# TRANSFER OF A *PYEMOTES*[1] EGG PARASITE PHORETIC ON WESTERN PINE BARK BEETLES TO THE SOUTHERN PINE BEETLE[2]

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----- ABSTRACT—*Pyemotes giganticus* has the widest phoretic latitude of any known *Pyemotes*, probably riding all scolytids and at least one tenebrionid beetle associate. The female heteromorph is not phoretic. The feeding latitude is narrow; the mite is known to feed only on scolytid eggs, and then reluctantly. Parasitism of a natural host, *Pseudohylesinus nebulosus*, is very low, probably far less than 1 percent. Phoretomorphs gave birth to males, phoretomorphs, and female heteromorphs. Normal females bore phoretomorphs and males. Adults were born head first and the males did not assist in births. -----

## INTRODUCTION

Of the regionally native mite species phoretic on *Dendroctonus frontalis* Zimmerman 1868, the southern pine beetle (SPB), several are predators of SPB immature stages, but none is parasitic (Moser 1976). Perhaps this contributes to the beetle's propensity for periodic population explosions. The three other main competitors for pine phloem (*Ips* spp.) rarely become epidemic; perhaps all host at least one mite parasite. Because no effective native mite parasites exist for SPB, one productive approach to biological control of *D. frontalis* involves the search for extraregional mite parasites. But any mite species selected for introduction must also ride adult beetles during dispersal flights, because once the mite is introduced, phoresy is essential for its survival. Though several mites have been documented as effective brood parasites of *D. frontalis* (Moser 1975, Moser *et al.* 1978), none would ride beetle adults.

*Pyemotes giganticus* Cross, Moser, and Rack 1981 was first collected in 1966 by D. N. Kinn from adults of 16 bark beetle species of diverse genera taken from 10 species of conifers in California, Oregon, and Washington (Cross *et al.* 1981). This mite seemed to be confined to the western United States; but it can be phoretic on an unusually broad number of beetle species. So it might attack and ride any scolytid from conferous trees, including the southern pine beetle.

Morphologically, phoretomorphs and males of *P. giganticus* are practically indistinguishable from those of *P. dimorphus* Cross and Moser 1975, (Cross *et al.* 1981), but *P. giganticus* differs from all other *Pyemotes* by the presence of a giant female heteromorph. Phoretomorphs are common, but the normal and heteromorph forms are much less frequent.

This report documents the discovery of the first extraregional *Pyemotes* that rides SPB adults, and which attacks SPB eggs under experimental conditions.

## METHODS AND MATERIALS

To check if *P. giganticus* overwinters in the phoretic state, I had 1000 overwintering *Pseudohylesinus nebulosus* (LeConte 1859) caught in light-traps during March 1978 at Otis, Ore., shipped to Pineville, La., and scanned for phoretic mites.

1. *Pyemotes giganticus* Cross, Moser, and Rack 1981 (Acarina: Pyemotidae).
2. *Dendroctonus frontalis* Zimmerman 1868 (Coleoptera: Scolytidae).
3. U.S.D.A. Forest Service, Southern Forest Experiment Station, 2500 Shreveport Highway, Pineville, Louisiana 71360, USA.

I received 198 bolts of Douglas-fir, *Pseudotsuga menziesii* (Mirbell 1825) Franco 1950, also collected at Otis during the spring and summer of 1977, 1978, and 1979. The bolts contained galleries and brood of *P. nebulosus*. Half of the 1977 and 1978 bolts were dissected and the bark beetle galleries searched for females of *P. giganticus*, which were used to study the mites' biology and phoretic behavior. The other bolts were held in rearing cans, and phoretic mites were collected from emerging parent and brood adults. Eight bolts received in May and June 1979 were dissected and checked for the number of successful *P. nebulosus* galleries and beetle life stages and for numbers and species of mites seen in the galleries. The number of *P. giganticu* attacking beetle eggs was also recorded.

To determine if *P. giganticus* phoretic on parent adults of *P. nebulosus* would reattach to *P. nebulosus* brood adults as well as adults of Central Louisiana bark beetles, I exposed phoretomorphs to adults of the pine bark beetles, *Dendroctonus frontalis*, *Ips avulsus* (Eichhoff 1868), *I. calligraphus* (Germar 1824), *I. grandicollis* (Eichhoff 1867), *Pityophthorus annectans* LeConte 1878, and a cedar bark beetle, *Phleosinus canadensis* Swaine 1917. Phoretomorphs were gently teased from recently emerged parent adults of *P. nebulosus* and placed individually in plaster of Paris chambers of the type described by Moser (1975). Here they were exposed to 20 individuals each of both sexes of parent and brood adults of the SPB, the 3 *Ips* species, and to 10 unsexed individuals each of *P. annectans*, *P. canadensis* and to *P. nebulosis* brood adults.

