

LIFE CYCLE AND PRODUCTION OF *SKWALA PARALLELA* (FRISON) (PLECOPTERA: PERLODIDAE) IN A COLORADO MONTANE STREAM

Robert A. SHORT & James V. WARD

Department of Zoology and Entomology, Colorado State University, Fort Collins, Colorado, USA 80523

Address all correspondence to: Dr. J. V. Ward, Department of Zoology and Entomology, Colorado State University, Fort Collins, Colorado 80523, U.S.A.

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Abstract

The life cycle and production of *Skwala parallela*, a perlodid stonefly, was investigated in a third-order Colorado montane stream. The species exhibited a univoltine life cycle with a distinct cohort. Small nymphs appeared in May. Rapid growth was exhibited throughout summer and autumn. During winter, growth slowed somewhat but was continuous until April. Maximum density of 34 nymphs/m² occurred in July. Based upon the instantaneous growth method, annual production was 395.3 mg/m² or 3.95 kg/ha dry weight with a P/B ratio of 4.4

Introduction

Plecoptera nymphs are a conspicuous component of the macroinvertebrate fauna in unpolluted mountain streams. Members of the Setipalpia are generally considered to be predaceous and may compete efficiently with fish for prey items (Brocksen, Davis & Warren, 1968). Although life cycles have been determined for a number of the Perlodidae in North America (e.g., Minshall, & Minshall, 1966; Cather & Gauvin, 1975), information on production is lacking. In a recent review of secondary production in fresh waters (Waters, 1977), only one member of the Perlodidae was included and no definitive information was given on its production. Moreover, Waters & Crawford (1973) have stressed the need for more empirical data on productivity in aquatic systems.

Skwala parallela (Frison) is widely distributed throughout western North America (Baumann, Gauvin & Surdick, 1977). Adult emergence occurs from February through July. Since *Skwala parallela* was the most abundant large invertebrate predator in a Colorado montane stream, a study was undertaken to determine its life cycle and production.

Study area

Trout Creek is a third-order stream within the Manitou Experimental Forest in the South Platte River drainage system of central Colorado. The study section is located in a broad alluvial valley in the montane zone (2230 m a.s.l.). Willow shrubs (*Salix* spp.) grow on the floodplain; open ponderosa pine forest occupies higher ground. The substrate of the stream consists primarily of gravel and some rubble derived from disintegrated Pikes Peak granite. Rooted aquatic macrophytes (*Veronica*) occur at low densities. Stream width varies from 3 to 5 m with depths generally less than 0.5 m.

During the year of study, water temperatures ranged from 0-19°C. Total dissolved solids averaged 139 mg/l. Flow was relatively constant, varying from a mean monthly high of 110 l/sec in June to a low of 50 l/sec in September. Nitrate-nitrogen averaged 0.246 mg/l and orthophosphate averaged 0.171 mg/l during that period. At the time of maximum stream flow (June 1977), mean suspended solids values ranged from 12-40 mg/l.

Methods

Benthic samples were taken at approximately monthly intervals from June 1977 through May 1978. Fifteen replicates were collected from riffle areas on each date with a Surber sampler equipped with 250 μm mesh. All samples were preserved in 5% formalin.

In the laboratory *Skwala parallela* nymphs were separated from detritus and stored in 80% ethanol. Interocular distance (I.O.) was measured to the nearest 0.1 mm with an ocular micrometer at 10X. Dry weight was determined after drying to constant weight at 60°C.

Annual production for *Skwala parallela* was calculated using the instantaneous growth method. The cohort turnover ratio was determined by dividing the total cohort production by the mean cohort standing crop (Waters & Crawford, 1973).

Results and discussion

The results of interocular distance measurements of *Skwala parallela* nymphs are shown in Figure 1. A univoltine life cycle is indicated since only small nymphs were collected in June. Growth was rapid throughout the summer and fall months. During winter growth slowed somewhat but was continuous until April when the largest nymphs were found. The anomalous value for March (Fig. 1) may have resulted from the small number of nymphs collected as well as from temporal differences in the emergence of males and females. The life cycle of *S.*

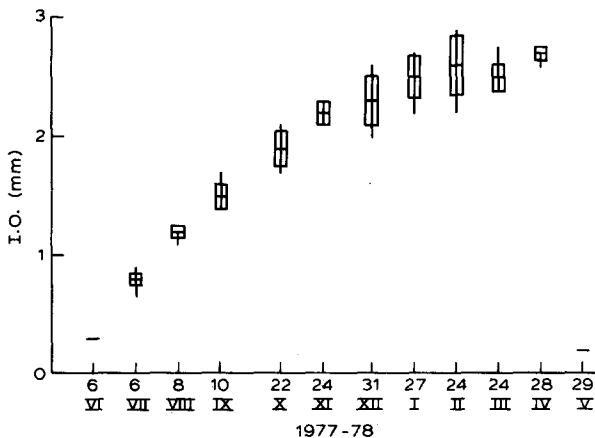


Fig. 1. Growth of *Skwala parallela* in Trout Creek, Colorado, shown by changes in interocular distance (I.O.) Mean values are shown as horizontal lines. Vertical bars indicate $\pm$ one standard deviation. The vertical lines indicate range.

parallela was very similar to that of another perlotid, *Megarcys signata*, in a Utah mountain stream (Cather & Gaufin, 1975). Although no adults were collected in the present study, mature nymphs with well-developed wing pads were collected in December and January indicating emergence in the period February through April. Small nymphs of very uniform size were collected in May, which indicates that hatching occurs soon after emergence and oviposition, the species thus displaying the 'slow seasonal cycle' of Hynes (1970).

