis from which increasingly accurate forecasting schemes can be developed for predicting both tree condition and mortality subsequent to defoliation. This basis, which is derived from a review of certain historical records, consists of a series of 323 tables giving both annual and cumulative tree mortality rates, as well as the subsequent condition classes of the surviving trees, for particular tree species or species groups, and according to the history of defoliation. These tables were prepared by sorting raw data from permanent plots."

The records used were compiled between 1911 and 1931 from 264 circular plots (0.18-acre) along the eastern seaboard of New England, from Wareham, Mass., to Kennebunk, Me. Annual records were maintained through 1922 on 121 of the original plots. Average mortality at the end of this period was 58 percent in white oak, 55 percent in gray birch, 46 percent in both black and scarlet oak, 27 percent in red oak, 26 percent in white pine, and 25 percent in red maple. Within any given species, mortality rates tended to be highest among suppressed trees and lowest among dominants and also highest among trees classified in poor condition prior to defoliation. Species alteration because of gypsy moth activity was not documented directly, but it can be inferred from the records that the decline of pioneer gray birch stands was accelerated, that the ratio of white to red oak was reduced, and that the white pine component of mixed stands was increased.
Oak stands: 15, 19, 20, 24, 25, 26, 27

81. Campbell, R. W.
1973. **Numerical behavior of a gypsy moth population system.** For. Sci. 19:162-167.

"The numerical behavior of a gypsy moth population system observed in eastern New England between 1911 and 1931 is described. Rates of change in egg mass density from year (n) to (n + 1) were related to rates of change in density from years (n − 1) to (n) and to an index of the density level of the overall population system, termed zone density. When zone density was high, individual populations tended to increase to and maintain high density levels. When zone density was low, individual populations tended to achieve and maintain low densities. Numerically unstable populations between years (n − 1) to (n) tended to remain numerically unstable from years (n) to (n + 1)."

Generation: 1, 2

82. Campbell, R. W.
1973. **Forecasting gypsy moth egg-mass density.** U.S. Dep. Agric. For. Serv. Res. Pap. NE-268. 19 p.

"Several multiple-regression models for gypsy moth egg-mass density were developed from data accumulated in eastern New England between 1911 and 1931. Analysis of these models indicates that: (1) the gypsy moth population system was relatively stable in either the OUTBREAK phase or the INNOCUOUS one; (2) several naturally occurring processes that could terminate the OUTBREAK phase are represented by the models, but they do not indicate mechanisms sufficient to change the system for the INNOCUOUS phase to the OUTBREAK one. Some of the implications arising from the above conclusions are discussed." Results from the data also support the following conclusions: (1) Heavy precipitation in June of the year (n + 1), if sufficiently widespread, may indicate the abrupt collapse of the OUTBREAK phase; and (2) mechanisms similar to those described by Wellington (1965) for the western tent caterpillar and by Morris (1969) for the webworm may also operate in the dynamics of gypsy moth populations.

Eggs: 2; Generation: 2, 12

83. Campbell, R. W.
1974. **Relationships between overstory composition and gypsy moth egg-mass density.** U.S. Dept. Agric. For. Serv. Res. Note NE-191. 6 p.

This study provides evidence that the favored food theory has relatively little merit, at least with respect to relationships between overstory composition and subsequent gypsy moth population density. There was virtually no difference between the stable-state distribution of gypsy moth egg-mass densities in favored food stands and that in poor food stands when zone densities (egg-masses per acre) were low, and surprisingly little when they were high. "About 17 percent of the favored food stands could be expected to support more than 5,000 egg masses per acre when zone density was high, compared with only about 10 percent of the poor food stands. An almost identical proportion of the stands in each cover type could be expected to support fewer than 500 egg masses per acre at high zone densities."

Eggs: 12

84. Campbell, R. W.
1974. **Relation between overstory composition and subsequent defoliation by the gypsy moth.** J. For. 72.

"The percentage of favored food in the overstory was closely related to the subsequent level of defoliation by the gypsy moth. Thus the silvicultural recommendations that are based on the 'favored food' theory may be valid with respect to abating the damage done by this insect to the forest." The percentage of favored food in the overstory was not closely related to gypsy moth egg-mass density.

Oak stands: 15, 20, 21

85. Campbell, R. W., and J. P. Standaert.
1974. **Forecasting defoliation by the gypsy moth in oak stands.** U.S. Dept. Agric. For. Serv. Res. Note NE-193. 7 p.

"A multiple-regression model is presented that reflects statistically significant correlations between defoliation by the gypsy moth, the dependent variable, and a series of biotic and physical independent variables. Both possible uses and [possible] shortcomings of this model are discussed."

Oak stands: 15

86. Campbell, R. W.
1974. **The gypsy moth and its natural enemies.** U. S. Dept. Agric., Agric. Inf. Bull. 381. 27 p.

"Patterns of gypsy moth behavior are described, especially those related to population density. Natural mortality-causing factors that operate

against this insect are also described. Several agents kill subadult male and female gypsy moths at different rates. Major determinants of year-to-year changes in gypsy moth numbers are described."
Review

87. Campbell, R. W., D. L. Hubbard, and R. J. Sloan.
1975. **Patterns of gypsy moth occurrence within a sparse and numerically stable population.** Environ. Entomol. 4: 535-542.

"Patterns of subadult gypsy moth, *Porthetria dispar* (L.), occurrence within a sparse, numerically stable population that was studied in 1965 were modeled as functions of insect stage and certain components of environmental structure. Our results imply that (a) once newly hatched larvae find suitable foliage, they tend to stay on or near it until after they have molted into instar III; (b) these insects begin to wander sometime before reaching instar IV, and continue to do so until suitable daytime resting locations are found. These locations are usually in the litter at the tree base, but the insects will aggregate under bark flaps on dead limbs or on the dead boles of trees in clumps in preference to the litter if these are available; (c) most of the insects pupate in the locations used earlier for resting sites, but some eventually pupate in objects that may be many feet away from the closest living host tree; and (d) bark flaps may have provided less hazardous resting sites for the growing larvae and pupae than other potential resting locations within the environment."

The percentage of insects more than 6 feet above the forest floor was about 45 percent as the insects began to molt into instar V, increasing to 65 percent at the pupal stage, and stabilizing at 65 percent. About 45 percent of the insects were found between the litter and 6 feet above the forest floor as they began to molt into instar V. This declined to 10 percent as the insects began to pupate, then rose to about 25 percent as the last larvae pupated. About 10 percent were found in litter as they began to molt into instar V and 30 percent as the insects began to pupate. The percentage then declined steadily as pupation progressed.
Instars I-III: 1; Instars IV-VI: 1; Larvae: 1; Pupae: 1

88. Campbell, R. W., D. L. Hubbard, and R. J. Sloan.
1975. **Location of gypsy moth pupae and subsequent pupal survival in sparse, stable populations.** Environ. Entomol. 4: 597-600.

"About 90 percent of the gypsy moth, *Porthetria dispar* (L.), pupae found in a series of sparse stable populations studied between 1965 and 1968 were either beneath bark flaps or in the litter. Male larvae were more likely to pupate in bark flaps than females. Pupal survival was usually higher among pupae beneath bark flaps than among those in the litter, and bark flaps provided virtually the only pupation locations in the whole environment, within the highest density stratum studied, where female pupae had a reasonable survival probability. Adult gypsy moth production in these populations could be accurately estimated from knowledge of pupal density and sex ratio, and the number of bark flaps per 0.01-acre. Bark flap removal is suggested as a potentially useful technique for preventing outbreaks."
Adults: 2; Pupae: 1, 12

89. Campbell, R. W.
1975. **The bimodality of gypsy moth, *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae) populations (Abstract).** J. N. Y. Entomol. Soc. 83:287-288.

Populations of the gypsy moth in North America tend to have two numerical modes—innocous and outbreak. A population may remain in the innocuous mode for many years, but an outbreak within a general area may last for as long as a decade. Changes from the innocuous mode to the outbreak mode and vice versa usually occur within 2 or 3 years.
Generation: 2

90. Campbell, R. W., M. G. Miller, E. J. Duda, C. E. Biazak, and R. J. Sloan.
1976. **Man's activities and subsequent gypsy moth egg-mass density along the forest edge.** Environ. Entomol. 5:273-276.

"When gypsy moth, *Porthetria dispar* (L.), egg-mass density was low (less than 50 egg masses/acre), density was 10 times higher along the forest edge than within the forest. Man-made objects (MMOs) left along the forest edge in suburban areas contained ca. 1/2 of the egg masses found at low densities. MMOs that were rough, or dry, or protected from light contained

more egg masses than those that were smooth, or frequently moist, or exposed to light. Rough, dry MMOs that were protected from light contained the most egg masses. Apparently, these latter MMOs function as "bark flap" equivalents by providing a degree of protection for the growing larvae and pupae. It is postulated that sparse gypsy moth populations may tend to increase numerically from innocuous levels in situations where abundant larval resting and pupation locations other than the litter are available for the growing insects. Thus, littering the forest edge with MMOs could be a "triggering mechanism" for subsequent gypsy moth outbreaks."
Eggs: 2,12; Generation: 2,12

91. Campbell, R. W., and R. J. Sloan.
1976. **Influence of behavioral evolution on gypsy moth pupal survival in sparse populations.** Environ. Entomol. 5:1211-1217.
"Vertebrate predators killed about 70 percent of the gypsy moth, *Lymantria dispar* (L.), pupae in a series of sparse, numerically stable populations studied in New England between 1965 and 1968; and white-footed mice, *Peromyscus leucopus* Raf., were the most important predators. Pupae in the litter were more likely to be preyed upon than those in other locations, and female pupae were more likely than males to be killed by vertebrates. All other agents (primarily parasites) killed about 15 percent of the pupae. It is postulated that the growing insects exhibit behavior that enables them to evade natural enemies in Europe, by resting and pupating in the litter at the bases of their host trees. In North America, however, this behavioral trait often assures not only high gypsy moth mortality but also the destruction of many of the parasites that may have caused this trait to evolve. It is also postulated that a new behavioral adaptation may be evolving by this pest in response to new conditions in North America. Certain management implications from the above findings and postulates are described, and further research studies are recommended."
Larvae: 1,4,9,12; Pupae: 1,4,10,12

92. Campbell, R. W.
1976. **Comparative analysis of numerically stable and violently fluctuating gypsy moth populations.** Environ. Entomol. 5:1218-1224.
"Sparse gypsy moth, *Lymantria dispar* L., populations studied in the vicinity of Glenville, N. Y. between 1958 and 1964 tended to increase rapidly to outbreak levels. Conversely, equally sparse populations studied in the vicinity of Eastford, Conn. between 1965 and 1971 tended to remain sparse. Major mechanisms determining numerical differences between the two areas acted primarily during three age-intervals. First, the survival rate among instars I to III was higher in Glenville than in Eastford, although this difference decreased as density increased. These results were interpreted as a consequence primarily of airborne dispersal processes that occur largely during instar I. Second, the survival rate among instars IV to VI was higher in Glenville than in Eastford, and this difference increased as density increased. Although predation processes were probably responsible for most of the instar IV to VI mortality among the sparse populations in both areas, these results suggest that predation during this state was effective in maintaining sparse populations at innocuous levels only in Eastford. Third, pupae were more likely to survive in Glenville than in Eastford, and this difference was relatively constant across the entire density range that was common to the two areas. Since vertebrate predators, especially *Peromyscus leuopus*, were known to have killed most of the pupae in the Eastford populations, these results imply that these predators played a major role in maintaining the Eastford populations at innocuous levels."
Generation: 1,2; Instars I-III:2; Instars IV-VI: 2,9,10; Pupae: 2,10

93. Campbell, R. W., and R. J. Sloan.
1977. **Natural regulation of innocuous gypsy moth populations.** Environ. Entomol. 6:315-322.
"Preliminary studies on the determinants of numerical stability among a series of sparse gypsy moth, *Lymantria dispar* (L.), populations studied between 1965 and 1970 led to the hypothesis that year-to-year numerical stability among these populations was determined largely by a combination of predaceous birds, which tended to concentrate on instar IV to VI larvae and small mammals, especially *Peromyscus leucopus*, which tended to concentrate on the pupae. Test results in 1971 both supported the above hypothesis and emphasized the importance of selective predation on the female pupae by mammals in maintaining these sparse populations at innocuous levels. These same results also indicated that vertebrate

predators were consuming about one half of the parasitized instar IV to VI larvae and most of the parasitized pupae in the sites studied. Thus, the percentage of the gypsy moth population that *contains* parasites may often be much higher than the percentage that is actually *killed* by these same parasites. These results suggest not only that the activities of vertebrate predators may have been critically important in maintaining these sparse gypsy moth populations at innocuous levels, but also that the role of parasites in the dynamics of such populations in North America may be considerably more constrained by the activities of these predators than has previously been reported. Conversely, parasites may play their most important role within outbreak foci, since these foci are characterized in part by sparse gypsy moth populations that exhibit exceptionally low rates of vertebrate predation."

Instars IV–VI: **4,9,10,12; Pupae: 4,10,12; Sex ratio: 10**

94. Campbell, R. W., and R. J. Sloan.
1977. **Release of gypsy moth populations from innocuous levels.** Environ. Entomol. 6:323–330.

"Prior studies led to the premise that gypsy moth, *Lymantria dispar* (L.), populations tend to increase numerically from innocuous levels in environments where abundant, sheltered resting and pupation locations reduce the probability that the growing insects will be eaten by vertebrates. Although such locations may be found anywhere within the environment, and either may occur naturally or be introduced by man, they are usually above the forest floor, close to or part of a suitable host tree, and dark, dry, and rough. Test results described herein both supported this premise and led to the conclusion that environmental conditions that tend to produce or represent abundant sheltered locations for this pest also tend to produce or represent potential outbreak foci. Such environmental conditions include dry, rocky ridges, excessively drained sands, remnant "wolf-trees," and ice storms. Other environmental conditions that may contribute to the release of gypsy moth populations from innocuous levels include changes in habitat or food sources of predators, tree age, nutrient and moisture deficiencies, air pollution, land abuse, and climate. Qualitative differences between individual insects may also contribute to population release from innocuous levels."

Generation: 2,12; Instars: IV–VI **9,10,12; Pupae: 10,12**

95. Campbell, R. W., and R. J. Sloan.
1977. **Forest stand responses to defoliation by the gypsy moth.** For. Sci. Monogr. 19.

"Records accumulated between 1911 and 1931 from a series of plots in eastern New England were analyzed to determine some of the changes in the forest that followed heavy and repeated defoliation by the gypsy moth, *Lymantria dispar* (L.) Oak trees required about 10 years to recover totally from a single heavy defoliation. Dominant trees were degraded less than subdominants and were less likely to die. Trees rated in poor condition were more likely to die after defoliation than those rated good. Tree species not favored as food by the insects were more likely to die after heavy defoliation than oak trees. Red maple, *Acer rubrum* (L.), was more likely to be killed by one heavy defoliation than white pine, *Pinus strobus* (L.). When defoliation, overall, was low, nearly all of it occurred on favored-food trees, but the insects became less selective as overall defoliation increased. Heavy and repeated defoliation resulted in more and more one-storied stands. For two reasons, heavy defoliation and subsequent tree mortality tended to reduce the susceptibility of the residual stand to further defoliation. First, differential loss rates *among* favored-and nonfavored-food species tended to alter forest composition toward less susceptible types. Second, certain trees *within* any given tree species were consistently defoliated more heavily than others. These trees were also more likely to die."

Generation: 2; Oak stands: 15,16,19,20,21, 22,24,25,26,27,28; All stands: 15,16,19,20,21,22, 24,25,26,27,28

96. Capinera, J. L., and P. Barbosa.
1976. **Dispersal of first-instar gypsy moth larvae in relation to population quality.** Oecologia 26:53–64.

"Field studies of dispersal by first-instar gypsy moth larvae, indicate that almost all larvae undergo an initial dispersal episode. However, in laboratory studies large larvae (from large eggs) disperse more frequently than small larvae (from small eggs) in the presence of favored food. Large larvae may be better adapted for dispersal. When

larvae encounter unacceptable food or are denied food, they disperse more frequently, . . . dispersal by small larvae is nearly as frequent as dispersal by large larvae. Factors affecting egg size may contribute to shifts in dispersal patterns of gypsy moth larvae and distribution of populations."
Instars I–III: 1

97. Cardé, R. T., C. C. Doane, and W. L. Roelofs.
1974. **Diel periodicity of male sex pheromone response and female attractiveness in the gypsy moth (Lepidoptera: Lymantriidae).** Can. Entomol. 106: 479–484.
"In field studies, gypsy moth males were attracted to synthetic cis-7, 8'epoxy-2- methyloctadecane (disparlure), the female sex pheromone, and virgin females from 0900 to 2000 [hours] (Eastern Standard Time). The greatest numbers of males were lured to the synthetic attractant or the calling female from 1100 to 1500 [hours]. These periods of male response are longer than reported in previous (1896 and 1932) New England investigations and suggest the possible recent evolution of a new diel rhythm of male sex pheromone response."
Adults: 1

98. Cardinal, J. A.
1967. **Control of the gypsy moth in Quebec** [in French English summary]. Phytoprotection 48: 92–100.
"The gypsy moth situation in Quebec has reached an alarming state and some drastic measures will be undertaken. Five counties are affected by this last outburst, covering some 20,000 acres. The records of its steady progress towards northern regions and its sporadic behavior since its introduction into Massachusetts in 1869 offer a constant challenge. Renewed strategy is necessary to face this progressing menace. The Canadian authorities are worried about its gradual adaptation to climate. Research is now oriented towards synthetic sex attractant that could be spread by plane over large areas to reduce population."
Generation: 12

99. Cardinal, J. A., and W. A. Smirnoff.
1973. **Experimental introduction of the nuclear polyhedral virus of *Porthetria dispar* L. (Lepidoptera: Lymantriidae) in the forest** [in French, English summary]. Phytoprotection 54: 48–50.
"A 4-year gypsy moth infestation in Huntingdon County is maintained in an almost endemic state by a viral infection of the larvae. Tentative dispersion of the virus into other gypsy moth-infested territories was made in forest by treating egg masses and foliage with a viral aqueous suspension; rearing of larvae was also successful in forest for subsequent use of viral suspension. There are very promising possibilities to create epizootic viral infections where the gypsy moth population is densely built."
Eggs: 7; Generation: 7; Larvae: 7

100. Ceballos, P. J.
1961. **An experiment on the reproduction of an ichneumonid *(Pimpla instigator F.)* in captivity** [in Spanish]. Bol. Serv. Plagas For. 4(8): 97–101.

101. Chapman, J. W., and R. W. Glaser.
1916. **Further studies on wilt of gipsy moth caterpillars.** J. Econ. Entomol. 9: 149–169.
From their studies the authors concluded that wilt is a true infectious disease that seems to be transmitted between generations through the egg. Some gypsy moths seem immune to it. It is filterable through Berkefeld "N" candles but not through Pasteur-Chamberland "F" filters. In their experiments the period from inoculation by feeding until death varied from 13 to 29 days. They worked with both American and Japanese gypsy moth stock. A new disease, which differed clinically and microscopically from wilt, attacked instars IV and V of the foreign stock. Numerous *Saccharomycetes* and *Micrococci* were isolated from the intestines of diseased animals, but no polyhedra were found in them.
Eggs: 7; Instars IV–VI: 6; Larvae: 7

102. Chu, Hai-Tsin.
1962. **Contribution to the ontogensis and biology of *Apanteles solitarius* Ratz., parasite of the gypsy moth *(Porthetria dispar* (L.))** [in Russian]. Vestn. Mosk. Univ. Biol. Pochvoved. 1962(6): 26–32.

103. Chu, Hai-Tsin.
1965. **Effect of *Apanteles solitarious* Ratz. larvae on the mesenteron of the gypsy moth *(Porthetria dispar* (L.))** [in Russian]. Vestn. Mosk. Univ. Briol. Pochvoved. 1965(4): 34–37.

104. Chugunin, Y.

1949. **Focal periodicity of gypsy moth outbreaks** [in Russian]. Zool. Zh. 28(5): 431-438.

105. Chugunin, Y. V.

1959. **Cycles of increase of pest insects and the microbiology method of controlling them**[In Russian, English summary] First Int. Conf. Insect Pathol. Biol. Control 1958: 81-93.

"The gypsy moth in the Crimea is a very suitable object for the study of natural control of the pest by microorganisms. In most cases, 3-year outbreaks of the pest occur in the climatic conditions of the locality. After this period a spontaneous liquidation of the populations by disease and parasites can be observed. The waves of the disease . . . [just] as the outbreaks, start at the southern shore of the peninsula and go to the north. Protozoa, fungi, and bacteria are involved in natural control of the outbreaks."

Generation: 2,4,5,7,8

106. Clement, G. E.

1917. **The gipsy moth in the woods.** Pages 1-16 *in* Control of the gypsy moth by forest management. U. S. Dept. Agric. Bull. 484.

Although at first the gypsy moth was thought to be omnivorous, it was later found that they prefer certain food plants. Young larvae do not eat conifers except for tamarack, which is not abundant in the gypsy moth region. Once established, an infestation in a wood will probably remain for as long as the food supply lasts, though the degree of infestation will vary. Among defoliated trees, oak has suffered the highest mortality owing to three factors: the presence of *Agrilus bilineatus*, whose damage is usually evident beneath the bark of all dead specimens; the fact that the gypsy moth region is the northern limit of white oak, causing further stress; and the tendency of oaks to be on the poorest sites. Pure stands of conifers are immune to serious damage; the percentage of unfavored hardwoods influence's the amount of damage. Dying trees harbor borers which can attack defoliated trees that would otherwise be able to recover. Young larvae can feed on shrubs and when older proceed to unfavored tree species. In a full stand, shrubs are shaded out. If the stand is properly managed, there are no shrubs. Trees of a favored species should not be eliminated because of the gypsy moth; rather, mature or defective trees should be removed.

Oak stands: 15, 16, 25; All stands: 15; Non- oak stands: 15

107. Clement, R. C., and I. C. T. Nisbet.

1974. **The suburban woodland: trees and insects in the human environment.** Audubon Conserv. Rep. 2. Mass. Audubon Soc., Lincoln, Mass.

This paper reviews and synthesizes work done on aspects of forest ecology, demonstrating that there is a natural balance between trees, insects, and other forest inhabitants. Details are given on the life system of the gypsy moth.

Generation: 1,2,12; All stands: 15, 20

108. Cointat, M.

1948. **Observations on an invasion of *Lymantria dispar* L. in the forest range of Uzès** [in French]. Rev. Eaux For. 86(1): 11-32.

109. Collado, J. G.

1931. **Notes on Spanish tachinids (Dipt.). I. Some parasites of caterpillars in El Escorial** [in Spanish]. Eos 7: 349-354.

110. Collins, C. W.

1915. **Dispersion of gipsy moth larvae by the wind.** U. S. Dep. Agric. Bull. 273, 23 p.

Wind is almost wholly responsible for the general spread of the gypsy moth in New England, as proven by experiments utilizing tanglefoot screens which caught larvae carried by wind as far as 13.5 miles. Larvae are sufficiently active at 55°F to be caught by wind velocities ranging from 2 to 23 mph, although more dispersal activity occurs at temperatures of 65 to 85°F. with wind velocities of at least 8 mph. Larvae have been caught at times when winds were blowing from all directions except the north, with the greatest numbers carried aloft by westerly winds. From the time the gypsy moth first appeared in Providence, R. I. in 1901, it spread at a rate of 5 miles per year northeast and 3 miles per year west, which tends to verify the data collected in connection with these screen experiments.

Instars I-III: 1

111. Collins, C. W.

1917. **Methods used in determining wind dispersion of the gipsy moth and some other insects.** J. Econ. Entomol. 10: 170-177.

Data were collected on long-distance wind dispersal of gypsy moth larvae across Cape Cod Bay off

the coast of Massachusetts, from an infestation 19 to 30 miles distant. Three or four other species of Lepidoptera larvae were also carried by the wind and caught in the traps.
Instars I-III: 1

112. Collins, C. W., and J. E. R. Holbrook.
1929. **Trapping *Calosoma* beetles.** J. Econ. Entomol. 22: 562-569.

A *Calosoma* beetle trap was designed by the authors for the purpose of obtaining a count of the number of beetles per tree or per given area. The trap construction is discussed as is the possibility of using the trap to collect large numbers of beetles for colonization.
Larvae: 3; Pupae: 3

113. Collins, C. W., and C. E. Hood.
1920. **Life history of *Eubiomyia calosomae*, a tachinid parasite of *Calosoma beetles*.** J. Agric. Res. 18: 483-497.

E. calosomae was first noted on *Calosoma sycophanta* in 1912, 6 years after its introduction to the United States. It has been bred from *C. sycophanta*, *C. frigidum*, and *C. calidum* and is very widespread. It is believed to be native to New England. The flies are more active during late afternoon and early morning when beetles are quiescent. They oviposit on the exoskeleton singly or in small groups of eggs. Larvae hatch soon after being deposited (3 to 12 hours) and enter the host immediately, probably through spiracles. First and second instar larvae attach to host trachae, hibernating at second instar when the host *Calosoma* burrows beneath the ground. Host and parasite both resume activities around the same time in May or June. Third-instar larvae move freely in the host body cavity where blood and fats have been reduced by parasite feeding. *Calosoma* is further weakened by the process of surfacing after hibernation, and it dies on the ground surface or just below. The fly pupates in the body cavity or under the elytra after death of the host. There are two generations per year: Adults issue in May to June and again in July to August. Many of the second generation dies because most *Calosoma* hibernate by July 15 and no hosts are available. This keeps down the parasite population. If the range of *C. calidum* were to overlap with that of *C. sycophanta*, the rate of parasitism would increase because of a longer host season. The highest rate of parasitism on *C. sycophanta* was 3.4 percent, but the average on *C. calidum* is 4.4 percent. One secondary parasite has been reared from pupae of *Eubiomyia: Chalcis* larvae.

114. Collins, C. W., and S. F. Potts.
1932. **Attractants for the flying gipsy moths as aids in locating new infestations.** U. S. Dept. Agric. Tech. Bull. 336.

"Male gypsy moths are strongly attracted to living virgin females. A scent is given off from the vicinity of the copulatory-pouch opening and is sensed by the male through its antennae. Some males fly as far as 2.38 miles, but usually the distance of flight is much shorter; and catches of males are seldom made at traps over 1/2 mile distant from a colony. . .Certain extracts made from the region of the female genitalia attract males. . .[but] none of the attractant was found in glands of the reproductive system internally. . .The attractant is of a complex fatty nature and is saturated. When exposed, it is active for several weeks, a period equivalent to the flight season of the males. . ."
Adults: 1,13

115. Collins, C. W., and W. L. Baker.
1934. **Exploring the upper air for wind-borne gipsy moth larvae.** J. Econ. Entolol. 27: 320-327.

Field work has shown wind to be the chief agent of larval dispersal. Especially important are the warm surface westerlies which over a 40-year period caused the gypsy moth to spread 2-1/2 times as rapidly to the northeast and southeast as to the northwest and southwest. In the 1932 and 1933 seasons, an airplane with sticky traps mounted below one wing flew over southeastern Massachuetts. The flights were made daily during the period of peak larval hatch when ground temperatures were higher than 70°F. During 1932, nine flights and 40 screen exposures were made at altitudes ranging from 300 to 5000 feet from May 10 to 12. The average trap exposure time was 12 minutes, 11 seconds. Despite weather conditions unfavorable for maximum larval activity, one first-instar larva was caught at the 300- to 500-foot range and two at 1000 feet. In 1933, with a newly designed trap, 14 flights and 62 exposures were made between May 10 and 23 at altitudes ranging from 500 to 3000 feet. The average exposure time was 11 minutes, 27 seconds, and the exposure space doubled

to 2 square feet. Only one gypsy moth larva was caught at 2000 feet. Despite the small numbers caughts, the authors found the results satisfactory because the size of the sample was minute considering the cubic feet of air above the infested area.
Instars I-III: 1

116. Collins, C. W.
1934. **Natural enemies of the gypsy moth, brown-tail moth, and some other forest and shade tree pests in Massachusetts.** Mass. Comm. Conserv. State For. Annu. Rep. 1933: 31-32.

From 1929 to 1933 collections and observations were made in designated 10-acre woodland areas in New England to determine the percentage of parasitism and predation in each life stage. Owing to a large increase in gypsy moth infestation, the percentage of parasitism and predation declined from 1932 to 1933 despite an increse in the number of insect enemies.
Generation: 2,3,4

117. Collins, D. L.
1960. **Population studies of the gypsy moth (*Porthetria dispar* L.) in New York State.** Pages 215-218 *in* Proc. 11th Int. Congr. Entomol., 1960, Vol. II, Sec. VIII For. Entomol.

This paper outlines some studies that were undertaken in New York State in the late 1950's to investigate factors affecting gypsy moth populations dynamics.
Generation: 1,2

118. Collins, S.
1961. **Benefits to understory from canopy defoliation by gypsy moth larvae.** Ecology 42: 836-838.

"Two observations suggest that light intensity is the critical factor controlling elongation of maple in the woods. First, the halting of elongation in the undefoliated woodland coincide with the estimated canopy closure. Second, in the defoliated stand where the understory was not fully shaded, elongation continued past the normal stopping time. It did stop when refoliation occurred. . .The chronology of elongation, defoliation, and refoliation leaves no doubt that maple could exploit increased light intensity [caused by oak defoliation]"
Oak stands: 15, 21; All stands: 20; Non-oak stands: 24

119. Connecticut Agricultural Experiment Station, New Haven.
1915. **The gypsy moth.** Conn. Agric. Exp. Stn. Bull. 186. Entomol. Ser. 21. 24 p.

Although several enemies of the gypsy moth are native to the United States, none is effective in holding it in check. *Calosoma scrutator* Fabr. has been found under burlap bands. In captivity one ate 137 gypsy moth larvae in 13 days. *C. calidum* and *C. frigidum* are also predatory. Eggs of *Tachina mella* Walk. were observed on the backs of gypsy moth larvae, and tachinid adults emerged from pupae. The gypsy moth pupae were closely packed with fly puparia, but only one adult emerged per pupa. Predaceous soldier bugs eat gypsy moth larvae. More than 40 species of birds were seen feeding on the gypsy moth in different stages, but only a few are useful, these include the cuckoo, oriole, robin, catbird, bluejay, crow, chipping sparrow, chickadee, and vireo. Wilt disease may be indigenous to the United States; it killed many larvae from 1913 to 1915.
Generation: 9; Larvae: 3,4,6

120. Corliss, J. M.
1955. **Damage to our forests caused by the gypsy moth in 1953.** J. Econ. Entomol. 48: 263-264.

In 1952 unusual increases in egg mass populations were noted, and extensive defoliation was predicted for 1953 unless large-scale spraying was undertaken. An unprecedented increase in defoliated areas did occur (1951:21,314 acres; 1952:293,052 acres; and 1953:1,500,000 million acres). Records of the previous 25 years show decided cyclical recurrence of defoliation peaks following minor crests at approximate 8-year intervals: 1929:551,133 acres; 1937:1, 487,077 acres. Causes of the cycles are obscure. Retardation in growth is shown to be directly proportional to percentage of defoliation. Mortality of young white pine is substantial in defoliated mixed stands. There is increasing evidence that defoliation in two successive seasons (or one complete stripping in some cases) is fatal to softwoods, particularly hemlock. Long-term records for losses to softwood species are not available. Three tornadoes in heavily infested regions on June 9, 1953 may have dispersed the gypsy moth. Larvae were in the third instar and could have been carried aloft. This is disputed by some meterologists and entomologists who point to wind velocities of 350 mph and subfreezing temperatures.

All stands: 15,18,24,26; Generation: 2; Instars I-III:1, 12

121. Cosenza, B. J., and J. D. Podgwaite.

1966. **A new species of *Proteus* isolated from larvae of the gypsy moth *Porthetria dispar* (L.).** Antonie van Leeuwenhoek J. Microbiol. Serol. 32:187-191.

A slime-producing bacterium was isolated from living and dead gypsy moth larvae and named *Proteus myxofaciens*. It fermented glucose but not lactose, was oxidase-negative, hydrolyzed urea, deaminated phenylalamine, and produced H_2S.

Larvae: 5

122. Cosenza, B. J., and F. B. Lewis

1966. **Taxonomic considerations of four "wild"-type crystalliferous bacilli and their toxicity to larvae of the gypsy moth, *Porthetria dispar*. J. Invertebr. Pathol. 8:520-525.**

"Four strains of wild-type spore-forming, crystalliferous bacilli were isolated from dead or diseased gypsy moth larvae. . .Results showed that the four crystalliferous bacilli conform to the description of *B. thuringiensis* var. *thuringiensis* Berliner. . .All crystalliferous isolates were found to be pathogenic. In feeding trials employing 3900 instar II larvae, significant differences were observed in the toxicity of the laboratory-prepared, crystalspore powders of each "wild" strain."

Instars I-III: 5; Larvae: 5

123. Crawford, J. C.

1910. **Technical results from the gyspy moth parasite laboratory II Descriptions of certain chalcidoid parasites.** U. S. Dept. Agric. Bur. Entomol. Tech. Ser. 19, part 2:13-24.

Chalcis species known to occur in the United States are included in a key to the genus along with those species introduced purposely as parasites of the gypsy or brown-tail moths and those accidentally included with material shipped to the gypsy moth laboratory. A new species, *Chalcis fiskei*, is described. A key separating the common American species of *Hypopteromalus* from two exotic forms and a key differentiating the Japanese species of *Pleurotropis* are given. Appropriate species of these genera are described as are *Perilampus inimicus* and *Dimmockia secundus*, both new species.

Generation: 4

124. Crossman, S.S.

1917. **Some methods of colonizing imported parasites and determining their increase and spread.** J. Econ. Entomol. 10: 177-183.

The following egg parasites are in the family Encyrtidae: *Anastatus bifasciatus* Fonsc. and *Schedius kuvanae* How. *Schedius* hibernates as an adult, ovipositing in gypsy moth eggs 1 to 2 weeks prior to hatching in spring. This spring generation carries the species through the summer. In July, soon after gypsy moth eggs are laid, *Schedius* attacks them, and a generation is produced every 25 days until the onset of cold weather, giving four generations and a partial fifth per year. Parasitism by *Schedius* is ascertained by exit holes on eggs. *Schedius* spreads more rapidly than *Anastatus*, which has one generation per year. It oviposits in gypsy moth eggs soon after they are laid. Parasite larvae devour egg contents before the embryo develops, remaining in the host egg through the year until a week or so before gypsy moth eggs are laid. They then pupate, emerge, and attack new eggs. Laboratory rearing and colonization are discussed.

Eggs: 4

125. Crossman, S. S.

1922. **Apanteles melanoscelus, an imported parasite of the gipsy moth.** U. S. Dep. Agric. Bull. 1028.

This paper, covering the history, dispersal, and biology of *Apanteles melanoscelus*, concludes that this parasite is firmly established in New England and is spreading despite heavy secondary parasitism. Its value is enhanced by its ability to complete its life cycle on several native insects. It has two generations per year on the gypsy moth and is very abundant in many localized areas.

Instars I-III: 4

126. Crossman, S. S., and R. T. Webber.

1924. **Recent European investigations of parasites of the gipsy moth *Porthetria dispar* (L.) and the brown-tail moth, *Euproctis chrysorrhoea* L.** J. Econ. Entomol. 17: 67-76.

In investigating the gypsy moth and brown-tail moth situation in Europe, the authors found a medium-intensity infestation at Debrezcen, Hun-

gary, from which they collected over 100,000 gypsy moth larvae and pupae and reared nearly 44,000 parasites. Experimental work at Debrezcen indicated that 71 percent of the last two larval stages were killed by the parasites *Apanteles fulvipes* Hal., *Blepharipa scutellata* R. D., *Carcelia gnava* Meig., *Compsilura concinnata* Meig., *Lydella nigripes* Fall., *Parasetigena segregata* Rond., *Sturmia gilva* Hartig., *Tachina larvarum* L., and *Zenillia libatrix* Panz. *P. segregata* killed 40 percent of the larvae. In Europe the gypsy moth has periods of abundance followed by periods of inconspicuousness. At the time of writing there were several places in central Europe with small areas of light to medium infestations, and indications were that *P. dispar* was on the increase in some regions.
Instars IV–VI: 4; Generation: 2

127. Crossman, S. S.
1925. **Foreign travel and entomologists met while searching for enemies of the gipsy moth.** J. Econ. Entomol. 18: 164–172.

This is an anecdotal and factual background to early parasite importation work. It describes the author's meetings with foreign entomologists, their work, and the extent of the gypsy moth problem in each area. As a result of the author's investigations, six European laboratories (one each in Hungary, Poland, Bulgaria, and Yugoslavia and two in Spain) sent over 100,000 tachinid puparia of the species *Blepharipa scutellata* R. D., *Carcelia gnava*, Meig., *Compsilura concinnata* Meig., *Lydella nigripes* Fall., *Parasetigena segregata* Rond., *Tachina larvarum* L., *Tricholyga grandis* Zett., *Zenillia libatrix* Panz., *(Zygobothria) Sturmia gilva* Hartig. to the Melrose Laboratory in Massachusetts. More than half of these were *P. segregata*. Small numbers of other parasites and predators were also sent.
Larvae: 4

128. Crossman, S. S.
1925. **Two imported egg parasites of the gipsy moth *Anastatus bifasciatus* Fonsc. and *Schedius kuvanae* Howard.** J. Agric. Res. 30: 643–675.

Schedius kuvanae Howard was imported from Japan, and *Anastatus bifasciatus* Fonsc. was received with material from Japan and Europe. *S. kuvanae* appeared to be more common in Japan than *A. bifasciatus*. When both species were present in the same collection of eggs from Japan, the percentage of parasitism was low. The percentage of parasitism by *Schedius* ranged from 0 to 33.3 percent in different collections, while parasitism by *Anastatus* never exceeded 2 to 3 percent. The percentage of *Anastatus* parasitism in material from Europe ranged from 0 to 25 percent. Detailed biological information is given on these two *Encyrtidae* (Hymenoptera), and the results of colonization in the United States are discussed.
Eggs:4

129. Cuéllar, A. R.
1958. **Suggestion about the biological fight against *Lymantria dispar* in the egg stage** [in Spanish]. Bol. Serv. Plag. For. 1: 41–53.

Biological control in the egg stage of the gypsy moth is discussed, with special attention to the thermal requirements of gypsy moths and parasites. Twenty-five years ago, the release of *Anastatus disparis* Ruschka and *Ooencyrtus kuwanae* How. were involved in the decline of *L. dispar*, although it was not proven that the parasites were solely responsible for this decline. However, in place of the gypsy moth came *Tortrix viridana*, *Malacosoma neustria*, *Ephesia nymphaea*, and *Catocala nymphagoga*.
Eggs: 2,4,12,13

130. Culver, J. J.
1919. **A study of *Compsilura concinnata*, an imported tachinid parasite of the gipsy moth and the brown-tail moth.** U. S. Dep. Agric. Bull. 766.

Compsilura concinnata Meigen was introduced into Massachusetts in 1906 as a parasite of the gypsy moth and brown-tail moth. Its distribution in Europe, colonization in the United States, classification, life history, seasonal history, parasites, hosts, and economic importance are discussed.
Larvae: 4

131. Cushman, R. A.
1927. **New species and new forms of Ichneumonidae parasitic upon the gipsy moth parasite, *Apanteles melanoscelus* (Ratzeburg).** J. Agric. Res. 34: 453–458.

The efficacy of *Apanteles melanoscelus* (Ratzeburg), an introduced parasite of the gypsy moth, is hampered by the activities of hyperpara-

sites native to the United States. *Hemiteles apantelis* n.sp., *Gelis apantelis* n.sp., *G. inutilis* n.sp., *G. nocuus* n.sp., *G. bucculatricis* (Ashmead), and *G. urbanus* (Brues) are described.
Instars I–III: **4**

132. Davis, I. W.
1920. **Gipsy and brown-tail moth work in 1919.** Conn. Agric. Exp. Stn. Bull. 218: 135–144.

Since there had been no marked apparent wind spread of the gypsy moth since 1916, the number of egg clusters in infested towns decreased and the quarantine was partially lifted. The budget allotment for gypsy and brown-tail moth suppression and imported nursery stock inspection was $70,000 for the 2-year period ending June 30, 1921; it had been $40,000 for the preceding 2-year period. A town-by-town account of work done on gypsy moth suppression is given.
Instars I–III: **1**

133. Delassus.
1923. ***Liparis dispar* in Algeria** [in French]. Rev. Agric. Afr. Nord. 21(211): 520–524.

134. Delassus.
1925. **The struggle against *Liparis dispar* in the mountains of Edough** [in French]. Rev. Agric. Afr. Nord. 23(327): 334–336, (328): 348–352.

135. Diaz, B.
1923. **Parasites of *Lymantria dispar* L.: *Apanteles vitripennis*** [in Spanish]. Rev. Fitopatol. 1(2–3): 80–82.

136. Dimitrievskaya, O. E.
1956. **Gypsy moth as a pest of coniferous forests** [in Russian]. Lesn. Khoz. 1956(10): 80.

137. Dissescu, G.
1963. **Research on the biology of the principal oak tree defoliating caterpillars.** Report on Ph.D. thesis. Brasov Polytech. Inst. (For. Dep.), Brasov, Romania.

Eight oak defoliators were studied from 1954 to 1961 in the forests of the plains region of Romania to help elucidate factors in their population dynamics. Outbreaks of the gypsy moth were more frequent than those of the other insects studied. Within one gradation, dependent on forest conditions, gypsy moth fertility varied from 200 to 700 eggs, a greater range than for any of the othe species studied. Equations were derived to predic average fertility (F) from the weight in grams (W of egg clusters from which hair had not been removed: F = 1198.16W + 38.59 (use January to March) and F = 1204.56W + 40.89 (use September to October). Error was + 2–3 percent. Less satisfactory equations were derived using the weight of the egg cluster without hair, the volume of the cluster without hair, and the product of the dimensions of the cluster. To determine fertility from the pupal stage, the female weight the day the moths emerged was used in the equation F = 503.71W – 108.97. Mortality of gypsy moth larvae and pupae varied, depending on the source of the material. The greater mortality in material from sunnier places (forest margin or upper crown), may have been due to a higher density of larvae there. The closer a population was to crisis, the higher the percentage of mortality. Mortality of prepupae and pupae increased when larvae had consumed all of a favored food and were forced to switch to a less favored species. Three fourths of the total diet was consumed in the last instar. Males consumed 28.8 percent of what females consumed. The gypsy moth female was the most voracious of the species studied. In addition to foliage eaten, defoliation was caused by larvae cutting off leaves. Females cut off 12.9 percent in relation to what was eaten, and males 6.2 percent. A linear relationship was found between amount eaten and fertility: average quantity of oak leaves eaten in mm² = 103.27 *x* average fertility of females hatched from larvae + 78679.67. The average total diet of a gypsy moth caterpillar could vary 2.2 times when average fertility ranged between 100 and 750 eggs. The data demonstrated that less defoliation occurs in the crisis phase than in the eruption phase with equally dense populations.
Oak stands: 15; Fecundity: 2,13; Generation: 2,12

138. Dissescu, G., and I. Ceianu.
1967. **Observations on the parasitization of eggs of *Lymantria dispar* (L.) by *Anastatus disparis* Ruschka** [in Romanian]. Rev. Padurilor 82(9): 470–475.

139. Doane, C. C.
1967. **Bioassay of nuclear-polyhedrosis virus against larval instars of the gypsy moth.** J. Invertebr. Pathol. 9: 376-386.

"The relative susceptibility of three larval instars of the gypsy moth, *Porthetria dispar*, to a nuclear-polyhedrosis virus was studied by bioassay in the laboratory. The LC_{50} values for 1st-, 2nd-, and 3rd-instar larvae were 0.23, 2.3, and 2.5 polyhedral inclusion bodies per mm^2 of food surface (PIBs/mm^2). LT_{50} values of larvae fed on serial-dilution concentrations of 69,879 to 0.06 PIB's/mm^2 were established. From measurements of the amount of feeding on surfaces treated with 69 PIB's/mm^2, a concentration producing approximately 100 percent mortality, the average doses were 2233, 11,690, and 25,197 PIB's, respectively. Ingestion of PIB's was initially benign and, with heavy doses, depended on their concentration on the food. The effects of low doses on molting, pupation, and adult emergence were observed. If the larvae survived two molts following exposure to the virus, no heavy mortality occurred later. The lowest concentration preventing a second molt in the three instars was 69 PIB's/mm^2."

Larvae: 7

140. Doane, C. C.
1967. **Pathogens of the gypsy moth.** Proc. Int. Colloq. Insect Pathol. Microb. Control, 1966. 6: 200-203.

A nuclear polyhedrosis virus and *Streptococcus faecalis* were tested for their pathogenicity to the gypsy moth. Two test series were run with the virus: Series I larvae were exposed to heavy doses at 24°C, and Series II larvae were exposed to lighter doses at 28°C. A concentration of 70 polyhedral inclusion bodies (PIB's)/mm^2 was used in both series, causing total mortality of instar III-larvae at 28°C, with 30 percent survival at 24°C. LT_{50} times for various concentrations of PIB's/mm^2 are given for different larval stages as are LC_{50} concentrations. Large numbers of polyhedra were found in adults from treated larvae; comparatively low numbers of polyhedra were found in 60 percent of adults from untreated larvae, which nevertheless points up the problem of latent infection. A second virus, probably cytoplasmic, was found in the gut wall of many larvae. *S. faecalis* was studied because of its association with polyhedrosis disease. However, it may be able to multiply only when the viral disease becomes acute.

Adults: 7; Larvae: 5,7

141. Doane, C. C.
1968. **Changes in egg mass density, size, and amount of parasitism after chemical treatment of a heavy population of the gypsy moth.** J. Econ. Entomol. 61: 1288-1291.

"Applications of a short residual phosphate, Gardona® (2-chloro-1- (2,4,5-trichlorophenyl) vinyl dimethyl phosphate) applied in 50-acre plots against dense populations of the gypsy moth, *Porthetria dispar* (L.), protected foliage but prolonged the outbreak by allowing numerous larvae to survive. In untreated woods, starvation and polyhedrosis reduced the number of larvae to a lower level. A study of the eggs of the succeeding generation showed that there were more egg masses in the treated plots and that they were of larger size than those outside the plots. There was also less parasitism by the egg parasite *Ooencyrtus kuwanae* (Howard) inside than outside the plots. The level of parasitism throughout the test area was high compared with that in previous reports."

Eggs: 4,12; Larvae: 7,12,13

142. Doane, C. C.
1968. **Aspects of mating behavior of the gypsy moth.** Ann. Entomol. Soc. Am. 61: 768-773.

"Females *in copulo* for periods of 1 to 4 minutes produced relatively few, scattered, infertile eggs while those mated 8 minutes or more produced fertile eggs in normal egg masses. An increasing number of females were fertilized during copulation periods of 5, 6, and 7 minutes. There was some evidence that normal egg-laying behavior may be released in unfertilized females. Certain of the females mated for periods of 5, 6, and 7 minutes; although sterile, they behaved like mated females and deposited egg masses normal in both appearance and number of eggs."

Adults: 1; Fecundity: 1

143. Doane, C. C.
1970. **Field application of a *Streptococcus* causing brachyosis in larvae of *Porthetria dispar*.** J. Invertebr. Pathol. 17: 303-307.