To see if *P. giganticus*' phoretic latitude might extend to beetle associates unrelated to scolytids, I acquired three bolts of western hemlock, *Tsuga heterophylla* (Rafinesque 1832) Sargent 1898, during spring 1976 with galleries of *Pseudohylesinus tsugae* Swaine 1917. Several adults of *Corticeus subopacus* (Wallis 1933), a tenebrionid associate, emerged from the bolts and were scanned for phoretic *P. giganticus*.

The ability of recently born and fertilized *P. giganticus* phoretomorph and heteromorph females to bond phoretically with SPB, the three *Ips* species, and brood adults of *P. nebulosus* was checked by placing five unsexed bark beetles of each species in plaster of Paris cells with physogastric phoretomorphs giving birth to both phoretomorphs and female heteromorphs. Observations terminated 2 days after the last mite was born.

I tallied brood production of physogastric females by removing physogastric females from galleries, placing them in plaster of Paris cells, and recording numbers of males, phoretomorphs, and female heteromorphs, and their order of birth.

The attractiveness of bark beetle brood as food was determined by separately placing eggs, early larvae, and pupae of SPB, the three species of *Ips* and *P. nebulosus* in the plaster of Paris cells with recently born and mated phoretomorphs and female heteromorphs of *P. giganticus*. Beetle brood were observed daily for evidence that mites had attacked or fed on them. Phoretomorphs tests were replicated 10 times each, and female heteromorphs five times. To see if phoresy increased attack aggressiveness the latter tests were replicated 20 times with phoretomorphs removed from emerged *P. nebulosus* parent adults in plaster of Paris cells with brood of the above five species of bark beetles.

To simulate field conditions I removed phoretomorphs from parent adults of *P. nebulosus* and allowed them to reattach to brood adults of SPB, the three species of *Ips* and *P. nebulosus*. The beetles with phoretic mites were then allowed to bore into and form egg galleries in phloem sandwiches of the type described by Bushing (1967). I observed these mites under the plexiglass at least once daily to see if they attacked beetle brood. Emerging brood adults were checked for any phoretic mites.

Using *Pinus taeda* L. 1753 as a phloem source, I allowed three pairs of *D. frontalis* to penetrate and form galleries in each of five sandwiches; the female of each of the 15 pairs carried a single phoretomorph. The same procedure was repeated for each of the three *Ips* species. And another sandwich was colonized with a single pair of *D. frontalis*; the female carried five phoretomorphs. Still another pair of parent adults of *P. nebulosus*, both carrying

three phoretomorphs, made galleries in a sandwich composed of Douglas-fir phloem. I observed behavior of the mites daily until the parent adults emerged; them I opened the sandwiches and inspected them to see if any beetle brood had been attacked, and for *Pyemotes* reproduction.

Brood adults emerging from three *Pinus taeda* were checked for phoretic *Pyemotes*. The bolts were 20-cm diameter and 1.3-m long and had been inoculated in the laboratory with pairs of *D. frontalis* ; the females carried phoretomorphs. Two bolts were stocked with 14 pairs, each female carrying a single phoretomorph. The third bolt had nine pairs, each female carrying three phoretomorphs. Emerging beetles were checked for mites. After emergence the bolts were dissected and checked for evidence that beetle brood had been attacked and for *Pyemotes* reproduction.

## RESULTS AND DISCUSSION

Only 44 of the 1000 overwintering *Pseudohylesinus nebulosus* had phoretic mites, and only two of these had *Pyemotes giganticus*. Thirty-eight beetles had a single mite, three had two mites, two had three mites, and one carried four mites. Four mite species were present. There were 38 *Calvolia* sp. hypopae, two males and 20 females of *Choriarchus reginus* Kinn 1966, and two females each of *Pyemotes giganticus* and *Microdispodides* n. sp. *Choriarchus reginus* and *Microdispoidides* n sp. were phoretic under the elytra; but *P. giganticus* were attached to the setae near the coxae, and the *Calvolia* sp. were distributed generally over the body.