"A motile strain of *Streptococcus faecalis* originally isolated from a naturally infected larva and tested for pathogenicity under laboratory conditions was tested in the field. Mistblower sprays

prepared from broth cultures induced brachyosis in gypsy moth larvae feeding in apple trees. One application was made against larvae in late 2nd and early 3rd instar, and a second application was tested against larvae in the 4th instar. The test demonstrated the ability of the bacterium to produce disease and prevent defoliation even in an area with a heavy population . . . Epizootic outbreaks of disease in dense larval populations commonly occur with these organisms acting in a density-dependent manner. NPV is transmitted from generation to generation on the egg surface. Mortality, as a direct result of acquisition of the virus from the egg, occurs almost solely in the first instar." Cadavers of first-instar larvae probably are the inoculum source for larva-to-larva transmission. It is not known how streptococci are transmitted from generation to generation.
Eggs: 7; Generation: 5; Instars I–III: 7; Larvae: 5

144. Doane, C. C., and J. J. Redys.
1970. **Characteristics of motile strains of *Streptococcus faecalis* pathogenic to larvae of the gypsy moth.** J. Invertebr. Pathol. 15: 420–430.
"A bacterial disease of larvae of the gypsy moth, *Porthetria dispar,* is caused by infection of the gut with a streptococcus. The morphological, biochemical, and serological features of the organism were consistent with those of *Streptococcus faecalis*. The bacterium is ingested with food, multiplies in the digestive tract, and causes diarrhea. The diarrheic discharge contains a high concentration of infectious streptococci. The gut, especially the foregut, becomes distended with liquid from the hemocoelom. Streptococci are found in especially high concentration in the midgut. The infected larva does not feed, and as liquid is lost continually, body length decreases markedly and death occurs in 3 to 15 days. The cadavers usually have a characteristic mummified or desiccated appearance. Serological studies with antisera prepared by immunizing rabbits with several isolates indicate that at least three distinct serotypes were isolated from infected larvae. They appear to be serologically different from noninsect *S. faecalis* strains tested. It is suggested that this antigenic difference may form the basis of pathogenicity of the species. A pilot study revealed that an immunofluorescence technique may be an extremely valuable tool in identifying these organisms in insects and in determining their distribution in nature."
Larvae: 5

145. Doane, C. C.
1970. **Primary pathogens and their role in the development of an epizootic in the gypsy moth.** J. Invertebr. Pathol. 15: 21–33.
"The development of an epizootic was studied in a dense population of larvae of the gypsy moth, *Porthetria dispar*. The two pathogens involved were a nuclear polyhedrosis virus and a variant of *Streptococcus faecalis*. It was known that there was approximately 10 percent acute infection from transovum transmission of the nuclear polyhedrosis virus. The origin of the initial inoculum of the variant of *S. faecalis* is unknown, but it became common in the second and later instars. The behavior of the larvae increased the relative density of the population and enhanced the rate of larva-to-larva spread of the pathogens. Larvae in the first four instars fed most heavily in the tops of trees, and dead larvae accumulated on the upper surfaces of the leaves. These cadavers disintegrated and adhered firmly to the leaves, forming an abundant source of inoculum for feeding larvae. This occurred early enough to account for the later, massive increase in disease. Results from counts in the field and collections of larvae reared in the laboratory indicated that there was an increasing rate of infection and mortality that reached a climax when larvae were in the last instars. The threatened defoliation did not occur, and the population declined sharply. Although the nuclear-polyhedrosis virus appeared to be most important, up to 50 percent of the larvae in some collections were killed by the variant of *S. faecalis*. Observations indicated that the epizootic was density-dependent and that the rapid spread of pathogens in the susceptible population was enhanced by the behavior of the larvae during the early instars."
Larvae: 1,5,7

146. Doane, C. C., and P. W. Schaefer.
1971. **Field observations on the flight activity of *Calosoma sycophanta* (Coleoptera: Carabidae).** Ann. Entomol. Soc. Am. 64: 528.
This is the first report that adult *Calosoma sycophanta* are strong and agile fliers. They were observed flying upwind to an apple orchard infested with gypsy moths on a hot (85–87°F), humid day

in 1965 and again in flight under similar conditions in June 1970.
Larvae: 3

147. Doane, C. C.
1971. **A high rate of parasitization by *Brachymeria intermedia* (Hymenoptera: Chalcididae) on the gypsy moth.** Ann. Entomol. Soc. Am. 64: 753–754.

Brachymeria intermedia is occasionally of primary importance as a gypsy moth parasite in warm Mediterranean countries. In 1911 in Sicily, 15,567 parasites emerged from 16,500 pupae. The more usual rate is 4 percent, which was the average in a study in Spain and Portugal. In New England (1966, 1967, and 1971) Leonard found a 0.3 to 4.8 percent range. In Connecticut in January, a higher percentage was found in places where the canopy was open and along the forest edge. The area had been heavily defoliated the previous year. In the Mediterranean region, most cases of high *B. intermedia* parasitism were in areas of high defoliation.
Pupae: 4,12

148. Doane, C. C., and R. T. Cardé.
1973. **Competition of gypsy moth males at a sex-pheromone source and a mechanism for terminating searching behavior.** Environ. Entomol. 2: 603–605.

"*Porthetria dispar* (L.) males exhibiting pheromone orientation or searching behavior may be recognized by slow, slightly zigzag forward flight, with body held at an angle of roughly 45 degrees to the horizontal plane and antennae directed up and forward. The mean search time for males searching alone at a natural pheromone source was 20.52 ± 3.88 seconds; then males ended searching behavior. After termination of searching behavior, males held the body more horizontally, and forward flight was direct, rapid, and usually up or across the path of wind until they were lost from sight. Two males at a natural sex pheromone source touched wing tips in a mean time of 4.38 ± 1.01 seconds of arrival of the second male. Searching behavior was terminated by rapid wing-touching within two seconds in one or both males in 86 percent of the contacts. The evolutionary significance of this aggressive competition may be that it tends to disperse males from dense to sparse populations, thereby increasing the chance of males mating with isolated females, which have greater reproductive potential than females from dense populations."
Adults: 1; Fecundity: 2

149. Dobrivojević, K.
1963. **Some observations on the mass occurrence of gypsy moth in the district of Valjevo from 1947–1961** [in Serbo-Croatian, English, summary]. Zast. Bilja 14(76):677–692.

There were two gradations (1946–1950, 1953–1957) and two periods of latency of the gypsy moth in Valjevo during the observation period, 1947 to 1961. Owing to variations in the terrain and in the plant communities, the gypsy moth appeared in both dense and sparse populations. Greatest damage occurred in the flatlands. Conditions were warmer and drier in the first gradation, damage was greater than in the second gradation. Foci of the gypsy moth were in oak and elm habitats. A polyhedrosis epidemic appeared over the whole territory in the gradation crisis. The birds *Oriolous galbula* L. and *Sitta europea* L. were important predators of larvae and eggs, respectively. Competing species were *Aporia orategi* L. and *Malacosoma neustria* L.
All stands: 18; Eggs: 9; Generation: 2,12; Larvae: 7,9; Oak stands: 15; Non-oak stands: 15

150. Domin, K.
1928. **Aftereffects of the influence of the gypsy moth on forest underbrush in Brdech** [in Czechoslovakian]. Veda Prir. (Prague)., 9(9): 262–264.

151. Dowden, P. B.
1933. ***Lydella nigripes* and *L. piniariae*, fly parasites of certain tree-defoliating caterpillars.** J. Agric. Res. 46: 963–995.

In Europe, *Lydella nigripes* is a widespread, though minor, parasite of both *Porthetria dispar* and *Nygmia phaeorrhoea*. The literature reports it overwintering as a first-instar larvae in *Bupalus piniarius* L., but this study shows that two species are involved. *L. piniariae* is a parasite of *B. piniarius* and does not attack hairy larvae. It has only one generation per year and is able to complete development in only three host species. It is considered an important factor in controlling the pine geometrid moth. *L. nigripes* has three to four generations per summer, is exceptionally polyphagous, and shows a preference for hairless lar-

vae, although it will larviposit in hairy larvae. Owing to these limitations and to the fact that it is in competition with aggressive larval parasites, such as *Compsilura concinnata,* it is not an efficient parasite of the gypsy or brown-tail moth and has not been able to establish itself in the United States.
Larvae: 4,12

152. Dowden, P. B.
1934. ***Zenillia libatrix* Panzer, a tachinid parasite of the gypsy moth and the brown-tail moth.** J. Agric. Res. 48: 97–114.
Early in the 20th century, when the gypsy moth (*Porthetria dispar* (L.)) and the brown-tail moth (*Nygmia phaeorrhoea* Don.) were being reared in Europe for the purpose of collecting natural enemies to export to the United States, *Zenillia libatrix* was shown to be a parasite of minor importance. Oviposition is on leaf edges, and reproductive capacity varies with the size of the fly (from 820 to 2439 eggs in this study). It is widespread in Europe but is inefficient as a parasite of the gypsy moth because it is very polyphagous and is double brooded, so that many individuals complete a generation in the fall after host larvae have gone into hibernation.
Larvae: 4,12

153. Dowden, P. B.
1935. ***Brachymeria intermedia* (Nees), a primary parasite and *B. compsilurae* (Cwfd.), a secondary parasite of the gypsy moth.** J. Agric. Res. 50: 495–523.
Brachymeria intermedia is a European parasite of gypsy moth and other Lepidoptera pupae. *B. compsilurae* is a native North American parasite of *Compsilura concinnata* and *Sturmia scutellata,* imported tachinid parasites of the gypsy moth. A lieterature review of the genus *Brachymeria* is given, as is biological information on both species. *B. intermedia* overwinters as an adult, passing through two or possibly three generations per year. It oviposits in a host pupa and requires a development time from egg to adult of from 18 days in August to 62 days in September. It has five larval instars. *B. compsilurae* is known to parasitize only tachinids. It overwinters as a full-grown larva within the host puparium and is univoltine in single-generation hosts and multivoltine in multibrooded hosts. It oviposits through the primary lepidopterous host pupa or larva, locating the tachinid maggot probably by odor. Development from egg to adult requires 23 to 28 days for males and 25 to 31 days for females. The five larval instars bear no resemblance to those of *B. intermedia,* although the adults are morphologically similar.
Pupae: 4

154. Dowden, P. B., and H. L. Blaisdell.
1959. **Gypsy moth.** U. S. Dep. Agric. For. Serv., For. Pest Leaflet 41, 4 p.
This article covers distribution of the gypsy moth as of 1959; description of its life history and habits, including the larval and adult stages, host trees and damage; and natural and applied control. No data are provided.
Generation; 2, 4; Larvae: 1; All stands: 15

155. Dowden, P. B.
1961. **The gypsy moth egg parasite, *Ooencyrtus kuwanai,* in southern Connecticut in 1960.** J. Econ. Entomol. 54: 876–878.
The life cycle of *Ooencyrtus kuwanai* consists of one spring generation and three summer generations. About 20 days are required for complete development from egg to adult. As the season progresses, the developmental time increases. Newly oviposited gypsy moth eggs are parasitized by adult *O. kuwanai* from the spring generation. As each generation emerges it parasitizes more eggs. The last summer generation overwinters as adults and parasitizes overwintering gypsy moth eggs in the spring. Parasitism averages 30 to 40 percent. The major limitation is the inability of *O. kuwanai* to reach eggs buried in the egg mass.
Eggs: 4

156. Drees, H., and H. Schwitulla.
1956. **Tests on the use of *Apanteles solitarius* Ratz. W. against *Lymantria dispar* L.** [in German]. Anz. Schaedlingskd. 29(6): 81–85.

157. Dunbar, D. M., R. M. Weseloh, and G. S. Walton.
1972. **A fungus observed on egg clusters of the gypsy moth, *Porthetria dispar* (Lepidoptera: Lymantriidae).** Ann. Entomol. Soc. Am. 65: 1419–1421.
Paecilomyces farinosus (Dickson ex. Fries) Brown and Smith, an omnivorous entomogenous imperfect fungus, readily grows as a saprophyte on waste products in gypsy moth eggs parasitized by

Ooencyrtus kuwanai (Howard). *P. farinosus* did not parasitize intact gypsy moth eggs in the laboratory.

Eggs: 4,8

158. Dunbar, D. M., and G. R. Stephens.

1975. **Association of twolined chestnut borer and shoestring fungus with mortality of defoliated oak in Connecticut.** For. Sci. 21: 169–174.

Following severe oak defoliation (1969–1971) by the gypsy moth and elm spanworm, increasing oak mortality was seen in Connecticut. A study was undertaken in 1972 to determine if *Agrilus bilineatus* (Weber) and *Armillaria mellea* (Vahl.) Quel. were contributing to this increase, as they were reported to have done in West Virginia, Pennsylvania, and New Jersey on previously defoliated trees. "During 1969 to 1973, mortality of previously defoliated oak on 13 0.04-ha plots in nine Connecticut towns ranged from 18 to 79 percent. Girdling by the twolined chestnut borer, *A. bilineatus* (Weber), but not attack by the shoestring fungus, *A. mellea* (Vahl.) Quel., appeared to be the main cause of mortality. Emergence holes of *A. bilineatus* (Weber) were found at breast height on 50 to 100 percent of oaks dead at least 1 year, and all dying (21) and recently dead (36) trees contained live larvae. Of 21 apparently healthy trees sampled, 43 percent had been attacked (mainly in the upper bole) by *A. bilineatus* (Weber). In contrast, *A. mellea* (Vahl.) Quel. mycelial fans were present in none of the living, 31 percent of the recently dead trees, and 80 percent of the trees dead 1 year."

Oak stands: 15,16,25

159. Edel'man, N. M.

1953. **The influence of the feeding regime on the development of gypsy moths *(Lymantria dispar)* and poplar leafeaters (*Melosoma populi* and *M. tremulae*** [in Russian]. Entomol. Obozr. 33: 33–46.

When nutritional conditions are optimal growth of these insects is completed in a shorter time. For example, *L. dispar* finished its growth on oak 8 days sooner than on birch. Weight is also correlated with the quality of the nutrition. Data are also given on the N reserves, respiratory coefficient, and fat content under different nutritional conditions.

Generation: 13

160. Edel'man, N. M.

1956. **The biology of *Lymantria dispar* L. under conditions of the Kubinskogo district of the Azerbaijan S. S. R.** [in Russian]. Zool. Zh. 35(4): 572–582.

161. Edel'man, N. M.

1957. **The application of *Lymantria dispar* L. food specialization as the basis of preventive measures** [in Russian, English summary]. Zool. Zh. 36(3): 408–420.

"Peculiarities of the feeding habits of *L. dispar* may be used as a [basis] of preventive measures by means of plantings restricting the propagation of this pest. Development of preventive measures has to be carried out by means of such a combination of woody plants which provides the greatest possible decrease of the oak damage. Selection of woody plants may proceed in [the] three following directions:

(1) Introduction of species undamaged by *L. dispar*. The moths of *L. dispar* lay their eggs on all the woody plants without selectivity, independently of the feeding habits of their larvae. As the third instar larvae remain on the trees on which they have hatched, they have to succumb, lacking the possibility to feed upon this plant. *Fraxinus*, Ulmaceae trees, wild pear, *Acer tataricum, Caragana arborescens, Sambucus nigra, Euonymus,* [and] *Lonicera* belong to the species undamaged by the above pest under the conditions of the Voronezh district.

(2) Introduction of species attacked by *L. dispar*, but with delayed development compared with the pest. [The] late form of *Quercus robur* belongs to such species in the Voronezh district, as its development is delayed with respect to that of *L. dispar*. Simultaneously, such a measure will check the reproduction of some other leaf-eating pests, for example, *Tortrix viridana* and *Operophthera brumata*.

(3) A number of species, although intensively fed upon by the larvae, bring about metabolism disturbance in the latter and consequently low fecundity of the moths. *Silia parvitolia, Betula alba, Acer platanoides,* and *A. negundo* belong to such species in the steppe aforestation zone."

All stands: 15; Fecundity: 13; Larvae: 13

162. Edel'man, N. M., and A. M. Efros.

1962. **The effect of plant growth stimulators on**

phytophagous insects. Dokl. Biol. Sci. [English transl. Dokl. Akad. Nauk. SSSR Ser. Biol.] 142: 88-91.

Gypsy moth larvae were reared on oak leaves and artificial media. The leaves and media were treated with five different phytohormones. Larvae fed the treated media had a shorter developmental period, much higher larval weight, and a generally improved physiological condition.

Oak stands: 15; Generation: 13

163. Eichhorn, O.

1965. **On some larch pests and their parasites in Japan, Europe, and Canada** [in German, English, and Russian, summaries]. Beitr. Entomol. 15(1-2): 111-126.

"The above paper deals with four pests of larch and their parasites in Europe, Japan, and Canada: *Pristiphora erichsonii* Hartig, *Pachynematus itoi* Okutani, *Diprion nipponicus* Rohwer, and *Lymantria dispar* Linnaeus. The life history and distribution of the two Nematine species, *Pristiphora erichsonii* and *Pachynematus itoi* in Europe and Japan, are more intimately dealt with." The gypsy moth has spread beyond its normal range of distribution in Japan and become a great problem on larch.

Larvae: 12; Non-oak stands: 15

164. Emchuk, E. M.

1938. **Catalase dynamics in *Porthetria dispar* and *Dendrolimus pini* during development** [in Ukrainian, English and Russian summaries]. Acad. Sci. Ukr. SSR Rep. Inst. Zool. Biol. 5: 161-180.

This is a report of a study to determine cold resistance during gypsy moth development with parallel analysis of the catalase index. This is an index of the quantity of oxygen/cc given off in 5 min/100 mg of live dry weight. It is a characteristic indication of the state of the organism under definite conditions. The catalase index gradually lowers from the second instar, as does cold resistance. In pupae the index increases, as does cold resistance. Data show that larvae feeding on oak have a higher catalase index than those feeding on apple leaves and that fasting larvae have a higher index than those feeding normally.

Larvae: 13

165. Escalera, F. M.

1925. **A new experience in fighting the plague of *Lymantria dispar* in Argelia** [in Spanish]. Verh. III Int. Entomol. Kongr. Zurich 1925 2: 414-416.

166. Escalera. M. M.

1924. **Note on two Coleoptera that attack *Lymantria dispar* and *Tortrix viridana* in El Escorial** [in Spanish]. Bol. R. Soc. Esp. Hist. Nat. 24(5): 273-274.

167. Escalera, M. M.

1925. **Biological note about *Lymantria dispar*** [in Spanish]. Bol. R. Soc. Esp. Hist. Nat. Secc. Biol. 25: 337-340.

Colonies of *Xyladrepa 4-punctato, Calosoma inquisitor,* and *Apanteles* were transported from Spain to North Africa. The *Apanteles* were in cocoons. The plague of *Lymantria* virtually disappeared from La Herreria owing to the great increase of parasites and predators.

Generation: 3; Instars I-III: 4

168. Felt, E. P.

1942. **The gypsy moth threat in the United States.** Eastern Plant Board Cir. 1. 16 p.

History of the gypsy moth and the control measures and expenditures to eradicate it. Maintainance of the barrier zone is recommended to prevent spread.

Review

169. Fiske, W. F.

1910. **Parasites of the gypsy and brown-tail moths introduced into Massachusetts.** Wright and Potter Printing Co., Boston. 54 p.

Since the natural controls of the gypsy moth were seen to be equal in America and in Europe, except for the lack of effective parasites in America, it was felt that importing parasites from Europe and Japan would cause the decline of the gypsy moth in this country. The early work was completely experimental, since the European literature gave no information on the relative value of the parasites and did not distinguish between parasites and hyperparasites. An important theoretical principle was that a sequence of insects was necessary and

that no one parasite was sufficiently abundant in Europe or Japan to offset the 6-fold rate of increase of the gypsy moth in America. The Japanese race of gypsy moth was larger, stronger, and had a greater fecundity (1/4 to 1/3 more eggs per mass) than the European variety. This indicated greater resistance to control factors, but also more effective controls, as the gypsy moth was not an important pest in Japan. Thirteen species or primary parasites were reared from gypsy moths imported from Japan, seven of them important. All but one was identical or very similar to European parasites. There were at least 22 European parasites, 15 of them important. The greater number of European parasites was probably due to the greater climatic variation in the areas investigated in Europe. The only native American species to be ranked as effective as the imported ones was *Theronia fulvescens,* a relatively ineffective parasite very similar to imported *Theronia* species. The parasites studied were received in sufficient numbers from Europe or Japan to colonize in America. They form a sequence of attack as complete as that in Europe or Japan. A detailed life history is given for each as well as a projected date by which they should become effective in America.
Eggs: 4; Generation: 12; Larvae: 4; Pupae: 4

170. Fiske, W. F.
1910. **Superparasitism: an important factor in the natural control of insects.** J. Econ. Entomol. 3: 88-97.

Superparasitism is usually detrimental to the parasites involved. Commonly, the parasites either die before completing development or the resultant adults are stunted, with very low fecundity. In a system in which the parasites are not able to discern a parasitized from a nonparasitized host, superparasitism is prevalent. In such a system, parasitism rarely exceeds 50 percent. This theoretical situation apparently conforms to field observations.
Generation: 4

171. Fiske, W.F.
1913. **The gypsy moth as a forest insect, with suggestions as to its control.** U. S. Dep. Agric. Bur. Entomol. Circ. 164, 20 p.

At the time of the first outbreak in the United States, the gypsy moth was thought to be omnivorous. Now it no longer is a field and garden pest, less of a problem in orchards than the American tent caterpillar, and less of a problem in forests than was expected. Amelioration within the Boston area is due to perfection of methods of artificial repression, death or removal of more susceptible trees, importation of parasites and predators, and development of wilt disease.
Parasites: Thirty species appear to be important in Europe and Japan, all of which have been introduced into the United States. Of these, one third seem to have become established, which is considered successful. In 1912, 50 percent of gypsy moths were destroyed in the area northwest of Boston.
Wilt disease: This is similar to flacherie of silkworm. *Gyrococcus flaccidifex* bacterium is conveyed from generation to generation through the egg. It is not known how it was introduced. Infection will not cause death except in a weakened host, but larvae can pass on disease. The dead caterpillar body becomes black liquid, and germ cells are easily transferred. Death is most likely to occur on the topmost branches of a tree. Gypsy moths with the infection cannot be reared on unfavorable food.

Stand composition: Sprouts, and to a lesser extent seedlings, are not so liable to injury as larger trees of the same species. Species in underbrush generally feed from less favorable food sources. Thus, larvae falling from an oak to the ground will find their way back to the oak, whereas when they fall on underbrush they will eat unfamiliar food and be less resistent to disease.
Comparison with Europe: In Europe, the invasion of the first decade of the 20th century declined; now the gypsy moth is found in low numbers in virtually all oak forests in Italy and Germany. In apparently all locations where gypsy moth numbers were high, a wilt-type epidemic broke out and numbers decreased. Populations were held at an innocuous level by parasites. In the United States, however, the decline was followed by a phenomenal increase of the straggling remainder. The role played by parasites is obviously less important than had been assumed. Though the increase of the moth was prevented or retarded through parasitism, actual outbreak was checked mainly by disease. Two outbreak areas in southern Italy, where there were varied and abundant parasites but no sign of wilt disease, were observed. Parasites killed 90 percent but the invasion spread back and forth over the area, defoliating a part each year so that trees were defoliated every 2 to 3 years for more than a decade.

Oak stands: 15; All stands: 15,19; Generation: 2,4,12; Larvae: 5,6,7

172. Fiske, W.F.

1916. **Insects injurious to vegetation.** Bull. Entomol. Res. 7: 383–389.

The concept that competition among plants may be affected by insects is introduced. An example is offered using the gypsy moth in its relation to pine and oak. These trees are active space competitors. Since the gypsy moth prefers oak to pine, the latter species benefits, as oak is injured to a proportionately greater extent.

All stands: 20

173. Fitze, K.

1959. **Establishing gypsy moth foci on the territory of Bosnia and Herzegovina in the course of 1958** [In Serbo-Croatian, English summary]. Zast. Bilja 52/53: 171–173.

To determine localities where the gypsy moth occurs throughout the gradation, even during latency (i.e., its foci), male adults are caught by traps. From the number of males caught, the number of egg clusters is inferred. In 1958, 45 traps were laid and observed from June to August. The results were positive in 76 percent of the cases and negative in 24 percent. It was concluded that the presence of the gypsy moth can be established by means of traps even in cases where egg clusters are almost impossible to find. It was also found that the gypsy moth occupies, even in latency, far wider areas than previously thought. From this it can be deduced that it is autochthonous in areas which it was assumed to have invaded in the course of gradations.

Adults: 2; Generation: 2

174. Flanders, S.E.

1963. **Hyperparasitism, a mutualistic phenomenon.** Can. Entomol. 95: 716–720.

"Hyperparasitism is a mortality factor that generally is beneficial to the continuous reproduction of the species involved. The parasites of a primary parasite of a phytophagous insect may exhibit two distinctive types of secondary relations to that insect. These types are defined as follows. Direct secondary parasitism: that type of host-parasite symbiosis where only the primary's parasitized host or the primary itself is attacked. Indirect secondary parasitism: that type of host-parasite symbiosis where the primary's phytophagous host is attacked whether parasitized or not parasitized. The host mortality caused by direct secondary parasitism, this being manifested when the percentage of the primary parasitization of the phytophagous host is minimal.

Hyperparasites are considered beneficial because they stabilize the population fluctuations of the primary parasites. This prevents outbreaks that recur in areas where the phytophagous insects and their regulative primary parasites have been temporarily eliminated. Outbreaks of the phytophagous insect are thus a function of the population lag between reinfestation and parasitization.

Generation: 4

175. Forbush, E.H., and C.H. Fernald.

1896. **The gypsy moth: *Porthetria dispar* (Linn.).** Part I. Wright and Potter Printing Co., Boston. 251 p.

Part I by Forbush (251 pages) covers the history of the gypsy moth in America, its increase and distribution, and methods of control, giving special attention to control by birds. The pest was introduced in Medford, Mass., from France by Leopold Trouvelot who was doing experimental crosses with silkworms. Though it escaped in 1868 or 1869, it went unnoticed for 10 years except by Trouvelot. Its early increase was retarded by climate, isolation, birds, and fires. By 1880 it had caused severe damage in the immediate vicinity of Trouvelot's house. Although mechanical control measures were used, it spread to woodlands. Outbreak conditions existed after 20 years in which everything but horse chestnut and grass was eaten. The rate of annual increase was 6 to 7 egg clusters in the second season to 1 cluster in the first. Increase of large colonies was limited only by food; fecundity decreased with food shortage. Larvae deprived of food died or developed prematurely, laying fewer eggs. Larval life span ranged from 6 to 12 weeks. Larvae developed faster and consumed more in warm, dry weather (parasite development sped up also). In 1895 it was unusually warm; larvae developed in 6 to 7 weeks and thus had shorter exposure to vertebrate enemies. Since they developed faster, they ceased feeding earlier and the trees were not stripped throughout the summer. They refoliated in midsummer while females were laying eggs. In one area, there were two generations per year, with larvae leaving the cluster in September. Cold is believed necessary for embryo development. Isolated colonies do not spread until numbers have increased and all the foliage is destroyed. They will then migrate considerable distances.

The presence of many enemies causes the gypsy moth to scatter. Birds transport larvae by carrying them to their young and dropping them; also, larvae cling to bird feathers. Occasionally they are transported by the wind or carried along running streams. Egg clusters are laid on leaves on the tree or on the ground, and these may be blown away. Hiding places for larvae include brush heaps, old stone walls, fences overgrown with vines, lumber piles, tin cans, rags and paper. According to Samuel's *Birds of the Northeast* (1980), Trouvelot placed 2000 silkworms on a small oak, and all were eaten by robins and catbirds within a few days. Birds broke through protective netting to devour 95 percent of the silkworms (*Telea polyphemus*) beneath them.

Entomologists generally believe hairy caterpillars are immune to predation by birds, which is perhaps true in Europe. A writer in France in 1833 said that in 20 years of observation he did not see a bird feed gypsy moth larvae to its young. In Russia the cuckoo is said to be the only bird that eats gypsy moth larvae. In several Russian provinces, birds completely abandoned areas where the gypsy moth was numerous. However, in Bavaria, starlings, titmice, and finches gathered in great numbers to feed on an outbreak of closely related nun moth larvae (*Liparis monacha*). In European literature only titmice and cuckoos are mentioned as destroying larvae, while woodpeckers, creepers, and titmice eat eggs. Flocks of titmice and wrens were reported to have cleared eggs in winter from an area in Germany that had been completely defoliated. In the spring, 20 pair of titmice nested there, and larvae noticeably decreased. There was no problem the third season. Information on the most useful birds follows.

Cuckoo: A large bird, it prefers large larvae and eats them whole. It is especially valuable in severe local ravages. Some birds will eat pupae if no larvae are available. The adult carries larvae to its young and brings fledglings to the most heavily infested areas when they learn to fly. The yellow-billed cuckoo has been observed to eat 9 to 10 full-grown larvae in 1/2 hour. The black-billed cuckoo does not eat as many, but spends more time beating larvae to kill them or knock off hairs before swallowing them whole. Neither species is very numerous in infested regions, but both are common and are attracted to infestations of gypsy moths. Perhaps because they are large and easily identified, they are considered the most important bird.

The *Baltimore oriole*, a regular consumer of hairy larvae, will take them from under burlap. The adults feed them to the young as a steady diet; often a small part of a larva is eaten. They eat mostly full-grown larvae. The *catbird* feeds on larvae and pupae of all sizes and feeds both to its young when the gypsy moth penetrates into the thicket. It frequents badly infested localities. The *chickadee* skins or tears large larvae to pieces. It stands on larvae and strikes with its bill until they split. It breaks pupae open and eats a small portion of body tissue and juices. It also feeds on adult females and pecks at but does not eat eggs. The *blue jay* feeds larvae and pupae to its young. It finds hidden larvae and pecks at them in bark crevices and also pinches or hammers them to death and drops them. It is common on badly infested trees.

The *chipping sparrow* is primarily grainivorous but was observed killing full-grown larvae in badly infested spots. The *robin* is often seen at the base and on low branches of infested apple and other trees. It is thought by some to be of major importance in killing larvae and pupae. The *red-eyed vireo* is believed to prefer smooth-skinned larvae but often is observed breaking open tents of hairy tent caterpillars. It is known to eat and probably to feed gypsy moths to its young. It usually tears larvae apart but also consumes them whole and feeds them alive to its young. *Crows* feed at and take their young to badly infested areas. They eat larvae, pupae, and adult females, tear dead bark off branches, and penetrate clumps of bushes and rubbish on the ground in search of prey. Under experimental conditions, it was found that crows in captivity rapidly tire of a gypsy moth diet. *Yellow-throated vireos* were observed feeding larvae to young after pecking off the heads.

The *English sparrow* was introduced to Boston in 1868 and drove out species (bluebirds, wrens, house swallows, and martins) that kept the gypsy moth in check during initial years. It was observed that where the English sparrow became numerous, the gypsy moth also increased; bird houses taken over by the sparrow crawled with gypsy moths. Birds may be implicated in the spread of gypsy moths during severe infestations when they will travel far for food for their young, and perhaps larvae drop or are rejected by the young. Birds are most beneficial at low population densities when they eat caterpillars that are readily available and carry them to the next only when it is nearby. Capturing males generally does no good unless the male fertilizes an isolated population. More species of birds attack moths in orchards than in woodlands.

Adults: 9; Eggs: 9,10; Fecundity: 2,12; Generation: 2,12; Instars I-III: 9; Instars IV-VI: 9; Larvae: 1,9,10,12; Pupae: 9

176. Forbush, E. H., and C. H. Fernald.
1896. **The gypsy moth: *Porthetria dispar* (Linn.).** Part II. Wright and Potter Printing Co., Boston. 244 p.

Part II of *The Gypsy Moth* by Fernald (which includes a bibliography) covers the insects' behavior, morphology, and natural enemies as well as insecticides used to combat it. The authors also discuss its prevalence in Europe.

Situation in Europe: The gypsy moth disappeared from England by the mid-19th century, perhaps owing to high predation as a result of the darker English foliage. It is widely distributed in Russia but rarely numerous in the same locale for more than 3 years. It eats all species of trees except ash (*Fraxinus excelsior*) and wild pear and is a major problem in fruit trees. In Germany, natural enemies are protected: bats, cuckoos, starlings, crows, titmice, and tree-creepers. The German scientist, Dr. B. Altum, wrote to Fernald: "I have never known a devastation in Germany equal in severity and extent to that in your country. . . An importation of predaceous insects to oppose this destructive *dispar*, e.g. *Calosoma sycophanta*, etc., cannot possibly be of any industrial importance. These work in no noteworthy degree even in our far smaller *dispar* calamities." In Europe the gypsy moth is generally found where there are large areas of cultivated forests, as in Bavaria.

Natural enemies: The female is often attacked while laying and is mutilated or eaten by birds and predaceous insects. The large wood ant, *Camponotus pennsylvanicus* (DeG.), will kill a female, gnaw open the abdomen, remove the egg mass, and eat body tissues and fluids, but has not been seen eating eggs. Harvest spiders feed on these eggs. Hymenopterous parasites oviposit in tissue beneath the cuticle, while dipterans lay their eggs on the body surface so they are thrown off when molting. *Theronia melanocephala* (Br.) is the most abundant parasite, attacking pupae and prepupae. The wood pewee has been observed as a predator. *Pimpla pedalis* Cress. breeds from gypsy moth and from tent caterpillar (*Clisiocampa americana*), which pupates 4 weeks earlier.

A list is given (page 377) of hymenopterous parasites in Europe, all of which have cogeneric species in the United States that do not attack the gypsy moth. A large number of *Vespa maculata* L. were observed at a new gypsy moth colony, flying close to the ground, setting around the bases of trees, searching trunks, and occasionally going to the top. They caught male gypsy moths on the wing. *V. consobrina* Sauss. and *V. germanica* Fab. were also observed feeding on the gypsy moth. *Polistes pallipes* St. Farg., a large brown wasp, stung and paralyzed larvae, sucked out fluids, and carried away parts. *Cimbex americana*, the American sawfly, was seen carrying off larvae as was the ant *Fromica subserica*. Among the Coleoptera, several species of *Calosoma* and two species of *Harpalus* and *Platynus limbatus* ate the gypsy moth in the field but not in confinement; *Dermestes lardarius* was found in a mass of pupae. Several Coleoptera larvae were found feeding on egg clusters; *Ptinus brunneus* was the only imago reared from these. In Europe, *C. sycophanta* is predaceous on larvae, *Tiresias serra* (Fab.) on eggs, *Dermestes ater* and *D. lardarius* on both eggs and pupae.

A study found 29 per cent of 5547 gypsy moth larvae bore eggs of dipteran parasites. A list of dipteran parasites in Europe is given, all but one of which, *Achaetoneura fernaldi*, are tachinids of different genera or subgenera of the ones in the U.S.A. *Dasyllis sacrator* Walk. preys on females while they are laying, and *Asilus sericeus* Say captures males on the wing. Arboreal hemipterans prey on larvae, especially in badly infested areas: These include *Podisus cynicus* (Say), *P. serieventris*, and *Monecles insertus*. Spiders prey on all stages but pupal. *Phloeothrips* destroys eggs. Among vertebrate enemies, the common skunk (*Mephitis mephitica* Shaw) feeds on females laying eggs and probably also on pupae in badly infested areas; *Rana silvatica*, the wood frog, preys on females; *Hyla pickeringii*, the tree frog, in one instance preyed on second brood larvae; *Bufo lentiginosus americanus*, the common garden toad, eats many larvae in brushland.

Life stages: The female scatters eggs by dropping them, or as a result of disturbance by males attempting to mate while she is laying; thus naked eggs are found at bases of trees or in bark crevices. Of these 85 per cent were fertile on test. Eggs do not lose vitality in cold and wet weather, but temperatures greater than 140°F will destroy them. Mites eat out ragged, irregular openings in eggs, destroying them rapidly, especially in the fall (*Nothrus* near *ovivorus* Pack, *Trombidium bulbipes* Pack). It is possible to have a partial fall hatching in an occasional egg cluster under favorable conditions. The majority of eggs hatch in the warmest part of the day. There is great variation in size and in the number of molts of equal-age larvae. Larvae can float in water for several days without food, can live *in* water 2 to 3 days, can eat water plants (*Nymphaea odorata, Pontederia cordata, Alisma plantago*), and thus can be dispersed along streams. The author does not consider dispersal by wind important; dispersal by man and animal is important in the egg stage. Larvae will eat cotton plants—leaves, stem, boll—voraciously, but are found primarily on orchard trees and elm, on maples and others when they are starving, and more likely on older trees (Appendix A). Smaller larvae tend to eat on lower branches and to move around the tree to shaded places; larger larvae may go to the extreme tips of upper limbs. They return to the same resting and eating places. They cease feeding at daylight, later when the day is cloudy. Small larvae can resist cold but not heat; the reverse is true of older larvae, a finding that correlates with weather conditions during that life stage.

Newly hatched larvae have been observed to spin out silk 4½ feet to 69¼ feet. Larvae in later instars could not be induced to spin, but have been observed spinning in 2nd, 3rd, and 4th molts. When numerous, the larvae collect in masses to spin a cocoon. The percentage pupating on the tree bole increases with abundance. The adult male flies in a zigzag course, most vigorously from 10 a.m. to 3 p.m. on warm days. Females have been observed flying when distrurbed by males. The female is rarely polygamous. Reports of parthenogenisis in Europe: Carlier reports three generations without mating, but the last produced only males. One egg cluster can start a new colony, since males and females emerge simultaneously and will mate.

Adults: 1,3,9,10,11; All stands: 15; Eggs: 3,12; Generation: 3,9,10,12; Larvae: 1,3,11,13; Prepupae: 4; Pupae: 1,3,4,10; Sex ratio:2

177. Force, D. C.
1972. **r- and K-strategists in endemic host-parasite communities.** Bull. Entomol. Soc. Am. 18: 135-137.

The parasite with the highest reproductive capacity was found to be the poorest competitor for a host attacked by one or more other parasite species. There is a general inverse relationship between reproductive capacity and competitive ability, suggesting that a parasite complex develops an r-K strategy sequence. General ecological theory explains the large parasite complex by saying that the parasite is very niche-specialized and does not have the potential to adapt to change. The author offers a contrary theory, since numerous introduced pests have been controlled over wide geographical areas by only one or two of their introduced parasites from a much larger endemic complex. In biological control, the parasites that are imported are usually those collected most often from endemic sites. In older disturbances these are likely to be K-strategists, which are most numerous because of competitive selection. These will not be aggressive colonizers. Thus r-strategists are needed, which will be few in number but geographically widespread and more common in new disturbances.

Generation: 4

178. Fratzian, A.
1973. **Growth and vitality of oak stands after being eaten by gypsy moths, *Lymantria dispar* L., in Romania** [in German, English summary]. Anz. Schaedlingskd., Pflanz. Umweltschutz 46: 122-125.

Investigations were carried out in Romania in three oak stands (*Quercus pedunculata*) situated in two phytoclimatic regions. Results show that a one year defoliation affects the growth of the trees during the year of defoliation plus the two following years. The total loss of growth is equivalent to 1 year. Two consecutive years of defoliation resulted in a loss of 1.3 years' growth in old trees and 2.2 years' growth in young trees.

Oak stands: 15,24

179. Fratzian, A.
1973. **Influences of defoliation caused by *Lymantria dispar* on the growth and vitality of oak stands** [in Romanian, German, summary]. Pages 194-197 *in* Influenta defolierilor produse

de insecte asupra productivitatii padurilor. Editura Ceres, Bucaresti (English transl.).

Lymantria dispar is one of the most dangerous forest pests in southeastern Europe. Experiments were conducted on a variety of sites (18 stands infested with *L. dispar* and 11 artificially defoliated) to determine the influence of defoliation on the growth and vitality of oak stands. The following conclusions were drawn: When timber volume decreases, *L. dispar*-caused defoliation decreases. Young stands are more sensitive to infestation than older stands. Neither stand composition nor yield class affects the influence of the infestation on the growth of the stand. A moderately intense infestation (30 to 40 per cent) affects growth only during the attack year. Higher intensity infestations (50 to 80 per cent) influence growth the year following attack as well. Total denudation affects growth for 2 years following defoliation. The total growth loss equals or exceeds a single year's growth. Two successive years of total defoliation cause growth loss during the years of defoliation and during the next two years, with the greatest loss (more than 50 per cent of the annual growth) in the second year of infestation. With these repeated attacks total losses equal 1.2-2 percent of annual growth. Artificially induced defoliation has results equal to insect defoliation. Depending on whether the defoliation is early or late in the season, the greater growth loss is in the year of defoliation or in the following year. Mortality was noticeable only in stands of the weakest class. Different species of oak have different susceptibilities to mortality: 25 percent of *Quercus penduculata* died after 2 successive years of total defoliation. In stands of *Q. frainetti* and *Q. cerris,* mortality is sporadic and generally does not exceed 1 percent. Population increases of *L. dispar* are periodic between 5 and 20 years, depending on geographic region, stand structure, and climatic factors.

Oak stands: 15,19,20,24,25; Generation: 2,12

180. French E. W.
1974. **The gypsy moth, *Porthetria dispar* (L.): annotated bibliography 1890–1972.** U.S. Dep. Agric. For. Serv., State and Private For., Northeast Area. 168 p.

Annotated bibliography indexed by author and subject.

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181. Friend, R. B.
1945. **The gypsy moth in Connecticut.** Trans. Conn. Acad. Arts Sci. 36: 607–629.

Reports covers life cycle and habits, injuriousness, effects of climate, host plants, natural enemies, artificial control measures, and extent of the problem in Connecticut.

Review

182. Fukaya, S.
1936. **Parasites of *Lymantria dispar* L.** [in Japanese]. Oyo Dobutsugaku Zasshi 8(6): 332–335.

183. Fukaya, S.
1938. **Effect of temperature and humidity upon the development of *Apanteles liparidis* Bouché and its parasites** [in Japanese]. Oyo Dobutsugaku Zasshi 10(6): 234–244.

184. Furuno, T.
1964. **On the feeding quantity of the gypsy moth (*Lymantria dispar* Linne) and the camphor silk moth (*Dictyoploca japonica* Butler)** [in Japanese, English summary]. Nippon Rin Gakkai-Shi 46(1): 14–19.

Feeding quantity is correlated with amount of frass in individuals feeding on *Quercus acutissime* Carr. The total leaf area eaten at the larval stage was 700–1100cm^2 for males and 1100–1800cm^2 for females. Insects in the last instar ate 60 to 70 percent of the total. The total number of frass pellets evacuated at the larval stage was about 1500. a straight line logarithmic correlation between feeding quantity and amount of frass was formulated for the gypsy moth.

Larvae: 1

185. Furata, K.
1972. **Effect of larval density of *Porthetria dispar* on its population after fasting** [in Japanese]. For. Prot. (Tokyo) 21(5)(242): 92–95.

186. Furuta, K.
1972. **The relationship between population density and mortality in the range of latency of *Lymantria dispar* L.** [in Japanese, English summary]. Nippon Oyo Dobutsu Konchu Gakkai-Shi 16(3): 121–126.

"Eggs and larvae of the gypsy moth, *L. dispar,* were artificially placed on larch and birch trees, both of which were about 2-2.5 m [in] height, and the environmental resistance of the population, which was kept under a condition of latency, was analyzed. Except [for] death by airborne dispersal in their first instar, most larvae were killed by the predation of birds. The sparrow, *Passer montanus kaibatoi* Munsterjelm, and other birds preyed on the larvae over the third instar. At first the predation was caused independently of larval density, but it soon changed to be density-dependent. Most of the 260 larvae that were placed in the egg stage on 29 larch trees (1 to 40 larvae on each tree), and 2200 larvae that were placed in third instar (20 to 200 on each tree), were preyed upon density-dependently in their third and fourth instars. The 165 larvae of the fifth instar and 125 larvae of the sixth instar having been placed in low density levels (1 to 20 larvae on each tree) were also immediately preyed upon density-dependently. Parasitism by *Apanteles liparidis* was observed; however, as the percentage of third-instar larvae that were parasitized was less than 20 percent, and the parasites killed the fifth-instar larvae, predation by birds, which began in the third instar, was regarded as the regulatory factor of the population."

Instars I-III: 4,9; Instars IV-VI: 4,9; Larvae 2,9

187. Furuta, K., and C. Koizumi.
1975. **The mortality factors of experimental populations of *Lymantria dispar* in a larch plantation and natural forest.** Nippon Rin Gakka-Shi 57(12): 432-435.

"The mortality factors of an experimentally established population were observed and analyzed in order to elucidate the control factors which stabilize an insect population during periods of low density. The larvae of *L. dispar* were placed on birch trees (*Betula ermanii* var. *communis*) surrounded by one hectare [of] unstocked space in a natural forest zone in Hokkaido, on larch trees (*Larix leptolipis*) which were planted in a natural forest, and on birch trees (*B. platyphylla*) in a 100-hectare larch plantation. The distance between the *B. ermanii* var. *communis* and *L. leptolepis* stands in the natural forest was about 100 m, and 6 km between the larch plantation and the natural forest. Although more than 90 percent of the larvae on *B. ermanii* var. *communis* or *B. platyphylla* were killed in one month from June to July, only about 65 percent of the larvae were killed on *L. leptolepis* in the natural forest. The larvae on the larch trees in the natural forest were not preyed upon by birds. The differences in mortality among the stands seemed to be caused mainly by bird plundering. The Gordioidea parasite was found on about 20 percent of the larvae on the birch trees, but was not observed in other stands. All the stands were plagued by a species of dipterous parasite which caused high mortality and showed a tendency of density-dependency."

Generation: 2; Larvae 4,9; Non-oak stands: 15

188. Furuta, K.
1976. **Studies on the dynamics of the low density populations of gypsy moth and toda-fir aphid: analysis of the environmental resistance factors by artificial host increase method** [in Japanese, English summary]. Bull. Gov. For. Exp. Stn. Kansai 279: 1-85. For. Prot. 4.

This study was done to determine which factors keep an insect species at a low density level. When this level is below the potential for the species, control is by environmental resistance factors. The key factor, which is the environmental factor that dominates changes in density, is not always the factor that controls the insect population at low levels over a period of years. The life table method of evaluating environmental resistance factors is very difficult to develop with species at low population levels. Using instead the artificial host increase method for phytophagous insects, numbers of the insect are artificially released in the egg or larval stage. Mortality factors in each developmental stage are then observed. If two or more groups of different numbers are released simultaneously, it can be seen whether a factor varies in intensity with this difference in numbers. One of the main purposes of these experiments was to confirm whether the factor that varied in intensity with density differences in the subpopulation could control a low density population over the years. It was found that all the important control factors at low density levels were polyphagous predators. These change the cyclical fluctuation of population, if it exists, to one in which a latent population is maintained over a number of years with an occasional outbreak. In the case of the gypsy moth, most released larvae were rapidly preyed upon by birds.

Generation: 2; Larvae: 9

189. Galloway, C. W.
1962. **The comparative defoliation of oaks.** J. Elisha Mitchell Sci. Soc. 78(2): 93

The author found that defoliation of 16 species of oak occurred sequentially. Knowing the rate of defoliation of each species makes it possible to identify trees in the field by the condition of the crown.

Oak stands: 18

190. Georgijević, E., and V. Vaclav.
1958. **Problem of gypsy moth focuses in Bosnia and Herzegovina** [in Serbo-Croatian, English summary]. Zast. Bilja 41-42: 67-74.

The gypsy moth appears autochthonously in various localities in Yogoslavia that differ considerably from one another. However, the gypsy moth dwells permanently in these areas, and they can be considered its foci. The authors tried to determine which of the 127 localities in Bosnia and Herzegovina in which the gypsy moth appeared in 1957 were its foci. They did this by establishing the presence of *Anastatus disparis* Ruschka, a specific gypsy moth egg parasite with low mobility. Using the hypothesis that *A. disparis* is an indicator of foci, they determined that the gypsy moth can be found permanently in 14 localities. "The reliability of this hypothesis has to be corroborated by further investigations to be carried out in the course of several years."

Eggs: 4; Generation: 2,12

191. Georgijević, E., and V. Vaclav.
1958. **Stationary investigations of the dynamism of gypsy moth populations in localities where no control measures against this pest have been taken (1957)**[in Serbo-Croatian, English summary] Zast. Bilja 41/42: 107-122.

Ten localities with 51 test plots of 100m^2 were studied for 1 year in the territory of Herzegovina to observe gypsy moth developmental stages, movement, and mortality factors. Gypsy moths from each locality were also reared in the laboratory. Analysis of the data obtained from these reared larvae offered a heterogeneous picture of causes of mortality: tachinid parasitism, entomophagous hymenoptera, disease, virus, and *Calosoma sycophanta* predation were major factors in different localities. The graduation lasted an average of 3 years and vanished rapidly. Egg clusters were found under stone piles, in cracks of limestone masses, in sheltered places on the ground and under the earth surface, in interspaces between stones in stone walls, with only a small percentage of the clusters in trees. The principal food plant in investigated areas where a complete browse was observed was *Carpinus orientalis*.

Eggs: 2; Instars IV-VI: 3,6; Larvae 2,4,6; Non-oak stands 15; Pupae: 2,4,6

192. Georgijević, E. D. Lutersek, K. Fice, and V. Vaclav.
1959. **Problem of gypsy moth focuses in the PR of Bosnia and Herzegovina.** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 89-94.

Gypsy moth foci in Bosnia and Herzegovina were studied for 3 years beginning in 1957. The gypsy moth appears autochthonously throughout these provinces in all but the central mountain region and plateaus. There are probably genetically different populations in the region connected with specific biotopes with characteristic food plants.

Eggs: 4; Generation:2

193. Georgijević, E. Dragutin L., V. Vaclav, and J. Batinica.
1959. **Stationary investigations into the dynamism of gypsy moth populations: localities where no control measures against the gypsy moth have been taken (1959).** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 79-88.

"Dynamics of gypsy moth populations in localities of Herzegovina have been followed since 1957. This was the peak year of gradation, and since that time the population has rapidly dropped in all of the investigated localities (15 with 63 test plots). The rapid decrease of the population, which took place in 1958, was chiefly caused by diseases and natural enemies, which particularly manifested themselves in those localities where the trees had been browsed up in 1957. In 1959 the gypsy moth population reached its maximum in all localities, and the pest was in the period of latency. An exception was Tihaljina, where a treatment was carried out in the immediate neighborhood of the examined locality in 1956. After that a negative reaction of the biocenosis in the form of a rapid numerical decrease of the gypsy moth's natural enemies was observed. It recovered in 1959 and again reduced the increased gypsy moth population."

Generation: 2,3,4

194. Gere, G.
1964. **Change of weight, lipid and water content of *Lymantria dispar* L., with special regard to the chemical and energetic changes during insect metamorphosis and imaginal life.** Acta Biol. Hung. 15(2): 139-170.

The results of studies on age, changes in weight, fat, and water content of the gypsy moth (*Lymantria dispar* L.) are presented. "These insects do not feed in the imaginal stage, hence their food and energy supplies are covered by reserve substances stored during the larval stage. The reserve is utilized preponderantly to assure propagation. In the want of food uptake, they decompose the substances of their bodies during life at a rate which calls, from the point of view of production biology, for the coining of a special term, defining these animals as self-decomposers. (The term is undoubtedly applicable to all other holometabolous insects which do not feed in the imaginal stage.) Though this characteristic is valid for both males and females, there is still a certain difference concerning the management of the reserves between individuals of the sexes, just as they differ also in morphological respects. Subsequent to the ceasing of food uptake by the caterpillars, the loss of weight of the males is so great that the weight of a dying moth is only 6.6 percent of the greatest weight of the larva. The decrease in weight is further aggravated by the fact that the imago, after hatching from the pupa, frees itself from all dispensable material, so that its weight will diminish to the smallest possible amount, which again results in its being able to convert a considerably lesser amount of energy covering the work of muscles involved in flight. The males thus utilize their available energy resources almost exclusively for flight in search of mates. The fat content of the male moth is very high, 18.76 percent of the live weight at an age of 33 hours. This supply of fat will be gradually utilized during flight, although a fraction of it will still remain unused at the time of death of the moth. The water content also strongly decreases during the hatching from the pupa and in the first hours of life of the imago. There is no more than 56.5 percent water found in a 24-hour-old male moth. However, the relative water content will diminish but slightly or, in the second half of the period of flight, not at all. This is explicable by the fact that the insect utilizes the water produced in the oxidation of fatty substances. While the males use their food reserves and energy supplies mainly for flight, the females convert them to the production of eggs. The females utilize far less material to cover their metabolic processes than do the males. If no eggs are laid, their weight decreases only by 31.7 percent during the imaginal stage. Also their fat supply, relatively much less than that of the males, decreases insignificantly. An oviposited female, on the other hand, presents quite another picture. The weight of such an insect at its death is generally only 19.2 percent of its weight after its hatching from the pupa. A considerable part of the fatty substances of the insect (about 80 percent of the initial supply) is also transmitted into the eggs. An oviposited female has a higher water content than the eggs; this again proves that the insect transmits the substances of a higher energy content into the eggs."

Adults: 13; Eggs: 13; Larvae: 13; Pupae: 13

195. Glaser, R. W., and J .W. Chapman.
1913. **The wilt disease of gipsy moth caterpillars.** J. Econ. Entomol. 6:479-488.

In a paper published in *Science* in 1912, the authors described *Gyrococcus flaccidifex*, a micrococcus they believed to be etiologically connected with the wilt disease. They later found it to be simply a casual intestinal parasite. In an attempt to find the cause of the wilt disease, they perfected a system of filtration through a Berkefeld "Grade N" filter such that no bacteria or polyhedral bodies were present in the filtrate. All that was visible in the filtrate were very minute dancing granules, which were found also in diseased tissue but never in healthy tissue of gypsy moth larvae. Larvae were fed red oak leaves smeared with filtrate material, and those that died were flaccid, disintegrated, and full of polyhedral bodies. Wind is not an important factor in the rapid spread of the disease. Infection in nature occurs when larvae feed on leaves soiled by the juices of dead individuals.

Larvae: 5,7

196. Glaser, R. W.
1915. **Wilt of gipsy-moth caterpillars.** J. Agric. Res. 4: 101-128.

There is no record of the wilt disease in the United States prior to 1900. It may have been introduced with parasites imported in 1905, some of which may be important in dispersal of the disease. The first printed record of wilt appeared in USDA

Bulletin 91 by L. O. Howard and W. F. Fiske (1911). Experimental work is described, and a summary of information known about the wilt disease to date is given.
Larvae: 7

197. Glaser, R. W.

1918. **A new bacterial disease of gipsy-moth caterpillars.** J. Agric. Res. 13: 515–522.

In 1915 an infectious disease was found in certain cultures of the Japanese gypsy moth. Its causal agent was *Streptococcus disparis*, a new species described in this paper. In nature it is transferred when healthy larvae eat food soiled by feces of infected animals. Thus it enters via the alimentary tract, spreading to all tissues, and causing the most striking changes in muscle tissue. It is not pathogenic to *Bombyx mori* L. (silkworms) or to *Cirphis unipuncta* Haworth (army worms), or to humans, rabbits, or guinea pigs. When introduced in the field it produced an epidemic in Sherborn and North Carver, Mass. and was successful in infecting the American variety of gypsy moth in other locations as well.
Larvae: 5

198. Glaser, R. W.

1918. **The polyhedral virus of insects with a theoretical consideration of filterable viruses generally.** Science 48: 301–302.

Experiments done to prove that the wilt disease is caused by an organism and not by an enzyme or toxin involved a large series of passage infections. "Twenty-five gypsy moth caterpillars were infected at a dilution of 1:1000 with material obtained from a caterpillar previously dead of wilt." All 25 died, and one of these was the source for the second passage. Similar third and fourth-passage infections were performed, and all experimental animals succumbed. The period from infection to death was considerably shorter in the last passage. This suggests increasing virulence and strengthens the argument that the disease is caused by parasitic ultramicroscopic organisms.
Larvae: 7

199. Glaser, R. W.

1927. **Studies on the polyhedral diseases of insects due to filterable viruses.** Ann. Entomol. Soc. Am. 20: 319–343.

"This study concerns itself primarily with two polyhedral diseases, namely, grasserie of silkworms and wilt of tent caterpillars." Experiments show that these diseases and the gypsy moth wilt, which are similar histopathologically, are caused by distinct, specific viruses.
Larvae: 7

200. Gogola, E.

1968. **Width of the head capsule in relation to the sex and number of instars in the larval development of gypsy moths, *Lymantria dispar* L.** [in Czechoslovakian, Russian and German summary]. Biologia Bratislava 23(8): 610–616.

201. Goldschmidt, R.

1934. **Lymantria.** Bibliogr. Genet. 11: 1–186.

This is an extensive work on the genetics of the gypsy moth. Particular attention is paid to geographical races and to the results of crosses between them, such as intersexuality, the phenomenon of beginning development as one sex and, without a change in chromosomes, finishing as the other sex. In *Lymantria*, female factors are inherited maternally within cytoplasm and male factors are determined by the X chromosome. Sex is determined by a quantitative relation between male and female factors. Over the Eurasian continent races are not very distinct, although some differences are noted. Generally the species works "toward a relative constancy of forms within an area," since means of dispersal are limited. When there is dispersal to a new climatic regime, success of the species depends on its ability to adapt and synchronize its life cycle with the seasonal cycle.

The original home of the genus *Lymantria* was Southeast Asia, and only a few of the species spread to the Palearctic. The northern limit of the gypsy moth now seems to be the isotherm of Stockholm, and owing to human transport, the southern limit may be as far south as North Africa. The smallest forms in both sexes are from southern Europe and Massachusetts. Medium sizes are in northern Europe and Turkestan as well as in Hokkaido, North Hondo and Korea; in northeastern and southwestern Japan the gypsy moth is large. Body size and rate of development are not correlated and egg size shows no racial difference.

Four main racial types have been distinguished based on larval coloration: (1) dark—Europe, Russia, Turkestan, Mediterranean, North China (Tsingtao), and Manchuria; (2) light—southwest Japan, extending into Korea; (3) intermediate—

northeast Japan; and (4) bright markings—Hokkaido. Wing and body color are determined simultaneously, as seems to be the case in all Lepidoptera. The geographical variations of adults are: (1) European forms—distinguishable from Japanese forms, but similar grayish brown males are found in Korea, China, and Manchuria. In southern Europe and Turkestan, males may also be yellow- brown. Females are all whitish with clear zigzag bands. (2) Island of Hokkaido— males, vary, but most commonly are whitewinged, except for the base and edge of the wings. (3) Japan—female wings are gray. The color of the abdominal hair used to cover the eggs is dark in northern European types and light in southern European, Massachusetts, and Turkestan forms. There is the same north-south difference in Japanese and Korean races.

"The formation of geographical races or subspecies is not a first step toward speciation but leads only to diversification within the limits of the species. This diversification is mainly of an adaptive nature, adapting the species to different special environmental conditions within the area to which it is adapted as a species. This adaptation proceeds by mutation and immigration into a fitting environment, according to the principle of preadaptation."

Adults: 1,12; Generation: 1,12,13; Larvae:13

202. Gonzalez de Regueral, A.
1946. **Combating the gypsy moth** [in Spanish]. Montes 2(8): 132-140.

203. Gould, W. P.
1971. **Making the gypsy moth go away and stay away by modifying the forest environment to make it less susceptible.** R. I. Resour. 17: 1-4.

The author proposes that the best method for removing the threat of gypsy moth defoliation is through silvicultural practices. This entails removing species of the food class A type. In most instances this results in a white pine stand.

All stands: 19,20

204. Granett, J.
1974. **Estimation of male mating potential of gypsy moths with disparlure-baited traps.** Environ. Entomol. 3: 383-385.

Estimation of gypsy moth, *Porthetria dispar* (L.) male mating potential has been made using box-type disparlure-baited traps. This potential, estimated by the reciprocal of the time elapsed before virgin females mated during the natural gypsy moth flight, was proportional to 22-h trap catches. Seasonal trap catches tended to be proportional to population as estimated by counts of pupae under burlap bands, with estimates adjusted for numbers of oak trees in 0.1-ha plots. Trap catches were highest when traps were adjacent to large trees and 1.5 m or less above the ground." Male moths frequently fly up and down beside large tree trunks in search of females. It may be possible to use pupal counts as an advance indication of adult population trends and male mating potential.

Adults: 1; Pupae: 2

205. Gravatt, G. F., and G. B. Posey.
1918. **Gipsy moth larvae as agents in the dissemination of the white-pine blister-rust.** J. Agric. Res. 12: 459-462.

Gypsy moth larvae feed on the peridermium stage of *Cronartium ribicola*, the white-pine blister-rust, and carry thousands of aeciospores on their bodies. They also feed on the leaves of *Ribes* spp. In some cases the only *Ribes* leaves infected with *C. ribicola* are those showing gypsy moth injury. Germination tests made of spores on the bodies of larvae collected on cankers showed approximately the same percentage germination as spores collected directly from the cankers, but tests of spores in frass pellets showed very poor germination. Because the gypsy moth can be carried as far as 20 miles in the wind, can transport viable spores, and feeds on both white pine and *Ribes*, the larvae are certainly a factor in spreading blister-rust.

Instars I-III: 1; Non-oak stands: 15

206. Grigorova, R.
1964. **Two strains of *Bacillus thuringiensis* Berliner isolated from the larvae of gypsy moth, *Lymantria dispar*** [in French, English summary]. Pages 179-191 in Colloq. Int. Pathol. Insect. Lotte Microbiol., Paris, 1962.

Two strains of spore-forming and crystal-forming bacteria were isolated from the larvae of *Lymantria dispar*: one in 1959 in the field and another in 1962 in the laboratory. Both strains were serologically and physiologically investigated. The field-isolated strain was found to be *Bacillus thuringiensis* serotype I *berliner*, and the laboratory strain was identified as *B. thuringiensis* serotype IV biotype 6 *dendrolimus*. The field-isolated strain was more virulent for *L. dispar* larvae then the *dendrolimus* strain, even at one fourth the concentration.

Larvae: 5

207. Grisson, P.

1955. **Abrupt regression of *Lymantria dispar* L. because of the predatory activity of *Calosoma sycophanta* in the Corsican cork oaks** [in French.] Rev. Zool. Agric. Appl. 54(4-6): 51-56.

In the southeastern part of Corsica, a gypsy moth outbreak which peaked in 1952-53 almost completely defoliated the cork oaks for three consecutive seasons. In 1954 *Calosoma sycophanta* L. was the main control agent of gypsy moth larvae in Languedoc, Maures, and Corsica. Local estimates placed the number of beetles per tree at 100.

Generation: 2; Larvae: 1,3; Pupae: 3

208. Gyorfi, J.

1941. **Secondarily detrimental insects after damage done by *Lymantria dispar*** [in Hungarian; German, French, and English summaries]. Erdezeti Lapok 80(3): 120-123.

The following list of species is given. Coleoptera: Buprestidae—*Dicerca alni* Fisch., *Lampra rutilans* F., *Chrysobothris affinis* F., *Coraebus bifasciatus* 01., *Agrilus biguttatus* F., *A. viridis* L., *A. angustatus* Ill. Eucnemidae—*Melasis buprestoides* L. Cerambycidae—*Aegasoma scrabricorne* Scop., ***Rhagium mordax*** Deg., *Cerambyx scopolii* Füssl., ***Rhopalopus insubricus*** Germ., *Pyrrhidium sanguineum* L., *Callidium variabile* L., *Xylotrechus arvicola* Oliv., *Clytus arietis* L., *C. tropicus* Panz., *Plagionotus arcuatus* L., *P. detritus* L., *Liopus nebulosus* L., *Haplocnemia nebulosa* F., *Saperda scalaris* L. Curculionidae—*Cryptorrhynchus lapathi* L., *Gasterocercus depressiorostris* F. Ipidae—*Xyleborus monographus* F., *X. dryographus* Rtzb., *Anisandrus dispar* F. Platypodidae—*Platypus cylindrus* F. Hymenoptera: Siricidae—*Xiphydria longicollis* Geoffr., *X. prolongata* Geoffr. Lepidoptera: Cossidae—*Zeuzera pyrina* L. Sesiidae—*Trochilium spheciforme* Gong. This list represents the results of the author's investigations carried out on material gathered in Hungarian woods attacked by *Lymantria*.

All stands: 16, 17

209. Gyorfi, J.

1943-1944. **Ecological investigations on the life of Hymenoptera** [in Hungarian and German]. Erdeszeti Kiserl. 45(1-4): 1-68.

210. Gyorfi, J.

1945. **Observations on the nutrition of ichneumon fly imagos** [in Hungarian, German, and French summaries]. Erdeszeti Kiserl. 45:87-114.

211. Gyorfi, J.

1961. **The parasites of *Lymantria dispar* L. according to newest researches** [in Hungarian, English and German summaries]. Erdeszeti Kut. 57 (1-3): 275-285.

"In Hungary the gypsy moth (*Lymantria dispar* L.) damages mainly the pure stands of Turkey and pedunculate oak (*Quercus cerris* L. and *Qu. robur* L.) growing on the. . .mountains Vért- Pilis-Cserhát-Mátra as well as in the eastern part of the county Somogy and in the western part of the counties Baranya and Tolna. By eating the leaves, the caterpillars of this moth cause losses primarily in increment, and if the attack continues for a rather long time, the weakened trees and woodlots may be entirely destroyed by secondarily injurious insects and fungi. The gypsy moth is polyphagous to such a high degree that it feeds—with the exception of wild pear (*Pyrus pyraster* L.), ash (*Fraxinus* sp.), privet (*Ligustrum vulgare* L.) and lilac (*Syringa vulgaris* L.)—sometimes attacks even these species. However, turkey and pedunculate oak are the principal host plants of this moth. It propagates in stands of these two species and seeks other plants only after becoming too numerous." It flourishes if the equilibrium of the biotic community is disrupted, as when parasites that previously held it in check die out. "The principal species of these controlling parasites are as follows: the beetle *Trombidium holosericeum* L.; the real ichneumon flies *Protichneumon disparis* Poda, *Theronia atalantae* Poda, and *Hyposoter disparis* Vieill.; the braconids *Apanteles fulvipes* Hal., *A. liparidis* Bouché, *A. porthetriae* Muesb., *A. melanoscellus* Rtzb., *A. lacteicolor* Vier., and *Microgaster tibialis* Nees.; the chalcids *Brachymeria intermedia* Nees and *Anastatus disparis* Rusch.; as well as the species *Compsilura concinnata* Meig., *Lydella nigripes* Fall., *Parasetigena segregata* Rond., *Sturmia scutellata* R.D., *Carcelia excisa* Fall., *Tachina larvarum* L., and

Trustica Meig. belonging to the Tachininae. All these parasites are described." Their primary and secondary hosts, as well as the plants preferred most by ichneumon flies, are enumerated. "From the data, the conclusion could be drawn that the propagation of the gypsy moth may be controlled best by mixed forests planted on good soil and having a rich undergrowth."

Oak stands: 15, 16; All stands: 15; Eggs: 4; Larvae: 4; Pupae: 4

212. Hackett, K. J.
1971. **Parasites associated with various densities of the gypsy moth, *Porthetria dispar*, in Yugoslavia.** M. S. thesis. Rutgers Univ., New Brunswick, N. J.

This is a survey of parasites associated with various population densities of gypsy moth larvae in the Danube River Valley, Yugoslavia. In Bagremera, a woodlot with grassy underbrush where density was highest, a crow infestation fed on gypsy moth adults. In Celarevo, where there has never been a recorded outbreak, the low density was perhaps due to periodic flooding which drowns larvae, prevents tree-to-tree migration, and kills eggs if the water is at about room temperature for one month. There was no statistical difference in percentage of total parasitism between the six areas studied, but classes of parasites differed.

Apanteles spp. were more prevalent in low-density areas, except for *A. solitarius* which has up to three generations per year and can therefore build up very rapidly in high-density gypsy moth populations. *A. prothetriae* has one generation per year on gypsy moth, and its buildup is dependent on alternate overwintering hosts. *A. ocneriae* is found in small numbers in high- and low-density areas' *A. liparidis* is prevalent in stabilized areas only; however, both are gregarious. Some investigations believe *A. solitarius* and *A. melanoscelus* are the same species since they interbreed in the laboratory, but their life cycles differ: *A. Solitarius* has two broods emerging in spring and overwinters in first instar, or as prepupae within cocoon, or as female at tree base; *A. melanoscelus* overwinters as diapausing larvae and has one brood emergence in spring.

Their host preferences differ: *A. solitarius* favors satin moth, whose presence may have drawn this parasite to Bagremera. *Apanteles* spp. respond to gypsy moth density in two ways: In stabilized areas a greater species diversity accounts for a higher incidence of parasitism; in high-density areas multibrood species predominate. *Hyposoter* spp. (Ichneumonidae) abundance is not related to density factors but to environmental conditions. It overwinters on ground and therefore is killed in Celarevo where there is flooding. It produces 1200 eggs per female per year. Hyperparasitism mortality is high in Yugoslavia in the overwintering cocoon stage.

Tachnids: *Carcelia gnava* Meigen is multibrooded, with perhaps only one generation on gypsy moth, since it would not breed in the laboratory. It is probably of minor importance. *Compsilura* sp. differs from *C. concinnata* in that environmental tolerences are narrower and sex ratio of female to male was 3:1 instead of even. Both are abundant in areas of low to medium host density, since they follow population trends of alternate and overwintering hosts which are prevalent in gypsy moth latency. *Exorista larvarum* L. emerges from larvae and pupae; it is the most abundant parasite in high-density areas. The female lays up to 2000 eggs, attacks avidly, and will develop in diseased larvae, but needs alternate hosts. *Sturmia scutellata* may be beneficial in low-density areas owing to its superior searching abilities. Since it will lay up to 5000 eggs, it is also valuable in high host density areas. It emerges mostly from pupae. It is especially important the first year after culmination, when the predominant parasite is determined by the life stage of the moth when the collapse occurs. Parasites emerging from that stage predominate the following year. An unidentified *Sturmia* sp. was also found; it overwinters as a larva rather than a pupa. Previous importations of parasites (1905–1914, 1922–1933) were from areas of high density from the first year after culmination; thus high-density parasites predominate.

Adults: 9; Eggs; 12 Larvae: 2, 4, 12

213. Hadžistević, D., and H. Hadžihalilović.
1959. **Gypsy moth gradations on the territory of PR Bosnia and Herzegovina** [in Serbo-Croatian, English summary]. Zast. Bilja 52–53: 153–159.

"The authors give a survey of gypsy moth gradations on the territory of the PR of Bosnia and Herzegovina, based on the information concerning these gradations already published in the professional literature and various other publications. The arranged data show that this pest appeared 10

times in overpopulation in the course of the last 76 years (in the period from 1880 to 1956)."
Generation: 2

214. Hall, R. C.
1935. **Cape Cod pitch pine: its resistance to gipsy moth defoliation and its advantages as a forest tree.** J. For. 33: 169-172.

Pitch pine is the tree species of the forest community of Cape Cod least affected by the gypsy moth. It appears to be the least preferred food species present. During severe outbreaks the older needles are eaten, but never the new growth. The turnover rate of pitch pine foliage is about 2 years. This type of defoliation, therefore, has little effect on tree condition.
Non-oak stands: 15, 19, 26

215. Hanson, J. B., and J. M. Reid.
1972. **Evaluation of larval and pupal parasitism of the gypsy moth in northeastern Pennsylvania.** U. S. Dep. Agric. For. Serv., State and Private For., Northeast Area. 7p.

Larvae were collected and maintained in the laboratory. Pupae were marked in the field. Percent parasitism was calculated for the larvae and pupae as well as for each parasite. Virus accounted for 44 percent of larval mortality. *Apanteles melanoscelus* and *Blepharipa scutellata* accounted for 90 percent of the deaths due to parasitism. Virus killed 61 percent of the pupae, with *B. scutellata* accounting for 91 percent of pupal mortality due to parasitism.
Larvae: 4, 7; Pupae: 4, 7

216. Hanson, J. B., and R. C. Reardon.
1973. **Selected references pertaining to gypsy moth parasites and invertebrate predators.** U. S. Dep. Agric. For. Serv., State and Private For., Northeast Area. 26p.

Selective bibliography on gypsy moth parasites and invertebrate predators.
Bibliography

217. Harding, K. C.
1930. **A change in nesting habits of the wood pewee.** Bird Banding 1(3): 144.

In 1924 some wood peewees (*Myiochanes virens*) built their nests 50 feet above the ground in oak trees near Holderness, N. H. During the next 2 years, gypsy moths stripped the oaks at about the time the young wood peewees hatched. The fledglings perished either from exposure to sun and rain or from predation by crows or hawks. The wood peewees changed their nesting habits and in 1927 began to built their nests in beech and maple saplings, the leaves of which were not eaten by the gypsy moth.
Larvae: 9

218. Hartmann, G. C., and S. S. Wasti.
1974. **Infection of the gypsy moth, *Porthetria dispar*, with the entomogenous fungus *Conidiobolus coronatus*.** Entomophaga 19: 353-360.

"Fourth-instar larvae of the gypsy moth, *Porthetria dispar* (L.) were infected with the fungus *Conidiobolus coronatus* (Cost.) Batko using the spore-shower techniques for varying periods of time. Larvae treated for more than 20 minutes showed 100 percent mortality Virulence of the pathogen was increased by inoculating larvae of the wax moth *Galleria mellonella* (L.) three times in succession. Typical symptoms of the infection were lightening of color, flaccidity, shrinking, and finally desiccation of the larvae. Observations on the histopathology of infected larvae showed penetration of the integument by hyphae within 22 hours after inoculation, and at 34 hours postinoculation the hemocoelom, head, nervous system, and muscles were completely infected. A localized mycelial growth in the digestive system resulted, probably caused by the ingestion of spores, but penetration of the gut wall was not recorded."
Instars IV-VI: 8

219. Heil, K. H.
1937. **An outbreak of the gypsy moth on the Rhine** [in German]. Nachr. Schadl- Bekaempf. 12(4): 218-225.

220. Henze, O.
1934. **On the effect of air in motion on the development of Lepidoptera** [in German]. Z. Angew. Entomol. 21(3): 385-405.

221. Hinckley, A. D.
1970. **Male gypsy moth dispersal on Long Island (Lepidoptera: Lymantriidae).** J. N. Y. Entomol. Soc. 78: 170-174.

"During July 1969, virgin female gypsy moths were used as decoys to sample male gypsy moth populations on Long Island. Although most common near an area in which larvae had completely defoliated tall oaks, male moths dispersed into

areas where infestations were sparse or nil. Increases in the average size of male moths were noted at several trapping sites during the sampling period, this change being attributable to the early emergence of small moths in severely defoliated areas." Males are by no means confined to zones where their chances of encountering virgin female are high. Intervals between catches of males seemed to be directly correlated with the distance from the main infestation site. Smaller moths reflected earlier emergence and seemed to have been subjected to malnutrition during their larval stages in the defoliated foci.
Adults: 1, 2; Larvae: 13

222. Hofmann, C.
1933. **The influence of starvation and restricted space on the growth and reproduction of Lepidoptera** [in German]. Z. Angew. Entomol. 20(1): 51-84.

223. Holbrook, R. F., M. Beroza, and E. D. Burgess.
1960. **Gypsy moth (*Porthetria dispar*) detection with the natural female sex lure.** J. Econ. Entomol. 53:751-756.
The time of flight of the male moth "depends greatly on the weather, especially on the temperature. The more northerly or cooler areas have later flights. However, the time of flight is not uniform even in the same general vicinity; flights in cooler areas are delayed . . . few males are trapped on rainy days or when the temperature is below 70°F. Usually the main flight takes place over a 10- to 14-day period; however, continued cool weather during the summer of 1956 stretched this flight period to about a month."
Adults: 1, 12

224. Houston, D. R.
1973. **Diebacks and declines: diseases initiated by stress, including defoliation.** Proc. Int. Shade Tree Conf. 49: 73-76.
The gypsy moth, along with leaf rollers, leaf tiers, and the elm spanworm, has initiated oak decline over large areas of the Northeast, Mid- Atlantic, and Southeast. Defoliation causes a biochemical change in the wood tissue: starch reserves decline, and sugars that are normally present in small amounts (glucose and fructose) increase. Severe drought also brings about these changes. These conditions render the tree susceptible to invasion by *Armillaria mellea*, which readily metabolizes glucose and fructose, but utilizes sucrose (the sugar that normally predominates) poorly. Other biochemical changes are caused by defoliation, such as changes in the concentration of certain amino acids in roots and in the phenolic compounds of bark, but these have not yet been correlated with activities of secondary organisms. In areas frequently defoliated y the gypsy moth, trees may not be as badly affected by severe defoliation as trees in sites disturbed infrequently. This is because of the relative energy demands of small, slow-growing trees versus those of large, rapidly growing trees.
Oak stands: 15, 16, 18, 23, 25

225. Howard. L. O.
1905. **The gypsy and brown-tail moths and their European parasites.** U. S. Dep. Agric., Yearb. Agric. 1905: 123-138.
This is an article for lay persons, reviewing the life histories of the gypsy moth and brown-tail moth and methods for controlling them.
Generation: 1

226. Howard, L. O.
1907. **The gipsy moth and how to control it.** U. S. Dep. Agric. Farmer's Bull. 275.
Review of introduction of the gypsy moth to the United States, its distribution as of 1907, its life history, and control measures.
Generation: 1,2

227. Howard, L. O.
1910. **Technical results from the gipsy moth parasite laboratory. I. Parasites reared or supposed to have been reared from the eggs of the gipsy moth.** U. S. Dep. Agric. Tech. Ser. 19.
No native American parasites have ever been reared from the eggs of the gypsy moth, probably owing to the character of the egg mass. It is compact and is covered by the scales of the parent, possibly to disguise its character from potential parasites for many generations. Only two of the parasites reared from abroad seem to be of primary importance: *Anastatus bifasciatus* Fonsc. and *Schedius kuvanae* Howard. The latter came from Japan, and the former has been reared in Japan, the Crimea, and Hungary.
Eggs: 4,12

228. Howard, L. O., and W. F. Fiske.

1911. **The importation into the United States of the parasites of the gipsy moth and the browntail moth: a report of progress with some consideration of previous and concurrent efforts of this kind.** U. S. Dep. Agric. Bur. Entomol. Bull. 91.

This is a classic history of parasite introduction efforts, including a chapter on early work done to control other insect pests and a chapter on gypsy moth parasitism in Japan, Russia, and Europe. Details are given on a number of the introduced parasites. Disease is discussed as a factor in gypsy moth control, particularly as related to the need for continuing parasite importations. Since first noted by Fiske in 1907, the wilt disease became important as an efficient means of control. Observations in parts of Russia where parasite control was inefficient and observations on diseases of other large lepidopteran larvae indicate, however, that disease alone does not exert a controlling influence until the insect has already become a pest. Thus it does not diminish the need for parasite introduction.

Eggs: 4,12; Larvae: 4,7,12; Pupae: 4,12

229. Howard, L. O.

1916. **The practical use of the insect enemies of injurious insects.** *from* U. S. Dep. Agric., Yearb. Agric.

This is a review of attempts to import parasites. In ordinary years in their native homes, parasites and native enemies destroy 90 percent of hatched gypsy moths.

Eggs: 4

230. Howard, L. O.

1922. **A sideline in the importation of insect parasites of injurious insects from one country to another.** Proc. Nat. Acad. Sci. U.S.A. 8: 133-139.

Although parasites and predators have been imported to control specific pests, usually those introduced from abroad, they often also act to control other native pests.

Generation: 4

231. Hoy, M. A.

1975. **Hybridization of strains of the gypsy moth parasite, *Apanteles melanoscelus*, and its influence upon diapause.** Ann. Entomol. Soc. Am. 68: 261-264.

"Colonies of *Apanteles melanoscelus* (Ratzeburg) from France, Yugoslavia, and Connecticut were crossed, and photoresponse curves were obtained for the three strains and their hybrids under laboratory and outdoor insectary conditions. Photoperiodic responses of the Connecticut strain were different from those of the French and Yugoslavian parasites and their hybrid. The triple hybrid was different from the French, Yugoslavian, and Connecticut strains in its diapause characteristics. The laboratory-determined critical photophases at 24°C were: Connecticut, 16-17 h; French-Yugoslavian-Connecticut hybrid, 15 h; French, Yugoslavian, and French-Yugoslavian hybrid, 12.5-13.5 h. Under outdoor insectary conditions, the average percentage entering diapause for each strain was: Connecticut, 96 percent; a newly collected French colony, 99 percent; a laboratory French colony, 8 percent; Yugoslavian, 8 percent; French-Yugoslavian hybrid, 7 percent; and French-Yugoslavian-Connecticut hybrid, 30 percent."

Larvae: 4

232. Jacentkovský, D.

1935. **The tachinid enemies of *Liparis dispar* L.** (in Czechoslovakian). Lesn. Pr. 14(9-10): 451-457.

233. Jahn, E., and A. Sinreich.

1957. **Observations on the occurrence of the gypsy moth (*Lymantria dispar* L.), the browntailed moth (*Euproctis chrysorrhoea* L.), and the green oak leaf rollers (*Tortrix viridana* L.) in lower Austria and in Burgenland in the years 1952-1956** [in German]. Anz. Schaedlingskd. 30(9): 139-146.

234. Janković, L.

1954. **Some observations on the vertical expansion of the gypsy moth** [in Serbo-Croatian, English summary]. Zast. Bilja 23: 102-103.

"After giving several observations on the vertical expansion of the gypsy moth, the author concludes that this pest, from the oecological point of view, gets easily accustomed to different climatic conditions, causing the same damage in its new surroundings as it did in the most suitable places to its development. Comparing the gypsy moth females coming from various altitudes proved that there were great differences in their respective sizes. The latest appearance of the gypsy moth pupa, so far noted in . . . [Yugoslavia], was about the middle of September in the forest, and the female imago that developed from this pupa in the laboratory was observed in October.''

Generation: 12

235. Janković, L.

1956. **Some observations on the ecology of the gypsy moth (*Lymantria dispar* L.) in hill and mountain forests in Yugoslavia** [in Serbo-Croatian, English summary]. Rec. Trav. Inst. Biol. Beogr. 7(8): 2-20.

At higher altitudes the density of gypsy moth is kept down by regulatory factors (climate). Biotic factors (parasites and predators) are less important because "late spring frosts, which are common at the altitude [of] 1300 m, regularly destroy the vegetation so that the caterpillars, being without food, have a higher mortality. High numbers of rainy and snowy days hinder the normal feeding of caterpillars in those regions, prolonging . . . [the development of the larvae.] The fecundity of the gypsy moth is also influenced by such conditions." The upper limit reached by the gypsy moth in Yugoslavia is 1550 m above sea level. At this altitude they do not have optimal living conditions, but they can exist normally for a few years. From this it is concluded that "the gypsy moth has a wide ecological valence for climatic factors and also that it is adaptable to the wide amplitudes of ecological factors."

Fecundity: 12; Generation: 12; Larvae: 12

236. Janković, L.

1958. **Comparative oecological investigations of the gypsy moth in hilly and mountainous biotopes on the Mokra Gora (Jovin Grob) and Kopaonik in the period from 1954 to 1957** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 81-87.

The gradation of the gypsy moth differs between highland and lowland regions. A characteristic feature of the highlands is that "gypsy moth clusters are hardly perceptible in them, regardless of the degree of gradation." Most clusters are deposited "in sheltered places (in heaps of twigs, piles of stones, under peeled-off bark, under superficial roots, and on the ground)" rather than on tree trunks. The gradation curve shows a rather gradual increase as well as decrease in the population, as opposed to the gradation curve in lowland forests. In 1957 there was a 4-month difference between the first observed emergence of a male moth in the lowlands and in the mountain forest of Kopaonik at 1550 m. In the mountains, pupation is under stones and pupae are preyed upon by a species of *Carabus*. In the lowlands, *Carabus* is not a predator because pupation is in the trees, and these beetles do not climb trees. In the mountains there is a comparatively high percentage of unfertilized eggs (27 percent), indicating protogyny. The rainy and snowy days in the mountains hinder normal larval feeding, prolong the duration of development, and influence fertility. At the highest altitude, beech is the principal tree species. These factors taken together control the population of gypsy moth at higher altitudes.

Eggs: 2; Fecundity: 12; Generation: 2,12; Instars I-III: 12; Larvae: 3; Non-oak: stands 15; Prepupae: 3; Pupae: 3

237. Janković, L.

1958. **Comparative oecological investigations of the gypsy moth in the enclosure of Trstena (near Mladenovac)** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 139-142.

In a study lasting from 1947 to 1957, two gradations and the period of latency between them were observed in a lowland forest (130 m) representative of the terrain of Sumadija. The first gradation began in 1946 and culminated in 1949 when 9,452 egg clusters/ha were laid. The population decreased rapidly by the following year owing to tachinid parasitization of larvae (86 percent). The second gradation (1953-1957) was represented by an atypical curve with a slower-than-average population increase and a lower-than-average number of larvae in the progradation. The average number of eggs decreased with the progress of the gradation. The average number of eggs in a cluster was almost the same in the culminant years of both gradations.

Eggs: 2; Generation: 2; Larvae: 2,4

238. Janković, L.

1958. **A contribution to the knowledge of gypsy moth foster plants in the nature in the course of the last gradation (1953-1957)** [in Serbo-Croatian, English summary]. Zast. Bilja 49/50: 35-39.

As the 1953-1957 gradation progressed, the number of gypsy moth host plants increased. In the first year the larvae ate only the optimal food: oak in low-lying biotopes, willow and poplar in

marshy regions, oak and beech in the hills, and beech in the mountains. In a pure oak stand in culmination the larvae browsed first in the trees, then passed to the shrubs, and finally to the ground cover. During the course of the gradation, 276 host plants were noted. Complete defoliation was observed on 33 species of forest trees, 7 fruit trees, 19 shrubs, 19 cabbage-like plants, 25 weeds, and 3 species of cultured plants.
Oak stands: 15; All stands: 15; Larvae: 2

239. Janković, L.
1958. **Dynamism of the gypsy moth population of Jakovački Ključ** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 35–48.
Nineteen 1000m^2 test plots, representing a variety of habitats (old forest, middle-aged forest, young forest, and thicket), were studied at Jakovački Ključ, Serbia, in 1957 when the gypsy moth was in retrogradation. Observations on egg clusters included the number per square hectare (304 old forest, 365 middle-aged forest, 207.4 young forest, 43.4 thicket); number per tree (0.6 old forest, 0.3 middle-aged forest, 0.03 young forest, 0.003 thicket); height at which clusters are deposited (40.7 percent up to 50 cm, 97.3 percent up to 4 m); size of cluster; percentage of trees infested with clusters (5.4 percent; average number of eggs (175.5 in thicket, 204.2 in young forest, 202.2 in middle-aged forest, and 204.5 for whole biotope); percentage of unfertilized eggs (22.5 percent), and the percentage of clusters deposited in trees (90.3 percent) and on shoots (9.7 percent), a ratio that changes during the gradation. Observations were also made on the duration of the life stages, larval behavior, number of larvae per tree, sex ratio (6:1 in favor of males), fertility (94.1 percent of fecundity), and percent parasitization (80 to 100 percent).
Eggs: 2; Fecundity: 2; Generation: 2,4,12; Sex ratio: 2

240. Janković, L.
1958. **Foster plants of the gypsy moth (*Lymantria dispar* L.) in the open in the course of a single gradation** [transl. from Serbo-Croatian]. Rec. Trav. Inst. Biol. Beogr. 2(2): 1–15.
Number of food species and intensity of defoliation by the gypsy moth "depend on the stage of the gradation, floral structure of the biotope, and geographical position." In the progradation, *Quercus* is the principal food species. In the pre-eruption, *Quercus, Carpinus, Ulmus, Populus,* and *Salix* are important. Food sources in the eruptional stages include all forest and fruit trees, shrubs, herbaceous plants, weeds, industrial, cultural, and fodder plants, fruits, and vegetables. A total of two hundred eight plant species recorded as food sources of the gypsy moth includes 60 species of forest trees, 16 species of fruit trees, 33 species of shrubs, and 99 species of herbaceous, industrial, and fodder plants. The vast majority of the plants are defoliated only during an outbreak. Knowledge of all food plant species may help in predicting the effect on the gypsy moth population, if all the presently preferred food species are removed.
Larvae: 1,2

241. Janković, L.
1959. **Quantitative ecological investigations of the gypsy moth at the locality Jakovački Ključ (report on the activity in 1959)** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 109–111.
"The gypsy moth at Jakovački Ključ has been studied since 1953. In 1959 the population became latent, allowing the first study of the species in this phase of its population dynamics. Investigations were concerned with number of clusters per square unit, site of deposition, size and form of clusters, height of deposition, and percentage of hatched caterpillars. Life history was also observed. The first larvae hatched April 1, followed by mass hatching from April 5 to 10, with the last on April 18. The caterpillar stage was completed in 58 days (53 in 1958). The number of clusters differed according to the type of forest. No clusters were observed in acacia groves and old forests; 4 clusters were found on 1 ha of the thicket, 2 in a new forest, and 10.5 in a middle-aged one. The average number of eggs was 700 (503 in 1958); the percentage of unfertilized eggs was low, only 0.95 in comparison with 4.7 in 1958. The average surface of the cluster was 820 mm^2 in comparison with 539 the previous year. Most clusters (86.6 percent) were deposited at a height of less than 50 cm. These results, particularly the small number of clusters per square unit, the high average number of eggs in a cluster, the very low percentage of unfertilized eggs, and the height at which the clusters were deposited, show that the gypsy moth at Jakovački Ključ is in the period of latency."
Fecundity: 2; Generation: 1,2

242. Janković, L.
1960. **Vertical distribution of the gypsy moth (*Lymantria dispar* L.) and its ecology** [in Serbo-Croatian, English summary]. Zast. Bilja 57/58: 203–209.

The gypsy moth is found in three altitude zones in its natural range: lowland (to 300 m), hilly (300-1200 m), and mountains (+1200 m). In lowlands, life conditions are optimal. Gradations appear constantly, with a numerical peak every 3 to 5 years resulting in total browse. There is rapid increase with gradual or rapid decrease. Caterpillar stage is a maximum of 60 days. Female fertility decreases to a 200-egg average at the posteruption stage. In the hilly zone, the gradation lasts 2 to 3 years. The caterpillar stage lasts for more than 2 months. Protogny is 23 percent, and fertility is a high 689 eggs. Completely browsed areas are rare. In the mountains there is insignificant numerical variation and no tendency to hasty increase. Protogyny is a permanent phenomenon. The percentage of nonfecundated eggs increases to 100 percent. *Carabus hortensis* L. is a predator of caterpillars and larvae.

Adults: 3; Fecundity: 12; Generation: 2,12; Larvae: 2,3

243. Janković, L.
1970. **Certain ecological conditions of the hill and mountain populations of the gypsy moth (*Lymantria dispar* L.)** [in German, Serbo-Croatian summary]. Ekologija 5(1): 129–136.

244. Janković, L.
1971. **Certain ecological conditions of the hill and mountain populations of the gypsy moth (*Lymantria dispar* L.)** [in German]. Pages 504-505 *in*. Proc. 13th Int. Congr. Entomol., 1968. Nauk. Leningrad.

245. Janković, M., D. Zecević, and V. Vojnović.
1959. **Races of the gypsy moth in Yugoslavia (report for 1959)** [in Serbo-Croatian, English, summary]. Zast. Bilja 56: 99–107.

"Further investigations of gypsy moth races of Yugoslavia, carried out by the Biological Institute of the PR of Serbia in the course of 1959 in localities of different geographical distance, showed [the] following results: It was established that the linear size of gypsy moth eggs (length and width) progressively increased from the northern populations to the southern ones. An analogous regularity was also observed concerning the beginning of the hatching of caterpillars: The caterpillars of northern localities begin to hatch first and those of the southern localities last. Physiological endurance of hatched caterpillars to low temperatures decreased from north to south, whereas the average duration of the total gypsy moth development increased from northern localities to southern ones. Finally, the investigations made in 1959 demonstrated that the number of exuviations of female caterpillars was less with populations from northern and mountainous localities than with populations from southern and lowland localities."

Generation: 12,13

246. Kal'vishch, T. K.
1969. **The causal agents of mycoses of some leaf-eating insects in Siberia and Kazakhstan** [in Russian]. Mikol. Fitopatol. 3(5): 403–409.

247. Kamiya, K.
1934. **Studies on the morphology, bionomics, and hymenopterous parasites of the pine caterpillar (*Dendrolimus spectabilis* Butler)** [in Japanese, English summary]. Bull. For. Exp. Stn. Korea 18.

The morphology and bionomics of *Dendrolimus spectabilis* Butler are given. It is found in Japan, Korea, eastern Siberia, and northern China. Twenty-three hymenopterous parasites are known. One, *Apanteles liparidis* Bouché, which is widely distributed in Japan, Europe, Siberia, and America, has more than four generations a year. It infests the larvae of the gypsy moth in the first two generations and the larvae of the pine-caterpillar in the last two. Between these two, it appears to spend one or two generations on other hosts. It is known to infest *D. spectabilis, D. albolineatus, D. pini, Lymantria dispar, Notolophus postica, Euproctis chrysorrhoea*, and *Porthesia similis*. Natural enemies vary with the season. Larvae coming out of pine-caterpillars are attacked by *Hemiteles* sp., and larvae emerging from gypsy moth may be attacked by any of 10 hymenopterans. Pupae from the pine-caterpillar generations are attacked by a Coleoptera larvae and those from the gypsy moth generations by an ant.

Instars I–III: 4

248. Kamiya, K.
1940. **On the natural enemies of *Apanteles liparidis* Bouché** [in Japanese]. Oyo Dobutsugaku Zasshi 12(3–4): 120–122.

249. Kansu, I.
1962. **The effects of the food on the larvae of the butterflies and moths and an experiment on the gypsy moth larvae** [in Turkish, English summary]. Ankara Univ. Ziraat Fak. Yayin. 2: 116–138.

Groups of 25 gypsy moth larvae were reared in the laboratory on different food material. It was found that no larva can live on pear leaves. At 26 °C and 60 to 70 percent relative humidity, mortality was 12.0 percent on oak, 23.3 percent on apple, 26.0 percent on quince, 52.1 percent on plum, and 70.0 percent on apricot. The male larval and prepupal developmental periods were 28.20 days on oak, 31.00 on apple, 27.70 on quince, 32.90 on apricot, and 36.25 on plum. For females the periods were 33.08, 33.24, 35.06, 37.60, and 38.00 days, respectively. Initial pupal weights were 451, 372, 399, 341, and 256 mg for males, and 1278, 1074, 742, and 708 mg for females, respectively. These results indicate that mortality and pupal weights are influenced by food and that oak is the most suitable host plant.

Oak stands: 15; Larvae: 12,13; Non-oak stands: 15; Prepupae: 13; Pupae: 13

250. Karas'ov, V. S. and T. I. Satarova.
1973. **The effect of tannins from *Salix, Populus,* and *Quercus* on the development of *Porthetria dispar*** [in Ukrainian]. Zakhist Rosl. 17: 44–46.

251. Karnig, J. J., and W. H. Lyford.
1968. **Oak mortality and drought in the Hudson highlands.** Black Rock For. Pap. 29. Harvard Black Rock Forest, Cornwall, N.Y.

This discusses the high oak mortality in southeastern New York during the drought of 1962 to 1966, which affected most of the northeastern United States. Drought is very rare as a mortality factor in these areas. The effect is greater on shallow ridge soils and on susceptible species. Crown class or degree of competition is unimportant as a factor affecting loss due to drought. The mortality of oak may not have been entirely due to drought since there was severe defoliation by cankerworms (*Paleucrita vernata*) and loopers (*Erannis tiliaria*). Most heavily affected were the scarlet oak-black oak type, whose basal area declined from 46 percent baseline to 3 percent.

Oak stands: 17,18,22,24,25

252. Kato, M., and K. Okazaki.
1941. **The outbreak of *Liparis dispar japonica* Motschulsky (Lymantriidae) in the year of Showa 16 (1941)** [in Japanese]. Oyo Kontyu 3: 103–119.