About 10 percent of several hundred parent adults reared from the Douglas-fir bolts had as many as nine, but usually two to three phoretomorphs of *P. giganticus* attached to the setae at the bases of the coxae (fig. 1), but rarely on the legs. Curiously, no phoretomorphs were seen on any of the several thousand brood adults reared from the bolts. The lack of phoretomorphs may explain their low incidence on the overwintering *P. nebulosus*. The ratio of brood adults to parent adults in the overwintering beetles is not known, but they are virtually all brood adults with only a small percentage of parent adults (Julius Rudinsky, personal communication).

In 1979 I received eight bolts with *P. nebulosus* attacks and dissected them to determine the incidence of parasitism. Three bolts received in May had 37, 56, and 64 egg galleries containing eggs; *P. giganticus* was absent.

Five bolts received in June contained 15, 15, 17, 20, and 27 egg galleries. *Pyemotes giganticus* were found in only two of the bolts. In the bolt with 27 attacks, three phoretomorphs were seen in one of the egg galleries with 30 egg niches, but no evidence of the physogastric mother was found; all 30 eggs had hatched into first-instar larvae. In the bolt with 17 attacks, three galleries contained *P. giganticus*. In the first egg gallery containing 12 unhatched eggs, a dead, partly swollen phoretomorph was found in an egg niche along with the beetle egg remains. The second gallery held 18 eggs; 12 had hatched to first-instar larvae. One live, physogastric normal mother with 16 daughter phoretomorphs clustered around her was seen in one of the egg niches. She died with an unborn male. The third egg gallery contained 30 first-instar larvae, each in larval galleries radiating away from the egg gallery. Three phoretomorphs were seen crawling in the egg gallery, but no physogastric mother was found.

Apparently the mite does attack eggs, but its impact is negligible in the field where the percentage of parasitism was less than one percent.

The phoretomorphs teased from parent adults of *P. nebulosus* all reattached within 1 min to the brood adults of *P. nebulosus* and to both sexes of parent and brood adults of the SPB, to the three *Ips* species, and to the adults of *P. annectans* and *P. canadensis*. This variety of hosts confirms previous unpublished records by Kinn that this mite has an unusually broad phoretic spectrum. That this mite is phoretically aggressive toward *P. nebulosus* brood adults, at least in the laboratory, is evidence that the mite' s absence on flying brood adults is at least not due to lack of phoretic attraction by brood adults. We know that phoretomorphs of *P. giganticus* will

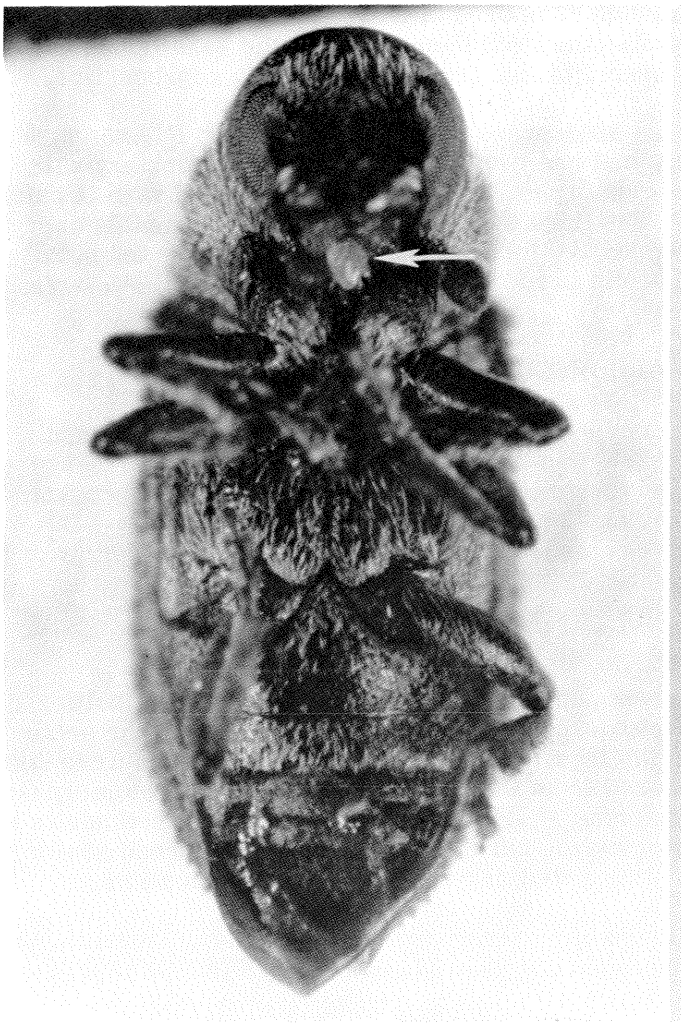

Fig. 1 (left): *Pseudohylesinus nebulosus* adult with phoretomorph (arrow) of *Pyemotes giganticus* attached in the vicinity of the base of coxae 1.
Fig. 2 (right): *Corticeus subopacus* adult with phoretomorph (arrow)) of *Pyemotes giganticus* attached between bases of coxa 1 and coxa 2.