The Japanese gypsy moth got into rice fields from adjacent forests, fed on the leaves of rice plants, and arrested plant growth. Climatic conditions in 1941, especially suitable amounts of rainfall, were thought to have been predisposing factors. The migration of the larvae to the rice began June 20. They were carried to the vicinity on silken threads, then crawled on the ground. Many drowned. *Tachina larvarum* parasites were numerous. Adults emerged from early July to mid-August.

Adults: 1; Larvae: 1,4,12; Non-oak stands: 15,18

253. Kegg, J. D.
1971. **Impact of gypsy moth: repeated defoliation of oak in New Jersey.** J. For. 69: 852–854.

Defoliation in Morristown, N.J. is described and the percent mortality for each of eight genera is given. Oak mortality increased with each year of defoliation, from 6 percent baseline to 28 percent after 2 years and 69 percent after 4 years. Chestnut and black oak had less than 20 percent mortality, while scarlet, white, and northern red oaks had close to 40 percent. Greatest mortality was in the 6 to 12 inch diameter breast height (dbh) class and the greater than 26-inches dbh class. Oak density decreased from 24 percent to 19 percent, and birch (which also sustained repeated defoliation) increased from 19 percent to 21 percent. Basal area of oaks decreased from 41 percent to 32 percent, with greatest losses in the 6- to 12- inch dbh class, which declined from 36 percent to 18 percent of oaks. Large oaks did not recover from repeated defoliations, and heavily defoliated trees often did not survive the winter. Oak is the genus most vulnerable to mortality following repeated defoliation. Most beech, birch, hickory, and maple recovered well after defoliation.

Oak stands: 15,16,20,22,24,25,27,28

254. Kegg, J. D.
1972. **Oak mortality on the rise.** New Jersey For. Pest Rep. 7(4).

After 2 years of heavy defoliation by the gypsy moth, oaks in the Newark watershed of northern New Jersey showed continued mortality 3 years after the insect population collapsed. In 1968 oak mortality was 6.5 percent; in 1969, when there was 70 to 100 percent defoliation, mortality was 14.3 percent. In 1970, also with 70 to 100 percent defoliation, it was 38.0 percent; in 1971, 58.5 percent; and in 1972, 63.4 percent. White oak sustained the greatest loss (84.1 percent) and scarlet oak the least (27.3 percent). The severity of loss may not be as great on oaks growing on the sandy soil of southern New Jersey, as least as the situation appears after one season of gypsy moth attack.

Oak stands: 15,25,28; Generation: 2

255. Kegg, J. D.
1973. **Oak mortality caused by repeated gypsy moth defoliations in New Jersey.** J. Econ. Entomol. 66: 639-641.

The stand under investigation is in the Newark watershed where the gypsy moth was first reported in 1968. Composition at this time was 63 percent oak with a 0.6 percent baseline mortality throughout the forest stand. Tree mortality was monitored from 1968 to 1972. The highest mortality rate occurred among the species of the white oak group. Less preferred and nonpreferred species maintained a baseline mortality. After 2 years of 75 to 100 percent oak defoliation, their density declined from 63 percent to 23 percent. Basal area of oak declined from 93.8 to 41.4 feet. Representing tree condition by percentage of dead branches proved effective in forecasting oak mortality for the following year. Weakened trees were attacked by *Agrilus bilineatus* (Weber) and the root rot fungus *Armillaria mellia* (Vahl). "Mortality tended to be greater on southeastern, southern, and southwestern aspects where moisture stress was greatest."

Oak stands: 15,16,20,21,22,24,25,27,28

256. Kelus, O. G.
1941. **Geographical distribution and areas of the gypsy moth outbreaks in the USSR** [in Russian]. Vestn. Zashch. Rast. 1941(1): 45-52.

257. Keremidchiev, M. T.
1972. **Dynamics of outbreaks of the gypsy moth (*Lymantria dispar* L.) in the People's Republic of Bulgaria** [in Russian]. Pages 51-54 *in* Proc. 13th Int. Congr. Entomol., 1968. Vol. 3 Nauk, Leningrad. (English transl. by U. S. Dep. Agric. For. Serv. Telecom GM-75-7033).

From 1891 to 1932 gradations lasted 3 years, with depression periods of 5 to 11 years. The length of the gradations increased to 4 to 5 years, with 2 to 3 year depressions during the period from 1932 to 1946. A 12-year gradation broke out in 1946. Two widespread gradations (1946 to 1957 and 1962 to 1967) broke out after a rise in the sum of mean daytime air temperature by 2.3 percent to 9.0 percent in April, May, and June together with a decrease in precipitation to half of normal. Drought causes a biochemical change in the leaves. Mass reproduction of the gypsy moth occurs in low regions with favorable temperatures where forests originate from shoots. Outbreak is also encouraged by the extensive spread of cattle grazing and the human activity of felling deciduous trees with low age turnover. Food plant preferences are more apparent early in the gradation. Fertility and survival rates are contingent on food quality. Food quantity affects adult size and sex ratio. At the beginning of a gradation, the ratio between male and female is 55:45, at culmination it is 34:66, and at the end of the gradation it is 78:22. Only after the third year of the gradation do the numbers of parasites and predators increase significantly.

Oak stands: 15; All stands: 15,23; Generation: 2,3,4,12

258. Khanislamov, M. G., L. N. Girfanova, Z. S. Yafaeva, and R. K. Stepanova.
1958. **Mass reproduction of the gypsy moth in Bashkiriya: studies on the foci of pests of Bashkirian forests** [in Russian]. UFA 1958: 5-45.

Gypsy moth outbreaks in Bashkiriya are repeated every 8 to 13 years. Progradation is related to meteorological conditions (a combination of low precipitation to temperature ratios in May and June following a very severe winter). The primary foci of the gypsy moths are in the relatively open forest-steppe zone; the average duration of outbreaks there is 6 years. The insects begin to die away under the action of biocoenotic factors.

Most important in limiting the gypsy moth population are the entomophages, which exterminate more than 80 percent of the individuals at the foci. Under laboratory conditions, the gypsy moth feeds best on poplar, aspen, and birch; under natural conditions during latency, the gypsy moth prefers aspen, birch, and oak-birch plantings, therefore these species should be kept under constant observation.
Generation: 2,4,12; Non-oak stands: 15

259. Khanislamov, M. G., I. M. Girfanova, Z. S. Yafaeva, and R. K. Stepanova.
1962. **Conditions under which foci are formed and numerical increases occur in the gypsy moth (*Ocneria dispar*) in Bashkiriya** [in Russian]. UFA 2: 32-66.

During latency the gypsy moth was concentrated primarily in disorganized deciduous stands with low cover. However, the foci were not stable. Eggs were frequently found on birch, which are distinguished by early foliage. The gradation emerges from latency when there is a spring drought followed by a severe winter. Outbreak occurs more rapidly in stands where the population density during progradation is higher and the number of natural enemies fewer. A limited number of pests is affected by diseases and specialized parasites. Large-scale reproduction of the gypsy moth depends upon the physiological condition of growing stock. Leaves from weakened trees are more nourishing for the pests. Individuals from developing foci are more sensitive to the physiological condition of food plants than individuals from populations in latency. A bibliography of 83 references is included in this article.
All stands: 19; Generation: 2,12; Non-oak stands: 15

260. Khanislamov, M. G., and Z. S. Yafaeva.
1964. **Biological regulation of pest populations in various stages of their developmental cycle.** Pages 165-167 *in* Biological control of agricultural and forest pests. Inst. Biol. Bashkiria State Univ., UFA n.d.

The authors observed the gypsy moth in two of its foci in Bashkiriya for 11 years, beginning in 1952 at the gradation climax and ending in 1962, with the insect in total decline in one area and in the beginning of a slow rise in the other. They found that the role of parasites changed with the phase of the gradation and that different parasites were important in each focus: Diptera predominated in the site on the Russian plains and Hymenoptera in the southern Urals. They noted further that the efficacy of the various biotic controls varied with the phase of the gradation.
Generation: 2,4,6

261. Kireyeva, I. M.
1969. **Specific developmental features of gypsy moth (*Porthetria dispar* L.) under different photothermal conditions** [in Russian]. Vestn. Zool. 3(1): 86-88.

The effect of temperature (16, 22, 28, and 32°C) and illumination (24-hour illumination, 17.7-hour illumination, and 24-hour darkness) on pupal development was investigated. At low temperatures, with a prolonged illumination period, the duration of the pupal development is shortened and viability increases. At high temperatures, the shortest development time and greatest viability are observed at 17-hour illumination. The effect of illumination depends on temperature conditions and is most pronounced at a low temperature.
Pupae: 12,13

262. Kireyeva, I. M.
1973. **Some features of *Porthetria dispar* L. population in the Kherson and Transcarpathian regions** [in Ukrainian, English summary]. Dopov. Akad. Nauk. Ukr. RSR, Ser. B. Heol. Heafiz Khim. Biol. 6: 565-568.

"The investigations were performed in the territory of the Transcarpathian and Kherson regions [which] differ in their [topographical] relief and climate. The experiments resulted in a conclusion that the geographic populations of *Porthetria dispar* L. differ in a number of ecological peculiarities (time of caterpillar birth, duration of development, and survival ability) which indicate their adaptation to the local life conditions. Seasonal rhythm of temperature is one of the main factors determining adaptation of the insects' life cycle."
Generation: 12

263. Klepac, D.
1959. **The determination of loss of growth in forests attacked by the gypsy moth (*Lymantria dispar*)** [in Serbo-Croatian, French summary]. Sum. List. 83(8-9): 280-290.

264. Kochetova, N. I.
1968. **Sex ratio in *Anastatus disparis* Rusch. (Hymenoptera, Eupelmidae) under its development on different hosts** [in Russian, English summary]. Zool. Zh. 47(10): 1572-1574.
"The investigations carried out on *Anastatus disparis* Rusch. have shown that, . . . [when infecting] the usual host (*Porthetria dispar*), the developing progeny consists of both males and females . . . [when infecting] unusual hosts, the progeny consist only of males. This can be explained by the fact that the usual host stimulates . . . both fertilization and egg laying, whereas unusual ones stimulate only egg laying."
Eggs: 4

265. Kokhmanyuk, F. S.
1964. **Effect of different conditions on the disposal of the eggs laid (oviposition) by the gypsy moth *(Ocneria dispar)*** [in Russian]. Nauchn. Dokl. Vyssh. Shk. Biol. Nauk. 1: 24-26.
In stands lacking undergrowth and an herbaceous cover, eggs are deposited on dry places, with a preference shown for dead trees. Temperature and humidity during oviposition affect the height at which eggs are deposited. Most clusters are on the southern sides of trunks and structures.
Adults: 1, 12

266. Kokhmanyuk, F. S.
1964. **Oviposition in *Ocneria dispar*** [in Russian, English summary]. Zool. Zh. 43(2): 290-291.
"About 20 percent of *Ocneria dispar* females oviposit at 2 to 3 sites at a height of more than 100 cm above ground level. Solar rays, wind, and humidity cause the fractional oviposition in *O. dispar*. The greatest number of eggs laid by *O. dispar* occurs from 2 to 6 p.m. on the 3rd to 4th day after the onset of oviposition."
Adults: 1, 12

267. Kokhmanyuk, F. S.
1965. **Gypsy moth (*Ocneria dispar*) control in the roadside plantations.** Zashch. Rast. 10(4): 30-31. (Transl. from Russian by C. E. Nikiforoff. NAL Transl. 17032.)
The most common habitats of the gypsy moth were found to be roadside plantations, especially along the Brest-Moscow highway where willows were completely defoliated in 1956, 1958-59, 1961, and 1963. In the center of the infestation there were from 21 to 58 oviposition sites per 10 trees; at 5 to 7 km, 7 to 18 sites per 10 trees; at 10 to 15 km, no oviposition sites. The population level remained steady, but the center of the focus shifted, probably owing to first-instar dispersal by wind (to at least 3 to 4 km) and to some females' flying into automobile headlights.
Adults: 1, 2; Instars I-III: 1, Non-oak stands. 15

268. Kolybin, V. A., and L. M. Zelinskaya.
1969. **Ecologo-physiological peculiarities of *Porthetria dispar* L. population in the lower Dnieper area: Communication I. Structure of population** [in Russian, English summary]. Vestn. Zool. 3(3): 37-42.
"The ecological analysis of *Porthetria dispar* population structure in the lower Dnieper area showed that it consists of four micropopulations connected with certain fodder plants and isolated during separate stages of a life cycle of the insect. Such dismembering of *P. dispar* population into separate micropopulations favors the maintenance of the pest quantity and makes pest control more difficult."
Generation: 2

269. Kolybin, V. A., and L. M. Zelinskaya.
1971. **Ecologo-physiological peculiarities of *Porthetria dispar* L. population in the lower Dnieper area: Communication II. Parasites and diseases** [in Russian, English summary]. Vestn. Zool. 5(1): 26-31.
"Under conditions of the lower Dnieper area, about 20 species of parasitic and carnivorous insects are found to affect *Porthetria* dispar (L.) *Anastatus disparis* Ruschka is of greatest importance in limiting the number of the pest at the egg stage, *Apanteles vitripennis* Hal at . . . [the larval] stage, and Sarcophagidae at . . . [the pupal] stage." In the region under investigation, the mortality of *P. dispar* (L.) has been established to be caused by polyhedrosis and microsporidiosis. "The role of parasites, carnivorous insects, and diseases in limiting the quantity is not the same in different micropopulations and changes according to the pest gradation phases."
Eggs: 4; Generation: 2, 6; Larvae: 4; Pupae: 4

270. Kolybin, V. A., L. M. Zelinskaya, and V. V. Barabanova.
1971. **Ecophysiological characters of the population and the mass appearance of *Porthetria dispar* L. in the lower Dnieper region** [in French]. Pages 400–401 *in*. Proc. 13th Int. Congr. Entomol., 1968. Nauk Leningrad.

271. Komárek, J.
1950. **The different effects of entomoparasites and diseases on invasions of insects** [in Czechoslovakian, Russian and English summaries]. Sb. Cesk. Akad. Zemed. Ved. 23(3/4): 232–237.

"The paper discusses the results of an extensive attempt to stop the spread of some harmful phytophagous insects introduced from Europe into North America by means of the importation of entomophagous parasites and foes [predators?] from their original European home. The basis of the attempt was the idea that by the transfer of the parasites and by artificial breeding such a decrease in the hosts would be achieved that their spread in America would stop." Cases are cited of phytophagous Lepidoptera and Hymenoptera from Czechoslovakia whose outbreaks fluctuate. "The species *Lymantria dispar, Pyrausta nubilalis, Gilpinia hercyniae (Diprion polytomum), Semasia rufimitrana,* and other Tortricidae living on firs are cited. In Czechoslovakia the ecology of these species was studied with regard to the origin of the eruptions and to the significance of entomoparasites and diseases that limit a fluctuating overmultiplication. The different effect of parasites and infectious diseases was recognized. Empirical experience conformed that in the listed species of Lepidoptera and Hymenoptera the parasites are never able to control their host so as to prevent it from multiplying from time to time in mass in its original home. By themselves, the parasites cannot stop an eruption once started. The mass multiplication is terminated in most harmful insects always by the epidemic spread of a virus infection, except in the species *Pyrausta nubilalis,* where no infectious epidemic could be ascertained . . . The experience obtained in North America in the period in which the importation of parasites and their multiplication was carried out intensively agrees in general with the observations made in Czechoslovakia on the different effect of parasites, wild animals, and diseases on the invasions of harmful phytophagous Lepidoptera and Hymenoptera. A graph . . . shows the curves for the host, the parasites, and the virus disease in the case where the host begins to multiply massively and eruptively."
Generation: 2, 4, 7, 12

272. Komárek, J., and V. Skuhravý.
1952. **The influence of temperature on periodical outbreaks of the gypsy moth (*Lymantria dispar* L.)** [in German, Russian and Czechoslovakian summaries]. Cas. Cesk. Spolecnosti Entomol. 49(1–2): 15–30.

273. Kondakov, Y.P.
1961. **Distribution of egg clusters of the gypsy moth in forests of the southern part of the Krasnoyer region** [in Russian]. Uch. Zap. Krasnodar. Gos. Pedagog. Inst. Im. Trinadtsati-Letiya VLKSM. 20(2): 17–32.

Data from 1954 to 1956 indicate that the base of the bole of thick-trunked pines is the primary site for gypsy moth egg clusters in lowland pine forests. Rarely, the clusters are found higher than the level of snow cover or on birch. Thus clusters of eggs withstood temperatures down to -53°C. Seven species of birds destroyed up to 35 percent of the overwintering eggs. Caterpillars that hatched on the pines were carried by wind to favored foods, birches in gardens, and green plantations. In the mountains eggs are laid in cracks and clefts of unprotected rocks. The larvae are windblown into mountain valley forests where they feed primarily on birch and larch.
Adults: 1; Eggs: 9, 12; Instars I–III; 1

274. Kono, H.
1938. **On the influence of sunspot periods on the periodic outbreaks of *Porthetria dispar* (L.) in Japan** [in Japanese]. Bot. Zool. Tokyo 6(8): 1361–1376.

275. Kono. H.
1939. **On the influence of sunspot periods on the periodic outbreaks of *Porthetria dispar* (L.) in Japan,** II [in Japanese]. Bot. Zool. Tokyo 7(8): 1356–1358.

276. Kono, H., and Y. Sugihara.
1940. **Observations on the oviposition of *Porthetria dispar* L.** [in Japanese]. Oyo Dobutsugaku Zasshi 12(2): 69–74.

277. Kononova, N.E.
1964. **Survival of leaf-devouring insects in relation to the condition of the plant** [in Russian, English summary]. Zool. Zh. 43(1): 37–42.

"Physiological conditions of plants cause a strong effect upon the survival of larvae (especially those of early instars), upon the time of their development, and upon the fecundity of the imago. An improvement [in] the development of the plant due to application of fertilizers and [to] watering increases its resistance to leaf-devouring insects, decreasing larval survival. Deterioration of the plant condition increases survival of the larvae, providing for their fast development, and increases the number of the eggs deposited, which [creates] a sharp increase in population. The age of the leaves and related anatomo-morphological peculiarities also play a protective role against damage caused by young larvae which are unable to gnaw the upper layer of "old" leaves and perish from starvation. In the case of an artificial injury [to the] epidermis of such leaves, larvae survive better, while often perishing on well-developed plants with marked symptoms of intoxication. This [points out] the presence in oak leaves of protective subtances of a toxic nature against the larvae of specialized pests."

All stands: 23

278. Kovačević, Ž.
1926. **Malacosoma neustria** L. **and *Porthetria dispar* (L.) and their parasites** [in German]. Anz. Schaedlingskd. 2(8): 93–94.

279. Kovačević, Ž.
1954. **The importance of the polyhedry for the mass appearance of some insects** [in Serbo-Croatian, English summary]. Zast. Bilja 23: 3–20.

The expression of latent virus is not only dependent on quantity and quality of food but also on the genetic susceptibility of the insect. This may be on an individual, population, or race level. Other factors affecting the expression of virus are macroclimate and microclimate.

Generation: 7

280. Kovačević, Ž.
1956. **Food-plant selection and the occurrence of plant pests (a contribution to the knowledge of population dynamics)** [in German]. Anz. Schaedlingskd. 29(7): 97–101.

The influence of food choice on the life processes and population dynamics of four polyphagous agricultural and forest pests was investigated in the laboratory. Gypsy moth eggs were collected during retrogradation. Larvae were fed on one of the following, any of which might be chosen by them in the field: oak, beech, hornbeam, apple, or plum. Only those larvae fed on oak survived from year to year. The food source also affected the development period and the number of instars. It is concluded that the duration of a gradation is not dependent on starvation, but on the physiological effect of the main nourishing plant. For insects fed on oak the cause of mortality varied during the gradation: in progradation, physiological debility was the major cause (parasites and predators were not factors in these controlled experiments), while polyhedral virus became important during retrogradation. However, with unfavorable nutrition, physiological debility was the major cause even during retrogradation. In different regions of the country, different species of oak functioned as the main sustaining food, suggesting genetic differences in the groups of gypsy moths.

All stands: 23; Larvae: 2, 7, 13; Generation: 2, 12; Oak stands: 23.

281. Kovačević, Ž.
1958. **Pathogenic microorganisms as companions to and as mortality factors of the gypsy moth, *Lymantria dispar* L., and the American fall webworm, *Hyphantria cunea* Drury** [in German]. Anz. Schaedlingskd. 31: 148–150.

282. Kozhanchikov, I. V.
1940. **The importance of the physical conditions of environment upon the development of the eggs of the gipsy moth (*Lymantria dispar* L.)** [in Russian]. Vestn. Zashch. Rast. 1940(3): 3–16.

283. Kozhanchikov, I.
1949. **The importance of seasonal changes of food plant leaves in the development of gypsy moth (*Ocneria dispar* L.).** [Transl. from Rus-

sian.] Dokl. Akad. Nauk. SSSR Biol. Sci. Sect. 66(6): 1203–1206.

One possible explanation for the univoltine life cycle of the gypsy moth is the phenology of vegetation. Groups of larvae were fed on spring, summer, or fall vegetation of oak, willow, or mountain ash. In all cases the survival rate of those larvae fed spring foliage was much higher. Total mortality resulted in those fed with summer foliage from mountain ash. Of the larvae that survived on willow foliage, the individuals reared on spring foliage weighed the most. The duration of development remained constant. Larvae fed on fall oak foliage added an instar and took longer to develop.

Generaton: 12; Larvae: 13

284. Kozhanchikov, I. V.
1952. **The question of vital thermal optimum: IX. Temperature scale as a factor in the development of the gypsy moth and the oak saturnid** [in Russian]. Entomol. Obozr. 32: 27–42.

285. Kudler, J.
1969. **Problems and feasibility of the use of bacteria for control of defoliating forest insect pests** [in German, Russian and English summaries]. Rep. Conv. Ger. Entomol. 10,1965, Dresden 80: 451–455. Dtsch. Akad. Landwirtsch. Wiss. Ber.

"The present contribution discusses findings and experiences of investigations into the use of entomogenous bacteria for control of some clean eating pests from the order Lepidoptera in Czechoslovakia. The most suitable control factor seems to be *Bacillus thuringiensis*. Application and resulting theoretical aspects of its use are included."

Larvae: 5

286. Kulman, H. M.
1971. **Effects of insect defoliation on growth and mortality of trees.** Ann. Rev. Entomol. 16: 289–324.

"Defoliation and growth measurements relate to a complex of factors. Flower production and the size, abundance, food storage capacity, hormone production, photosynthetic efficiency, and respiration of foliage vary with tree age, species, season of the year, and the age, exposure, and crown location of the foliage. These must be considered when making quantitative statements of foliage loss because they affect foliage growth and production, tree survival, and the quantity and/or location of reduction in shoot and diameter growth. Variations in ring growth at different vertical levels in the trunk and the separate response of spring and summerwood growth are especially important. . . The importance of foliage for growth and survival decreases directly with its age and inversely with its exposure. Evergreen conifers usually survive a single complete defoliation in spring before the elongation of the new foliage. Later defoliation that includes the new foliage often causes mortality. Pines and deciduous trees usually show an immediate response to defoliation if it occurs before shoot or ring growth is completed. Growth responses in spruce and firs are often delayed for one to several years. The first growth responses in the trunk are usually found within the living crown, but considerable variation is reported. Most deciduous trees survive several defoliations and produce new sets of leaves in the same season. Secondary agents, such as site, tree age, and climatic conditions influence the survival of defoliated trees."

All stands: 15,24,25,26; Review; bibliography

287. Kumar, L. P.
1974. **Occurrence of *Lymantria obfuscata* Walker, the Indian gypsy moth, as a pest of cacao in south India.** Curr. Sci. (Bangalore) 43(9): 395.

The Indian gypsy moth is a pest of forest and fruit trees in certain regions of north India and is now for the first time found in south India feeding on tender leaves of cacao. The Indian gypsy moth is closely related to *Lymantria dispar*.

Non-oak stands: 15

288. Kurir, A.
1943. **The influence of abiotic environmental factors on eggs of the gypsy moth (*Lymantria dispar* L.) during winter diapause. I. The effect of ice** [in German]. Z. Gesamt Forstwes. 75/69(4–6): 105–132.

289. Kurir, A.
1944. ***Anastatus disparis* Ruschka egg parasite of *Lymantria dispar* L.** [in German]. Z. Angew. Entomol. 30(4): 551–586.

A. disparis has one generation per year in Central Europe, as does its host, since it usually attacks fresh eggs of the gypsy moth. One parasite develops per host. The adult lives about 15 days.

Within the host egg, *A. disparis* can tolerate temperatures down to −26°C. Two new secondary parasites, *Torymus anastativorous* n.sp. Fahringer and *Tyndarichus kuriri* n.sp. Fahr., are reported.

Eggs: 4

290. Kurir, A.
1953. **The food plants of the gypsy moth (a contribution to the knowledge of its feeding habits)** [in German]. Z. Angew. Entomol. 34(4): 543–586.

291. Kuwayama, S.
1929. **Activity of *Lymantria (Porthetria) dispar* Linn. in Hokkaido** [in Japanese]. Oyo Dobutsugaku Zasshi 1(2): 106–109.

292. Lamamié de Clairac, A. P., and C. M. García.
1972. **Biology of the gypsy moth (*Lymantria dispar* L.) in the province of Salamanca in 1972** [in Spanish]. Bol. Inf. Plagas 99: 3–14. Servicio de Defensa contra Plagas e Inspeccion Fitopatologica, Salamanca, Spain.

293. Langhoffer, A.
1926. **The gypsy moth and the destruction of our oak forests** [in Serbo-Croatian, German summary and Table of Contents]. Zagreb. Sveuc. Zavod sum. pokuse. An. Exp. For. 1: 150–233.

294. Langhoffer, A.
1929. **The large numbers of oak destroyed in Yugoslavia considered from the entomological standpoint** [in German]. Congr. Int. Zool., 1927. 10(2):1196–1203. (English transl. by U.S. Dep. Agric. For. Serv. Telecom GM-75-7093)

The cause of widespread oak wilt in Yugoslavia is moth defoliation of the first foliage, followed by oak mildew (*Microsphaera alpitoides* Griff. and Maubl.) attack on the newly refoliated sprouts, and perhaps followed by beetles destroying the cambium of the weakened trees. Prior to 1909, when oak mildew was introduced to Yugoslavia, gypsy moth defoliation generally caused a decrease in acorn production and in annual growth, but did not cause mortality.

Oak stands: 15, 16, 23, 25

295. Leius, K.
1961. **Influence of food on fecundity and longevity of adults of *Itoplectis conquisitor* (Say) (Hymenoptera: Ichneumonidae).** Can. Entomol. 93: 771–780.

"The females of many species of chalcids, braconids, pteromalids, and ichneumonids feed on the body fluids or hemolymph of their host. The fact that the adult males do not partake of this food indicates that such feeding may be associated with egg production. Carbohydrate foods, in addition to the body fluids of the host, are essential to egg production in certain species. Feeding on the host by females of certain hymenopterous parasites increases their value as control agents. This feeding sometimes may be more important than parasitism as a cause of host mortality. *Itoplectis conquisitor* (Say), a host-feeding parasite, is considered in this paper." Females were observed feeding on host body fluids exuded when the ovipositor pumped up and down. Adults were also observed feeding on flowering plants, particularly umbelliferous ones, and on aphid honey dew. Parasite adults do not feed on the first day of emergence. For the next week, they feed only on carbohydrate and vegetable protein; then the female punctures the host pupae and feeds on body fluid. There is no evidence that it feeds on other host tissue. On the first day of feeding on body fluids, no eggs are laid, but an average of 12 pupae are punctured. On the second day, twice as many are punctured and six eggs are laid. At the peak, five or six punctures are made for each egg deposited. This series of experiments was conducted at 72°F. Females fed on body fluids, carbohydrates, and pollen lay more eggs and live longer. Males fed on host pupae do not live longer, and longevity of males decreased when they were fed on honeydew.

Pupae: 4

296. Leonard, D. E.
1966. **Differences in development of strains of the gypsy moth, *Porthetria dispar* (L.).** Conn. Agric. Exp. Stn. Bull. 680. 31p.

"The purpose of this investigation was to establish a reference point or base for subsequent study of biological differences in the gypsy moth and their possible effects on population dynamics. Even in this preliminary study, substantial differences within and between strains are evident. A small percentage of gypsy moth larvae of both sexes from Connecticut and Quebec, Canada, underwent an additional larval instar. Extra-instar larvae were found in 11 of 12 strains, with a higher incidence of extra-instar males than females. According to Goldschmidt, the variation in number of molts is controlled by three alleles of the I gene. The occurrence of seven larval instars in some females suggests that other alleles might be present. Comparison of normal larvae showed that male and female development times were about equal in instars I and II, but males took longer than females to complete instars III, IV, V, and the pupal stage. Extra-instar larvae took longer to complete the first two instars than normal larvae, but all other immature stages proceeded at a rate faster than normal larvae. The total development time from egg hatch to adult for five males was 58.77 days at 23°C and 44.61 days at 27°C, whereas six females took 61.65 days at 23°C, and 48.73 days at 27°C. This shows a marked tendency toward protandry. However, six males developed in 62.59 days at 23°C, and 48.75 days at 27°C, closely approximating the times of six females. Seven females took the longest time to develop; 68.29 days at 23°C, and 50 days at 27°C. Larvae that underwent an aditional molt tended to lag in their development during the first two instars, and this lag may have been due to the wandering habits of these larvae. During what would normally be the last instar (V in males and VI in females), those larvae that underwent an additional molt had a differing behavioral pattern. Normally, in the last instar, larvae do not construct any silken webbing until the prepupal stage. Those that molt again construct a silken mat early in the stadia and cease feeding on the 5th or 6th day. The molt occurs about a week after the instar begins, contrasting to a stadium of about 2 weeks if prepupae are to be formed. Also, the tubercules on the dorsum of six males and seven females are a more brilliant red color. Pupal mortality was highest in larvae that underwent an additional molt. An increase in temperature, from 23°C to 27°C, reduced development time by nearly 25 percent. Lack of illumination had little, if any, influence on development time. The widest range in variation of development time occurred at 23°C. The decrease in development times at 27°C was not due to a differential rate in any one stage, for the percent of time spent in each stage did not differ from specimens reared at 23°C. The fastest developing strains were those collected in Canada. This suggests adaptation of these strains has occurred in a relatively small number of generations. Using frass as an indicator of feeding, most feeding occurs during the last larval instars. The frass produced during instars I and II is about 1/40th of the total for males and about 1/160th of the total for females. In instar III, five males produced slightly more frass than six females, but six males produced noticeably less frass than five males. In instar IV, extra-instar larvae produced the least frass, with five males producing the greatest amount. In instar V, five males accounted for the most frass, but six females also fed heavily during this instar. Extra-instar males and females produced about the same amount of frass. During instar VI, six females produced about 4 times the amount of frass of last-instar males. The last-instar frass production of six males was equivalent to the frass produced by the last-instar five males, but seven females produced less frass than six females during their respective last larval instars. The ratio of dry weight of frass to pupal weight was quite uniform between strains, but slightly lower for males than females. There was a tendency for the pupal weights of the earliest emerging adults to be heavier than those of later emerging adults."

Larvae: 2,13: Pupae: 13

297 Leonard, D. E.

1967 **Parasitism of gypsy moth in Connecticut by *Brachymeria intermedia*.** J. Econ. Entomol. 60: 600-601.

Leonard had previously determined that this parasite was established in North America. This study was made to determine its efficiency as a parasite. The total percentage of gypsy moths it parasitized was 1.7 percent, with a high of 4.7 percent in East Lyme. Equal numbers were recovered from male and female pupae. Dipteran parasites emerged from 25 percent of the total number of pupae; another 25 percent did not emerge owing to polyhedral virus disease. These are laboratory figures; in the field the survival rate is lower as a result of predation. The percent of *B. intermedia* parasitism in collections made in Portugal and Spain in 1925 ranged from 2.8 to 4.1 percent.

Pupae: 4,7,12

298. Leonard, D. E.
1967. **Silking behavior of the gypsy moth, *Porthetria dispar.*** Can. Entomol. 99: 1145–1149.
1145–1149.

"Newly hatched larvae remain near the egg and consume a part of the chorion." There is little movement for 12 hours after hatch. After feeding, gypsy moth larvae construct silk resting mat on which they remain. The mat provides a point of attachment for exuvia and therefore facilitates molting. Prior to molting this mat is reinforced or a new, dense, molting mat is constructed. "Late in the last larval instar a sparse cocoon is constructed. When larvae are starved, a shift in behavior is noted, with increased locomotion, irritability, and the trailing of a strand of silk as larvae wander. First-instar larvae, quiescent and anchored on resting mats, are not readily induced to spin down on silk threads, hence are not readily dispersed by wind. Hungry first-instar larvae, more apt to be spinning down, are presumed to be more readily dispersed by wind. Larvae that undergo an additional instar have a longer prefeeding phase and might be more readily dispersed than normal larvae." Hunger causes a change in behavior, which may explain the change in periodicity of older larvae at high densities. Hunger induces wandering, which may disrupt the feeding of other larvae. Thus the diel periodicity of an entire infestation could be rapidly disrupted even though foliage is not entirely consumed. This behavioral change insures dispersal of larger larvae away from an infestation where food would be depleted before development was completed.

Larvae: 1,2; Prepupae: 1

299. Leonard, D. E.
1968. **Additional larval instars: inducement and effect on gypsy moth population biology.** Paper presented at Entomol. Soc. Am., Dallas, 1968.

When larvae are starved, crowded, or reared in a cool environment during instar I, the percentage of larvae with extra instars increases. Substantial differences are found in the propensity for extra instars among individual egg masses. Extra instars correlate with the size of the eggs. As the size of the eggs diminishes, the percentage of extra instars increases. Larvae with extra instars exhibit prolonged first instar, shorter pupal stage, longer development time to adulthood, and higher pupal weight. The prolonged first instar is due to a longer prefeeding phase, which increases the possibility for wind dispersion. Higher pupal weight positively correlates with increased fecundity, thereby increasing the probability of establishment in uninfested areas. This mechanism is believed to be environmental as well as genetic. This is supported by the fact that extra instars apparently occur in the same generation that is initially stressed.

Generation: 2,12,13

300. Leonard, D. E.
1968. **Diapause in the gypsy moth.** J. Econ. Entomol. 61: 596-598.

"Rearing *Porthetria dispar* (L.), through one generation at light regimes of 11, 13, 15, 17, and 19 hours per 24-hour day at temperatures of 19.5°C and 28°C had no influence on the induction or termination of dispause. Rearing temperature of 28°C caused egg mortality. A few eggs obtained in rearings at 19.5°C hatched without chilling. However, this hatch occurred 14 to 18 weeks after oviposition. This hatch of unchilled eggs appears to be analogous to the frequent observations in nature of egg hatch in the fall. Treatment of eggs up to 24 hours old with hydrochloric acid did not affect induction of diapause." Results suggest an obligatory diapause.

Generation: 1,12

301. Leonard, D. E.
1968. **Effects of density of larvae on the biology of the gypsy moth, *Porthetria dispar.*** Entomol. Exp. Appl. 11: 291-304.

"The crowding of larvae of *Porthetria dispar* in laboratory cultures induced physiological and morphological differences. Larvae that were crowded developed faster than isolated larvae, but the development of instars varied in a characteristic manner. In crowded larvae (1) instar I was longer, (2) instars II to IV were shorter; (3) in males the penultimate and last instar were shorter; (4) in females the penultimate and last instar were longer; and (5) in both sexes the pupal period was shorter. The pupal weights from crowded larvae were less, indicating a loss of fecundity. Crowding larvae increased the percentage of larvae that had increased survival. The coloration of adult males reared in crowded cultures was lighter than the coloration of adults reared in isolated cultures.

"There was a weight difference of 35 percent for female pupae and 20 percent for male pupae be-

tween those in dense and in sparse populations. Crowding also caused an increase in the number of extra-instar larvae. In dense populations, adults formed earlier than in sparse populations in nature. This is tentatively explained as follows: Since crowded larvae show a greater number of extra-instar larvae, and since these larvae have a longer prefeeding stage during which increasing hunger can cause an increase in silking, they are more likely to be dispersed by wind. Thus, sparse populations spread by wind have more extra-instar larvae and show later adult emergence.
Larvae: 1,2

302. Leonard, D. E.
1968. **Sexual differential in time of hatch of eggs of the gypsy moth.** J. Econ. Entomol. 61: 698–700.
Female larvae hatch before male larvae. Because the development time of the males is shorter than that of the females, the males are the first to pupate. The male adults emerge 3 or 4 days prior to the females. This might be a mechanism to insure that mature males are available for eclosion when the females emerge, even in sparse populations.
Generation: 1,13

303. Leonard, D. E.
1969. **Intrinsic factors causing qualitative changes in population of the gypsy moth.** Proc. Entomol. Soc. Ont. 100: 195–199.
"A change in the quality of individuals of the gypsy moth can be induced by several intrinsic and extrinsic factors. This change is expressed by a prolongation of instar I, an increase in larval activity during instar I, and an increase in the number of larval instars. The lag in development at instar I is associated with a longer prefeeding phase during which larvae are more active. These active larvae are more readily dispersed by wind. The behavioral shift can be induced during instar I by crowding, starvation, or cool temperature, or in the maternal generation by factors affecting the size of eggs. The most important effect of the qualitative change on the population biology is that it provides a mechanism for numerical self-regulation that responds rapidly to changes in population density, and is more efficient than if it were dependent solely on selection for expression. A new approach to control by prevention of the qualitative change is suggested, whereby populations would be maintained at sparse levels where suitable host plants prevail to suppress outbreaks and subsequent widespread dispersals of larvae."
Generation: 2,12,13

304. Leonard, D. E.
1970. **Effects of starvation on behavior, number of larval instars, and developmental rate of *Porthetria dispar.*** J. Insect Physiol. 16: 25–31.
"The behavior, number of larval stadia, and developmental rate of the gypsy moth, *Porthetria dispar,* can be altered by deprivation of food. The behavioral change is an increase in locomotory activity associated with hunger. The number of larval instars can be increased by food deprivation during instar I, but in instars II, III, or IV no significant increase was obtained. Food deprivation early in instars II, III, or IV reduced the numbers of subsequent ecdyses. When food was withheld early in an instar, the rate of development was accelerated during the remainder of the instar. The removal of food just before the cessation of feeding prior to apolysis also accelerated development." Starvation enhances dispersal, which is advantageous for survival of larvae in dense populations.
Instars I–III: 1,12; Instars IV–VI: 1,12; Larvae: 13

305. Leonard, D. E.
1970. **Feeding rhythm in larvae of the gypsy moth.** J. Econ. Entomol. 63: 1454–1457.
"The feeding rhythm of larvae of *Porthetria dispar* (L.) was determined from field observations. In stages I through III larvae began feeding at dawn, but not when temperatures were below 45°F. The peak of feeding occurred in the morning, with some feeding observed throughout the day. When not feeding, or at night, larvae remained quiescent on the undersides of leaves. At stage IV there was a sharp shift in the feeding rhythm, with feeding initiated in the evening and reaching a peak at sunset. About midnght, feeding activity began to decline, with small increases in feeding noted before sunrise, and between 7 and 8 a.m. The numbers of larvae feeding during the day were small." Stage I larvae fed on the upper surface of leaves, making small holes. Stage II larvae fed mostly in holes rather than on margins. Many stage III larvae continued to feed at these sites, enlarging the holes considerably. Some fed from the undersides of the leaves and some at leaf

margins. Stage IV to VI larvae fed almost exclusively on the margins of the leaves.
Instars I–III: 1,12; Instars IV–VI: 1,12

306. Leonard, D. E.
1970. **Intrinsic factors causing qualitative changes in populations of *Porthetria dispar* (Lepidoptera: Lymantriidae).** Can. Entomol. 102: 239–249.

"Evidence is presented to suggest that the gypsy moth, *Porthetria dispar* (L.), is numerically self-regulating through a shift in the quality of individuals induced by changes in nutrition. This qualitative change affects dispersal, behavior, developmental rate, and fecundity, and this provides *P. dispar* with the ability to respond to intrinsic and extrinsic factors faster and more efficiently than if dependent on selection. Adaptability is further facilitated because the change in quality can be induced either in the previous generation by the amount of nutrient reserves provided the eggs or during the current generation by hunger, crowding, or cool temperature. This change is best characterized by an increase in the number of larvae with additional instars. In these larvae, a prolongation of instar I and a shift in behavior increase their potential for dispersal. The similarities and differences between *P. dispar* and *Malacosoma pluviale* (Dyar) are discussed."
Eggs 13: Instars I–III: 1: Larvae 12,13

307. Leonard, D. E.
1971. **Air-borne dispersal of larvae of the gypsy moth and its influence on concepts of control.** J. Econ. Entomol. 64: 638–641.

"*Porthetria dispar* (L.) disperses as an air-borne stadium I larva. A field study of dispersal from a dense population indicates that dispersal occurs throughout most of the duration of stadium I. Records taken at regular intervals during the day show that most dispersal occurs in late morning and closely coincides with activity of larvae. During the night, at low temperatures, or in periods of rain, larvae are inactive and few are dislodged even by strong winds. The long duration of hatch makes it difficult to prevent dispersal and get sufficient kill by a single application of a short-residual insecticide. Population management to maintain gypsy moth populations at densities too sparse to induce dispersal is suggested as an alternative method of control." Observations of larvae in ". . . dense populations in nature indicate that many larvae will not settle and feed even when there is an abundance of available food. The duration of this active stage apparently is lengthy and must influence the duration of dispersal. These larvae respond to air movement by arching their bodies, releasing their attachment to the substrate."
Instars I–III: 1,12; Larvae: 1,12

308. Leonard, D. E.
1971. ***Brachymeria intermedia* (Hymenoptera: Chalcididae) parasitizing gypsy moth in Maine.** Can. Entomol. 103: 654–656.

"*Brachymeria intermedia* (Nees), an introduced parasite of the gypsy moth, was recovered from gypsy moth pupae collected in Fryeburg, Maine (latitude 44°). The recovery of this parasite in Maine shortly after it was reported established on gypsy moth in Connecticut suggests that *B. intermedia* is rapidly expanding its range. The wide range of hosts attacked by the parasite, and its occurence in northern New England, make it a promising potential biotic agent on a variety of northern pest species of lepidopterans, either through natural spread or by artificial introduction." *B. intermedia* oviposits in open (defoliated) rather than in shaded areas. It emerges the second week in July.
Pupae: 4,7; Oak stands: 15

309. Leonard, D. E.
1971. **Effects of larval density on the population biology of the gypsy moth, *Porthetria dispar*.** Pages 519–520 *in* Proc. 13th Int. Congr. Entomol., 1968. Nauk, Leningrad.

Larvae reared individually are found to produce heavier pupae than those reared in groups. Female pupal weight is correlated with fecundity. Maturation speeds up with grouped larvae, and an increased number of individuals with an additional instar develop under these conditions. This is thought to be nutritionally induced, either maternally or through starvation, in early larval life. Larvae produced in nutritionally stressed areas remain active and suspend on silk threads, which facilitates wind dispersal. Those larvae that survive and develop an additional instar produce females of high fecundity.
Fecundity: 12; Larvae: 1,12,13

310. Leonard, D. E.
1971. **Population quality.** Pages 7-20 *in* Toward integrated control. U.S. Dep. Agric. For. Serv. Res. Pap. NE-194.

"The quality of insects comprising populations may be an important factor in the biology of that population. In the gypsy moth, qualitative changes occur primarily as a response to increasing density. They appear to be characterized by a nutritive change affecting the physiology of the insect, particularly the hormonal system." This usually induces extra-instar development. "A major response to the qualitative change is an increase in dispersal. Such a density-regulated mechanism to induce dispersal can operate more rapidly and efficently than one with direct genetic links which depends on selection for its expression."

Eggs: 13; Generation: 12; Larvae: 1,2,13

311. Leonard, D. E.
1972. **Survival in a gypsy moth population exposed to low winter temperatures.** Environ. Entomol. 1: 549-554.

"A population of *Porthetria dispar* (L.) exposed to low winter temperatures in Maine was examined to determine the amount of egg mortality and to determine the fate of the surviving population through one generation. Eggs protected by snow survived temperatures that reached −32.2°C (−26°F). The height above ground where egg masses were deposited was critical. A high percentage of egg masses (81 percent) was deposited below a height of 5 feet, but most hatch occurred in egg masses found below 1 foot. Egg mortality due to low temperature was 85 percent. An epizootic of nuclear-polyhedrosis virus further reduced the size of the subsequent population." The stand investigated was 83 percent *Populus tremuloides*. Cold treatment just prior to hatch increased larval mortality due to virus.

Eggs: 12; Larvae: 5,7; Non-oak stands: 15

312. Leonard, D. E.
1974. **Recent developments in ecology and control of the gypsy moth.** Annu. Rev. Entomol. 19: 197-229.

This article reviews pertinent literature since 1960.

Review; Bibliography

313. Lépiney, J. de
1928. **Insects harmful to cork oak within the forests of Morocco (second study)** [in French]. Ann. Epiphyt. 14(4): 313-321.

314. Lépiney, J. de.
1928. **Preliminary note on the role of ocellar vision on the behavior of larvae of *Lymantria dispar*** L. [in French]. Bull. Soc. Zool. Fr. 53: 479-490.

315. Lépiney, J. de.
1930. **A study of the biological complex of *Lymantria dispar*** [in French]. Mem. Soc. Sci. Nat. Maroc 23 (partial English transl. by H. J. MacAloney).

In the forests of Mamora and Zaers, where it is epidemic, gypsy moth hatch begins between mid-February and mid-April and lasts for 1 to 1½ months. Adult emergence is sometime between the end of April and the beginning of July. Larvae are attracted to silhouettes of erect, elongated forms, an example of visual perception with stemmata. Very young larvae are positively phototrophic, an orientation that disappears almost completely after the first feeding and becomes negative in older larvae. Young larvae cling constantly to the substrate, alternately resting and feeding. Older larvae are not bound by a dominant impulse to remain on the substrate; they react to variations in light and go into a diurnal resting stage in which they become torpid. The gypsy moth has long been present in the cork oak forests of Morocco. Five consecutive years of defoliation does not kill the cork oak, but defoliation does diminish or suppress the acorn crop, reduce the annual accretion of wood and cork, and make the cork difficult to remove by decreasing vasculary circulation. *Tenebroides maroccanus* and *Trogoderma versicolor*, predators of the gypsy moth in Morocco, have not been included in the biological complex of the gypsy moth elsewhere in the world.

Generation: 3; Instars I-III: 13; Instars IV-VI: 13

316. Lépiney, J. de.
1933. **The role of management of water and forests of Morocco and of the Institute of Scientific Research in the biological struggle against *Lymantria dispar* with the aid of *Schedius kuwanae*** [in French;]. 5th Congr. Int. Entomol., Paris, 1932. 5(2): 807-812.

317. Likventov, A. V.
1955. **Fertility, weight of eggs and survival of progeny of the gypsy moth** [in Russian]. Zool. Zh. 34: 1061–1065. (English transl. by computer and E. Alan Cameron).

Data on egg weight can be a very useful index for predicting vigor and density of future generations of the gypsy moth. As pupal size and weight increase, fecundity increases, and as fecundity increases, egg weight decreases. When eggs weigh 0.60 to 0.65 mg predominantly, the progeny are weak and reduced in number. When eggs weigh 0.80 to 0.90 mg predominantly, a population increase can be expected.

Eggs: 2,13; Fecundity: 2,13; Pupae: 2,13

318. Likventov, A. V.
1960. **The restraining effect of oak-linden stands on reproduction of the gypsy moth** [in Russian]. Tr. Vses. Inst. Zashch. Rast. 15: 33–40.

319. Linde, R. J. van der.
1967. **Studies on the populaton dynamics of *Euproctis chrysorrhea, Lymantria dispar* and *Malacosoma neustria* in relation to the ecology of the habitat** [in German]. 14th IUFRO-Kongress, 1967. München V., Sec. 24: 635–649.

320. Linde, R. J. van der.
1971. **The sailing flight of the young caterpillars of the gypsy moth (*Lymantria dispar* L.) and the influence of food plants on this phenomenon** [in German, English summary]. Z. Angew. Entomol. 67(3): 316–324.

Gypsy moth eggs were placed on small oak trees, and the trees were enclosed with wire mesh to study wind migration of the larvae. Mass movement occurred when the tree had not leafed out or when the tree was a nonpreferred species. The author estimated that the minimum wind velocity necessary for migration was around 1 m/sec.

Instars I–III: 1,12

321. Lipa, J. J.
1969. **Studies on *Arma custos* (Fabr.) (*Hemiptera: Pentatomidae*)** [in Polish, Russian and English summaries]. Pr. Nauk. Inst. Ochr. Rosl. 11(1): 197–214.

Arma custos plays an important role in the control of the gypsy moth by preying on the larvae. "Adults overwinter in the litter and begin their activ[ity] at the end of April or in May. First clusters of eggs were observed in May, and maximum of oviposition took place in June and July. Total fecundity ranged up to 94 eggs. Development of eggs lasted an average of 10 days. Total development from egg to adult stage lasted from 35 to 75 days depending on temperature, food, etc. Adults and larvae of *A. custos* were effective predators. They killed and destroyed larvae, pupae, and eggs of several insects. A list of preyed insects as well as a list of plants on which *A. custos* was collected are included."

Larvae: 3

322. Littlefield, E. W., and S. H. Spurr.
1947. **Forest site conditions and the gypsy moth. Part III. The role of silviculture in maintaining conditions unfavorable to the gypsy moth. Harv. For. Bull. 22: 40–47.**

Massive outbreaks can be prevented by manipulating stand composition. Favored food species, such as oaks, gray birch, and poplar, should be thinned or removed. Replacement should be with conifers or defoliation-resistant hardwoods. In addition, the understory should be maintained to increase cover for predators.

All stands: 15,18,19,20

323. Liu, C. L.
1941. **Beginnings of a north China pest survey.** Peking Nat. Hist. Bull. 15(3): 225–234.

"*Lymantria dispar* var., a close relative of the notorious gypsy moth, was first discovered in an apricot orchard in the western hills and apparently limits its depredations to that host." There was heavy injury to apricot in Peking and Hopei regions. The pest survey was not intensive outside of the Peking area.

Non-oak stands: 15

324. Longworth, J. F., and J. C. Cunningham.
1968. **The activation of occult nuclear-polyhedrosis viruses by foreign nuclear polyhedra.** J. Invertebr. Pathol. 10: 361–367.

"A high mortality from nuclear polyhedrosis was recorded when larvae of *Aglais urticae* and *Porthetria dispar* were each fed the nuclear-polyhedrosis virus of the other species. The two viruses are morphologically and serologically distinct . . ." In *P. dispar*, larvae died 9 days after being fed homologous virus, and 87 percent were dead 18 days after infection. Controls (untreated larvae)

showed only 10 percent death by nuclear polyhedrosis.
Larvae: 7

325. Lozinskiy, V. A.
1930. **A note on the beetles of the genus *Calosoma* Web.** [in Ukrainian]. Kiev Ukr. Nauchno-Issled. Inst. Sakharnoi Prom. 1: 147–155.

326. Lozinskiy, V. A.
1957. **The small gypsy moth in the southern Ukrainian woodlands** [in Russian]. Zashch. Rast. Vred. Bolezn. 1: 51–52.

327. Lozinskiy, V. A.
1961. **On the correlation existing between the weight of pupae and the number and weight of eggs of *Lymantria dispar* L.** [in Russian, English summary]. Zool. Zh. 40(10): 1571–1573.

In investigations in 1959, female pupae of the gypsy moth were collected in July in mixed woodlands near Odessa in the Ukraine, where an outbreak of the moth was in its early stages. They were weighed, and the females that emerged were confined with males. After oviposition, the eggs were counted and weighed individually. The weight of the pupae was positively correlated with the number of eggs but not with egg weight, which is a variable depending on local ecological conditions and the phase of the nidus.
Eggs: 13; Fecundity: 2, 13; Pupae: 13

328. McManus, M. L.
1973. **A dispersal model for larvae of the gypsy moth, *Porthetria dispar* L.** Pages 129–138 *in* US/IBP Aerobiol. Program Handb., U. S. Int. Biol. Program.

Factors, that influence wind dispersal of first-instar larvae are light, temperature, humidity, and wind velocity. As temperature and humidity increase, the larvae ascend the tree at a faster rate. Larvae are also airborne longer under these conditions. Wind dispersal may be the reason for a sometimes poor correlation between egg masses per acre and population density.
Instars I–III: 1, 12

329. McManus, M. L.
1973. **The role of behavior in the dispersal of newly hatched gypsy moth larvae.** U. S. Dept. Agric. For. Serv., Res. Pap. NE-267. 10 p.

"Newly hatched gypsy moth larvae are morphologically and behaviorally adapted for airborne dispersal. The diel periodicity of both hatching and dispersal from the egg mass and photopositive behavior assure that larvae are in optimal position for dispersal when air turbulence is maximal at midday. The rate of larval activity depends upon ambient temperature and relative humidity (R^2 = 0.77). The larvae continually trailed silk and did not feed upon reaching the foliage. Rather, the larvae appeared predisposed to disperse and were readily dislodged by slight winds."
Instars I–III: 1, 12

330. Magnoler, A.
1968. **Laboratory and field experiments on the effectiveness of purified and non-purified nuclear polyhedral virus of *Lymantria dispar* L.** Entomophaga 13: 335–344.

Experiments showed nonpurified virus to have a greater efficacy than purified virus. This could be due to the presence of free virions, saprophytic flora, or toxic metabolites of saprophytic flora. Further experimentation is needed to determine the longevity of the increased virulence in the field.
Larvae: 5, 7

331. Magnoler, A. and A. Cambini.
1973. **Radial growth of cork oak and the effects of defoliation caused by larvae of *Lymantria dispar* L.** [in Portuguese, English and German summaries]. Bol. Inst. Prod. Flor. 35(4/3/9): 9–10, 53–59. (English transl. by U. S. Dep. Agric. For. Serv. Telecom GM-75-7179.)

The purpose of this work was to test the applicability of Duff's and Nolan's (1953) technique of series analysis of wood growth rings in establishing the effects of defoliation of cork oak (*Quercus suber* L.). Combined examination of the oblique and vertical series allows evaluation of the effects of the defoliation and discovery of the first year in which consequences of the damage occurred.
Oak stands: 15, 24

332. Majchrowicz, I. and W. G. Yendol.
1973. **Fungi isolated from the gypsy moth.** J. Econ. Entomol. 66: 823–824.

Gypsy moth lavae and pupae, dead from apparent mycoses, were collected from sites in Pennsylvania, some of which had been previously sprayed with *Bacillus thuringiensis*. Eleven fungal species were isolated from 360 of the 1480 dead larvae and pupae. A greater proportion of specimens with fungal growth were from the sprayed sites. Species isolated were *Beauveria bassiana*, *Candida* sp., *Cladosporium*, *Paecilomyces farinosus*, *Paecilomyces* sp., *Penicillium frequentans*, *P. implicatum*, *P. cyaneo-fulvum*, *P. lanosum*, *P. citrinum*, *Aspergillus flavus*, *P. decumbens*, *P. notatum*, and *P. pulvillorum*. (*B. bossiana* and *P. faninosus* were isolated from over 80 percent of fungus-contaminated specimens.) An unidentified *Candida* was found on 42 percent of the egg masses; *P. farinosus* was on 23 percent. *P. farinosus* and *Candida* sp. were isolated most frequently from pupae and *P. farinosus* and *B. bassiana* were most frequent on larvae. Twenty-one fungal isolates were tested for pathogenicity. Only six were pathogenic to third-instar larvae, and not all isolates of the same fungus were equally pathogenic. *B. bassiana* produced 79.3 percent mortality; *P. farinosus*, 93 percent, 67 percent, and 74 percent (in different cultures); *Paecilomyces* sp. 63 percent; and *P. fumoso-roseus* 38 percent.

Eggs: 8; Larvae: 8; Pupae: 8

333. Maksimović, M.
1953. **Some observations about gradation crises of gypsy moths in plain and mountain forests in 1950** [in Serbo-Croatian, English summary]. Zast. Bilja 15: 12-27.

Two forest areas were compared: Crni Lug, a plains forest of *Quercus pedunculata*, and Istocna Boranja, a mountain forest of *Fagus sylvatica*. The plains forest averaged 17.8 egg masses per trunk, while the mountain forest averaged about 5 egg masses per trunk. The upper elevation limit for gypsy moths in this area was 850 m. Hatch in the mountain forest was as much as 4 weeks later than in the plains forest, depending on elevation. The mountain population suffered very high mortality in the first instar owing to low temperatures and rain. In the plains forest, high mortality was due to parasites of *Apanteles* spp. and tachinids. Overall, a gradient appeared from lower elevations to higher elevations. As elevation increased, biological control decreased and climatic control increased.

Generation: 2, 4, 12

334. Maksimović, M.
1954. **Numbers of eggs in the gypsy moth clusters in 1953** [in Serbo-Croatian, English summary]. Zast. Bilja 26: 1-4.

The number of eggs in a gypsy moth cluster reaches its maximum during progradation and its minimum during retrogradation. The average number of eggs during progradation is 2½ times that during retrogradation.

Eggs: 2

335. Maksimović, M.
1962. **The action of abiotic factors on the gypsy moth population in the forest Jakovački Ključ in 1958.** [transl. from Serbo-Croatian by M. Pantelic of Zast. Bilja 52-53: 37-44, 1959]. Off. Tech. Svc., U. S. Dep. Commer. OTS 60-21662.

The hatching of the gypsy moth can vary by 1 month from year to year. It was established that hatching of gypsy moth caterpillars begins when the average temperature of one 10-day period in the month is over 10.0 °C. High daily temperatures after hatching caused an acceleration of gypsy moth development in 1958. They then moved into a zone favorable for development and mortality resulting from the complex action of abiotic factors was minimal (10.6 percent in this study).

Eggs: 12; Generation: 12; Larvae: 12

336. Maksimović, M.
1958. **A contribution to the investigation of the numerousness of the gypsy moth by means of the trap method** [in Serbo-Croatian, English summary]. Zast. Bilja 49-50: 41-47.

Trapping males gives an indication of population density. Ten males caught in traps indicates 4 clusters/ha, which is a density approaching latency; 13 to 19 males indicates 7.1/ha, a light infestation. Critical density (18.6 to 27.6 egg clusters/ha) is indicated by 24 to 67 males. At this density the number is likely to increase rapidly in the following generation.

Adults: 2, Eggs: 2

337. Maksimović, M.
1958. **Some effects of the temperature upon diapause of the gypsy moth** [in Serbo-Croatian, English summary]. Zast. Bilja 41-42: 23-33.

Temperature was manipulated to test its influence on the diapause of the gypsy moth.
Eggs: 12

338. Maksimović, M. and M. Janković.
1960. **Some effects of abiotic factors in the forest Jakovački Ključ in 1959** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 71-73.

Winter temperatures as low as −20°C in 1958-1959 did not affect the percentage of eggs hatching (86 to 100 percent). An increase in temperature reduced the average duration of larval development. Total preimaginal development varied under the influence of temperature maxima and minima. There was a tendency toward change in sex ratio favoring males as the duration of development decreased. As the duration of larval development increased, the average number of eggs laid by that generation of adult females increased. Larval mortality was highest when temperature minima were low.
Eggs: 12; Fecundity: 12,13; Generation: 12; Larvae: 12,13; Sex ratio: 13

339. Maksimović, M., M. Janković, and R. Marović.
1962. **Effect of abiotic factors upon the development of the gypsy moth in the locality of Jakovački Ključ in 1960** [in Serbo-Croatian, English summary]. Zast. Bilja 67/68: 113-124.

The absolute temperature minimum in the winter of 1959-1960 was −19.8°C, which reportedly had no effect upon the gypsy moth eggs. Hatching of controlled eggs occurred between April 1-21, with maximum hatching lasting 9 to 11 days. Low temperatures caused an extended period of larval development in both early- and late-hatching larvae. Average male development was 62.5 days, while female development was 72.6 days. Pupal development extended to 21.2 days for males and to 18 days for females in the first series (early hatches), and was of normal duration in the second series (late hatches). This was accounted for by the fact that the average developmental temperature was 20°C higher in the second series. The experimental adult life span was an average of 5 days, with a maximum of 10 days for males at an average temperature of 20.6°C for the first series, and 4.1 days' average with a maximum of 6 days for males of the second series. One female lived 11 days in the second series. The average number of eggs per cluster was 266 and 283, respectively, in series 1 and 2. It is stated that 45 to 48 percent of the total larval population in the forest can be presumed to have perished from the effects of temperature.
Adults: 12; Eggs: 12; Fecundity: 12; Larvae: 12; Pupae: 12

340. Maksimović, M.
1963. **Experimental research on the influence of temperature upon the development and the population dynamics of the gypsy moth** [transl. from Serbo-Croatian of Posebna Izd. Biol. Inst. N.R. Srb.-Beogr. 3, 1958.]. U.S. Dept. Agric. and Nat. Sci. Found. OTS 61-11203.

Research was done from 1950 to 1956 under controlled experimental conditions. Caterpillars were fed leaves from forest *Quercus pendunculata* Ehrh. Larval development at constant temperatures was shortest at 32°C: 25 days for males, 27 for females. The longest developmental period was at 16°C: 92 days for males, 97 days for females. The amplitude of variation in the duration of development decreased as the larvae grew older, showing the greater resistance of later instars. Development accelerated under variable temperatures, especially when nighttime minimums came close to the threshold temperature and the daytime temperature was favorable. Too great a difference between the high and low temperature retarded development as a result of physiological disruption. Development period of pronymphs and pupae at constant temperature decreased as temperature increased and was shorter for females. The maximum was at 16°C: 21 days for males, 17 for females. The shortest period, at 32°C, was 6 days for males, and 7 for females. The weight of male pupae raised at constant temperature was 24.5 to 39.4 percent of the female weight and was greatest below 20°C. Protogyny was observed at temperatures of about 16°C, and protandry at all higher observed temperatures. The life span of adult females under constant temperatures was longest at 16°C (11.7 days average) and decreased with an increase in temperature. Variable temperatures had a stimulating effect and lengthened life span. Fecundity declined with an increase in constant temperature: at 16°C the average number of eggs was 723.1, while at 32°C it was 275.5 eggs. The number of undeposited eggs in the ovarioles of the females increased with temperature. The number of unfertilized eggs was small, except at 32°C when it was 88 percent. The optimal fecundity was at variable or constant temperatures below 20°C. Newly hatched larvae endured starvation an average of 7 days at 20°C constant temperature and 100 percent relative humidity (H_R). Endurance declined with a decrease in H_R. Endurance increased with variable temperatures: at 11°C average there was no mortality for 8 days. Because of the great endurance of newly hatched larvae, starvation is probably not a normal factor of mortality under natural conditions. The gypsy moth is most sensitive to temperature at the embryonic stage. Exposure to −25°C during winter diapause killed an average of 20.9 percent after 1 day exposure, 61.4 percent after 2 days, 92.8 percent after 3 days, and 95.7 percent after 5 days. Eggs without hair on the cluster had 91 to 98 percent mortality after 1 day and 100 percent after 2 days at −25°C. There was greater sensitivity just before hatching: 20 minutes' exposure to −25°C caused 70 percent mortality, and 2 hours' exposure caused 100 percent mortality. The upper lethal limit at 80 and 100 percent H_R was 37°C: at 20 percent H_R it was 32°C. Below 20°C the H_R was less important. Sexual index varied with temperature: At a constant temperature of 16°C it was 0.6; at 20.9°C it shifted to the benefit of males; from 28°C to 30°C it stayed the same; and at 32°C it was only 0.33. There were similar changes under variable temperature. It was concluded that there is an optimum temperature for reproduction.

Adults: 1,2,13; Generation: 2

341. Maksimović, M.

1965. **Sex attractant traps with female odor of the gypsy moth used for forecasting the increase of population of gypsy moth.** Page 398 *in* P. Freeman, ed., Proc. 12th Int. Congr. Entomol. 1964.

"The trap method used in Yugoslavia discloses the presence of very small numbers of gypsy moths and also serves for an uninterrupted study of change in population density. It is also possible to indicate critical density for best control results. The relationship between numbers of egg clusters and numbers of males caught in traps was established. The average number of egg clusters to every 25 males caught was 10/ha, while for 26 to 100 males it may go up from 10 to 100/ha, which is the critical number. Results are given of the application of this method in an area with almost no control measures; these are compared with results obtained in areas where the trap method was applied together with introduction of control of critical numbers."

Adults: 1,2,13; Generation: 2

342. Maksimović, M.

1969. **Investigation of population dynamics of the gypsy moth by means of traps.** Pages 9–19 *in* E. Doyle, ed. Insect ecology and the sterile male technique. Proc. FAO/IAEA Div. At. Energy Food Agric., 1967, Vienna.

"The use in Yugoslavia from 1957 to 1964 of traps containing the sexual odor of the gypsy moth made it possible to study the population dynamics of the insect. The method was used in the wooded areas of three republics, Serbia, Bosnia and Herzegovina, and Croatia. The efficiency of the traps was also investigated. Thus, the *critical* number of males caught in a trap was determined and compared with the *critical* number of egg clusters per unit area. During the observation period, a percentage of traps with the *critical* number of males was found in Serbia. The smallest number of such focal points (4.2 percent) was recorded in the lowest population period. This increased to 51.1 percent in the pre-peak year (1964) of the cycle. The existence of the focal points and the variations in numbers during the lowest population period shows that this period does not appear everywhere at the same time. The traps showed various changes in the numbers of the insect in different ecological conditions, as a result of various factors that restrict or accelerate propagation. It was learned by using the traps that the smallest population density is not found in areas larger than a single wood, and even within a single wood the density varies. By establishing the ecologically unsuitable places for gypsy moths, the traps made it possible to investigate the factors that make the existence of the insect possible. . . . . . . The use of the trap method gave a clear insight into the need for control during the lowest population period. This was hitherto not recognized, and control measures were not taken. It has now been realized that the gypsy moth should be destroyed in the initial focal points."

Generation: 2,12

343. Maksimović, M., and I. Politeo.

1970. **A contribution to the biology of the gypsy moth on the island Hvar** [in Serbo-Croatian, English summary]. Zast. Bilja 21(108): 119-130.

Two areas of gypsy moth infestation on the island Hvar were compared because of the difference in stand composition. Jelsa Park contained *Populus pyramidalis, P. alba, Quercus ilex, Robinia pseudoacacia,* and *Salix babylonica*—all food species of the gypsy moth. The only known host plants of Vrba Park were a few *Q. ilex* and *P. tremulae*. In Jelsa, egg masses were found exclusively on *Populus* spp., while in Vrba egg masses were found on *Pinus halepinsis* and *Tamarix gallica*. During 2 years of population increase, the number of eggs per egg mass decreased twice as much in the preferred habitat of Jelsa. Hatching started 7 days later in Vrba Park, and pupation occurred about 15 days later.

Eggs: 2; Generation: 2,12

344. Maksimović, M., P. Bjegović, and L. Vasiljević.

1970. **Maintaining the density of the gypsy moth enemies as a method of biological control** [in Serbo-Croatian, English summary]. Zast. Bilja 21(107): 3-15.

The population density of the gypsy moth differs from year to year, with an outbreak every 7 to 9 years in Yugoslavia. During latency, natural enemies of the gypsy moth do not have enough hosts to maintain their population density and their numbers decline. The theory of integrated control is that the gypsy moth can be kept at a level sufficient to maintain its natural enemies which in turn will keep the gypsy moth in check for periods longer than 7 to 9 years. During spring, in the years 1964 to 1967, gypsy moth eggs were introduced into test plots which were subsequently compared with control plots for number of egg masses, number of eggs in each mass, egg parasites, sterile eggs, larval parasites, and degree of defoliation. The percentage of parasitization of the eggs did not vary significantly between test and control sites. Neither the number of eggs per mass nor the number of sterile eggs was an important factor in population reduction. *Apanteles porthetriae* Mues., parasite of young larvae, built up within 4 years and was an important control factor. From the results of this work, it appears that the gypsy moth gradation and resultant defoliation were prevented by the introduction of eggs. The parasites exerted a radial influence on gypsy moth population density, with lessening influence as the distance from the center of the introduction of eggs increased.

Eggs: 4; Generation: 2; Instars I-III: 4; Non-oak stands: 15

345. Maksimović, M., P. Bjegović, and L. Vasiljević.

1972. **Feeding and maintaining the density of the gypsy moth's enemies as a method of biological control.** Page 57, v. 3 Proc. 13th Int. Congr. Entomol., 1968. Nauk Leningrad.

For 4 years eggs were collected from areas of Yugoslavia where the gypsy moth gradation was at a peak. They were introduced to regions with light infestations to be used as food by the natural enemies of the gypsy moth. In a *Platanus occidentalis* forest in Macedonia there was a base population of 100 egg clusters/ha in 1964, to which 21 kg of eggs were added. That year many larvae developed, and there was heavy defoliation. In the next 3 years, 55 kg, 20 kg, and 14 kg of eggs were added, respectively, but the damage was slight. In a control forest 3 km from the first, the gypsy moth was near latency in 1964 and 1965, caused visible damage in 1966, and completely defoliated willow and partially defoliated *P. occidentalis* in 1967. That last autumn 422.2 egg clusters/ha were observed. *Ooencyrtus kuwanae* How. and *Anastatus disparis* R., parasitized 25 to 31.1 percent of the eggs in the test site, showing that egg parasites play an important regulatory role. *Apanteles porthetriae* Mues. was the dominant parasite: 5702 cocoons/ha were observed on the test site and 2151/ha on the control site. An increase in gypsy moth numbers can be prevented by keeping natural enemy numbers at a high level when the gypsy moth itself is at a low density level.

Eggs: 4; Instars I-III: 4; Generation: 2; Non-oak stands: 15

346. Malozemov, Y. A.

1962. **Developmental characteristics of foci of gypsy moths *(Porthetria dispar)* in the Il'men Game Reservation** [in Russian]. Pages 104-106 *in* B. P. Kolesnikov et al., eds. Dokl. Nauchno-Tekh. Konf. Molodykh Spets. Lesn. Proizvod. Urala Itogam Rab. 2nd, 1961. Sverdlovsk.

347. Manon.
1926. **Notes on *Liparis dispar* L. and on some of its varieties** [in French]. Rev. Zool. Agric. Appl. 25: 25: 39-42, 49-55.

348. Marcou, G., and I. Catrina.
1962. **Experimental research on the causes of dieback of oak in Rumania** [in French]. Proc. 13th IUFRO Congr., Vienna, 1961, Part D, Sec. 24/13.

349. Marcu, O.
1971. **Gypsy moth egg weight — an important prediction index** [in German, Rumanian and English summaries]. Brasov Rum. Inst. Politeh. Bul. Ser. B. Econ. For. 13: 111-118.

"There is a direct correlation between the mean weight of the eggs (mean value of the weight of 100 eggs) and the number of eggs laid, the percentage of hatching, the length of the newly hatched, famished insects' life, the weight of [the] pupae, and the fecundity of the adults of the next generation. The mean weight of the eggs, an easily ascertainable value, is therefore of great practical importance, indicating the percentage of hatching and the length of the larva's life, especially in a spring season with unfavorable conditions. These indications may help in correcting the population density and in avoiding the disagreement between the predicted level of damage and the real damages, and in some cases they may lead to cancellation of control measures."

Eggs: 2, 13

350. Marcu, O.
1972. **The influence of nutrition on the gypsy moth and its practical importance** [in Rumanian, German summary]. Brasov Rum. Inst. Politeh. Bul., Ser. B. Econ. For. 14: 171-178.

351. Marcu, O.
1972. **Research on the most important parasites of the gypsy moth** [in Rumanian, German summary]. Brasov Rum. Inst. Politeh. Bul., Ser. B. Econ. For. 14: 179-188.

352. Marović, R.
1971. **A study of the effect of low winter temperature on gypsy moth eggs *(Lymantria dispar).*** Zast. Bilja 22(115/116): 369-376.

"Under laboratory conditions, a constant temperature of 25°C in February brings about mortality of gypsy moth caterpillars in eggs. The effect is more pronounced when the eggs (whether deprived of hairs or in egg masses) are transferred directly from insectarium to -25°C than if they are preliminarily acclimatized at -6°C for 6 days. Eggs deprived of hairs are more susceptible than egg masses, but with a longer exposure, the protective effect of the hairs is not enough to prevent total mortality. In the field, winter temperatures of 21°C did not cause the death of egg masses. On the basis of laboratory investigations, it may be said that the caterpillars in eggs in the field can tolerate winter lows of 25°C for 3 to 4 days without increased mortality. It is possible that at higher altitude and in microhabitats where the temperature drops below -30°C, these minima reduce the gypsy moth. This should be the subject of further research."

Eggs: 12

353. Martelli, M., and M. A. Giovanni.
1958. **Preliminary research on insects of cork oak *(Quercus suber* L.) in Sardinia** [in Italian, English summary]. Boll. Zool. Agrar. Bachic. Ser. 2.2(1): 5-49.

Thirty-three phytophagous insects (1 Isoptera, 11 Hemiptera, 7 Lepidoptera, 2 Diptera, 3 Coleoptera, 9 Hymenoptera) and 53 symbionts of them (7 Diptera, 3 Coleoptera, 43 Hymenoptera) were observed on cork oak during 3 years of research. Those insects (*Lymantria dispar* L. and *Malacosoma neustrium* L.) presenting greater danger to the tree were studied more intensively.

Oak stands: 15

354. Masaki, S.
1956. **The effect of temperature on the termination of diapause in the eggs of *Lymantria dispar* Linne.** Oyo Dobutsugaku Zasshi 21(4): 148-157.

Experiments were performed to determine the range of temperature and the length of exposure to cold required for gypsy moth eggs to complete diapause. "When the eggs were subjected to a low temperature of 5°C for different periods and then incubated, the percentage hatch was increased, the mean hatching time after removal to high temperature was shortened, and the degree of [its] variability was reduced — all in proportion to the duration of exposure to the low temperature. The optimal temperature for the completion of diapause lies between 5 and 12°C, and the upper and

lower thresholds are about 20 and 0°C, respectively. There was no evidence indicating a clear-cut distinction between the diapause and postdiapause stage, and the larvae within the egg shell became competent to hatch gradually."
Eggs: 12, 13

355. Masner, L.
1958. **A new egg parasite of gypsy moth, *Lymantria dispar* (L.).** Entomophaga 3: 39–44.
Five *Hadronotus lymantria* n.sp. (Scelionidae: Scelioninae) were reared from eggs of the gypsy moth in East Slovakia. It is described as a new species. It is the third scelionid known to parasitize gypsy moth eggs. The others are *H. howardi* Mokr. et. Ogl., reported to infest 75 to 85 percent of eggs in the Crimea, and *Telenomus phalaenarum* Nees. A morphological key is given to differentiate between the three species.
Eggs: 4

356. Masson, J.
1970. **Four species of tachinids bred from a rearing of *Lymantria dispar* caterpillars in the laboratory** [in French, English summary]. Ann. Fac. Sci. Marseilles 43B: 51–61.
The following tachinids emerged from *Lymantria dispar* pupae reared in the laboratory: *Compsilura concinnata* Meig., *Drino inconspicua* Meig., *Eucarcelia separata* Rond., and *Exorista larvarum* L. Of these, *E. separata* is considered a rare parasite of *L. dispar.*
Larvae: 4; Pupae: 4

357. Menzel, R.
1923. **The occurrence of a very useful parasitic fly (*Compsilura concinnata* Meig.) in Java** [in Dutch]. De Thee 4:89–90.

358. Mercet, R. G.
1918. **Parasites of *Liparis dispar*** [in Spanish]. Rev. Montes, Madrid 42(1004): 775–781.

359. Mercet, R. G.
1923. **Chalcids parasitizing lepidopteran larvae** [in Spanish]. Rev. Fitopatol. 1(1): 12–19.

360. Mercet, R. G.
1926. **A new parasite of *Porthetria dispar*** [in Spanish]. Rev. Fitopatol. 2-3: 48–50.

361. Merker, E.
1960. **The influence of tree condition on the mass increase of some forest pests** [in German, English summary]. Z. Angew. Entomol. 46(4): 432–445.
Changes in soil have an influence on the trees and thus upon the gradations of insect pests in the forest. For instance, both the amount of water in the soil and its fertility contribute to lowering the populations of harmful insects. Fertilized soil is capable of decimating dangerous forest insects. Populations of larvae of *Lymantria monacha* L. and *L. dispar* L. have had a mortality of 50 to 80 percent after the plants have been fertilized with calcium carbonate and ammonium nitrate.
All stands: 15, 23, 24

362. Merker, E.
1964. **The effect of food on the development of *Lymantria dispar*** [in German]. Allg. Forst Jagdztg. 135(2): 34–36.

363. Miao, C. P.
1939. **Study of some forest insects of Nanking and its vicinity.** III: Observations on the gypsy moth (*Porthetria dispar* L.) Contrib. Biol. Lab. Sci. Soc. China. Zool. Ser 13(5): 57–77.
The gypsy moth is widely distributed in China. Food plants in the vicinity of Nanking (32° N, 118° E) are *Prunus persica* Stokes, *P. salicina* Lindley, *P. pseudocerassus* Hance, *Liquidambar formosana* Hance, *Quercus fabri* Hance, *Q. acutissima* Carriere, *Q. aliena* Blume, *Q. serrata* Thunberg, and *Q. glauca* Thunberg. A morphological description of each life stage is given. There are four larval molts prior to pupation, with a total larval period of 43 to 60 days. Newly hatched larvae rest on the egg cluster 1 + days, begin to eat leaf hairs, then to make holes in the leaf. They feed little on rainy days. Instead, they cling to the underside of the leaf or suspend themselves on a short thread. In good weather, they feed day and night, become very active, and hang on a long silk thread when disturbed. After feeding for 6 days, they rest 1 to 2 days before molting. Feeding resumes after the molt when the head becomes black. They have an irregular feeding pattern. Third- and fourth-instar larvae feed on the edge of a leaf or eat through it. Older larvae eat from the edge without boring through the leaf. They rest before spinning a silky, flimsy cocoon which is at-

tached to a tree trunk or between two leaves. The prepupal period is 1 to 3 days. They pupate May 15–June 7 for about 2 weeks. Imago emergence is primarily June 4–8. The female is unable to fly except when disturbed. Copulation is soon after emergence; eggs are laid (June 9–12) on any fixed object, expecially under branches. They emerge March 31–April 10.

Adults: 1; All stands: 15; Eggs: 2; Instars I–III: 1; Instars IV–VI: 1; Prepupae: 1

364. Mihalache, G. H., and I. Wagner.
1964. **A contribution to the study of the characteristics of the egg parasites of *Lymantria dispar* L. by means of the parasite *Anastatus disparis* Ruschka** [in Rumanian]. Rev. Padurilor 79(2): 79–82.

365. Mikkola, K.
1971. **The migratory habit of *Lymantria dispar* (Lepidoptora: Lymantriidae) adults of continental Eurasia in the light of a flight to Finland.** Acta Entomol. Fenn 28: 107–120.

Nine male gypsy moths were collected in Finland in 1958 and by their appearance were inferred to be of southeastern Russian origin. Migration was attributed to a warm air current from the southeast. The same migration had been observed 3 days earlier near Moscow as an unusual mass flight of both males and females. "According to a trajectory analysis, the moths had migrated intermittently, advancing with the warm front and/or flying chiefly by night." It was concluded that the continental summer drought was a major factor contributing to the evolution of the migratory habit in adult gypsy moths. It may affect the environment of the gypsy moth larvae in at least two ways: The defoliation caused by the caterpillars in spring and early summer is probably harder on the trees because of summer drought, and the quality of the food will vary with the intensity of the drought.

Adults: 1, 12; Larvae: 12

366. Minott, C. W.
1922. **The gipsy moth on cranberry bogs.** U. S. Dep. Agric. Bull. 1093. 19 p.

"Infestations of gypsy moths in cranberry bogs are due principally to wind dispersion of first-stage larvae, which occurs only when conditions of wind velocity and temperature are favorable. The time when maximum dispersion prevails is usually not longer than from 2 to 5 days. Because of the activity of the young caterpillars in seeking food, there are two daily periods of maximum dispersion, between 9 a.m. and 12 noon and between 2 and 5 p.m. Mortality of first-stage larvae is very great—large numbers perish from low temperatures, unfavorable food, predaceous insects, and disease. The embryos in all gypsy moth eggs deposited on cranberry bogs are killed by winter flowage, when the bogs are flowed from December 1 to May 1. Upon deciduous foliage in general, the feeding of the first-stage larvae is upon the leaf hairs, but the injury to cranberry plants is caused by feeding upon the terminal buds, and later upon the new growth. As a rule, vines recover more quickly from injury in wet bogs than in dry ones. Flooding is the most effective method of control in wet bogs, but spraying is the only method that can be employed in dry bogs."

All stands: 15; Generation: 1; Instars I–III: 1, 12

367. Minott, C. W., and I. T. Guild.
1925. **Some results of the defoliation of trees.** J. Econ. Entomol. 18: 345–348.

Decrease in growth with an increase in defoliation was found to be a linear relationship. Over a 10-year period, a one-third loss of foliage resulted in a one-third decrease in growth. Susceptibility to defoliation varied among individuals of a species. Most white oaks die after two, three, or four complete defoliations; however, one individual remained in good condition after five defoliations.

Oak stands: 19, 24, 25

368. Mirković, D. and V. Mišćević.
1960. **Influence of the browse of gypsy moth (*Lymantria dispar* L.) upon the accretion of oak trees** (in Serbo-Croatian, English summary]. Zast. Bilja 60: 3–19.

The annual growth of 254 trees in an oak wood at Jacovački Ključ was measured from 1945 to 1959. During this time there were two gypsy moth gradations (1946–1950, 1953–1957). Accretion in cubic capacity declined considerably during the years of the gradation, with minimum growth in 1957, the year of maximum average number of larvae per tree. When the arithmetic mean of the accretion during the 1953–1957 gradation is compared with that during latency, the losses amount to 18.1 per-

cent. When average accretion during the gradation is compared with the average of the trend of the accretion for the same period, the deficit is 49.4 percent. The average accretion during the gradation compared with the highest value of accretion prior to the gradation shows a 39.0 percent deficit. This last result is ". . .taken as the most probable, and it tallies with the results of other investigators utilizing different methods." The correlation between growth and climatic factors decreased considerably during the gradation. The negative influence of the gradation overcame the existing positive influence of climatic factors.
Oak stands: 15, 24; Generation: 2

369. Mizuta, K.
1960. **Effect of individual number on the development and survival of the larvae of two lymantriid species living in aggregation and in scattering** [in Japanese, English summary]. Nippon Oyo Dobutsu Konchu Gakkai-Shi 4(3): 146–152.

Gypsy moth larvae were reared with 1, 2, 5, 10, and 20 individuals per vessel at temperatures of 23 to 27° C and natural light conditions. "In every culture all the larvae developed successfully." As the number of larvae per vessel increased, larval and pupal durations, pupal weight, and fecundity decreased; the overcrowding had an adverse effect on the development of the gypsy moth.
Fecundity: 2; Larvae: 2; Pupae: 2

370. Mizuta, K.
1971. **Synchronized hatching of some lepidopterous insects.** Saijo Hiroshima Agric. Coll. Bull. 4(2): 91–96.

Laboratory experiments examined the effect of the egg mass on the rate of hatching of four species of Lymantriidae: three species of *Euproctis* and *Porthetria dispar japonica* Motschulsky. The hatching curves of the *Euproctis* showed a different pattern for isolated eggs and for egg masses, with more rapid and synchronized hatching in the egg masses. There was no significant acceleration in hatching of *P. dispar japonica* in egg masses. All species studies showed a diurnal rhythm of hatching. It is believed that hatching is synchronized by the behavior of the hatchlings. Newly hatched larvae crawled to the surface of the egg mass and nibbled at egg shells from which larvae had not yet emerged. Isolated individuals seemed to have difficulty getting out of the egg shell alone. It was not understood why *P. dispar japonica* did not show different hatching curves for isolated eggs and for egg masses, except that their larvae disperse just after completing hatching, in contrast to *Euproctis* larvae which aggregate.
Eggs: 1; Instars I–III: 1

371. Mokrzecki, Z., and A. A. Ogloblin.
1931. ***Hadronotus howardi* n. sp. (Microhymenoptera, Proctotrupidae).** Pol. Pismo Entomol. 10(1): 1–8.

This contains the morphological description of a new egg parasite, *Hadronotus howardi* n. sp., which in the Crimea has been observed to annihilate 75 to 85 percent of gypsy moth eggs.
Eggs: 4

372. Molis, S.
1970. **Some data on the biology of *Ocneria dispar* L. in South Lithuania** [in Lithuanian, English summary]. Acta Entomol. Litu. 1: 91–98.

"*Ocneria dispar* is a rather infrequent insect species in Lithuania, though during its massive propagation in the south of the Soviet Union (occurring after drought every 6 to 11 years)" it is carried by wind to southern Lithuania. A massive outbreak was registered in 1956. Data are presented based on investigations in southern Lithuania from 1959 to 1967. Pupae, moths, and fresh eggs "were detected in the orchards of the area (the town Kapsukas) on the 20th of June 1959." Moths fly and lay eggs from July to the middle of August. There are 256 to 386 eggs in one oviposition. "At the end of April or the beginning of May, dark, hairy larvae emerge . . ." and in 3 to 4 days, they begin crawling "in all directions searching for food and often are carried by the wind to great distances." The larvae are polyphagous. Within 30 to 40 days, males moult four times and females five times. After 3 to 4 weeks they emerge as moths. Natural enemies of *Ocneria dispar* are cuckoos, woodpeckers, blue titmice, and thrushes. The egg parasites, *Telenomus laevisculus* Ratz. and *Oenocyrtus tardus* Ratz. kill up to 10 percent of the eggs. The larvae are infected by the parasitic flies *Phorocera silvestris* R.-D. and *Blepharipoda scutellata* R.-D. In the climatic conditions of Lithuania up to 22 percent of the larvae are killed by these flies.
Generation: 1, 4, 9

373. Monastero, S.
1955. **The forests of Ficuzza threatened by the gypsy moth (*Lymantria dispar* L.)** [in Italian]. Boll. Ist. Entomol. Agrar. Oss. Fitopatol. Palermo 1: 167–174.

374. Moravskaia, A. S.
1958. **The gypsy moth is a pest of the forest and plantings** [in Russian]. Priroda (Moskow) 3: 90–93.

375. Moravskaia, A. S.
1973. **Influence of imaginal feeding on fecundity and life duration of adults in *Anastatus disparis* (Hymenoptera: Eupelmidae), egg parasite of the gypsy moth** [in Russian, English summary]. Zool. Zh. 52(12): 1809–1814.

In the experiment without imaginal feeding, the maximal life span of males was 5 days and of females 7 days. When insects were fed on sugar syrup, the maximal life span of males increased to 16 days, and that of females increased to 32 days; the maximal number of eggs matured in one female was nine. When they were fed both carbohydrates and host egg contents (as occurs in nature), the number of matured eggs reached 16. The maximal life span of females was 33 days. "To determine the effectiveness of *Anastatus*, one has to consider not only the number of eggs infested by the parasite but also [the number of eggs lost] as a result of pricking by a female for feeding on its contents. One female can exterminate, without subsequent infestation, up to 24 eggs of the gypsy moth."

Eggs: 4

376. Moravskaia, A. S.
1973. **A new additional host of *Anastatus disparis* (Hymenoptera: Eupelmidae), egg parasite of *Porthetria dispar*** [in Russian, English summary]. Zool. Zh. 52(1): 147–150.

"*Anastatus disparis* Rusch., a specific parasite of *Porthetria dispar* L., develops synchronously with its host. In the Tellermanovsky forest region of the Voronezh District, *A. disparis* develops mainly in the eggs of *P. dispar*, but it was reared from the eggs of *Palomena prasina* L. as well. *A. disparis* infests the eggs of *P. prasina* both in nature and under artificial conditions. In the eggs of *P. prasina*, *A. disparis* has the second additional generation during a year. Both males and females of *A. disparis* were reared from the eggs of *P* *prasina*."

Eggs: 4

377. Morgan, P.
1972. **Devastation of northeastern forests b the gypsy moth.** Northern Nut Growers Assoc Annu. Rep. 63: 56–58.

From 1969 to 1971 on the Newark, N.J. watershed, more than 1,052,000 oaks and 47,000 hemlocks and pines died from gypsy moth activity. I 1971, dead oaks averaged 60 trees per acre, wit white oaks suffering up to 80 percent mortalit (tabulated from 18,000 acres). A survey taken i the New Jersey National Historical Park in 197 showed that 10,000 oak trees had been killed b defoliation. This constitutes 33 percent of th park's oak forest.

All stands: 15,25,26

378. Mosbacher, G. C.
1967. **On the influence of temperature on th degree of intersexuality in *Lymantria dispar* L** [in German]. Zool. Anz. 30 Suppl.: 509–521.

379. Mosbacher, G. C.
1968. A mutant of *Lymantria dispar* L. with abnormal wing form and its temperature dependence in manifestation [in German, English summary]. Genetica 39: 25–40. The Hague, Netherlands.

"The mutant *Incisiva* (*Ic*), found in a German population of *Lymantria dispar* L., is characterized by a semicircular to parabolic incision on the tips of the hindwings (occasionally on the forewing also). The inheritance of this character is dominant, autosomal, and presumably monofactorial. Penetrance and expressivity of the *Incisiva* allele are strongly temperature-dependent. As a rule, the penetrance increases with decreasing temperatures from 0 percent in 27°C cultures to 100 percent in 16°C cultures. Modifying genes, which are partly sex-linked, can considerably decrease the penetrance of the gene in cold-cultured individuals. At low temperatures, incisions are often observed even on the tips of the forewings. In this case, the hindwings are split up to the base, thus displacing or even suppressing the radial and median veins. The size of incisions and their occurrence in forewings is influenced by the genetic background. The temperature-sensitive period for *lc* mutant manifestation was determined to be in the last two instars before pupation, i.e., in the fourth in males, and in the fifth in females. This temperature-sensitive phase coincides with the initial stages of development of the presumptive wing blade in the imaginal disc. The wing incision is recognizable as a split even before the main growth period of the wing blade at the beginning of the last larval instar."

Adults: 12,13

380. Mosher, F. H., and R. T. Webber.
1914. **The relation of variation in the number of larval stages to sex development in the gypsy moth.** J. Econ. Entomol. 7: 368–373.

In controlled laboratory experiments, it was found that those larvae that pupated in the fifth stage produced male moths, while those having a sixth stage developed into females.

Larvae: 13

381. Mosher, F. H.
1915. **Food plants of the gipsy moth in America.** U.S. Dep. Agric. Bull. 250. 39p.

Results of laboratory experiments to determine food preferences are given. Newly hatched larvae were put in trays with one food type. If all died, then a new trial was begun at the stage prior to the one at which the previous trial was discontinued. Food classes were based on number of larvae dying in laboratory trials and on field observations. The report concludes that white oak is probably the most favored food plant.

All stands: 15; Larvae: 12

382. Moucha, J.
1957. **On the influence of food in the development of the gypsy moth *(Lymantria dispar* L.)** [in Czechoslovakian, Russian and German summaries]. Cas. Cesk. Spolecnosti Entomol. 54(1): 73-80.

383. Muesebeck, C. F. W.
1927. **New species of chalcid flies parasitic on the gipsy moth parasite, *Apanteles melanoscelus* (Ratzeburg).** J. Agric. Res. 34: 331–333.

Three new parasites of *Apanteles melanoscelus (Coelopisthia scutellata* n. sp., *Hypopteromalus inimicus* n. sp., and *Dimmockia pallipes* n. sp.), which were found to be significant in reducing the activity of *A. melanoscelus*, are described.

Larvae: 4

384. Musebeck, C. F. W., and S. M. Dohanan.
1927. **A study in hyperparasitism with particular reference to the parasites of *Apanteles melanoscelus* (Ratzeburg).** U. S. Dep. Agric. Bull. 1487. 35 p.

Hyperparasites are generally less discriminating than primary parasites regarding host selection. They can easily adapt to a new host or to the absence of a host. When the primary parasite is protected by a cocoon or puparium, the hyperparasite is generally an external feeder. All observed parasites of *Apanteles melanoscelus* (Ratzeburg) are parthenogenic. *A. melanoscelus* is a solitary parasite of the gypsy moth, also sometimes reared from *Hemerocampa leucostigma*. Adults appear in May right after gypsy moth eggs hatch. They oviposit in first-instar larvae; larval development is in 18 to 20 days. They emerge from second and third instars to form their cocoons. Adults emerge 1 week later, mate, and oviposit in third-instar larvae. They develop in gypsy moths in 16 to 20 days, and cocoons appear in early July. They overwinter as mature larvae in cocoons on trees. Over a 3-year period, 28 percent of first generation *Apanteles* cocoons produced *Apanteles*, 53 percent produced hyperparasites, and 19 percent produced neither. The length of time the cocoon is exposed determines survival in the second generation: Probably no more than 0.5 percent of cocoons formed in July produce *Apanteles* the next spring, and close to 50 percent produce neither parasite nor hyperparasite. This is because of excessive hyperparasitism and because adult hyperparasites feed at oviposition holes, often without depositing eggs. Thirty-five species were reared from *Apanteles* cocoons; 14 species from 90 percent. They are listed in order of importance: *Eurytoma appendigaster* (Swed.), *Dibrachys boucheanus* (Ratz.), *Hemiteles tenellus* (Say), *Dimmockia incongruus* (Ashm.), *Gelis bucculatricis* (Ashm.), *G. apantelis* Cush., *Eupelmus spongipartus* Foerst., *Hypopteromalus tabacum* Fitch, *Habrocytus dux* Girault, *Hemiteles fulvipes* Grav., *Eupilminus saltator* (Lindm.), *Dimmockia pallipes* Mues., *Pleurotropis tarsalis* (Ashm.), and *P. nawaii* (Ashm.). The vast majority of hyper-

parasites are Hymenoptera in the families Ichneumonidae and Chalcidoidea.
Instars I–III: 4

385. Muesebeck, C. F. W.
1928. **A new European species of *Apanteles* parasitic on the gipsy moth.** Proc. Entomol. Soc. Wash. 30(1): 8–9.
Apanteles porthetriae is widely distributed in Europe but seems to have been frequently confused with *A. vitripennis* Haliday and occasionally with *A. Lateralis* Haliday and *A. solitarius* Ratzeburg. The species is named and described here. The type locality is Olaszliszka, Hungary; its type, allotype, and six paratypes are located in the U.S. National Museum.
Instars I–III: 4

386. Muesebeck, C. F. W.
1931. ***Monodontomerus aereus* Walker, both a primary and secondary parasite of the brown-tail moth and the gipsy moth.** J. Agric. Res. 43: 445–460.
The adult female of *Monodontomerus aereus* oviposts about the first of June. From one to four eggs are deposited during one insertion of the ovipositor. These are usually placed externally on the host within the cocoon, puparium, or pupae, but when oviposition occurs in living lepidopterous pupae or very fresh tachinid puparia, the eggs are deposited internally. "*Monodontomerus aereus* has been reared as a direct hyperparasite from cocoons or puparia of many primary parasites of the gipsy moth and the brown-tail moth. It has also been obtained from the pupae of certain Lepidoptera, and in these cases has sometimes been a primary and sometimes a secondary parasite."
Larvae: 4; Pupae: 4

387. Muesebeck, C. F. W., and D. L. Parker.
1933. ***Hyposoter disparis* Viereck, an introduced ichneumonid parasite of the gipsy moth.** J. Agric. Res. 46: 335–347.
"*Hyposoter disparis* has, on rare occasions, been observed to be a very abundant parasite of the gipsy moth in Europe, but it has not yet become an important control agent of that pest in New England. Apparently the parasitism is heavier in dense woodland than in open growth or on the outer edges of wooded areas. The potential effectiveness of the species as a parasite of the gipsy moth is offset to a considerable extent by failure of eggs to hatch or by early death of the parasitic larvae. From 10 [percent] to more than 30 percent of eggs and young larvae of the parasite dissected from host caterpillars that had been attacked in the laboratory and in the field were found to be dead and surrounded by phagocytes of the host. This suggests incomplete adaptation of the parasite to this host."
Larvae: 4

388. Munro, W.
1917. **Management of typical woodlots infested with the gipsy moth in the white-pine region.** Pages 17–49 *in* Control of the gipsy moth by forest management. U.S. Dep. Agric. Bull. 484.
Eighteen species of food plants are potentially controlling factors in management of the gypsy moth, owing to their silvicultural characteristics. Broken down by preference classes there are: Class I (species favored by larvae in all stages): *Populus tremuloides* and *P. grandidentata* (aspens), *Fagus atropunicea* (beech), *Betula populifolia* (gray birch), and the oaks *Quercus pumila, Q. velutena, Q. rubra, Q. coccinea,* and *Q. alba.* Class II (species favored by later instars): *Castanea dentata* (chestnut) *Tsuga canadensis* (hemlock), *Pinus rigida.* and *P. strobus* (pines). Class III (not favored, but a small proportion of moths may feed): *Acer rubrum* and *A. saccharum* (maples). Class IV (unfavored): *Fraxinus americana* (ash), *Juniperus virginiana* (red cedar), and *Chamaecyparis thyoides* (white cedar). The author proposes management techniques based on the proportion of each class in the stand.
All stands: 19; Larve 1

389. Nagaraja, H., P. R. Dharmadhikari, and V. P. Rao.
1968. **A comparative study of the external morphology of *Lymantria obfuscata* Wlk.** in India and *L. dispar* L. in the U.S.A. Bull. Entomol. Res. 59:105–112.
Morphological differences between *Lymantria obfuscata* and *L. dispar* and considered by U.S. Department of Agriculture lepidopterists to be small and trivial in an evolutionary sense. Perhaps the taxonomy should be reviewed if the two species are not shown to differ serologically. They are very similar biologically and have common or closely related parasites. The *Lymantria* species in the northwest Himalayas has been confirmed as *L.*

obfuscata. The habitat overlaps with the southern range of *L. dispar*.
Generation: 12

390. Nagasawa, Sumio.
1965. **On the number of larval moults in the "Takamatsu" race of the gypsy moth, *Lymantria dispar* L.** [in Japanese]. Nippon Oyo Dobutsu Konchu Gakkai-Shi 9 (1): 62-63.