bond phoretically to the cedar bark beetle, *P. canadensis*, because this beetle is host to *Pyemotes dimorphus* a species so closely related to *P. giganticus* that the phoretomorphs cannot be separated morphologically.

One specimen of the *Corticeus subopacus* had three phoretomorphs of *P. giganticus* attached when it emerged from the bolt infested with *P. tsugae* (fig. 2). This finding expands the phoretic latitude of *P. giganticus* to beetles other than scolytids and is the first record of a *Pyemotes* phoretic on a nonscolytid.

Behaviorally, *P. giganticus* differs from all other species of *Pyemotes*, because the others are either nonphoretic or are relatively host specific, riding at most on a single genus of scolytids. Except for *P. giganticus*, no *Pyemotes* is phoretic on the southern pine beetle, although most readily attack laboratory cultures of brood.

The recently born and fertilized phoretomorphs were attracted to and mounted bark beetle as aggressively as those teased from the parent adults of *P. nebulosus*. Only one newly born heteromorph female was available for testing, but it refused to ride adults of SPB or the

Fig. 3: Southern pine beetle female seen through glass, boring egg gallery in phloem sandwich. Phoretomorph of *Pyemotes giganticus* (arrow) is attached to abdomen just behind base of coxa 3.

three *Ips* species. This is not surprising since the leg 1 claw of the heteromorph is not shaped for grasping setae.

Because physogastric females were rare and fragile, only two were found intact. The first physogastric phoretomorph, retrieved slightly injured, gave birth to 12 phoretomorphs, but no males or female heteromorphs. The second phoretomorph gave birth to two males, five heteromorph females, and 20 phoretomorph females, all born head first. A male was born first, then the female heteromorphs, the second male, and finally the phoretomorphs. Males did not assist in the birth of the females as is common with many species of *Pyemotes* (Moser *et al.* 1971). Rather they waited until the female was free of the birth canal and then mated with her.

Neither the recently born and mated phoretomorph nor heteromorph females attacked eggs, early larvae, or pupae of the five bark beetle species in the plaster chambers. Phoretomorphs removed from emerged parent adults also refused to attack.

The preceeding establishes that phoretomorphs may bear males, heteromorphs and other phoretomorphs, and that normal females may bear phoretomorphs and males. But it is still unclear as to which female morph produces the normal female.

One mite did attack a SPB egg under simulated field conditions. Of the 71 phoretomorphs introduced into the phloem sandwiches on 63 adults of the five bark beetle species, the only successful attack was one of the five attached to the single female *D. frontalis.* By the 6th day when the sandwich was opened, one phoretomorph had attacked and deflated an egg, and was fully swollen. In the gallery another mite was still attached to the beetle, and another was seen crawling; the other two could not be located. Parent adults were allowed to emerge from the other 61 galleries of the five scolytid species tested before the sandwiches were opened and searched for mites. In each case no phoretomorphs were seen on the parent adults, no mites could be located in the galleries, nor was there any evidence that any eggs had been attacked by the mites. Mites were still attached to female beetles as they were boring egg galleries (fig. 3).

From the bolts inoculated with *D. frontalis* and attached phoretomorphs, 156 and 430 parent and brood adult beetles emerged from two bolts, each stocked with 14 pairs of beetles. Only 20 beetles emerged from the third bolt stocked with nine pairs. No mites were attached to any of the emerged beetles. When bolts were dissected, no mites were found in the galleries, nor was there any evidence that they had attacked the immature stages of the beetle.

## CONCLUSIONS

These findings do not support the release of *Pyemotes giganticus* into the field as a biological control agent of SPB. Though information about phoresy show that the mite readily rides SPB and other southern pine bark beetles, the reluctance of *P. giganticus* to attack immature stages of any bark beetle, both in the laboratory and in its native habitat, suggests that this mite would not survive with SPB as its host.

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