391. Nakazima, S. and K. Furukawa.
1933 **Bionomics and external structures of *Liparis dispar*, an insect noxious to *Livistona chinensis*** [in Japanese] Miyazaki Koto Norin Gakko Gakujutsu Hokoku (Bull. Miyazaki Coll. Agric. For.) 5: 1-12.

392. Nechleba, A.
1927. **The loss of vitality and destruction of broods of forest insect pests** [in German]. Anz. Scharedlinskd. 3(10): 115-117.

393. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.
1963. **Annual Report. 1962-1963.** 2p.
In 1962-63, New Jersey conducted a mass release of gypsy moth parasites, including three parasites from Spain which had not yet been established in the United States. These were *Tricholyga segregata*, a tachinid larval parasite; *Brachymeria intermedia*, a hymenopterous pupal parasite; and *Apanteles vitripennis*, a hymenopterous larval parasite. The state was in the process of releasing every known gypsy moth parasite it could locate.
Eggs: 4; Larvae: 3,4; Pupae: 3,4

394. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.
1965. **Annual Report. 1964-1965.** 1 p.
The state of New Jersey is still carrying on its mass release of gypsy moth parasites and predators to control population levels. Collections of egg masses were made from 21 sites. *Ooencyrtus kuwanae* was found to be established at five sites as a result of earlier parasite release programs.
Eggs: 4; Larvae: 3,4; Pupae: 3

395. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.
1966. **Annual Report. 1965-1966.** 1 p.
New Jersey continued its mass release of gypsy moth parasites. Recovery studies were also conducted to determine the establishment of parasites. *Brachymeria intermedia* was recovered for the first time since its release in New Jersey two years earlier.
Eggs: 4; Larvae: 4; Pupae: 3,4

396. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.
1967. **Annual Report. 1966-1967.** 1 p.
"During this past year, the [New Jersey Bureau of Plant Industry] Laboratory has initiated a parasite management program. The objective of this program is to release those numbers of various species of parasites into the gypsy moth population as required annually to prevent peaking of the host population." The following parasites were reared: *Ooencyrtus kuwanae, Sturmia scutellata, Compsilura concinnata, Apanteles melanoscelus,* and *Brachymeria intermedia*. These are "expected to be amenable to management under the proper conditions."
Eggs: 4; Larvae: 4; Pupae:4

397. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.
1969. **Annual Report. 1968-1969.** 2 p.
"For the past 5 years, the Plant Laboratory has increased its efforts in the rearing of gypsy moth parasites, as part of an integrated approach leading to the suppression of this forest pest." Besides the established gypsy moth parasites, the following exotic larval parasites were reared: *Apanteles porthetriae, Exorista rossica,* and *Exorista segregata*." A total of 15,795,844 parasites were released during the year. It is planned to release 25,000,000 parasites next year." A table of numbers of parasites released in each county is given, along with a table indicating the extent of establishment of the egg parasite *Ooencyrts kuwanae* in gypsy moth populations. "Surveys conducted during June revealed that six infested areas of the state have decreased in gypsy moth population or are about to do so. The factors responsible for these population declines are virus disease and parasitism."
Eggs: 4; Larvae: 4; Pupae: 3,4

398. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.

1970. **Annual Report. 1969–1970.** 8 p.
During 1969-1970, New Jersey kept its parasite release program in operation. The following exotic larval parasites were reared: *Apanteles porthetriae, Exorista rossica, Exorista segregata,* and *Rogas* sp. A total of 19,184, 758 parasites was released. Tables are given indicating the number of parasites released per county, a winter egg mass survey table indicating egg masses per plot and percent parasitism is included.
Eggs: 4; Larvae: 4

399. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.

1971. **Annual Report. 1970–1971.** 6 p.
At the present time, seven species of parasites and one predaceous beetle are well established in New Jersey. The established parasites are as follows: Egg parasite—*Ooencyrtus kuwanae.* Larval parasites—*Compsilura concinnata, Sturmia scutellata, Parasetigena agilis, Apanteles melanoscellus, Hyposoter dispar.* Pupal parasite—*Brachymeria intermedia.* Predaceous beetle—*Calosoma sycophanta.*

Of those parasites now established, three are maintained in the laboratory: *O. kuwanae, A. melanoscelus,* and *B. intermedia.* All others are field-collected. In addition, three native ichnuemonids (*Itoplectis conquisitor, Coccygomimus pedalis, Theronia atalantae*) and three native predaceous beetles (*Calosoma fridigum, C. scrutator, C. wilcoxi*) and one Pentatomid have been found attacking gypsy moth larvae and pupae. For the past three years (starting in 1969) there has been a steady collapse or decline of the gypsy moth populations in approximately one third of the defoliated areas. Most of this acreage has been defoliated for two years in succession. No large plots that have been defoliated in three years have been noted, but there are areas where the population has collapsed after one defoliation. Associated with population collapse is 60 to 90 percent parasitism by *O. kuwanae* and a high incidence of the wilt disease. In some areas the gypsy moth population remained stable; the major parasite in those areas was *P. agilis.* Four new parasites are being reared: three tachinids (*E. larvarum,* imported from Yugoslavia; *E. rossica,* imported from India; and *E. segregata,* imported from Spain), and the brachonid *Apanteles* sp., imported from Yugoslavia. Parasites released during the year are indicated in table form.
All stands: 15; Eggs: 4; Generation: 1,7; Larvae: 4; Pupae: 3,4

400. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.

1972. **Annual Report. 1971–1972.** 25 p.
The Plant Laboratory continued its mass rearing program of gypsy moth parasites and recently acquired 10 new parasites from India and southern France, which are being reared in the laboratory. The collapse of the gypsy moth population continued; 40 percent of the acreage defoliated declined in population. In some cases, in the year following decline, parasites damped off resurgence of the gypsy moth. This damp-off extended to perimeter areas expected to be defoliated. Parasites in the damping-off process are *Apanteles melanoscelus, Sturmia scutellata,* and *Parasetigena agilis.* There are also stable areas averaging 20 to 200 egg masses per acre. The parasites that damp off the gypsy moth population each year are *A. melanoscelus, Compsilura concinnata, S. scutellata, P. agilis,* and *Ooencyrtes kuwanae.* There appears to be a level of gypsy moth population necessary to maintain parasites for equilibrium or stability; no data are given. Although there are no parasites which alone can suppress the gypsy moth population, they contribute importantly to the dissemination of the virus disease. Parasites that are associated with different stages of the gypsy moth outbreak are listed. Ten woodland plots and 17 suburban plots were set up to establish relationships between man and gypsy moth outbreaks. The data are being processed by the Northeast Forest Experiment Station at Hamden, Conn.
All stands: 15; Generation: 4

401. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.

1973. **Annual Report. 1972–1973.** 44 p.
The New Jersey Plant Laboratory has continued its mass rearing and release of native and imported parasites of the gypsy moth. Seven species of parasites and one predaceous beetle have become established in the state. Trends of parasitism appear to be related to different levels of the gypsy moth population. Parasites are host-density-dependent in stable populations and appear to be factors in maintaining stability following collapse of the gypsy moth population. *Brachymeria intermedia*

appears to be effective only in heavily defoliated areas where a great deal of sunlight penetrates the forest canopy. Data show *Ooencyrtus kuwanae* is host-density-dependent as related to egg mass size. The fewer the number of gypsy moth eggs per mass, the greater the percent rage of parasitism by *O. kuwanae*.
All stands; 15; Generation: 4

402. New Jersey Dep. Agric., Div. Plant Ind., Bur. Plant Lab.
1974. **Annual Report. 1973–1974.** 40 p.
Since 1963 there has been a program for rearing parasites of the gypsy moth and for evaluating their effectiveness in the field. Data are given on this work.
Generation: 4

403. New York State Dep. Farms and Markets, Bull. 148.
1922. **The gipsy moth, an imminent menace to the forest and shade trees of the State of New York: present status of the gipsy moth situation and discussions at a conference held in Albany, Nov. 16, 1922.**
The article includes a discussion of life history, means of spread, food plants, parasites, predators, and control measures.
Generation: 1,3,4; All stands: 15

404. Nichols, J. O.
1961. **The gypsy moth in Pennsylvania—its history and eradication.** Pa. Dep. Agric., Bull. 4404. 82 p. Harrisburg.
Most outbreaks of gypsy moth occur at irregular intervals (in about four out of seven or eight years) in older infested areas of New England. An undetected build-up over several years on Mt. Yeager, near White Haven in Luzerne County, Pa., exploded in 1957. Every tree within 30 acres was defoliated, with partial defoliation of an additional 100 acres. Five hundred trees in the area were dead the following year, 95 percent directly or indirectly as a result of the gypsy moth; 99 percent of these were oak and 87 percent chestnut oak. The result was a decrease in percentage of oak from 90 percent to 75 percent.
Oak stands: 20,25,27

405. Nichols, J. O.
1968. **Oak mortality in Pennsylvania—a ten-year study.** J. For. 66: 681–694.
Three types of tree injury are considered in this study: defoliation, frost damage, and drought. These types of damage rarely cause mortality in the stand, and drought appears to be the most innocuous of the three. However, a decrease in radial growth is noted in these types of damage. Mortality of trees is due mainly to *Agrilus bilineatus* (Web.). Severe defoliation reduces the crown structure of trees to epicormic shoots on the bole and large branches. If defoliation is reduced and the trees do not succumb to *Agrilus*, they may recover. However, a long time is required for the epicormic shoots to be replaced by a normal crown structure.
Oak stands: 15,16,18,21,24,25

406. Nielsen, J. C.
1918. **Tachinid studies** [in Danish]. Vidensk. Medd. Dan. Naturhist. Foren. 69: 247–262.

407. Nishigaya, J.
1918. **On the caterpillars of *Lymantria mathura* that appeared in abundance on the apple in 1918** [in Japanese]. Insect World 22: 13–20.

408. Nishiguchi, C.
1961. **Larvae of the gypsy moth and tannin** [in Japanese]. Nippon Rin Gakkai-Shi 43(3): 226–228.

409. Nolte, H.
1938. ***Calosoma sycophanta* as an enemy of the nun moth** [in German]. Anz. Schaedlingskd. 14(11): 129–132.

410. Nolte, H.
1940. **Can the ground beetle (*Calosoma sycophanta* L.) stop a pest plague?** [in German]. Forstwiss. Centralbl. 62(6): 135–138. (English transl. by U.S. Dep. Agric. For. Serv. Telecom GM-75-7040).
The life history of *Calosoma sycophanta* L. is given, with emphasis on the interaction of numbers of prey and predator. Under natural conditions neither *Calosoma* nor other enemies is able to force the collapse of an insect outbreak. In America, where they have been artificially introduced, the beetles have adapted and multiplied because sufficient food was available from the beginning.
Larvae: 3; Pupae: 3

411. Nonell y Comas, J.

1913. **Cork tree pests in the province of Gerona** [in Spanish]. Rev. Inst. Agric. Catalan S. Isidro, Barcelona 62(23): 355–358.

412. Nunberg, M.

1925. **Massive occurrence of the gypsy moth (*Lymantria dispar* L.) near Bochnia in 1924** [in Polish, German summary]. Pol. Pismo Entomol. 4(2): 118–133.

413. Oldiges, H.

1960. **Forest-floor fertilization and crown fauna** [in German, English summary]. Z. Angew. Entomol. 47(1): 57–60.

Tests in southern Germany in 1956 to 1959 on the effect of fertilizers applied to poor pine forest soils showed an increased mortality of *Dendrolimus pini* (L.) and *Panolis flammea* (Schiff.) when nitrogen was applied in the form of salt or ammonia gas. There was no increase in mortality of *Lymantria dispar* (L.) in beech or oak forests given similar treatment earlier in the same year. Evidently it was still too early for the treatments to have had an effect, since deeply rooted deciduous trees take longer to absorb the required amount of mineral fertilizer than pines

Oak stands: 15, 19, 23; Larvae: 13

414. O'Kane, W. C.

1922. **Division of insect suppression, plan and progress of work 1921–1922.** New Hampshire Dep. Agric., Div. Insect Suppression Circ. 15. 24 p.

Schedius kuvanae was unsuccessful as an imported parasite in New Hampshire owing to cold winters. However, *Anastatus bifasciatus* and *Apanteles melanoscelus* have become widely spread since importation.

Instars I-III: 4; Generation: 4

415. Operman, F.

1927. **Some notes on the gypsy moth (*Lymantria dispar* L.)** [in Serbo-Croatian, German summary]. Zagreb Sveuc. Zavod Sum. Pokuse. Glas Sum. Poluse 2:95–99.

416. Orlovskaya, E. V.

1961. **Research with polyhedrosis virus for control of the gypsy moth** [in Russian]. Byull. Vses. Nauchno-izsled. Inst. Zashch. Rast. 3-4: 54–57.

417. Orlovskaya, F. V.

1962. **Prospects for the use of viruses against insect pests [in Russian].** Zashch. Rast. Vred. Bolezn. 10: 20–23.

418. Orlovskaya, E. V.

1962. **Use of an experimental strain of nuclear polyhedrosis virus for creating epizootics in populations of the gypsy moth (*Porthetria dispar*)** [in Russian]. Vopr. Ekol. Kievsk. Univ. 8: 87–88.

419. Orlovskaya, Y. V.

1968. **Geographical distribution and manifestation of viral diseses in dendrophilous insect pests in the USSR.** Entomol. Rev. (English transl. Entomol. Obozr.) 47(4): 455–463.

A survey of viruses affecting insect pests in the USSR found 37 species affected by nuclear polyhedrosis viruses, 4 species of Lepidoptera and 1 of Coleoptera affected by cytoplasmic viruses, and 2 species of Lepidoptera affected by granulosis viruses. Nuclear polyhedrosis viruses sometimes cause total lysis or severe tissue damage, as is the case in epizootics. In nonepizootics, only small sections of tissue of the dead larvae are infected. During viral epizootics other pathogens are often encountered as well, or more than one type of virus may occur. The gypsy moth is affected by *Borrelinavirus reprimens* Holms., which was found in conjunction with microsporidiosis in all but one of the sites observed. External symptoms of virus usually appear a few hours before death: The larvae appear sluggish, softer, and relatively immobile, but without a color change in the integument. The internal contents of a newly dead gypsy moth are usually coffee-colored. In one of the observed sites, the gypsy moth hardly occurred for 7 years following an acute epizootic. Different species of insects are affected by the virus at different life stages. Viruses affecting one species of insect will not necessarily affect another, even if they exist in very close proximity.

Larvae: 7,8

420. Paillot, A.

1916. **The coccobacillus of the cockchafer: Its pathogenic action on some caterpillars of the macrolepidoptera** [in French]. C. R. Hebd. Seances Mem. Soc. Biol. Ses. Fil. 79(20): 1102–1103.

421. Paillot, A.
1917. **New parasitic microbes of larvae of** ***Lymantria dispar*** [in French]. C. R. Hebd. Seances Acad. Sci. 164(13): 525–527.

422. Paillot, A.
1917. **New microbe parasites of the cockchafer: their pathogenic action on the larvae of *Vanessa urticae, Lymantria dispar* and on silkworms** [in French]. C. R. Hebd. Seance Mem. Soc. Biol. Ses. Fil. 80(2): 56–58.

423. Paillot, A.
1919. **Contribution to the study of microbial parasites of insects: study of *Bacillus hoplosternus* (Paillot)** [in French]. Ann. Inst. Pasteur, Paris 33(6): 403–419.

424. Pantyukhov, G. A.
1962. **The effect of positive temperatures on different geographic populations of the European gold tail (*Euproctis chrysorrhea* L.) and the gypsy moth (*Lymantria dispar* L. — Lepidoptera: Orgyidae).** Entomol. Rev. [English trans. Entomol. Obozr.] 41: 169–175.

In the active phases of the life cycle of the gypsy moth, the rate and period of development in relation to temperature, lower thresholds, totals of effective temperatures, and optimum temperatures are almost identical irrespective of geographic location. Physiological indices are also identical.
Generation: 12,13

425. Pantyukhov, G. A.
1964. **The effect of low temperatures on different populations of the brown-tail moth, *Euproctis chrysorrhoea* L., and the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Orgyidae).** Entomol. Rev. (English transl. Entomol. Obozr.) 43: 47–55.

Susceptibility of gypsy moth eggs to cold during diapause is dependent on the climate of the area where the eggs are laid. In northern regions, the eggs contain more fats and carbohydrates, depressing the freezing point of the liquids in the egg. Differences in gypsy moth populations with respect to susceptibility of eggs to cold are completely physiological. Before and after diapause the individuals are identical. These physiological differences might, however, be the beginning of intraspecific differentiation.
Eggs: 12,13

426. Parker, D. L.
1933. **The interrelations of two hymenopterous egg parasites of the gipsy moth, with notes on the larval instars of each.** J. Agric. Res. 46: 23–34.

Tests were designed to show interrelations in the population dynamics of two gypsy moth egg parasites. It was concluded that it is advantageous to have both parasites in the same locality, as there is little serious competition between them. Because *Anastatus disparis* adults are probably more numerous at the time of deposition of host eggs, the potential for competion is greater when *Anastatus* attacks first and *Ooencyrtus kuvanae* then attempts to reproduce in the same gypsy moth egg. *Anastatus* does not suffer from these attacks. When *Anastatus* attacks a gypsy moth egg containing *Ooencyrtus* in the egg stage, the *Anastatus* develops. When *Ooencyrtus* is in the larval or pupal stage and the host egg is attacked, neither parasite develops. *O. kuvanae* hibernates in forest debris as an adult female, emerges in the first warm days of April, and oviposits later in the month. This first generation develops in 6 weeks, and the adults emerge in late May. A second generation emerges in early July and a third develops in 3 weeks on newly deposited gypsy moth eggs, emerging in August. There is time for four with a partal fifth generation in New England, but there are large losses over winter and many parasites in the early spring generations are oviposited into infertile and dead host eggs. Thus *O. kuvanae* is not considered as well suited to the gypsy moth life cycle as is the univoltine *A. disparis,* which overwinters in the host egg as a full-fed larva and emerges at the time of maximum gypsy moth oviposition in July. It develops from egg to mature larva in 12 to 15 days. It was found in the course of the investigations that both of these parasites have five larval instars, not three as was previously thought.
Eggs: 4

427. Parrott, P. J.
1913. **New destructive insects in New York.** J. Econ. Entomol. 6: 61–68.

The gypsy moth was first discovered in New York by W. J. Schoene of the Geneva Experiment Station on June 22, 1912. The infestation was believed to be no more than 3 years old and to have started from one egg mass, probably brought in on nursery stock. The infestation was confined to

a few old apple trees in a residential section. The New York Department of Agriculture spared no effort to exterminate the insect, which people were surprised to find in the western part of the state and not in the region adjoining Massachusetts.
Non-oak stands: 15

428. Patočka, J. and M. Čapek.
1971. **Population changes of certain oak defoliators (Lepidoptera) in Slovakia.** Acta Inst. For. Zvolen. 1971: 461-485.
In Slovakia, outbreaks originate from foci located in areas of high-quality food. Young larvae are especially sensitive to food quality. As an outbreak progresses, however, the population expands to less favored habitats. The initiation of an outbreak depends on the absence of a cold weather spell in mid-May, which usually occurs in Slovakia. *Calosoma sycophanta* population density depends on gypsy moth population density. During the innocuous phase of the gypsy moth population, *C. sycophanta* is very rare. The following parasites are always present, but appear to have little effect on the gypsy moth population density: *Apanteles solitarius, Compsilura concinnata, Parasetigena silvestris,* and *Sturmia scutellata.* Collapse of severe outbreaks is usually dependent on the virus *Borrelina reprimens* and the microsporidia *Nosema lymantriae.*
Generation: 1,7,8,12; Larvae: 3,4

429. Patočka, J.
1973. **Influence of food and location on the mortality of some injurious Lepidoptera living on oak** [in German, English summary]. Vest. Cesk. Spol. Zool. 37(4): 282-292.
"By field experiments, it was proved that the kind and quality of food and the character of the community have a significant influence on the mortality of several oak pests of the order Lepidoptera."
Generation: 12

430. Patterson, T. L.
1911. **Technical results from the gipsy moth parasite laboratory: III. Investigations into the habits of certain Sarcophagidae.** U.S. Dep. Agric., Tech. Ser. 19: 25-32.
Since species of Sarcophagidae were known to be primary parasites of grasshoppers and numerous species of Sarcophagidae had been reared in association with the gypsy moth, there was a question of whether they were purely scavengers on dead gypsy moth larvae or whether they were parasitic, causing the death of the larvae. It was found that female Sarcophagidae would not oviposit in freshly killed material, whereas they would in older, decomposing larvae, thus refuting the parasite theory. When larvae had been dead for 2 days, the female would crawl all over, make buzzing noises with her wings, puncture decaying skin several sections behind the head with her proboscis, and move her ovipositor directly over the puncture. She would larviposit, and the maggot would work its way into the body. Gypsy moth larvae, therefore, must be at a stage at which there is already an incision in the skin, or one could easily be made with the proboscis. No sarcophagids were reared from 2666 living gypsy moth larvae collected in the field, indicating conclusively that sarcophagids in New England were not parasitic on gypsy moth larvae. Also, no first-stage maggots developed when placed artificially within living pupae. Sarcophagids were more commonly associated with the gypsy moth in Europe and Japan. It is possible there are several parasitic species there.
Generation: 13; Larvae: 4; Pupae: 4

431. Pawlowicz, J.
1936. **Observations on some hymenopterans and dipterans parasitizing *Porthetria dispar* L., *Malacosoma neustria* L. and *Stilpnotia salicis* L. (Lep.)** [in German]. Zool. Pol. 1(2): 99-118.

432. Petre, Z.
1965. **Contributions to the study of an aspect of the polyhedrosis virus of *Lymantria dispar* L.** [in Romanian]. Stud. Cercet. Bidh. Ser. Bot. 17(3): 339-347.

433. Piatnicky, G. K.
1935. **Factors causing and controlling a mass increase of gypsy moth in Crimea** [in Russian, English summary]. Vopr. Ekol. Biolsenol. 2: 100-119.
Close observation of neglected forests, especially of hornbeam and curly oak, can give early indications of the gypsy moth outbreaks in the Crimea. Outbreaks begin rapidly (within 1 to 2 years), spreading over mountainous and submountainous regions, but not above an altitude of 600 to 800 m because of weather conditions. Distribution of gypsy moths over the outbreak region is predictable owing to their xerophylous nature: They increase in young, thin, uniform plantations and on

southern mountain slopes. The climax of the propagation usually occurs in the second or third year of the outbreak, followed the next year by a territorial shifting and a general reduction in area. This can be predicted: niduses of the following year are formed in, and practically coincide with, the borders of plantations where less than 50 percent of the foliage was injured the preceding year and which had no fewer than one larva per tree. Not more than one-half this number will form dense niduses. Control of the gypsy moth in the Crimea should be sought by maintaining mature, dense woods, planting nonpreferred species, locating and destroying small niduses, and using aviochemical methods.
Generation: 2,12

434. Picard, F.
1921. **The gypsy moth (*Lymantria dispar*)** [in French]. Prog. Agric. Vitic. 76(33): 160-165.

435. Picard, F., and G. R. Blanc.
1913. **Coccobacilli infections in insects** [in French]. C. R. Hebd. Seances Acad. Sci. 157(1): 79-81.

436. Picardi, A. C.
1973. **Gypsy moth population simulation: system postulation, validation, analysis.** Proc. 1973 Summer Computer Simulation Conf., Montreal. 73 CH0815-1 SMC: 1069-1074.
"This paper presents the results of a simulation and policy analysis of gypsy moth population dynamics. The case study affords an opportunity for some methodological observations on model postulation, validation, and selection of a simulation language for the particular system presented. Policy simulations showed [that] gypsy moth pheromones [are] effective in eliminating the pest in low-density areas and that nonpersistent sprays could be useful in reducing high-density populations to the levels at which pheromones would be effective."
Eggs: 4; Generation: 2; Instars I-III: 1,6; Instars IV-VI: 6; Larvae: 9,10; Pupae: 3,4; Sex ratio: 6

437. Pictet, A.
1919. **Experimental research on the adaptation of *Lymantria dispar* to conifers and to other varieties of trees** [in French]. Mitt. Schweiz. Entomol. Ges. 13(1): 20-54.

438. Podgwaite, J. D., and R. W. Campbell.
1970. **Disease in natural gypsy moth populations** Pages 279-284 *in* 4th Int. Colloq. Insect Pathol., College Park, Md.
"Diseased larvae of the gypsy moth *Porthetria dispar* (L.) from both sparse and dense populations were examined and categorizes on the basis of mortality factors. A significantly higher incidence of parasitoids, few bacterial pathogens, and the virtual nonexistence of polyhedral viruses were noted in the relatively stable sparse populations. Nuclear polyhedorsis probably represented the primary mortality factor in the dense populations, while pathogenic bacteria played a lesser role. Many insects examined from both population types revealed no infectious agent or overt cause of disease, a fact that may implicate noninfectious disease as a regulator in natural populations."
Larvae: 4,5,6,7,8

439. Podgwaite, J. D., and R. W. Campbell.
1972. **The disease complex of the gypsy moth.** II. Aerobic bacterial pathogens. J. Invert. Pathol. 20: 303-308.
"Eighty-six pathogenic aerobic bacterial isolates from diseased gypsy moth larvae collected in both sparse and dense populations were characterized and identified as members of the families Baccillaceae, Enterobacteriaceae, Lactobacillaceae, Pseudomonadaceae, and Achromobacteraceae. The commonest pathogens were *Streptococcus faecalis, Bacillus cereus, Bacillus thuringiensis,* Group C *Enterobacter* types, and *Pseudomonas* spp. However, *S. faecalis* and *B. cereus* were found operating only in the dense populations. The wide range of potentially pathogenic bacteria encountered may indicate that under conditions of high host density these bacteria may contribute significantly to the population dynamics of the gypsy moth."
Generation: 2; Larvae: 5

440. Prell, H.
1925. **On *Apanteles solitarisu* Ratz. as a parasite of nun moth larvae** [in German]. Anz. Schaedlingskd. 1(9): 103-105.

441. Proper, A. B.
1934. **Hyperparasitism in the case of some introduced lepidopterous tree defoliators.** J. Agric. Res. 48: 359-376.

Hyperparasites of the gypsy moth, the brown-tail moth, the oriental moth, and the satin moth play a major role in reducing the numbers of primary parasites. An average of almost one third of the cocoons and puparia are destroyed by them. In almost every case, each primary parasite has one species of secondary parasite that is far more abundant than any other. Parasitism of the cocoons of *Apanteles melanoscelus* was found to be 32.5 percent in the first generation and 84.4 percent in the second, with *Eurytoma appendigaster* (Swederus) the most abundant parasite. Depending on the primary host of *Compsilura concinnata* Meigen, hyperparasite relationships differ; the gypsy moth is hyperparasitized chiefly by *Dibrachys boucheanus*. *Brachymeria compsilurae* was found responsible for most of the 11 percent of paraistism of *Sturmia scutellate*, which is practically a specific parasite of the gypsy moth in New England. It lays eggs on the foliage where they are eaten by fourth-instar larvae.

Instars I–III: 4; Instars IV–VI: 4

442. Prüffer, J.
1923/24. **Observations and experiments on the sex manifestations of *Porthetria dispar* L.** [in Polish]. Rozpr. Wydz. Mat. Przyr. Pol. Akad. Umiejet. Ser. III. 23/24(A/B): 97–106.

443. Prüffer, J.
1937. **Further investigation on the male lure of *Lymantria dispar* L. (Lep.)** [in German]. Zool. Pol. 2(1): 43–66.

444. Pschorn-Walcher, H.
1964. **On the parasites of some injurious Lepidoptera from northern Japan.** Tech. Bull. Commonw. Inst. Biol. Control 4: 24–37.

A severe outbreak of gypsy moth was recorded in 1961 in the Tachikawa Forest District. Defoliation occurred exclusively in young larch plantations. One thousand each of larvae and pupae were collected for a parasite survey. *Apanteles liparidis* Bé. was the most numerous parasite. *Pimpla disparis* Vier. was the only other Hymenoptera encountered. *Brachymeria fiskei* Crawf. was also found, but it is believed usually to hyperparasitize tachinids. The tachinids *Exorista japonica* T. T., which is the Oriental counterpart of the European *E. larvarum*, and *Eucarcelia separata* Rond. were found. Both are very polyphagous. *E. separata* is also an important parasite in Yugoslavia. Larvae of a sarcophagid fly were quite abundant, but it was not ascertained whether they were primary parasites or whether they attacked cadavers of virus-killed larvae.

Generation: 4; Non-oak stands: 15

445. Rao, V. P.
1966. **Survey for natural enemies of gypsy moth.** PI 480: Project No. A7-FS-8, Grant No. FG-In 112. Commonw. Inst. Biol. Control, Bangalore, India. 50 p.

Lymantria obfuscata Walker occurs in the states of Assam, Himachal Pradesh, and Jammu and Kashmir in northern India. *L. dispar* does not occur in India. Illustrations are given comparing the external morphology of the adults and chaetotaxy of the larvae of these two species. The life history and morphology of *L. obfuscata* are described in detail, and much information is given on its natural enemies. *Anastatus* spp. parasitized up to 25 percent of the eggs of *L. obfuscata* in some places. *Apanteles* sp. (possibly new) and *A.* sp. nr. *conspersae* parasitized 25 to 30 percent of larvae in certain locales. In Sprinagar *A. liparidis* was reared from early instar larvae as a solitary parasite, whereas at Kotgarh it was gregarious and parasitized later-instar larvae. *Rogas* sp. controlled the population of instars II and III at Kulu. *Exorista rossica* Mesnil, *Drino discreta* Wwp., *Compsilura concinnata* Meigen, and *Ctenophorocera caerulea* Jaenn. Sub. sp. *maculisquama* were predominant among the Tachinidae which parasitized 15 to 25 percent of later-instar larvae annually. *Brachymeria euploeae* (Westwood) and *B. intermedia* were the most important pupal parasites, followed by *Pimpla* sp. and *Theronia* sp. The egg predators *Anthrenus* sp. probably *museorum* and *Orphinus* spp. were unimportant as control agents, but *Calosoma himalayanum*, *Campalita auropunctatus*, and *Craspedonotus himalayanum* were active against full-grown larvae. *Streptococcus*, nuclear polyhedrosis virus, *Bacillus* sp., *Alcaligenes* sp., *Brevibacter*, and *Aeromonas* sp., were isolated from diseased larvae. Diseases caused 10 to 25 percent larval mortality, with an increase in virus disease the last two years of the study.

Eggs: 3,4; Instars I–III: 4; Instars IV–VI: 3,4; Larvae: 5,6,7; Pupae: 4

446. Rao, V. P.

1972. **Evaluation of hymenopterous parasites of the gypsy moth and study of the behavior of promising species.** PL. 480: Project No. A7-FS-F1, Grant No. FG-In-304. Commonw. Inst. Biol. Control, Bangalore, India. 44 p.

Serological tests proved that *Lymantria dispar*, *L. obfuscata*, and *L. ampla* are different species. Parasites of *L. obfuscata*, the Indian gypsy moth, were evaluated for potential use in controlling *L. dispar* in the United States. *Exorista rossica* Mesnil and a possibly new species of *Apanteles* were considered the most valuable for this purpose.

Generation: 4,13

447. Reardon, R. C.

1970. **A new species of *Rogas* parasitic on the gypsy moth, *Porthetria* dispar (Hymenoptera: Braconidae).** Proc. Entomol. Soc. Wash. 72(4): 473–475.

Rogas indiscretus n.sp. is described (U. S. National Museum type no. 70842). It is an important parasite attacking early-instar larvae of *Lymantria obfuscata* Walker in the northeastern part of the Punjab, India. It was first reared on gypsy moth larvae in 1967 and released the following year. Initial recovery attempts from the release points in Connecticut and Massachusetts were unsuccessful in 1969.

Instars I–III: 4, 13

448. Reardon, R. C., M. W. Statler, and W. H. McLane.

1973. **Rearing techniques and biology of five gypsy moth parasites.** Environ. Entomol. 2: 124–127.

Biological data on five parasites of the gypsy moth are given: *Exorista rossica* Mesnil, tachinid from Kashmir, India; *Rogas indiscretus* Reardon, braconid also from India; *E. segregata* (Rondani) and *Apanteles porthetriae* Muesebeck, from Spain; and *A. melanoscelus* (Ratzeburg).The Indian species were reared from *Lymantria obfuscata*.

E. rossica parasitizes 15 to 25 percent of host larvae in Kashmir, completing three generations per year. Adults emerge at the beginning of May; the second generation begins in early June and the third in early July. One to three eggs per healthy host are laid in the thoracic region. Eggs are laid over a 25-day period, with a total of 250. A few mature host larvae or prepupae are parasitized. In the laboratory about one half as many eggs are laid; fourth and fifth instars are preferred. Parasite puparia are produced in 20 percent of host larvae if one egg is laid, 40 percent if two, 50 percent if three, 67 per1cent if four, and 71 percent if five eggs are laid on the host. In the field, *E. rossica* needs an alternate host for overwintering.

E. segregata is an important parasite in southern Europe, and *E. lavarum* is common in central Europe (also established in New England). All are successful parasites in their native habitats, which are quite different. Their behavior is similar to *E. rossica*. *R. indiscretus* attacks early instars of *L. obfuscata* in northeast India, parasitizing about 25 percent. Adults are in the field from May to June. The parasites form cocoons within mummified host larvae cadavers; they are abundant and obvious in mid-May. A high proportion of cocoons diapause over winter and emerge in spring. *R.indiscretus* attacks larvae somewhat later than *Apanteles* and earlier than *E. lavarum*. In the laboratory, one female *A. melanoscelus* parasitized an average of 15 larvae per day for a total of 75 cocoons produced. Information is given on laboratory biology.

A. porthetriae is a common solitary parasite throughout Europe. It is very numerous in large, open-grown oaks of south and central Europe and attacks early instars. It has been reared from *L. obfuscata* in India. There were many early attempts to establish it in the United States. It has a very similar biology to *A. melanoscelus*, except that it does not diapause as a pupa and therefore needs an alternate host.

Instars I–III:4,12; Instars IV–VI: 4,12

449. Reardon, R. C.

1973. **A survey for tachinid parasitoids of the gypsy moth on Cape Cod, Massachusetts.** Environ. Entomol. 2: 964–965.

Gypsy moth larvae were collected on five 1-acre plots and maintained in a laboratory. Parasite activity for the area was estimated from the parasites that emerged from the larvae. In 1970 and 1971, *Parasetigena agilis* (Robineau-Desvoidy) averaged 72 percent and 67 percent of the total parasitism, respectively. *Compsilura concinnata* (Meigen) and *Blepharipa scutellata* (Robineau-Desvoidy) comprised of 28 percent and 33 percent for 1970 and 1971, respectively. *Exorista rossica* Mesnil and *E. segregata* (Rondani) are two exotic species released in 1968, 1969, and 1970. *E.*

larvarum (L.) is also an exotic species previously released. These three species of tachinids were not recovered in the experiment.
Instars IV–VI: 4

450. Reiff, W.
1911. **The "wild disease," or "flacherie" of the gypsy moth.** Wright and Potter Printing Co., Boston. 60 p.

This is a report of early experiments on the gypsy moth wilt disease as well as a review of other larval diseases, including diarrhea, bead disease, muscardine, and pebrine. The influence of flacherie (wilt disease) on gypsy moth larvae depends on the manner and time of its appearance. There does not seem to be a difference in effect between a natural outbreak and artificially developed flacherie. Female larvae succumb to the disease more readily than males, perhaps because of their longer maturation period. Wilt causes females to lay very small egg clusters containing incompletely developed embryos. A high percentage of dead eggs are found in flacherie-infected areas. The author suggests that the disease may be passed transovarially, which means that the embryos are killed as a result of the organism itself and not as a result of the weak constitution of the female moth. The still-living embryos of the cluster then become carriers, and succumb to the disease at some point in the larval stage. The author recommends artificially introducing flacherie as a means of controlling the gypsy moth.
Larvae: 6,7,8; Sex ratio: 6

451. Rexrode, C. O.
1971. **Insect damage to oaks.** Pages 129–134 *in* Oak Symp. Proc. U.S. Dep. Agric. For. Serv., Northeast. For. Exp. Stn., Upper Darby, Pa.

Defoliation is a serious threat to oaks at this time. Continuous moderate defoliation of 1 year of heavy defoliation does not kill trees. Two consecutive years of 60 to 100 percent defoliation will cause mortality. Mortality is often not the direct result of defoliation but the result of borers and fungi which attack after the tree is weakened by defoliation.
Oak Stands: 15,25

452. Richerson, J. V., and E. A. Cameron.
1974. **Differences in pheromone release and sexual behavior between laboratory-reared and wild gypsy moth adults.** Environ. Entomol. 3: 475–481.

"Wild female *Porthetria dispar* adults emitted attractant at any time of day but made a maximal release between 1000–1530 h. Pheromone emission is greatest during the first 3 days of a virgin female's adult life and after the third day decreases until death. Wild females emit a burst of pheromone, as much as 841 ng/30 min, once in their life, usually on the second or third day. After the burst, the amount of lure emitted decreases rapidly. Unlike wild females, laboratory-reared (lab) females show no diel periodicity in pheromone emission, and release very small amounts of pheromone (4.9 ng/30 min). Laboratory and field bioassays indicated that approximately 30 percent of both sexes of lab moths either did not respond to pheromone or released no detectable amount of lure, compared with 9 percent sexual inactivity in wild moths."
Adults: 1,13

453. Richerson, J. V., E. A. Brown, and E. A. Cameron.
1976. **Pre-mating sexual activity of gypsy moth males in small plot field tests (*Lymantria (Porthetria) dispar* (L): Lymantriidae).** Can. Entomol. 108: 439–448.

"Pre-mating behavior of male gypsy moths was investigated in 0.2 ha circular plots containing from 0 to 72 virgin females/plot in untreated areas and in areas treated with an aerial application of 20 g/ha microencapsulated disparlure. Male moths in both treated and untreated plots oriented initially to trees, not directly to females. Mating was disrupted in treated plots but males continued search behavior. No anemotactic behavior was evident in either treated plots or untreated plots with females. In untreated plots, male moths were not caught on sticky panels (panels suspended at 2, 4, and 6 m) higher than pheromone-baited traps set at 2 m. In treated plots, equal number of males were caught at all panel heights and in baited traps at 2 m. Previous mating and pheromone exposure histories of males did not affect the response of these males to traps baited with 4-5 mg of disparlure in untreated plots. In a test of the relative attractiveness of a cotton wick and a new laminated bait dispenser in Johnson traps, traps baited with the laminated dispenser had a greater male moth catch/male contact to trap than the traps baited with the cotton wick. Not all males contacting the Johnson trap were caught. A mode of action for disparlure as a disruptive agent in the long-range sexual communication system of gypsy moth is proposed."

Adults: 1

454. Richerson, J. V., E. A. Cameron, and E. A. Brown.
1976. **Sexual activity of the gypsy moth.** Am. Midl. Nat. 95(2): 299-312.

"Female moths that had begun to deposit unfertilized eggs (spewing females) did attract males and were mated. However, only females that had spewed fewer than 10 eggs before mating were likely to deposit fertile eggs after mating. Males in a natural infestation did not discriminate between mated, virgin, spewing and nonspewing females. Both sexes of the gypsy moth were capable fo mating several times in 24 hours. About one third of the males in a dense population were mating with previously mated females. In the microencapsulated, disparlure-treated plots, only 1- to 4-day-old females were mated. In untreated plots, 1- to 8-day-old females were mated. Furthermore, fewer females tethered in the litter in the treated plots were mated than those females tethered in the litter in control plots. The disparlure treatment reduced the incidence of mating. In treated plots, more females tethered on the tree at 2 m were mated than females tethered in the litter. Videotaped activity of males in a dense population revealed that male orient to vertical silhouettes initially, and not to specific pheromone sources."

Adults: 1

455. Romanyk, N.
1958. **The treatment and the parasitism of *Lymantria dispar* in the oaks of Salamanca** [in Spanish]. Bol. Serv. Plagas For. 1(1): 27-32.

This discussion concerns the gypsy moth outbreak of 1955-57 in Salamanca and the combined effect of chemicals and parasites as control mechanisms. The outbreak began in scattered foci observed for the first time in 1952. It spread rapidly and in 1956 involved more than 100,000 hectares between pure *Quercus ilex* forests and mixed oak woodlands. Chemical dusts were used, but owing to economic constraints the treated areas were limited and total annihilation was not achieved. In the spring of 1957, three zones could be delineated: (1) zone without treatment, with outbreak conditions; (2) zone treated in 1956 with light reinfection; and (3) zone treated in 1955, reinfected but without reaching outbreak characteristics. In 1955 few parasites were observed; in 1956 *Apanteles vitripennis, Compsilura concinnata, Tricolyga grandis,* and a smaller number of *Brachymeria intermedia* were observed; in 1957—with up to 800 and more egg clusters per tree—there was still relatively little parasitism of eggs but more than 90 percent mortality of larvae and pupae. Larval mortality was attributed to *A. vitripennis* since their cocoons were observed on all trees. Pupal mortality was due to *B. intermedia* (32.5 percent), *Monodontomerus aereus* (52.5 percent), and tachinids (6 percent). The parasitism had the same characteristics in treated and untreated zones, demonstrating that treatments with dust are not so dangerous for parasite fauna as would be expected. The chemical treatments normally end before *L. dispar* larvae reach 2 cm and, with the exception of *Apanteles,* all the parasites enumerated above attack their host at a later stage. As a consequence of the parasites and the treatments, the *L. dispar* outbreak entered a regressive phase, disappearing completely in many places and remaining strong only in a few foci.

Oak Stands: 15; Eggs: 4; Larvae 4,12; Pupae: 4

456. Romanyk, N.
1960. **A new focus of *Lymantria dispar* L. in the oak forest of Toledo y Avila** [in Spanish]. Bol. Serv. Plagas For. 3: 41-46.

457. Romanyk, N. and A. Ruperez.
1960 **Principal parasites observed in the defoliators of Spain with particular attention to *Lymantria dispar* L.** [in Spanish, French summary]. Entomophaga 5(3): 229-236.

458. Romanyk, N.

1965. **The study of parasites, predators, and diseases of the gypsy moth (*Lymantria dispar*) and the possibility of their application in biological control.** Final Technical Report, Project No. E-25-FS-10, Grant No. FG-Sp-106-60. Servicio de Plagas Forestales, Madrid, Spain. 65 p.

A study was conducted from 1960 to 1965 on the parasitology and pathology of the gypsy moth, with special attention to parasites in Spain, that do not exist in the United States. The gypsy moth is a principal defoliator in Spain, especially of *Quercus ilex* (evergreen oak) and *Q. suber* (cork oak), both of which occupy large areas. *Q. ilex* is treated as a fruit tree (acorns are used for cattle feed), and its stands do not resemble forests. The plantation floor is pasture or cultivated. Intensive defoliation lasts 2 to 4 years, with a loss in productivity but with no mortality. The egg parasite *Anastatus disparis* is native to Spain, has one generation per year, and parasitizes only freshly laid eggs before the larvae are formed. In this study, there was 9.2 percent parasitism by *A. disparis*. *Ooencyrtus kuwanae* How. has several generations per year, prefers mature eggs with formed embryos, parasitizes only the upper layer of the egg cluster, and prefers eggs not covered with hairs. It will reproduce and live in a sterile gypsy moth egg. Its optimum fecundity is 200 eggs, and it will parasitize 15 to 20 percent of larvae. *Carabus gongoleti* Reiche was considered an important predator in the 1922-1923 outbreak but now is insignificant. *Calosoma sycophanta* is valuable. Its development is delayed with respect to the gypsy moth gradation, and thus it does not prevent outbreaks. At least 1.5 percent of pupae in all foci were attacked by dipteran scavengers during the first 4 years of the study, and more than 4 percent were attacked in 1964, especially by *Agria affinis* Fall. as well as by *Sarcophaga uliginosa* Kram., *S. tuberosa* Pand., and *Sarcophaga*, sp. The most important larval parasite, *Tricholyga segregata* Rond., was also found in a 1913-1936 study and identified as *T. grandis*, It has many hosts, overwinters in puparia in soil, and emerges when the gypsy moth is in its last instar. Generally, it lays one egg per larva and has perhaps two generations per year. Its fecundity varies from 270 to 620, probably as a result of feeding conditions in the larval state. *T. grandis* parasitizes 13 to 35 percent of gypsy moth larvae and needs a Mediterranean climate.

Exorista larvarum (Tachinidae), resembles *T. segregata* and emerges from pupae at the same time. It constitutes usually 5 percent of the total and causes 1.5 to 3 percent of the parasitism. *Hemipenthis morio* L. (Bombylliidae) is an ectohyperparasite on the overwintering pupae of both tachinids, killing about 90 percent during two years of the study. Hyperparasitism on Diptera pupae is generally high. *Brachymeria intermedia* Nees. is polyphagous and widespread in Europe and North Africa. It has at least two generations per year on different hosts. It overwinters as an adult, its size depending on the size of the host. It will oviposit only on pupae 2 to 4 days old, which are not completely hardened. Parasitized pupae then dry up. *B. intermedia* shows no preference for one sex over the other and has no regular hyperparasites. Its range is from 13.9 to 65.2 percent parasitism, with a mean of 31.8 percent. Lows for *B. intermedia* and *T. segregata* were from the same area in 1962 when there were great storms.

Apanteles vitripennis Hal. is widely distributed in Spain. It oviposits on the dorsal thorax in any of the early instars, preferring instar II. In the field, larvae develop in 12 to 20 days, bore out the ventral or lateral side, and make cocoons attached between the thoracic and abdominal legs of the gypsy moth. The gypsy moth larvae then move to shaded locations under leaves or on bark and die in a few days. There are two generations per year in Spain with one egg per gypsy moth larva. Even when only a small number of gypsy moth larvae is exposed to them, *Apanteles*, for unknown reasons, will not parasitize them all. Parasitism varies greatly within a focus, averaging out to a low 10 percent. *Apanteles* pupae are hyperparasitized in low numbers by *Hemiteles longicauda* Ths. and *Eurytoma verticillata* Fob. *A. vitripennis* is the most important species of the genus in Spain. During this study, there was no instance of significant parasitism by other *Apanteles* or by *Meteorus versicolor* Wesrn., perhaps because some *Apanteles* need an alternate larval host for overwintering and the other *Q. ilex* defoliators also overwinter as eggs. *Pimpla instigator* F. destroyed more than 20 percent of pupae in an isolated case on Menorca Island; otherwise they are rare. Unfavorable weather conditions are felt more by the parasite than by the host. In the study area, parasites were generally active, but defoliation was heavy, especially in the last three years.

In general, parasitology is not a sufficient natural control. Observations over five years show that microbial enemies have been important only in isolated cases. *Nosema lymantria* Weiser, *N. muscularis* Weiser, and *Plistophora schubergi* Zwolfer are protozoans pathogenic to gypsy moth. They appear spontaneously in instars IV and V, causing a reaction in the gypsy moth, that increased logarithmically with respect to dose and size. In the laboratory, spores were ingested with food and germinated. The new form migrated to body interior, affixed to specific tissue, and sporulated. The spore stage can resist great temperature and humidity change but is very sensitive to ultaviolet light. The nonspore stage is very delicate and susceptible to adverse weather conditions. No clear relationship was found between ingested dose of virus and disease production.

There was no epizootic in the field during the study. Fungi are not of utilizable pathogenicity. Bacteria behave logarithmically vis-à-vis dose ingested and animal size. Toxins affect nervous centers and cause paralysis. Spores germinate, migrate across the intestinal wall, reproduce, sporulate, and release septicemin which causes death. Toxic pathogenicity varies with strain. *Bacillus entomocidus* var. *subtoxicus, B. thuringiensis* Sotto, *B. thur.* (Vankova) *IHA, B. thur.* Galenae (Russian) *HA-3,* and *B. cereus* are effective against the gypsy moth. Their activity is proportional to pH, increasing with acidity.

Oak Stands: 15,25; Eggs: 4; Instars I-III: 4; Instars IV-VI: 4; Larvae 5,7,8; Pupae: 3,4

459. Romanyk, N.

1966. Natural enemies of *Lymantria dispar* L. in Spain [in Spanish, English summary]. Bol. Serv. Plagas For. 9(18): 157-163.

"From 1959 to 1965 studies were done on the foci of the *Lymantria dispar* L. existing in Spain, in connection with the natural enemies of this defoliator . . . Among the first-instar larvae parasites, the following stand out: *Anastatus disparis* Ruschka and *Ooencyrtus kuwanae* How. The average percentage of parasitized eggs was 9.2 percent for the first and 15 to 20 percent for the second. Among the last-instar larvae parasites, *Apanteles vitripennis* Hal. stands out with 7 to 14 percent of parasitized caterpillars. A mortality rate of 16 to 30 percent was observed among the last-instar larvae as result of *Tricholyga segregata* Rond. and *Exorista larvarum* L. parasitism. Finally, the *L. dispar* L. pupae suffered a parasitism between 20 percent and 62.5 percent, depending on the years, by *Brachymeria intermedia* Nees. Among the predators, *Calosoma sycophanta* was especially noted for its abundance."

Studies were carried out on the possibility of rearing and reproducing some parasites in the laboratory. "Protozoa, fungi, bacteria, and viruses have been observed among the microorganisms. They appeared sporadically and irregularly. A protozoan of the *Nosema* genus was found in abundance in the provinces of Toledo and Salamanca; as it did not have any of the characteristics of the known *Nosemas* of *L. dispar* L., it was described as *Nosema muscularis toletanica* (Ruperez, 1965). Fungi of [the] *Aspergillus* and *Beauveria* . . . [generally] appeared in relative abundance for only one year on pupae.

The bacterial complications have been frequent, but no satisfactory results have been obtained in the experiments carried out on the preparations made with native species. Better results were obtained with strains of the *Bacillus cereus-thuringienis* group, which have not been isolated in Spain. In the experiments made with virus preparations, the results obtained have always been very contradictory. Two virus diseases of intranuclear activity produced by bacilliform virus have been detected in existing foci of *L. dispar* L., and another virus disease of cytoplasmic activity caused by cocciforme virus was found on intestinal wall cells."

Eggs: 4; Generation: 5,7,8; Instars IV-VI: 4; Pupae: 4

460. Rotschild, E.V.

1958. **Extermination by rodents of the gypsy moth in the area of mass reproduction** [in Russian]. Byull. Mosk. O-Va. Ispyt. Prir. Otd. Biol. 63(4): 129-130.

Analysis of stomach contents revealed that three small mammal species (*Apodemus flavicollis, A. sylvaticus,* and *Dyromys nitedula*) were eating gypsy larvae and pupae in a forest area east of the Ural Mountains. Stomachs contained legs, head parts, and parts of integument and internal parts,

their economic importance [in Italian, French summary]. Ann. Acad. Ital. Sci. For. 9:139-151.

467. Ryvkin, B. V.

1951. **Some questions relating to the biology of the tachinid *Sturmia inconspicua* Meig. (Diptera, Larvivoridae) and its economic importance** [in Russian]. Dokl. Akad. Nauk. SSSR 76(5): 755-758.

468. Ryvkin, B. V.

1957. **Peculiarities of the gypsy moth outbreaks and their causes** [in Russian, English summary]. Zool. Zh. 36(9): 1355-1358.

The gypsy moth very often appears in abundance, and its outbreaks are very prolonged. Sometimes the gypsy moth migrates from its original location. "Insufficient ecological plasticity of the specific parasite of its eggs, *Anastatus disparis* (Rusch.), and of some other of its parasites have to be considered as well. According to the data of 74 areas of different districts of the European part of the USSR, the eggs of the gypsy moth oviposited in 1951 were parasitized to 1.9 percent and the eggs oviposited in 1953 (17 areas) were parasitized to 1.3 percent. Only in few areas did parasitism of the eggs reach 10 to 25 percent . . . [Other parasites]—Tachina flies, *Compsilura concinnata* Meig., *Phorocera silvestris* R.D., *Sturmia scutellata* R.D.—decrease the population density of the pest only to an insignificant degree. Preservation of the natural resources of *A. disparis* is carried out by means of collecting ovipositions of the gypsy moth in autumn and by keeping them in warm buildings in winter."

Eggs: 4; Generation: 2; Larvae: 4

469. Salatić, S.

1963. **Results of investigations of some factors in the effectiveness of gypsy moth egg parasites** [in Serbo-Croatian, English summary]. Zast. Bilja. 14(76): 693-699.

Studies of the effectiveness of Hymenoptera egg parasites showed that the development of *Anastatus disparis* Ruschka is not completely synchronized with that of its host. Many of the parasites emerge early in spring when the host is not in a stage that allows regeneration of the parasite. Imagos emerge 3 weeks after oviposition into the eggs of the host. Diapause does not occur at all. The males emerge first, followed a few days later by the females. The life of the male is very short (4 to 5 days), while females live up to 49 days. The percentage of parasitism depends upon the thickness of the egg cluster. In upper layers, the eggs are more heavily parasitized than in lower ones.

Eggs: 4

470. Sampo, A.

1968. **On the resinophilous allotrophy(change of food) of some Lepidoptera of forestal importance** [in Italian, English summary]. Ann. Fac. Sci. Agrar. Univ. Studi Torino 4: 317-344.

Lymantria dispar was observed feeding on *Picea pungens* in Valentine Park, Turin. The damage stunted the growth of the spruce plantation.

Non-oak stands: 15

471. Sandquist, R. E., J. V. Richerson, and E. A. Cameron.

1973. **Flight of North American female gypsy moths.** Environ. Entomol. 2: 957-958.

Limited evidence of flight of female gypsy moths is presented. This is neither a normal activity nor a significant factor in adult dispersal.

Adults: 1

472. Schaffner, J. V., Jr.

1927. **Dispersion of *Compsilura concinnata* Meig. beyond the limits of the gipsy moth and the brown-tail moth infestation.** J. Econ. Entomol. 20: 725-732.

By 1922, *Compsilura concinnata* had spread 100 miles westward beyond the known limits of gypsy moth and brown-tail moth infestations and was thriving on native pest insects. Its spread westward from New England was more rapid than its southward spread. It was discovered in the area south of the Adirondacks and in the Catskills.

Instars IV-VI: 4

473. Schaffner, J. V., Jr.

1934. **Introduced parasites of the brown-tail and gipsy moths reared from native hosts.** Ann. Entomol. Soc. Am. 27: 585-592.

Twelve of the larval parasites introduced into the United States in the campaign against the gypsy moth, the brown-tail moth, the satin moth, and the oriental moth are known to be firmly established. Five of these, *Apanteles lacteicolor* Vier., *A. melanoscelus* Ratz., *Compsilura concinnata* Meig., *Meteorus versicolor* Wesm., and *Sturmia* *scutellata* R.D., have been reared from field collections of native larvae. *A. melanoscelus* and *C. concinnata* can exist in this country independent of the hosts for which they were introduced. The latter, which requires alternate and hibernating hosts, has found a variety of suitable host species that have enabled it to disperse far beyond the limits of the infestation of the pests for which it was introduced.

Larvae: 4

474. Schedl, K. E.

1936. ***Porthetria dispar* in Euroasia, Africa and New England** [in German]. Z. Angew. Entomol. Monogr. 12. 242 p.

Review of the world literature on the gypsy moth through the mid-1930's.

Review; bibliography

475. Schieferdecker, H.

1969. **The reproduction of *Oencyrtus kuwanae* (Howard, 1910) under laboratory conditions** [in German, English and Russian summaries]. Beitr. Entomol. 19(7/8) : 803-815.

"*Ooencyrtus kuwanae* (Howard, 1910) can be grown in the laboratory on eggs of *Lymantria dispar* even if the latter have been sterilized. Their suitability as hosts decreases with increasing heat. They can be stored at + 2°C for 35 days. The parasites can develop even in eggs from which the larvae are about to emerge if there are at least 6 days at 20°C between oviposition and the emerging of the larvae. The parasites are attracted most by normal batches of eggs and least by sterilized and washed single eggs from which the hair has been removed . . . Freshly emerged females reach the peak of their oviposition at 20°C on the fourth and fifth days of their lives. Ninety-five percent of all eggs are laid within 11 days. The optimum temperature for the full utilization of the fertility is 21°C (with an average of 54 offspring per female). The optimum density of parasites for mass breeding is five female parasites on 100 *Lymantria* eggs."

Eggs: 4

476. Schmidt, F.

1959. **Effect of temperature and humidity in the time of the moulting period on the development of gypsy moth's caterpillars** [in Serbo-Croatian, English summary] Zast. Bilja 56: 53-60.

High relative humidity and low temperatures during molting induce physiological weaknesses which cause longer developmental periods and death of larvae. These climatic conditions cause a disorientation of the larvae so that often they do not feed immediately after molting. Polyhedrosis virus manifests itself in acute form under such conditions.

Larvae: 7,12,13

477. Schneider-Orelli, O.

1913. **On *Lymantria dispar* and *Euproctis chrysorrhoea*** [in German]. Schweiz. Z. Obst-Weinbau 22(2-3): 18-22, 38-41.

478. Sellers, W. F.

1953. **A critique on the time factor in biological control.** Bull. Entomol. Res. 44: 273-289.

The author discusses points raised in papers by Clausen (1951) and Thompson (1951). Clausen's main point was that on the basis of field observations, an introduced entomophagous parasite or predator that is to be effective will achieve full commercial control within three host generations, or within 3 years at the most, in the vicinity of colonization points. Full commercial control is the degree of control rendering other measures unnecessary. Thompson states the problem mathematically: n = pst, where n = host population, p = parasite population, s = effective reproduction rate/generation, and t = number of generations. Both agree there is no evidence of progressive adaptation which can transform an ineffective parasite into an effective one, but Thompson suggests more time may be necessary than Clausen allows. L. O. Howard and others suggest the parasite may need time to adapt to the new environment, but the author suggests this may mean that time is needed for adequate establishment in the form of an equilibrium of distribution, after which the parasite can respond effectively. Four factors are common to most cited cases of successful biological control: an initially high host population which allows the natural enemy to approach its potential reproductive rate; only one species of parasite or predator; a slow rate of dispersal with several host generations per annum; and the effective reproduction rate of the parasite exceeding that of the host. Here the host supply tends to a maximum, and parasite increase occurs in a restricted area where it is immediately effective. No cases of effective control of a univoltine host by an introduced univoltine parasite were cited by Clausen. An "equilibrium of distribution" must be established at the colonization site before the pest is exposed to the full effectiveness of the reproductive increase of the introduced insect. Equilibrium is obtained when there is no reduction in numbers of the parasite due to outward dispersal into uncolonized areas. They gypsy moth is presented as an example of the complexities involved in control. Unlike theoretically uniform populations, there are periodic local outbreaks of the gypsy moth for 3-year periods. That they are brought under control in 3 years may suggest that the controlling agencies are effective parasites. If the potential host population is below the capacity of the environment, parasitism is of control value. However, if the parasite merely reduces the population to a supportable level, the value is questionable, because without control the host would have eliminated itself by exhausting the food supply.

Generation: 2,4

479. Semevsky, F. N.
1971. **Optimization of caterpillar behavior in the gypsy moth (*Porthetria dispar* L.) in relation to their distribution in crown** [transl. from Russian UDK 595787: 591.51] Zh. Obshch. Biol. 32(3): 1-8.

This paper is based on the premise that larvae will optimize their behavior for maximum survival. An increase in mortality rate is observed in high levels of population density as a result of an increase in migrational intensity. First-instar larvae migrate upward to terminal leaves. If only one larva is present on the leaf, it will commence feeding. If more than one is present, the larvae swing the head and thorax until they are lifted by the wind, thus migrating to a new area. This behavioral mechanism reduces the possibility of starvation even in an outbreak situation.

Instars I-III: 1

480. Semevsky, F. N..
1972. **Prognosis in forest protection** [in Russian]. Lesn. Prom-St.' 1972. (English transl. by U.S. Dep. Agric. For. Serv. Telecom. GM-75-7098.)

"The bases for the theory of linear prediction are presented in this work . . . . [Its usefulness in predicting] the effects of . . . . . gypsy moth populations [of varying size is] examined. A critical analysis of existing practice is made. Reference materials on fodder norms, survival rates, decreased growth, and resistance of various species of trees to defoliation are given. Contemporary mathematical methods, which are of interest because of the application of mathematics to ecology, are presented."

All stands: 15; Generation: 2

481. Semevsky, F. N.
1973. **Studies of the dynamics of the numbers of the gypsy moth *Porthetria dispar* L. (Lepidoptera: Lymantriidae) at low population density levels.** Entomol. Rev. (English transl. Entomol. Obozr.) 52(1): 25-29.

"Studies were made of the population dynamics of the gypsy moth in the period between outbreaks. The method used consisted . . . [of] introducing test insects into the biocoenoses and observing their mortality . . . [The] results show that in periods between outbreaks the estimate of mortality due to predators is 0.957, that due to abiotic factors and diseases 0.56, and that due to parasites 0.55. It is concluded that in periods of depression the main role in the population dynamics of the gypsy moth is played by mortality due to predators and that mortality due to parasites does not increase significantly in the outbreak period. Migration and mortality from diseases in crowded hungry populations probably act as the regulator of population numbers."

Generation: 4, 6

482. Serafimovski, A.
1954. **A new gradation of the gypsy moth** [in Macedonian, French summary]. Sumar. Pregl. 2: 60-71.

483. Shapiro, V. A.
1956. **Principal parasites of *Porthetria dispar* L. and the prospects of using them** [in Russian]. Zool. Zh. 35(2): 251-265.

484. Shtcherbakov, T. S.
1914. **Observations on the gipsy moth (Lymantria dispar L.)** [in Russian.] Works of natural history museum of the Tauric Government Semstvo, 1914, Vol. III. Tauric Government Semstvo Press, Simpheropol (English transl.).

Detailed morphological descriptions of the egg and early instars are given. The phenomenon of larval flight is discussed. In experiments with first-instar larvae and food plants, all larvae offered arbor vitae or pine died without injuring the tree. Those given medlar or willow did not die, nor did they injure the tree. Wild cherry was slightly damaged, but after 15 days the larvae had not molted. Typical feeding holes were made on quince, and larvae molted on the 8th or 9th days. Larvae did best on apricot, apple, and pear, preferring flower buds to the leaves. In general, more of the leaf surface is damaged and destroyed than consumed. Workers in different parts of the world report different food plant preferences. Experiments showed that instar I larvae can live 10 to 11 days without food, but the dorsum turns black and there is a weight and size loss.

Instars I-III: 1,13; Non-oak stands: 15

485. Sinitsky, N. N., and I. M. Kireeva.
1968. **Dynamics of fat metabolism in pupae of *Bombyx mori* L., *Antheraea pernyi* G. M., and *Porthetria dispar* L. under different ecological conditions** [in Russian, English summary]. Vestn. Zool. 2(4): 51-55.

"The pupae of the investigated species differ in the quantitative fat content, while the type of changing fat metabolism completely coincides. During the initial and terminal periods of pupa development, a considerable amount of fat is spent, while in the intermediate period the fat expenditure remains low. The highest fat expenditure is observed at the second part of metamorphosis. Photothermal conditions affect the dynamics of fat metabolism in pupae. At low temperatures with a prolongation of illumination period, the metamorphosis duration is reduced and intensity of fat metabolism dynamics is somewhat increased. Under conditions of elevated temperature the minimal expenditure of general fat amount is observed under conditions of 12- to 17-hour illumination."

Pupae: 12,13

486. Sinitsky, N. N., A. V. Bogach, and I. M. Kireeva.
1971. **The role of temperature and light in the development and reproduction of certain species of Lepidoptera** [in Russian]. Page 440, vol. 1., Proc. 13th Int. Congr. Entomol., 1968. Nauk. Leningrad.

487. Sisojević, P.
1957. **Natural enemies of the gypsy moth** [in Serbo-Croatian]. Biljni Lek. 1957: 15-16.

488. Sisojević, P.
1959. **Investigations of the prepupae and pupae of the gypsy moth in Yugoslavia in 1958 (annual report, 1958)** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 174.

The aim of this study "is to record the insect parasites of the prepupae and pupae of the gypsy moth [and] to evaluate the size of the prepupae and pupae, sex ratio of adults, and the degree of parasitism as indicators of the population density and as a tool in forecasting."

Prepupae: 4,13; Pupae: 4,13

489. Sisojević, P.
1960. **Ecological studies of tachinid parasites of the gypsy moth (annual report, 1959)** [in Serbo-Croatian, English summary]. Zast. bilja 56: 113-115.

Three years after the population density of the gypsy moth reached its peak, the numbers of the moth have continued to decline and have sunk to extremely low levels (39 larvae/120 ha). "At the same time, only two species of the tachinid flies were found parasitizing the caterpillars of the gypsy moth: *Phorocera agilis* R.-D. and *Compsilura concinnata* Meig. The other eight species of tachinids (*Carcelia excisa* var. *separata* Rond., *Zenillia libatrix* Panzer, *Drino inconspicua* Meig., *Blepharipoda schineri* Mesnil, *Blepharipoda scutellata* R.-D., *Blondelia nigripes* Fall., *Exorista larvarum* L., *Exorista fasciata* var. *moreti* R.-D.) which were parasitizing the gypsy moth in previous years have not been found this year. Out of 28 caterpillars found on May 20, 15 (53.5 percent) had the eggs of *P. agilis;* 40 percent of them were superparasitized. That observation shows that this tachinid fly possesses a very good host-searching ability and that it may therefore exercise a significant role in reducing the numbers

of the host population even at its very low level. The mortality of the caterpillars caused by *P. agilis* was 35.9 percent; by *C. concinnara,* 7.7 percent. The alternate hosts were recorded for the species *P. agilis, C. concinnata,* and *Blondelia nigripes,* namely *Eriogaster* sp. and a geometrid for *P. agilis,* three noctuids and one arctiid for *C. concinnata,* and two noctuids for *B. nigripes.*"
Larvae: 4

490. Sisojević, P.
1960. **Investigations of the prepupae and pupae of the gypsy moth in Yugoslavia (annual report, 1959)** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 117–118.

"In this year the population density of the gypsy moth was so low in all 86 observed localities that the prepupae and pupae could not be found, the only exception being one locality) Stip, Macedonia). It was possible to find only 160 prepupae and pupae. The results of analysis of that material are: The size of the prepupae and pupae varied from medium to small, but medium-sized individuals predominated; the percentage of female adults was 42.9 percent; the total mortality (parasitism and mortality caused by other factors) amounted [to] 47.5 percent. According to these data, it seems unlikely that the population density of the gypsy moth will fall to the minimum in the next year. The main mortality factor was the tachinid fly *Blepharipoda scutellata* R.-D."
Prepupae: 4; Pupae: 4; Sex ratio: 2

491. Sisojević, P.
1975. **Population dynamics of tachinid parasites of the gypsy moth (*Lymantria dispar* L.) during a gradation period** [in Serbo-Croatian, English summary]. Zast. Bilja 26(132): 97–170.

The population dynamics of 10 tachinid parasites of the gypsy moth were studied from 1954 to 1960 in a 100-hectare lowland stand of *Quercetum roboris* at Jakovački Ključ in Serbia. The population density and parasitism of the oligophagous tachinids showed the same trends as the gypsy moth, but with their maximum densities delayed 1 or 2 years. With the polyphagous parasites, the trend was quite different, with the highest percentage of parasitism in the progression phase. In latency, only *Compsilura concinnata,* the most polyphagous of the tachinids studies, parasitized the gypsy moth. A moderate host density provides the most favorable conditions for increase of the parasites.
Oak stands: 15; Larvae: 4; Prepupae: 4; Pupae: 4

492. Škorić, V.
1926. **Causes of dying away of our oak forests** [in Serbo-Croatian, English summary]. Zagreb Sveuc. Zavod Sum. Pokuse. Ann. Exp. For. 1: 234–246.

This is a study of the characteristics of oak dieback in Slavonia. Shortly after foliation, leaves are eaten by larvae of *Lymantria dispar, L. chrysorrhea,* and *Malacosoma neustria. L. dispar* is the problem in most forests. Upon refoliation, the new leaves are attacked by the powdery mildew of oak, *Microsphaera alphitoides* Griff et Maubl., which thrives in dry air, in light, and near its temperature optimum. These conditions are met at the time of midsummer refoliation, especially by trees at the forest edge and those of stool-shoots, which the author found to be attacked most strongly. Many young oaks die after the third defoliation in one season. The vitality of older trees is lowered, as evidenced by invasion of *Xyleb* or *us* (Platypus) and *Agrilus* (Buprestidae). The fungus *Agaricus mellea* Quel. then invades via the insect wounds. The initial insect defoliation does not cause oak decay but sets the stage for this complex of fungi and insects.
Oak stands: 15,16,24,25

493. Smiley, D.
1964. **The gypsy moth in Ulster County.** John Burroughs Nat. Hist. Soc. Nat. Sci. Ser. 4(1): 1-11.

This is a review of the history, life cycle, food habits, and history of control of the gypsy moth.
Generation: 1,12

494. Smiley, D.
1967. **Conversations on ecology XIX.** Garden J. 1967 (March/April): 66–68.

Up to 1954, local infestations west of the Hudson River in New York State were rare and controlled from the ground. In 1954 strong easterly winds picked up young larvae east of the Hudson and dispersed them through Ulster and Greene counties. Early in 1957, the U.S. Department of Agriculture began aerial spraying of DDT on 3 million acres in the Northeast to destroy the gypsy

moth. They claimed complete success in eradicating it. In 1964, however, there was extensive forest tree defoliation on the dry ridges of the Shawangunks, and in 1965 thousands of acres in Ulster County were defoliated. In 1966 the egg-mass count was very high, and large areas were treated with Sevin. A 7500-acre tract in Mohonk, New York, owned by the author, was not chemically treated and was two-thirds defoliated. But as the larvae began to pupate, many fell to the ground and died before pupating. Others pupated, but their pupal cases were small. Almost no females emerged, and few egg masses were found. The author believes this decimation of the population was a result of viral disease and parasites. He opposes "controlling" the gypsy moth because oaks on dry ridges have become the dominant species as a result of human intervention and are destined to decline anyway.
Generation: 2; Instars I-III: 2; Larvae: 4,7; Oak stands: 15,19

495. Smiley, D.
1971. **Gypsy moths and man: a story of mutual accommodation.** John Burroughs Nat. Hist. Soc. The Chirp 18(4): 1–8.

A balanced ecosystem will control the gypsy moth over time. Deep snow allows shrews to eat eggs from the lower trunk. Wet weather in late spring limits build-up. Low spring rains are favorable to the gypsy moth and detrimental to trees. If gypsy moth defoliation occurs during drought, it may be beneficial to the tree since moisture is conserved, as happens when a tree is pruned. Larger larvae will feed on needle-bearing trees when forced to move from stripped deciduous trees. They eat only the outer parts of needle bundles; therefore a tuft of needles remains which allows the tree to survive until new needles are put out the next year. It is rare for defoliation to occur often enough in succession to kill many trees. Trees in Mohonk are not defoliated as severely the second year. When an area infested with gypsy moths is not sprayed, a small population is maintained even during low points in the cycle. These in turn maintain a parasite population that is responsive to an increase in the gypsy moth population. "Any form of pesticide control is *worse* then useless."
Eggs: 10; Generation: 2,4,12; Non-oak stands: 15

496. Smiley, D.
1975. **Gypsy moths and man: a story of mutual accommodation.** John Burroughs Nat. Hist. Soc., Ecosystem Sketch 22 and The Mohonk Trust Publ. 5. 9p.

This outlines the ecology of the gypsy moth and describes its effects on the Mohonk Forest in New York, which has been kept spray-free. This area has shown a steady decrease in gypsy moth egg density from 3581 egg masses (E. M.)/15-acre plot in 1971 to 88 E. M./plot in 1975. The gypsy moth will present no more problems at Mohonk, the author believes, because of the changing species composition of the forest due to earlier heavy repeated defoliation. The forest at Mohonk is reaching a "Natural accommodation" with the gypsy moth, and the natural enemies of the gypsy moth are expected to hold the population in check. Therefore, there is no need for artificial control.
Oak stands: 24; All stands: 15,18,28; Generation: 7,12; Larvae: 9; Pupae: 9,10

497. Smilowitz, Z., and L. Rhoads.
1973. **An assessment of gypsy moth natural enemies in Pennsylvania.** Environ. Entomol. 2: 797–799.

"An investigation was conducted to determine qualitatively the entomophagous natural enemies of *Porthetria dispar* (L.) in Pennsylvania. Seven exotic species were recovered: the larval parasites *Blepharipa scutellata* (Robineau-Desvoidy) (Tachinidae), *Compsilura concinnata* (Meigen) (Tachinidae), *Phobocampe disparis* (Viereck) (Ichneumonidae), and *Apanteles melanoscelus* (Ratzeburg) (Braconidae); a pupal parasite, *Brachymeria intermedia* (Nees) (Chalcididae), and *Ooencyrtus kuwanai* (Howard) (Encyrtidae), an egg parasite. The predator *Calosoma sycophanta* L. (Carabidae) was observed feeding on gypsy moths in one county. Two native ichneumonid parasites were recovered in the State, *Theronia atalantae fulvescens* (Cresson) and *Itoplectis conquisitor* (Say). A *Calosoma* beetle and two species of Pentatomidae were observed feeding on the gypsy moth in the field."
Eggs: 4; Larvae: 3,4; Pupae: 3,4

498. Smith, H. E.
1917. **Notes on New England Tachinidae, with the description of one new genus and two new species.** Psyche J. Entomol. 2(2): 54-58.

The parasite *Compsilura concinnata*, imported from Europe, has been recovered from the gypsy moth. As many as five individuals have matured in one host. This tachinid apparently overwinters in the host pupa. In early April when the parasite is ready to pupate, it emerges from the pupa but remains inside the pupal case of the host.

Pupae: 4

499. Soule, A. M. G.
1913. **Parasite introduction of Maine.** Q. Bull. Maine Dep. Agric. Augusta. 12(4): 10-18.

The parasites that have been reared in Maine or imported to control gypsy moth outbreaks are listed. General life histories are given for each parasite.

Eggs: 4; Larvae: 4; Pupae: 3

500. Spurr, S. H., E. W. Littlefield, and H. A. Bess.
1947. **Part II. Ecology of susceptible and resistant forest types and stands.** Pages 27-39 *in* H. A. Bess, S. H. Spurr, and E. W. Littlefield, eds. Forest site conditions and the gypsy moth. Harv. For. Bull. 22. Petersham, Mass.

This is a detailed analysis of the various elements that comprise forest types susceptible or resistant to gypsy moth defoliation. Favored food plants frequently occur in susceptible stands, but their presence alone does not indicate stand susceptibility. The defoliation potential of a stand is better related to land-use history, soil, physiography, and plant indicator species that reflect the environmental conditions. Nonfavored food plants may be defoliated when the environmental conditions are particularly well suited for maintaining a high larval population. Resistant stands are characterized by loamy soils, a moderately dense crown canopy, vigorous timber growth, and deep litter. Wild sarsaparilla, maple- leafed viburnum, arrowwood, New York fern, wood fern, and Christmas fern are the characteristic shrub and herbaceous indicators. Overstory indicators are sugar maple, white ash, black birch, basswood, yellow poplar, beech, and hemlock. In an oak stand, a high proportion of red oak indicates resistance. Sandy plains and ridges tend to be susceptible to gypsy moth outbreaks. They are characterized by black, scarlet and white oaks, gray birch, and aspen in the overstory; pine, scrub and white oaks in the understory; and lowbush blueberry, sweet fern, huckleberry, bracken, sedges, bayberry, and bush honeysuckle as groundcover. Most susceptible stands are pioneer forest associations which would become resistant with time if left undisturbed. Moderately heavy gypsy moth defoliation of these pioneer species hastens forest succession, but frequent severe defoliation creates conditions favorable for future outbreaks by opening up the stand, drying out litter, and setting back succession. Whole forest regions are resistant to heavy defoliation because they contain little favored food, or are confined to better sites, or have unfavorable climates. It is safe to assume that future heavy defoliation will be in areas ecologically similar to those that proved susceptible in New England.

All stands: 15,18,19,20,21

501. Stadler, H.
1933. **A new ichneumonid from gypsy moth larvae (*Lymantria dispar* L.)** [in German]. Entomol. Anz., Wien 13(2-4): 27-30, 43-45, 58-60.

502. Staley, J. M.
1965. **Decline and mortality of red and scarlet oaks.** For. Sci. 11: 2-17.

"Declining and dying *Quercus rubra* L. and *Q cocinia* Muench. were found to be affected by leaf roller defoliation, root rot, *Agrilus* attack, late spring frost, drought, and unfavorable soils. Symptoms of decline were reproduced artificially by defoliation of sapling *Q. rubra*. Other factors, such as root rot, drought, and frost, are considered contributory but not primarily causal. It was concluded that the initial symptoms of decline reflect a diminished availability of carbohydrates for growth, and that final symptoms of subsequent mortality reflect extreme moisture stress. A similar decline of European oaks is pointed out."

Oak stands: 16,17,18,23,25

503. Stauder, H.
1913. **Contribution to the biology of the caterpillars of *Lymantria dispar* L. (Lep., Lym.) and *Phalacropteryx pruecellens* (Lep. Psych.)** [in German]. Z. Wiss. Insektbiol. 9(5). 148-151.

504. Stefanov, D.
1960. **A biological adaptation of the gypsy moth (*Lymantria dispar* L.)** [in German]. Proc. 11th Int. Congr. Entomol., 1960, vol. II, sec. VIII: 262–265.

505. Stefanov, D., and M. Keremidchiev.
1961. **The possibility of using some predators and parasitic insects (entomophages) in the biological control of the gypsy moth (*Lymantria dispar* L.) in Bulgaria** [in Bulgarian, German summary]. Nauchni Tr. Vissh. Lesotekh. Inst. Sofia 9: 157–168.

506. Stephens, G. R., and D. E. Hill.
1971. **Drainage, drought, defoliation, and death in unmanaged Connecticut forests.** Conn. Agric. Exp. Stn. Bull. 718. 49 p.

Natural changes in four Connecticut forests were examined from 1959 to 1970, related to defoliation, drought, and soil drainage and compared with four other Connecticut woodlands previously studied. The four tracts all lie in Connecticut's upland region of metamorphic rock and glaciated soil, but otherwise differ from one another in soil, climate, and history. Drought did not significantly alter the mortality rate, but repeated defoliation increased mortality on all but poorly drained soils. Death of major species was 1.3 percent baseline, 1.5 percent in a dry site defoliated once, and 2.3 percent annually in moderate and well-drained sites defoliated twice. The mortality rate of oak, the prime target of defoliators, doubled with repeated defoliation.

All stands: 15,27,28

507. Stephens, G. R.
1971. **The relation of insect defoliation to mortality in Connecticut forests.** Conn. Agric. Exp. Stn. Bull. 723. 15 p.

From the standpoint of the effect on trees, the identity of the defoliating insect is important only insofar as it affects the time of defoliation and the amount of foliage removed. Defoliation early in the growing season is especially critical because new foliage does not become functional immediately and is produced at the expense of stored reserves. A single defoliation within a decade, as seen in this study, did not increase mortality beyond that in undefoliated stands. Mortality increased after two defoliations on medium-moist sites and three consecutive defoliations on dry sites. A single defoliation had little effect on mortality of trees in the canopy, but repeated defoliations did have an effect, especially on dry sites. White and chestnut oaks succumbed more readily than did red oaks. Oak mortality was greater than that of maples even in undefoliated sites. Repeated defoliation increased the loss of large oaks, but had little effect on maple, black birch, or yellow birch. One possible reason for the greater mortality among oaks is that they are attacked by defoliators more than other trees. However, there has been a decrease in the number of oaks in Connecticut forests since 1927, perhaps reflecting a gradual change in forest conditions since burning and clearcutting are no longer practiced.

All stands: 15,19,23,27,28

508. Summers, J. N.
1916. **Parasites of the gypsy and brown-tail moths in Maine.** Annu. Rep. Maine Comm. Agric., 1915, 14: 120–127.

This is a brief history of parasites introduced into Maine. *Anastatus bifasciatus* oviposits in gypsy moth eggs, the maggots devour the entire contents of gypsy moth eggs, then overwinter in the empty shell. They emerge just before new gypsy moth eggs are laid in late summer. *Apanteles lacteicolor* attack brown-tail and gypsy moths. They overwinter as maggots inside young brown-tail larvae. When these emerge from their webs in the spring, the *Apanteles* begin feeding. They emerge and spin cocoons at the end of May. The next generation attacks young gypsy moth larvae. When brown-tail larvae hatch in late summer, they are attacked by adults of this generation of *Apanteles*. *Meteorus versicolor* is very similar to *Apanteles*. Its cocoon hangs from trees by a fine thread. *Compsilura concinnata* deposits maggots inside larvae of both pests; these feed and emerge to form puparia. A number of broods develop in the summer. They also attack injurious native insects. *Calosoma sycophanta* is an important predator. According to the author, property owners "should not expect too much of the parasites."

Eggs: 4; Instars I–III: 4

509. Summers, J. N.
1922. **Effect of low temperature on the hatching of gypsy moth eggs.** U.S. Dep. Agric. Bull. 1080. 14 p.

An exposure of between 20° and 25°F is necessary to kill entire gypsy moth egg masses.

Temperatures around −15 °F will kill some of the eggs in the mass. Survival during severe winters depends largely on protection from wind by aspect and snow cover during temperature plunges.
Eggs: 12

510. Švestka, M.
1970. **Gradations of gypsy moth in stands of black locust** [in Czechoslovakian]. Lesn. Pr. 49(11): 519–521.

511. Szalay-Marzsó, L.
1957. **Observations during the summer of 1954 and 1955 in the Nyiregyháza forest in connection with the outbreak of *Lymantria dispar* L.** [in Hungarian; Russian and English summaries]. Ann. Inst. Prot. Plants Hung. 7: 113–123.

In the summer of 1954, an outbreak of *Lymantria dispar* was observed in the Nyiregyháza forest. It fully developed in 1955 and defoliated about 250 "cadastral yokes" of the forest's *Quercus pedunculata* stock. Most of the starving larvae in the defoliated region died of a virus disease, and only about 10 percent of the larval population reached a pupal stage. "The small size of the emerged moths and the low number of eggs (on an average, 140) was conspicuous. The number of eggs in the less infected areas of the forest rose to 325. In 1955, the high average number of eggs (747) in the noninfected regions and the great egg masses on the trunks of some trees give rise to the conclusion that damages in 1956 will be still more considerable. The collapse of the gradation in the defoliated areas was only local and did not influence the outbreak of the gypsy moth, taking the forest as a whole . . . [This] is confirmed by the very low degree of parasite activity, which is also a characteristic feature of a gradation before it reaches its peak.
Adults: 13; Generation: 4; Larvae: 7

512. Tadić, M. D.
1959. **Numerical frequency of gypsy moth egg parasites *Anastatus disparis* R. and *Ooencyrtus kuwanae* How. in some localities of the P.R. of Macedonia in 1958–59** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 27–31.

In individual and total gypsy moth egg clusters analyzed, there were a considerably greater number of eggs parasitized by *Ooencyrtus kuwanae* than by *Anastatus disparis*. By dissecting eggs it was found that in a single gypsy moth egg, two and even three imagos of *O. kuwanae* can develop.
Eggs: 4

513. Tadić, M. D.
1962. **A contribution to the knowledge of the diapause of the gypsy moth egg parasite *Anastatus disparis* R. on the island Hvar** [in Serbo-Croatian, English summary]. Zast. Bilja 63/64: 13–19.

In Yugoslavia *Anastatus disparis* remains in the state of diapause for 1 year. On the island Hvar, the life cycle of *A. disparis* varies from that in the rest of Yugoslavia. In 1957, 91,237 gypsy moth eggs from Hvar were analyzed. Of these, 7.6 percent were parasitized by *A. disparis*; 31.5 percent of the parasites emerged in the same year as oviposition, and 68.5 percent emerged in the year following oviposition. A possible explanation of this phenomenon is the difference in climate between Hvar and continental Yugoslavia.
Eggs: 4

514. Tallós, P.
1966. **Forecasting damage by *Lymantria dispar* L.** [in Hungarian; Russian and German summaries]. Erdo 15(12): 549–552.

515. Telenga, N.A.
1929. **Hymenopterous parasites of the family Ichneumonidae reared at the Kubanj plant protection station in 1927** [in Russian]. Zashch. Rast. (Leningrad) 6(1–2): 225–226.

Ichneumonid parasites reared from lepidopteran pests, including the gypsy moth, are listed. Three species reared from insects other than the gypsy moth are described. Those reared from the gypsy moth are: *Pimpla instigator* F. (which is also reared from *Euproctis chrysorrhoea* L., *Malacosoma neustria* L., and *Pieris brassicae* L.) and *Theronia atalante* Poda, which is reared only from gypsy moth pupae.
Pupae: 4

516. Tempel, W.
1939. **A mass occurrence of Asopinae (Hemiptera: Pentatomidae)** [in German]. Arb. Physiol. Angew. Entomol. Berlin-Dahlem 6(1): 51–56.

517. Templado, J.

1957. **Data on *Ooencyrtus kuwanai* How., a chalcidid parasitic on *Lymantria dispar* L. in Spain** [in Spanish]. Publ. Inst. Biol. Apl. Barcelona. 25: 119-129.

Ooencyrtus kuwanai was introduced into Spain 30 years ago, but in an oak forest of central Spain, not more than 20 to 25 percent of the eggs of gypsy moth are parasitized. Competition with the indigenous *Anastatus disparis* is slight; *A. disparis* parasitizes about 15 percent of the eggs. Its propagation is recommended, especially for oak forests in areas having a mild winter climate.

Eggs: 4

518. Templado, J.

1965. **Goldschmidt's work on *Lymantria dispar* and his opposition to neo-Darwinism** [in Spanish]. Bol. R. Soc. Esp. Hist. Nat. Secc. Biol. 63: 185-192.

519. Thompson, W. R.

1923. **A criticism of the "sequence" theory of parasitic control.** Ann. Entomol. Soc. Am. 16: 115-128.

The sequence theory, as stated by Fiske (1910), is that a sequence of parasites attack a particular host in different stages of its development, resulting in a stable host population. While a sufficient number of parasites are temporarily separated so as to fit the concept to the gypsy moth, the theory does not hold because the gypsy moth population density fluctuates considerably. The sequence theory rarely applies to natural systems because the parasite:host population equilibrium is so delicate.

Generation: 4

520. Thompson, W. R.

1923. **On determining winglessness of an ichneumonid parasite (*Pezomachus sericeus* Forst)** [in French]. Bull. Soc. Entomol. Fr. 1923(3): 40-42.

521. Thompson, W. R.

1946. **A catalogue of the parasites and predators of insect pests.** Sec. 1. Parasite host catalogue. Part 8. Parasites of the Lepidoptera (N-P). Imperial Parasite Service, Belleville, Ontario, Can.

Lists (pages 490-500) parasites and predators of *Porthetria dispar* (L.) and *P. dispar japonica* Mats., giving binomial names, author, order, family, and sites where reported.

Generation: 3,4,13

522. Tichý, V.

1962. **The influence of birds on the gradation of some injurious insects** [in Czechoslovakian, English summary]. Sbornik prednásek II. celostátni konference Československé společnosti v Praze. Praha 1962. 166: 129-137.

The influence of the density and diversity of bird populations on all developmental stages of forest insect pests is examined. From wintertime until the time the pest *Bupalus piniarius* reached larvae stage, bird density increased 308 percent. At the climax of the gradation, the chaffinch concentration increased 19-fold. Of a total of 67 bird species found, 14 were nesting, and 34 were observed feeding on the pest. *Parus major* consumed all stages of the insect; *Fringilla coelebs* consumed all but pupae. When gradation was at climax, 2.1 percent of eggs, 13.6 percent of larvae, and 14.7 percent of pupae were consumed by birds.

Schwenke's assumption (Beitr. Entomol. 1952) is that there is a 10 percent decline of larvae due to birds under normal conditions. In an infestation of *Tortrix viridana* and *T. loefflingiana* leafrollers, 121 species of birds were found, of which 37 dominant species constituted 90 percent of the population. Consumption of leafroller was ascertained in 58 species, primarily by starling (*Sturnus vulgaris*), great tit (*Parus major*), chaffinch (*Fringilla coelebs*), tree sparrow (*Passar montanus*), blue tit (*Parus coeruleus*), great spotted woodpecker (*Dendrocopus major*), white throat (*Sylvia communis*), chiffchaff (*Phylloscopus collybita*), and willow warbler (*P. trochilus*). Together, they consumed only 3 to 4 percent of the insects. In depredations showing great oscillations, the absolute number of insects consumed by birds rises with the advance of gradation, but the percentage falls. "Not even where the pest was strongly overpopulated was it possible to observe the so-called overfeeding with unilateral food as is often adduced in literature."

Larvae: 2,9

523. Tinbergen, L.

1960. **The natural control of insects in pine woods. I. Factors influencing the intensity of predation by songbirds. Arch. Neerl. Zool. 13: 265–343.**

The role of birds in regulating insect numbers is examined. Research is limited to Scots pine woods in the spring and summer brood season. The gypsy moth is not present, but two hairy caterpillars are *Lymantria monacha* L. and *Dendrolimus pini* L. Ninety-two broods were studied from 1948 to 1954: 67 great tit (*Parus major*), 13 blue tit (*P. coeruleus*), 7 crested tit (*P. cristatus*), and 5 coal tit (*P. ater*). Their hunting techniques are similar: Primarily visual clues are used; they take only prey which can be caught quickly; and rarely are these insects in flight. The blue tit is more likely to eat food in webs or galls. Adults may prepare large larvae before giving them to young by decapitating and plucking hairs. Moths may be brought wingless. Large larvae are more likely to be "prepared" than are small larvae. Older nestlings receive part of their food alive. It was found that *Lymantria* larvae averaged 5 percent of the food in late June and early July, with a maximum of 25 percent in early July 1951.

Lymantria were the largest larvae studied and were found to have the highest index of relative risk despite their cryptic behavior. Their size may compensate for their inconspicuousness, since birds actively search hiding places once it is known that these larvae are in the area. Synchronization of the life cycles of many species lowers the risk factor for all. There are marked differences in the oscillations. Percentage of predation falls steeply where there is high host density, because the bird density remains constant and because birds vary their diet and avoid more numerous species.

Generation: 2,4,9; Larvae: 9

524. Tomić, D.

1952. **A study of the influence of elevated temperatures and submergence in water on gypsy moth eggs** [in Serbo-Croatian, French, summary]. Glas. Sumar. Fak. Univ. Beogradu 5: 221–242.

525. Tothill, J. D.

1916. **The introduction and establishment in Canada of the natural enemies of the brown-tail and gipsy moths.** Agric. Gaz. Can. Ottawa. 3: 111–116.

As of 1916 the gypsy moth had not yet reached Canada but was expected to cross the international boundary within a few years. It was not known if climatological conditions would stop its northward expansion or if the insect would find a niche in the boreal forests. As a preventative measure, insect parasites and predators were imported to create a living barrier to prevent the northward spread of the gypsy moth.

Generation: 3,4.

526. Townsend, C. H. T.

1908. **A record of results from rearings and dissections of Tachinidae.** U.S. Dep. Agric. Bur. Entomol., Tech. Ser. 12, Misc. Pap. 6: 95–118.

A wealth of information is presented on the life histories and methods of rearing tachinid parasites. Five different styles of reproductive habits were observed: host-oviposition, leaf-oviposition, supracutaneous host-larviposition, subcutaneous host-larviposition, and leaf-larviposition. Conclusions can be drawn as to the type of reproductive habit by studying uterine eggs. For example, the thickness of the shell indicates whether it will hatch within the uterus, and chitinization indicates that it is made to withstand exposure following leaf-oviposition. It is concluded that *Blepharipa scutellata* and *Crossocosmia* sp. are important parasites of *Porthetria dispar* because of their great capacity for reproduction and because of their leaf-oviposition, which creates a situation in which all of their eggs must be eaten by the larvae whenever the gypsy moth is abundant.

Larvae: 4

527. Treyman, F. S.

1938. **The number of caterpillars hatched from eggs of the gypsy moth and their survival at an early age depending on the feeding conditions of the maternal generation** [in Ukrainian; Russian and English summaries]. Acad. Sci. Ukr. SSR. Rep. Inst. Zool. Biol. 5: 117–144.

Pupal weight, which depends on the quantity of food, affects not only the number of eggs laid but also the quality, and is closely connected with vital activity of the succeeding generation. Females emerging from pupae with greater weight yield egg clusters having a greater weight. In this study, large egg clusters had 84 percent hatched eggs, while smaller clusters only had 41.5 percent hatched eggs. The lower the pupal weight, the

higher the percentage of eggs and larvae perishing in the first and second instars. The average percentage of larvae perishing in the first and second instars was the same, however, whether the larvae came from eggs of a starving generation or from eggs of an abundantly fed generation. Nutritional conditions of the preceding generation affected the weight of the pupae of the daughter generation, although the larvae of the latter were fed equally. Prolonged and intense starvation of larvae produced very low-weight pupae which became sterile adults.
Adults: 13; Eggs: 13; Fecundity: 13; Larvae: 13; Pupae: 13

528. Tsap, L.I.
1965. **A study of most of the pests of oak forests in the Crimea** [in Russian]. Lesovod. Agrolesomelior. 6: 103–107.

529. Tschorbadjiew, P.
1925. **Report on research on the parasites of destructive insects in Bulgaria** [in German, Bulgarian title]. Bulg. Entomol. Druzh. 2: 84–9.

530. Tuleschkov, K.
1935. **On the causes of hibernation in the egg stage of *Lymantria dispar*, *L. monacha*, and other Lymantriids** [in German]. Z. Angew. Entomol. 22(1): 97–117.

531. Turček, F. J.
1948. **Birds in an oak forest during a gypsy moth outbreak in South Slovakia.** Am. Midl. Nat. 30(2): 391–394.
During a large gypsy moth outbreak in South Slovakia, the density of certain species of birds doubled or tripled. Nine species were seen eating larvae. The golden oriole (*Oriolus oriolus oriolus*), the hawfinch (*Coccothraustes coccothraustes*), and the starling (*Sturnus vulgaris vulgaris*) were the most important. The author hypothesized that the effect of birds on the gypsy moth population is to prolong the period between outbreaks.
Larvae: 9

532. Turček, F.
1950. **The bird population in some deciduous forests during a gypsy moth outbreak** [in Czechoslovakian; English and Russian summaries]. Bull. Inst. For. Res. Czech. Repub. 3: 108–131.
Because of defoliation, nesting success in outbreak areas is very low. Therefore, the effect of birds on the gypsy moth population depends on a daily influx of birds from surrounding areas. During an outbreak, birds eat a maximum of 2 percent of the larvae. Birds probably play a role in maintaining gypsy moth populations at innocuous levels but are of little consequence at outbreak densities.
Generation: 9

533. Turchinskaya, I.A.
1963. **Effect of leaf eating by the gipsy moth and other leaf-eating insects upon the growth of the oak** [in Russian, English summary]. Zool. Zh. 42(2): 248–255.
"Investigations carried out in Savalsk forest management, Voronezh region, in 1958–1961 found that the eating of leaves by such pests as the gypsy moth, green tortrix moth, water moth, and notodid did not lead to a dying of the oak groves even in cases when the mass outbreaks of these insects are of 2 to 3 years' duration. The decrease in growth in the stands damaged is different, fluctuating within a broad range . . . from 15 to 65 percent . . . [of] the growth of the same trees in . . . previous years without . . . damage to the foliage, [and] when weather conditions were similar. The loss of the foilage in the early spring and in summer affects tree growth in diameter in the same way. The damage . . . [to] leaves in summer is of no considerable importance to the growth of the trees in height."
Oak stands: 15,24

534. Turner, N., ed.
1963. **Effects of defoliation by the gypsy moth.** Conn. Agric. Exp. Stn. Bull. 658. 30 p.
The ". . .purpose of the study was to determine the effect of heavy defoliation by the gypsy moth in 1953 and 1954 on white pine survival and growth rates." The degree of initial defoliation and subsequent death or extent of recovery over a 5-year period was recorded. Conditions of the study involved a single defoliation and normal weather. Results: 100 percent defoliation by the gypsy moth resulted in 28 percent mortality of white pine, 74 percent of hemlock, and 5 percent of oaks; 90 percent defoliation caused mortality in 8 percent of white pine, 9 percent of hemlock, and 6 percent of oaks. Less than 90 percent defoliation caused little mortality and trees recovered within 5

years. Greatest mortality in white pines occurred in the second year after 100 percent defoliation, with appreciable amounts in the other 4 years; virtually all mortality of hemlock occurred the year following defoliation. Mortality of overtopped pines was greatest, but hemlock mortality was greatest in dominant and intermediate crown classes. Evidence of extensive killing of white pine is lacking, probably because of the rapid disappearance of pine after death.

Oak stands: 24; Non-oak stands: 15, 24, 26

535. U. S. Department of Agriculture, Forest Service and Animal and Plant Health Inspection Service.
1974. **Final environmental statement: cooperative gypsy moth suppression and regulatory program, 1974 activities.** 178 p.

This environmental impact statement reviews and synthesizes research material on the impact of the gypsy moth on trees, forest resources, and people. It evaluates the effect of various proposed control mechanisms. Reviews of the statement are included in the appendix.

Review; bibliography

536. U. S. Department of Agriculture, Forest Service and Animal and Plant Health Inspection Service.
1975. **Final environmental statement addendum to the final 1974 gypsy moth environmental statement.** 31 p.

This report contains a description of the present situation, results of 1974 suppression and regulatory activities, new information on pilot control projects (economic considerations, insecticide tests, and pertinent research results), proposed suppression projects, and a proposed regulatory program. It also contains comments from reviewers.

Generation: 1

537. Vaclav, V., E. Georgijević, and D. Lutešek.
1959. **Stationary researches in the dynamism of the gypsy moth population: localities where no control actions against the gypsy moth are undertaken (1958)** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 61-72.

Ten localities in Herzegovina were investigated. Various indicators showed that the gypsy moth was in retrogradation in all of them.

Generation: 2

538. Vaclav, V., E. Georgijević, and D. Lutešek.
1959. **Problem of gypsy moth focuses in Bosnia and Herzegovina *(Anastatus disparis* Ruschka as indicator of gypsy moth localities)** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 73-78.

The problem of gypsy moth foci in Bosnia and Herzegovina has been dealt with for 2 years. The specific egg parasite of the gypsy moth, *Anastatus disparis,* can indicate the foci. Last year analysis of gypsy moth eggs from 127 localities was conducted and "*A. disparis* was discovered in egg clusters from 14 localities. In 1958 the analysis of gypsy moth clusters with reference to egg parasites was carried out in 52 localities, and *A. disparis* was observed in 24 localities. This egg parasite appeared in the course of two consecutive years on the same terrains of Forest Administration Districts Trebinje, Bileća, Čapljina, Mostar, and Listica. It is likely that the south and southwest regions of Herzegovina . . . are a part of the gypsy moth's wider territory which also occupies the neighboring regions of the Middle and South Dalmatia near Čapljina, Ljubuški, and Trebinje as well as Montenegro near Bileće." Investigation of gypsy moth foci should continue into the latent period of the moth with the presence of *A. disparis* serving as an indicator of foci.

Eggs: 4; Generation: 2

539. Vago, C., and P. Atger.
1961. **Massive multiplication of insect virus during the pupal moult** [in French, German summary]. Entomophaga 6(1): 53-56.

540. Vago, C., J. Fosset, and M. Bergoin.
1966. **Dissemination of polyhedral virus by the *Ephippiger,* predators of insects** [in French, English summary]. Entomophaga 11(2): 177-182.

"Transmission of polyhedral viruses by *Ephippiger bitterensis* having ingested virus-diseased *Lymantria dispar* larvae was observed in nature and in experiments. The passage of polyhedral bodies in different parts of the gut was studied by histological methods, and the effect of the gut juice was found insignificant. These bodies were detected in dejections during 15 days after ingestion of diseased insects. Viruses were shown by electron microscopy and [by] the confirmation of

their pathogenic effect by infection tests. The significance of these results in epizootiology and in biological control is discussed."
Larvae 3, 7

541. Valentine, H. T. and R. W. Campbell.
1975. **A simulation model of gypsy moth/forest interaction.** For. Sci. 21: 233-238.

"A model developed from data collected in New England simulates the behavior of the gypsy moth (*Porthetria dispar* (L.))—forest system in many stands and over many years, yielding estimates of future egg mass density, defoliation, tree condition, and tree mortality. It will also yield frequency distributions of expected egg mass density and defoliation levels for one stand in 1 year. This information may be valuable to decision-makers concerned with regulating gypsy moth infestations."
Generation: 2, 12; Oak stands: 15, 20, 25; All stands: 15, 20, 25, 26

542. Varga, F.
1968. **New nutritive-biological examinations related to the gypsy moth (*Lymantria dispar* L.)** [in Hungarian, Russian, German, English summaries]. Erdezeti Faipari Egy. Tud. Kozl. 1: 129-141.

The author raised larvae of the gypsy moth on several plants at a temperature of 18 to 23° C. The purpose of the experiments was to decide whether the larvae were amenable to mass reproduction. The plants were: white poplar, black poplar, balsam poplar, *Populus euramericana* cv., *marilandica,* European oak, Austrian oak, and *Robinia.* The results showed that the leaves of white poplar, balsam poplar, and *Robinia* lack food value for the gypsy moth. The leaves of *Populus euramericana* cv. *marilandica* and black poplar are the two main nutritive plants of the gypsy moth. Leaves of European oak and Austrian oak have the same food value as the former two.
Oak stands: 23; Larvae: 1, 12; Non-oak stands: 23

543. Vasić, K.
1950. **Contribution to the knowledge of the cause of disruption in the sexual index in the critical-eruption stadium in the gypsy moth's development** [in Serbo-Croatian, French summary]. Glas. Sumar. Fak. Univ. Beogradu 1: 311-336.

Sex ratio is determined by abiotic and biotic factors after larval emergence. This depends not only on the higher susceptibility of one sex to these factors but also on selection for one sex or the other by parasites. Criteria for pre-eruptive and eruptive stages are given.
Sex ratio: 2,4,7,12

544. Vasić, K.
1950. **Results of an examination of the pupae of *Lymantria dispar* L. in 1948** [in Serbo-Croatian, French summary]. Zast. Bilja 2: 25-34.

545. Vasić, K. and L. Janković.
1958. **A contribution to the knowledge of indicators for the prognostication of the evolution of the gypsy moth gradation** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 3-15.

The stage of the gypsy moth gradation can be determined using fundamental and complementary indicators. Fundamental indicators are determined in the field and include number of clusters per square unit, number of clusters per tree, and number of trees infested with clusters. The significance of these numbers depends on the age of the biotope. Middle-aged forests have more food available, and thus it takes more clusters to seriously damage the trees.

Other fundamental indicators are: (1) Place where the clusters are deposited, since in latency in the lowlands and throughout the gradation in hills and mountains, egg clusters are hidden. The beginning of the gradation is characterized by deposition of visible clusters, especially on the lower tree trunk. As the gradation progresses, the height of oviposition increases and eggs are laid in various places—shrubs, leaves, branches, stones, etc. (2) Size and shape of the clusters, with large-sized clusters indicating pre-eruptional stages and small to medium clusters indicating a posteruptional year. (3) Polyphagy of larvae which increases in the course of the gradation. (4) Larval migration, which indicates the eruptional stage. (5) Number of pupae per pupal cluster, which increases from one to several score in the course of the gradation. (6) Predators which appear as the numbers of larmae increase. (7) Polyhedrosis, which cannot be used with certainty as a prognosticative sign of the reduction of gypsy moth numbers since it appears sporadically.

Complementary indicators include: (1) Number of eggs in clusters, which decreases with the numerical increase of the population. (2) Number of fertilized eggs, which increases with the progress of the gradation and which is far less in the lowlands than elsewhere. (3) Duration of hatching period, which draws out as the gradation nears its end. (4) Percentage of hatched larvae, which starts out very high and decreases rapidly in the posteruptional stage. (5) Percentage of parasitism, which gradually increases so that the number of parasites becomes almost equal to the number of hosts in the eruptional stage. (6) Sex ratio, which is normal in the beginning but then shifts to a prevalance of males, one of the unfailing signs of the imminent end of the gradation. (7) Fecundity and fertility, both of which decrease in the course of the gradation.

Eggs: 2; Fecundity: 2; Generation: 2,3,4,7,12; Larvae: 1,2; Pupae: 1,2; Sex ratio: 2

546. Vasić, K., and L. Janković.
1958. **Results of investigations of gypsy moth clusters on the territory of Yugoslavia in 1957** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 147–155.

Gypsy moth egg clusters were collected from all over Yugoslavia and evaluated for size and shape, average number of eggs, and percentages of fertilized eggs, parasitized eggs, and hatched larvae. Using these characteristics, the authors predicted the condition of the gradation in different parts of Yugoslavia. In most localities in Serbia, Montenegro, and Bosnia-Herzegovina, the gypsy moth was in retrogradation and the egg clusters were scare, small, of irregular shape, and with few eggs. However, a great number of large, normally shaped clusters were found in areas in Serbia where the gradation had passed culmination 2 to 3 years previously. In Croatia and Macedonia some of the cluster characteristics indicated the culmination stage. The gypsy moth frequently appears in exactly those places where chemical control had been used earlier.

Generation: 2

547. Vasić, K.
1958. **Comparative analysis of the respective courses of the gypsy moth gradation in the intervals 1946–1950 and 1953–1957** [in Serbo-Croatian, English summary]. Zast. Bilja 49/50: 9–22.

Climatic conditions in four localities observed during the gradations were analyzed and graphically related to gypsy moth population density. The climate during the 1946–1950 gradation was warmer and considerably drier than during the 1953–1957 gradation. Temperature showed a slight, though constant, decrease during both gradations in all investigated places. This correlates with laboratory experiments which showed that the gypsy moth has the highest biological potential at temperatures below 20°C. No conclusions were drawn regarding precipitation, except that during the more humid second gradation, the gypsy moth favored the warmer and drier regions of East Serbia. Also in the second gradation, there were two numerical maxima in several places, because the propagation did not oversatiate the capacity of the biotope, and because parasitic action was inhibited by the cold and rainy climate. Starvation was a more important factor in the first gradation, which extended over wider areas and had higher densities in individual biotopes. The polyhedry, of little importance in the first gradation, was in many places the major factor of crisis in the second gradation. The principal lines of the two gradations were similar: a slow increase in the 2-year preparatory phase, a precipitous rise in the prodromal year, a 40-fold increase between the prodromal and preeruptional years, and a 270-fold increase to the eruptional-critical year.

Generation: 2,12; Larvae: 4

548. Vasić, K., and P. Sisojević.
1958. **Parasites of pronymphs and pupae of the caterpillar in Yugoslavia in 1957** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 49–52.

Prepupae and pupae were collected in great numbers in 1957, at the crisis of the gradation, and reared for parasites. Various species of Sarcophagidae were most numerous; Tachinidae and Hymenoptera were also found. Of the tachinids, *Blepharipoda scutellata* R.D. was the most numerous (80.6 percent), followed by *Phorocera agilis* R.D. (16.7 percent), and *Compsilura concinnata* Meigen (1.2 percent). *Carcelia excisa* v. *separata* Rond., *Drino inconspicua* Meigen, and *Exorista larvarum* L. totaled 1.5 percent. Among Ichneumonidae were *Ichneumon disparis* Poda (30.6 percent), *Theronia atalantae* Poda (63.9 percent), and *Pimpla examinator* F., *P. rufata* Gm., and *P. instigator* F. (5.5 percent). The family Chalcididae

were represented as hyperparasites on 7.5 percent of parasites.
Prepupae: 4; Pupae: 4

549. Vasić, K.
1958. **Parasitic hymenoptera of gypsy moth** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 17-21.
Parasitic hymenoptera have not been found to be of great importance in reducing gypsy moth populations. An exception to this is species of the genus *Apanteles* which infrequently cause a crisis of the gradation. Ichneumonidae, except for *Hyposoter disparis* Viel and to a certain degree *Theronia atalanta* Poda, are either very rare parasites or hyperparasites (*Hemiteles* spp.) of the gypsy moth. All observed Chalcididae species are hyperparasites. A list is given of ichneumonids, braconids, and chalcids which have been reared from eggs, larvae, or cocoons of the gypsy moth.
Generation: 4

550. Vasić, K., and S. Salatić.
1959. **A new contribution to the knowledge of the parasitic hymenoptera of the gypsy moth: parasitic hymenoptera of the gypsy moth in 1958** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 45-50.
In addition to *Anastatus disparis* Ruschka, an autochthonous egg parasite of the gypsy moth, *Ooencyrtus kuwanai* How., an imported species, was observed. It was previously limited to a few localities in the warmest regions of Macedonia (Strumica and Stip). The percentage of parasitized gypsy moth eggs collected in autumn of 1957 was very low for both parasite species observed. The clusters containing fewer eggs were parasitized at the highest rate. It was also established that parasitism was highest where the gypsy moth was in its numerical culmination or in the first year of the retrogradation. The sex ratio in the populations of *A. disparis* was quite variable, but its value in localities with a small percentage of parasitized gypsy moth clusters was approximately normal (about 0.5). However, in localities where parasitism was higher, the ratio of males in the population was increased. Of the larval parasites, only *Apanteles melanoscelus* Ratzb. and *A. solitarius* Ratzb. were observed. The total percentage of parasitism by both these species varied at Jakovački Ključ (region of Srem) from 1.6 to 6.6 percent. Parasite cocoons were found only in May. The parasites of the prepupae and pupae were examined only on material from Macedonia. The only species observed was *Theronia atalantae* Poda. Four more species of hyperparasites were found, three on the pupae of tachinids (*Phygadeuon variabilis* Grav., *Brachymeria minuta* L., and *Perlampus ruficornis* F.) and one on the cocoons of *Apanteles Liparidis* Bouché (*Hemiteles fulvipes* Grav.).
Eggs: 4; Generation: 4; Larvae 4; Pupae: 4

551. Vasić, K., L. Janković, and P. Sisojević.
1959. **Indicators for the prognostication of gypsy moth gradations** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 181-183.
In 1958 work was continued to establish indicators for the prognostication of gypsy moth gradations. Particular attention was paid to the investigations of the density of egg clusters in various biotopes, places where eggs were deposited, number of eggs in the clusters, size and dimensions of clusters, percentage of larvae hatched in the wild and in the laboratory, and percentage of parasitism in each developmental stage.
Generation: 2

552. Vasić, K., M. Maksimović, M. Dordević, J. Ivanović, and V. Stanić.
1959. **Investigations in the diapause of the gypsy moth** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 161-162.
Duration of diapause was considerably reduced when eggs were kept at 14 to 15 °C after embryonic development was completed. Differences were established in the duration of diapause with insects reared at various temperatures. Oxygen consumption during embryonic development and diapause were analyzed, as were the embryo-histological changes during diapause.
Eggs: 12,13

553. Vasić, K., and L. Janković.
1960. **A contribution to the knowledge of characteristics of the indicators for the condition of gypsy moth populations in latency** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 39-44.
Detailed studies of the gypsy moth were started in 1953, at the beginning of the last gradation, so that only a limited amount is known about indicators of the latent phase of the gradation. The number of clusters is very small, varying from 2 to

60/ha, showing that the population density oscillates during latency. The number of eggs per cluster is rather large, averaging 700. This number decreases as the number of clusters per square unit increases. The number of unfertilized eggs is small, as is the case during the first years of progradation. During latency, clusters are usually deposited in hidden places, but in damp forests they are laid in conspicuous places as well. Most are deposited below 50 cm. Clusters are of normal form—oval and pear-shaped; round forms occur when the female has limited space. Large and medium-sized clusters are most frequent. The number of larvae hatching from clusters differs considerably under identical conditions.
Adults: 1; Fecundity: 2; Generation: 2

554. Vasić, K.
1972. **A biological method of control of *Lymantria dispar* L. and *Diprion pini* L.** Final Technical Report, Project No. E30-F59, Grant No. FG-YU-120. Institute of Forestry and Wood Industry of Serbia, Beograd, Yugoslavia.

This report covers the results of three separate investigations pursued over a 5-year period, all concerned with the question of biological control of injurious forest insects. The first involves the gypsy moth predator *Calosoma sycophanta* L., the second is about *Apanteles* parasites of early-instar gypsy moth larvae, and the third is on the sawfly parasite, *Neochrysocharis ruforum* Krausse.

The population dynamics of *C. sycophanta* are closely related to the population level of the gypsy moth. When the gypsy moth enters the latent phase of its gradation, *Calosoma* enters a perennial diapause, during which time the imagos remain in their hibernation cells. The predator has two types of diapause, trophical and sexual. The first is unstable and can be forcibly interrupted with ease, whereas the latter is stable and lasts 3 to 4 years. Individual imagos become trophically activated during the diapause, go to the surface and eat a small amount of food, then return underground and resume hibernation. This feeding allows them to survive long periods of prey latency. It is conceivable that an abundance of prey prolongs the trophical activity, which in turn causes reproductive activity. The predator population becomes trophically activated during the progradation of the prey and reproductively activated during the preculminative and culminative stages of the prey. During the course of investigations on *Apanteles* spp., a method of rearing large numbers of them in the laboratory was perfected. *A. porthetriae* Muesb. and *A. melanoscelus* are the species most widespread in Yugoslavia, the latter being of great importance in oak forests. *A. solitarius*, which is thought of as primarily a parasite of *Leucoma salacis*, was frequently found to parasitize the gypsy moth in poplar forests on the plains. *A liparidis*, the only gregarious species involved with the gypsy moth, was predominant in northwest Yugoslavia. These wasps are most effective in light, warm areas, rather than in dense forest.
Instars I-III: 4; Larvae: 3; Pupae: 3

555. Vasiljević, L.
1958. **Influence of the temperature oscillations in the nature upon the development of the polyhedry among gypsy moths** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 57-66.

In the course of larval studies in Serbia, May 25 to July 1, 1957, four periods of high larval mortality due to virus were conspicuous. Each of these high-mortality periods was preceded by a period of high maximum temperature followed by an incubation period of 1 to 4 days, the duration depending on how high the temperature rose during the heat spell. High daily temperature in the course of the gradation exerted a favorable influence on the development of a polyhedrosis epizootic. In regions where climatic conditions were not as favorable to the development of polyhedry, the gypsy moth numbers remained high.
Larvae: 7,12

556. Vasiljević, L.
1958. **Share of the polyhedry and other diseases in the reduction of the gypsy moth gradation which took place in the PR of Serbia in 1957** [in Serbo-Croatian, English summary]. Zast. Bilja 41/42: 123-137.

An epizootic caused by polyhedrosis virus occurred in Serbia, June 15 to June 20, 1957. In the regions where the gypsy moth was in gradation, three classifiable intensities of the epizootic were noted: (1) Gently sloping hillsides with southern exposure, dry air, and high maximum daily temperatures had the highest intensity epizootic with complete destruction of the gypsy moth. (2) Medium lowlands without excessively high daily temperatures and with moderate humidity had a lower intensity epizootic, which did not destroy the gypsy moth population completely. (3) Mountain

stream valleys with high relative humidity, and without high maximum daily temperatures, rarely or never had polyhedrosis epizootics, and probably serve as foci for maintaining the gypsy moth in latency. Of other gypsy moth diseases, *Beauveria* spp. mycosis was found to relate to precipitation during pupation, but not to relative humidity of the air; *Nosema lymantriae* Weiser caused protozoonoses in a small number of larvae and pupae; and bacterioses were scarce and appeared to be chiefly associated with virus diseases. Parasitization of larvae and pupae was very great in most regions and in many places acted in concert with the polyhedry to complete the gypsy moth gradation.
Generation: 4,5,6,7,8

557. Vasiljević, L.
1959. **The appearance of polyhedry in the gypsy moth during the first year after the end of massive population** [in Serbo-Croatian]. Zast. Bilja 52/53: 79–87.

Death from polyhedrosis virus occurs at all stages of gradation. A dense population of insects is not necessary to cause death from virus in individuals. In both field and laboratory studies, it was found that death due to virus continues in the first year after the end of the outbreak. In the gypsy moth, the infection usually starts at the beginning of pupation, especially with females, which have a longer developmental period. Moths of diseased larvae lay infected eggs, which is the reason for continued mortality from virus in a scarce population. The percentage of larvae dying from virus varies with the stage of gradation, the polyhedrosis playing a much smaller role in the reduction of numbers after the end of the outbreak. The condition of the eggs over the winter affects the percentage of survival from virus infection. Some researchers believe a resistance to polyhedry builds up after an epizootic which prevents another epizootic even though the insect population has again become dense.
Adults: 7; Eggs: 7; Generation: 2; Larvae: 7; Pupae: 7

558. Vasiljević, L.
1959. **Density of gypsy moth populations in various localities of the PR of Serbia in the first year after the epizootic diseases of the polyhedry type** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 167–171.

A gypsy moth gradation in Serbia was brought to a halt in 1957 by a virus epizootic. In this study, the relation between the intensity of the disease in 1957 and the population density in 1958 was correlated with the climatic and geographic conditions in various localities. It was found that the epizootic reduced the gypsy moth population in Serbia unevenly; that the gypsy moth was still present in all localities where it had been during the gradation; that the population density the year following the epizootic was closely connected with the intensity of the epizootic; and that the year after the epizootic the density was greatest in those locations characterized by "an agreeable freshness of air during the summer droughts." These locations are usually in the valleys of river mountains and have high humidity.
Generation: 2,7,12

559. Vasiljević, L.
1959. **Two years' fluctuation of the gypsy moth population after the end of the epizooty of the polyhedry type in some regions of the PR of Serbia** [in Serbo-Croatian, English summary]. Zast. Bilja 56: 75–78.

"During 1959, control of the flight of gypsy moths in several regions of the PR of Serbia was observed where an epizootic of polyhedrosis had occurred in caterpillars in the field in 1957. It was established that in most of these regions more . . . [moths] had been caught in the course of 1959 than in the course of the previous year. . . . Further checking of the population density will show whether the gypsy moth is already in progradation or still in latency in these regions."
Generation: 2; Larvae: 7

560. Vasiljević, L.
1961. **Influence of various phases of gradation upon the susceptibility of gypsy moth larvae to polyhedrosis** [in Serbo-Croatian, English summary]. Arh. Poljopr. Nauk. 45: 103–118.
Poljopr. Nauk. 45: 103–118.

The largest percentage of larvae killed by polyhedrosis virus came from a population in a state of culmination. Those most resistant to polyhedrosis were larvae from a population in a state of latency. Susceptibility of larvae in retrogradation and susceptibility of those reared in the laboratory represented a transition between the two previously mentioned groups.
Generation: 2,7; Larvae: 7

561. Vasiljević, L.
1961. **Susceptibility of gypsy moth larvae to polyhedral virus in nature during different phases of a population increase** [in French, English summary]. Entomophaga 6(4): 269-276.

"Experimental research was carried out to establish the polyhedral sensitivity of the caterpillars of *Lymantria dispar* L., in regard to their gradation phase in nature. Differences in polyhedral death rate after virus infection were revealed in relation to the culmination, the retrogradation, the latent phases as well as to an undetermined phase from which they originated. The possible reasons for this are . . . discussed."

Generation: 7; Larvae: 7

562. Vasiljević, L. A.
1962. **The infection of gypsy moth larvae by polyhedra of different ages** [in Serbo-Croatian, French summary]. Zast. Bilja 69-70: 107-114.

563. Vasiljević, L.
1964. **Susceptibility of the gypsy moth to the polyhedrosis in relation to duration of egg hibernation** [in Serbo-Croatian, English summary]. Zast. Bilja 15(80): 397-401.

In a laboratory experiment, it was shown that the longer gypsy moth eggs are in diapause the more susceptible the larvae that hatch from them are to polyhedrosis virus.

Eggs: 7; Larvae: 7

564. Vasiljević, L., and M. Injac.
1973. **A study of gypsy moth viruses originating from different geographical regions.** Plant Prot. 24(124-125): 169-186. (English reprint from Zast. Bilja.)

One gypsy moth gradation cycle in Yugoslavia usually lasts 8 to 9 years. The phases are: latency, progradation, culmination, and retrogradation. The chief factors controlling the sequence of gradation phases in Yugoslavia are parasites, predators, and polyhedrosis virus disease. At the time of a gypsy moth culmination, polyhedrosis involves 90 percent of the larvae just before pupation. It is even present in many pupae, preventing eclosion. Polyhedrosis is still present in the regression phase as a factor of population reduction, but in latency and progradation phases it is impossible to find gypsy moths killed by polyhedrosis. It was found that the same strain of larvae reacts differently to viruses from different geographical regions. One reason may be that larvae from different regions may not be in the same stage of gradation. Also there are definite differences in the pathogenicity of viruses from different areas.

Larvae: 2,7; Pupae: 2

565. Veber, J.
1956. ***Plistophora aporiae* n. sp., a parasite of *Aporia crataegi* L.** [in Czechoslovakian, Russian and German summaries]. Cesk. Parasitol. 3: 181-185.

566. Vives, J. L.
1959. ***Lymantria dispar* in cork plantations of our region** [in Spanish]. Mem. R. Acad. Cienc. Barcelona 1956 33(4): 49-60.

567. Vorontsov, A. I., and E. G. Mozolevskaja.
1972. **The effect of defoliators on the state and growth of oak woods.** Page 107 *in* Proc. 13th Int. Congr. Entomol., 1968., Nauk, Leningrad.

"Defoliation during different phenological periods causes various growth losses, their extent depending not only on the time of larval feeding, but on . . . habitat and [the] physiological state of the tree. Under the best conditions, where the period of oak growth is longer, most of the losses are caused by *O. dispar* and *Notodonta anceps* Goeze. Under less favorable conditions, where . . . oak growth begins and is reduced earlier, considerable growth losses are caused by *Tortrix viridana* L., *Operophtera brumata* L., and other early spring species. . . . Defoliation causes great changes in the ecosystem; it affects all elements (phytoclimate, soil, vegetation, and animal kingdom)."

Oak stands: 15,17,19,23

568. Vukasović, P.
1934. **On the invasion of gypsy moth larvae (*Lymantria dispar*) in the year 1934** [in Serbo-Croatian, French summary]. Arch. Minist. Poljopr. Yugosl. 1(2): 41-72.

569. Vukasović, P.
1936. **Contribution to the study of *Lymantria dispar* in 1935** [in Serbo-Croatian, French summary]. Arch. Minist. Poljopr. Yugosl. 3(4): 36-74.

570. Wallis, R. C.
1957. **Incidence of polyhedrosis of gypsy moth larvae and the influence of relative humidity.** J. Econ. Entomol. 50(5): 580–583.

This study indicates that the polyhedrosis virus has a latent stage which is transmitted through generations. The most important natural stress factor for manifesting virus appears to be humidity.

Generation: 7

571. Wallis, R. C.
1959. **Factors affecting larval migration of the gypsy moth.** Entomol. News 70: 235–240.

In laboratory tests it was found that larvae migrated toward moist sites only when responding to an interacting factor such as light, or when exhibiting the negative geotrophism of the early instars. "Middle- and late-instar larvae lost the geotrophic orientation and were distributed randomly regardless of the position of moist sites." When light was substituted for geotrophism as the interacting factor with moisture, young larvae were positively phototrophic and older larvae negatively phototrophic, regardless of the moist sites. When oak leaves were used as an attractant, it was found that the food alone elicited no migratory response, but that once food was encountered during random ambulatory movements or in the course of migration stimulated by other factors, the larvae accumulated on the leaves and fed. In tests conducted in darkness, young larvae exhibited a negative geotrophism, but when light was added the larvae migrated toward it no matter what direction it came from. Late-instar larvae did not migrate upward in the dark and lost their positive phototrophism. It was not clear from the experiments whether "this was a result of a loss of negative geotrophism and the development of an avoidance of light, or whether the larvae developed an avoidance reaction to the heat which was associated with light."

Instars I–III: 1; Instars IV–VI: 1

572. Wallis, R. C.
1960. **Environmental factors and epidemics of polyhedrosis in gypsy moth larvae.** Pages 827–829 *In* Proc. 11th Int. Congr. Entomol., 1960.

The most effective procedure for eliciting viral disease ". . . was utilization of excessive relative humidity at temperatures ranging between 80 and 85°F. The daily attack rate within a diseased colony was lowered by reducing the relative humidity within the rearing cage . . . It was [also] noted that larval migration and feeding were stimulated by reducing the humidity, whereas these activities were retarded under conditions of high humidity . . . During the 3- to 5-day period prior to feeding on foliage, [newly hatched larvae] were not susceptible to humidity changes, whereas older larvae were affected . . . At high temperatures, when metabolic activity was high, nutritional demand and feeding were at a maximum . . . [If there was an increase in relative humidity] without adequate air movement, the evaporation gradient between the caterpillar and its environment was lowered so that excess water ingested in the food could not be disposed of and feeding stopped—even though metabolic activity and nutritional demand were high. As a result, a secondary nutritional stress was incurred. At lower temperatures, when metabolic activity and subsequent nutritional demand were low, increased humidity and depression of the evaporation gradient did not result in such a stress."

Larvae: 1,7,12,13

573. Webber, R. T., and J. V. Schaffner, Jr.
1926. **Host relations of *Compsilura concinnata* Meigen, an important tachinid parasite of the gipsy moth and the brown-tail moth.** U. S. Dep. Agric. Bull. 1363. 31 p.

Compsilura concinnata emerges from its hibernating host in the spring as a last-stage larva. It pupates nearby, and after 10 days or so, the adult appears. This species is known to have many alternate hosts other than the gypsy moth and browntail moth, including 18 families of Lepidoptera among summer hosts. It uses little discrimination in its choice of hosts and will waste much effort in futile attacks upon unsuitable ones. *C. concinnata* habitually attacks only larvae that have reached the third stage. Owing to the gypsy moth's abundance, *Compsilura* attacks this species aggressively. In New England, there are two or more generations of *C. concinnata* on alternate hosts; the progeny of the second generation hibernate as larvae within Lepidopterous pupae.

Larvae: 4

574. Webber, R. T.
1932. ***Sturmia inconspicua* Meigen, a tachinid parasite of the gipsy moth.** J. Agric. Res. 45: 193-208.

This polyentomophagous parasite attacks the gypsy moth as well as the pine sawfly (*Diprion simile*). It overwinters as a larva in the pupa of a fly or a lepidopteran. Two generations are completed in the course of a year. Eggs are oviposited on the integument of the host.

Larvae: 4

575. Weiser, J.
1957. **Microsporidia of the gypsy moth and the nun moth** [in German, English summary]. Z. Angew Entomol. 40(4): 509-521.

"Two new microsporidians, which are described, were found infesting *Lymantria dispar* L. in Czechoslovakia. They are *Nosema lymantriae* and *N. muscularis.* A further microsporidian, *Thelohania similis*, was found in *Nygmia phaeorrhoea.* The course of the disease and the transference of the microsporidians to further secondary hosts in the same biotope show how closely the organisms are connected to the whole biozonose. This is also shown by the table of primary and secondary hosts of the individual microsporidians. It was found that two or more organisms can cause a mixed infection with combined symptoms. They can be isolated pure by transference to specialized secondary hosts. In one case, it was possible to infect a new host by mixing two microsporidians when one was not pathogenic to it in pure culture. Individual courses of epidemic processes, as known in human epidemiology, were found in the infection by microsporidians. In diseases of introduced pests, which they obtain in their new biozonoses, we can speak of natural sources of infection of these 'germs' in indigenous hosts, in the sense of Pavlovskij's theory."

Generation: 8

576. Weiser, J.
1963. **Protozoan diseases of the gipsy moth.** Pages 497-499 *in* J. Ludvik et al., eds. Progress in protozoology. Academic Press, New York.

A new species of protozoan *(Nosema serbica)* was named by Weiser. This protozoan attacks all the stages of the life cycle of the gypsy moth; transovarian transmission also occurs. Infected eggs usually hatch, but the larvae die before pupation. Larvae infected after hatching usually die as pupae or survive as adults, but the adult females are sterile. Occasionally adult females lay infected eggs which will hatch. Spread of the protozoan is dependent on gypsy moth density. The protozoan would not be useful as a spray for control but is useful for natural biological control. Owing to its density-dependent mechanism, the protozoan would help prevent severe outbreaks.

Generation: 8

577. Weseloh, R. M.
1972. **Field response of gypsy moths and some parasites to colored surfaces.** Ann. Entomol. Soc. Am. 65: 742-746.

Weseloh discusses the responses of the gypsy moth, of an egg parasite of the gypsy moth, *Ooencyrtus kuwanai* (Howard) (Hymenoptera: Encyrtidae), and of a parasite of the larvae of noctuids, Apanteles laeviceps Ashmead (Hymenoptera: Brachonidae) to differently colored surfaces. Stikem® -coated panels (white, yellow, red, blue, black, clear Plexiglas® and aluminum) were hung in two sites in Stonington, Conn. in the summer of 1971. "Numbers of insects caught varied according to species and date as well as color. *O. kuwanai* was attracted mainly to white and blue panels, *A. laeviceps* to clear Plexiglas panels, and gypsy moth males to red, blue, and black panels. The results are discussed as they relate to orientation in these organisms." Results may indicate that gypsy moth males tend to orient to dark objects, such as tree trunks, where females are likely to be located.

Adults: 1, 13; Eggs: 4; Larvae: 1

578. Weseloh, R. M.
1972. **Spatial distribution of the gypsy moth (Lepidoptera: Lymantriidae) and some of its parasites within a forest environment.** Entomophaga 17(3): 399-351.

"Aspects of the microhabitat distributions of the gypsy moth, *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae), and some of its parasites were investigated in the field by means of sticky panels and gypsy moth egg masses exposed at different heights in trees, by egg masses exposed within forested and cleared areas, and by gypsy moth pupal collections from different heights in trees. *Ooencrytus kuwanai* (Howard) (Hymenoptera: Encrytidae), *Apanteles melanoscelus* Ratzeburg (Hymenoptera: Braconidae), and gypsy moths were caught most frequently on sticky panels

placed in upper portions of trees. In contrast, *Apanteles laeviceps* Ashmead, a parasite of cutworms, was most often caught near the forest floor. *O. kuwanai* attacked equally egg masses exposed at different heights in trees, but parasitized those in a clearing less often than those within the forest proper. *Brachymeria intermedia* (Nees) (Hymenoptera: Chalcididae) emerged mostly from pupae collected near the tops of trees and not at all from those collected below 5 m. The results are discussed as they relate to field sampling procedures, behavioral activities of gypsy moth and parasite adults, and integrated control possibilities for the gypsy moth." The distribution of adult males was monomodal with time. Males orienting to a strong pheromone source were active at lower levels of the forest than those not so orienting and presumably flying randomly.
Adults: 1; Eggs: 4; Instars I-III: 1; Larvae: 4; Pupae: 4

579. Weseloh, R. M.
1972. **Influence of gypsy moth egg mass dimensions and microhabitat distribution on parasitization by *Ooencyrtus kuwanai* (Howard).** Ann. Entomol. Soc. Am. 65: 64-69.

Data were collected to study the relationship of egg mass size and microhabitat to percent parasitism. Results show a higher percent parasitism on small egg masses, probably because of the accessibility of more eggs to the parasite in smaller egg masses. Difference in site-specific correlation indexes cannot easily be explained by difference in percent parasitism or by variation in egg mass sizes. Local climatic effects, topographical influences, and population characteristics of the gypsy moth are probably important. No significant correlation was found between aspect or height and percent parasitism.
Eggs: 4

580. Weseloh, R. M.
1973. **Relationships of natural enemy field populations to gypsy moth abundance.** Ann. Entomol. Soc. Am. 66: 853-856.

"**Field populations of** *Porthetria dispar* (L.) and its natural enemies *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae), *Blepharipa scutellata* (Robineau-Desvoidy) (Diptera: Tachinidae), and *Colosoma sycophanta* (L.) (Coleoptera: Carabidae) were sampled during one summer and related by regression analysis. Natural enemies did not attack a greater proportion of gypsy moths at higher population densities of the latter, and so were not acting in a positive density-dependent manner at the time of the study. Also, absolute numbers of adult natural enemies were not positively correlated with gypsy moth numbers, implying that the natural enemies did not aggregate where gypsy moths were most abundant."
Adults: 3; Larvae: 3; Pupae: 3

581. Weseloh, R. M.
1974. **Relationships between different sampling procedures for the gypsy moth, *Porthetria dispar* (Lepidoptera: Lymantriidae) and its natural enemies.** Can. Entomol. 106: 225-231.

"A variety of field sampling procedures were used to estimate population levels of the gypsy moth, *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae), and the following natural enemies: *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae), *Blepharipa scutellata* (Robineau-Desvoidy) (Diptera: Tachinidae), [and] *Calosoma sycophanta* (L.) (Coleoptera: Carabidae). Regression analyses indicated, among other things, that gypsy moth egg-mass counts were not good indicators of tree defoliation, but that defoliation and number of gypsy moth larvae on branch terminals were correlated. Estimates of adult adundance of *A. melanoscelus* and *B. scutellata* were negatively correlated with estimates of numbers of immature parasites. Numbers of gypsy moth larvae parasitized by *A. melanoscelus* were positively correlated with numbers of *A. melanoscelus* cocoons sampled. Numbers of adult *C. sycophanta* were not correlated with larval numbers of this insect. It was concluded from these results that the procedures used to estimate numbers of natural enemy adults were not entirely adequate but may be useful for supplementing other sampling methods."
Larvae: 3, 4

582. Weseloh, R. M., and J. F. Anderson.
1975. **Inundative release of *Apanteles melanoscelus* against the gypsy moth.** Environ. Entomol. 4: 33-36.

"Pupae and adults of *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae) were released in five plots in three sites in Connecticut during the summers of 1973 and 1974. Gypsy moth numbers varied from low to high in the different sites. Weekly collections of caterpillars showed consistently greater percent parasitism by

A. melanoscelus in the release plots than in the check plots at all three sites for at least the first 2 to 3 weeks after release. In later collections, no differences occurred in the two sites where gypsy moth numbers were low. In the site with high host numbers, percentage parasitism in the release plots was higher than in the checks, even at the seventh weekly collection after release."
Larvae: 4, 6, 7

583. Yadava, R. L.
1970. **Influence of temperature and humidity on the development of nuclear-polyhedrosis of *Lymantria monacha* L. and *L. dispar* L.** [in German, English summary]. Z. Angew. Entomol. 65: 167–174.

"Experiments were conducted to study the influence of six different temperature levels, viz. 8 to 12° C, 16.5 to 17.5° C, 19.5 to 20.5° C, 23.5 to 24.5° C, 26.5 to 27.5° C, and 29 to 31° C, each in combination with three relative humidities, viz. 30 to 40 percent, 70 to 80 percent, and 90 to 95 percent, on the development of . . . nuclear-polyhedrosis virus in second- and fourth-instar nun moth (*Lymantria monacha* L.) and in the second-instar gypsy moth (*L. dispar* L.) caterpillars with the help of a William's multiple temperature-incubator. The temperature clearly influences the development of nuclear-polyhedrosis virus, while the relative humidity practically fails to do so. Up to the temperature range of 26.5 to 27.5° C, [the] higher the temperature [the] faster [is] the development of [the] virus; the next higher temperature level, viz. 29 to 31° C does not seem to accelerate virus development any more. The extent of influence of temperature on the development of Fed nuclear-polyhedrosis virus in the two larval instars, viz. second and fourth, seems to be equal, although the acuteness of virus infections in the former instar is quicker than in the latter one."
Larvae: 7

584. Zakula, S.
1971. **The state of infection from the gypsy moth in Bosnia and Herzegovina** [in Serbo-Croatian]. Sumar. Glas. 6(1): 13–20.

585. Zanforlin, M.
1970. **The inhibition of light orientating reactions in caterpillars of Lymantriidae, *Lymantria dispar* (L.) and *Orgyia antiqua* (L.) (Lepidoptera).** Monit. Zool. Ital. (N.S.) 4: 1–19.

Larvae of *Lymantria dispar* (L.) and *Orgyia antiqua* (L.) may ". . . die of starvation while striving towards the light when inside a test tube (as observed by Loeb), but yet are able to turn away from light in their natural habitat if they reach the extremity of a leafless branch (as observed by Degener)". A study of this problem has shown that: (1) The larva's ". . . tendency to crawl towards the light is inhibited by a specific stimulus, namely, lack of tactile stimuli in the forelegs." (2) The straight crawling tendency ". . . is suddenly inhibited by lack of tactile stimuli *in the direction of light*. (3) The reorientation turn or 'steering mechanism' is inhibited by lack of tactile stimuli *in the upwards direction* after a few repetitions of the reaction. Both conditions are present when the caterpillars are on a horizontal stick but not when inside a horizontal test tube. (4) The inhibition of the reaction to light allows the caterpillars to revert to an exploratory behavior that prevents the animal from being stuck at a dead end. This lasts for a certain period of time after which the crawling towards the light is resumed. (5) The period of time spent in exploratory behavior crawling away from light becomes longer with subsequent inhibitions of the reaction to light."
Larvae: 1

586. Zecević, D.
1955. **Winter feeding and development of the gypsy moth under laboratory conditions in 1952–1953** [in Serbo-Croatian, English summary]. Zast. Bilja 28: 3–20.

Results of experimental work in rearing gypsy moth in the laboratory during the winter are discussed. Egg clusters from Slovenia were used. Larvae fed on *Pyracantha coccinea* Roem., an evergreen plant. Diapause was interrupted, and larvae emerged after transfer to laboratory conditions. Length of developmental stages are given. The

question is raised whether, given favorable climatic and feeding conditions, the gypsy moth could produce two generations a year.
Generation: 1

587. Zečević, D.
1958. **Daily food consumption of gypsy moth caterpillars on oak trees and on *Pyracantha coccinea*** [in Serbo-Croatian, English summary]. Zast. Bilja 49/50: 23–33.

The larval and pupal stages were found to last a little shorter and longer, respectively, when the larvae were fed oak leaves rather than *Pyracantha* leaves. On an average, the larval stage lasted 42.8 days when oak-fed and 49.7 days when *Pyracantha*-fed, while the pupal stage lasted 11.1 and 10.1 days, respectively. Overall size and fertility was greater with oak feeding, yet this group showed a greater number of unfertilized eggs than *Pyracantan*-fed individuals. Average daily consumption of oak was 30.92 mm^2 in the first stage and 4,866.81 mm^2 in the sixth stage; daily consumption of *Pyracantha* was 9.66 mm^2 in the first stage and 2,612.04 mm^2 in the sixth stage. It is estimated that an egg mass of 500 eggs with complete hatching would yield enough larvae to consume about 43 m^2 of oak-leaf surface or 29 m^2 of *Pyracanta*-leaf surface. The quantity of oak corresponds to two 63-year-old trees or four 13-year-old oaks.
Oak stands: 15, 19; Larvae: 12; Pupae: 12

588. Zečević, D., L. Janković, and P. Sisojević.
1959. **Comparative ecological investigations of the gypsy moth in lowlands, hilly, and mountainous biotopes (annual report, 1958)** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 162–165.

Investigations started at the end of the preceding outbreak (1949) are still underway to determine the differences in the course of fluctuations of gypsy moth populations in different biotopes. It is planned to carry out this study until it covers at least two whole gradation periods.
Generation: 2, 12

589. Zečević, D., and M. Janković.
1959. **A contribution to the knowledge of variability of *Lymantria dispar* in Yugoslavia: Biometrical analysis of the egg stage with geographically distant populations** [in Serbo-Croatian, English summary]. Zast. Bilja 52/53: 7–14.

Goldschmidt (1924) showed that there were different races of gypsy moths in southeastern and middle Europe. Given the geographical situation of Yugoslavia and the various climatic regimes within the country, the authors considered it likely that different races existed in Yugoslavia. They measured various parameters of the egg, comparing populations from Macedonia, Montenegro, and the island of Hvar (Mediterranean region) with those from Slovenia, Slavonia, and Serbia (continental climate) and found striking differences in the size of eggs. Using biometrical analysis, they determined that eggs in Yugoslavia differ phenotypically. In general, eggs are larger in smaller clusters. This relation is not consistent, perhaps because it changes with stage of gradation.
Eggs: 2, 12, 13

590. Zhalnin, Y. S.
1956. **Establishing the necessity for control of the gypsy moth in the forest Kolkhoz of Dukhovnitsi on the basis of the study of its infection with egg-eating parasites** [in Russian]. Sb. Stud. Rab. Povolzh. Lesotekh. Inst. 3: 86–88.

591. Zhikharev, I.
1928. **Injurious and other Lepidoptera in the Darnitza Experimental Forest** [in Ukrainian, Russian summary]. Mitt. Forstl. Versuchswes. Ukr. 9: 231–240.

592. Zwolfer, W.
1927. **The pebrine of the gypsy moth and the brown-tail moth, a new infection of economic importance** [in German]. Z. Angew. Entomol. 12(3): 498–500.

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