Density values varied greatly over the study period (Fig. 2). The low value for June (< 2 nymphs/ m^2) was probably the result of inadequate sampling of early instars. A special effort was thus made in May of the following year, which resulted in the recovery of a large number of small nymphs. Maximum density occurred in July (34 nymphs/ m^2) and tended to decline until the hatching of small nymphs in May. While *S. parallela* is the most abundant large invertebrate predator in Trout Creek, its relatively low density is somewhat surprising. Trout Creek supports a diverse and abundant macroinvertebrate fauna, especially with regard to small Ephemeroptera (*Baetis* and *Tricorythodes*) and Chironomidae (Short & Ward, unpublished data). These taxa are major prey items for *S. parallela* (Richardson & Gaufin, 1971; Fuller & Stewart, 1977). Thus it would appear that the low densities found in Trout Creek are not the result of food limitation. The banks of Trout Creek are highly erodible. It is possible that siltation has reduced the suitable habitat somewhat, thus limiting the population of *S. parallela*. Furthermore,

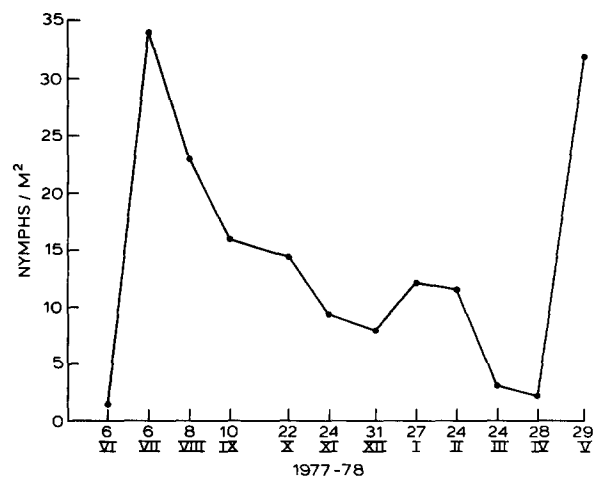


Fig. 2. Density of *Skwala parallela* in Trout Creek, Colorado.

Trout Creek passes through a relatively low gradient (12 m/km) floodplain in the study area and the substrate tends to be dominated by coarse gravel.

Production data for *S. parallela* are shown in Table 1. Since the entire population of *S. parallela* is composed of a single cohort (Fig. 1), cohort production is equal to annual production, in this case 395.3 mg dry weight/m². The greatest increment of total production occurred in January as a result of a large increase in mean body weight (Table 1). Values were also high for September, October and November, also periods of large increases in body weight. Production for April was computed on the assumption that maximum body weight was 35 mg. Values for March are not included due to the anomalous sizes of the nymphs as previously mentioned. Inclusion of the March data would not affect production since the value for March would be zero.

Production of zoobenthos is often expressed in kg/ha/yr (Waters, 1977). On this basis, annual production of *S. parallela* in Trout Creek was 3.95 kg/ha/yr. This is within the range reported for other stream insects (Waters, 1977), which emphasizes the importance of *S. parallela* as a predator in the system despite its low density. If growth is estimated to equal 12% of ingestion (Cummins, 1975), then a production of 3.95 kg/ha/yr would require that 36 kg/ha/yr be ingested, which further emphasized the significance of this species.

An important facet of productivity studies is the production to biomass ratio (P/B). According to Waters

(1977), P/B ratios are usually near 5 for univoltine zoobenthic species. An annual P/B value of 4.4 was calculated for *S. parallela* in Trout Creek. The cohort turnover ratio (3.7) was somewhat lower since the March data were deleted from mean standing crop calculations. The importance of the production to biomass ratio is that it allows a rapid means of estimating production by simply multiplying the P/B ratio by mean standing stock (Waters, 1977). Results obtained in the present study are encouraging and support the value of the P/B ratio as a means of determining production, at least until more precise methods of sampling stream benthos are developed.

Acknowledgments

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Table 1. Production of *Skwala parallela* determined by the instantaneous growth method. G = instantaneous rate of growth, < B > = mean standing crop, P = production (tabular form based on Waters and Crawford, 1973).

Date	Standing crop-B (mg/m ²)	Mean wt. (mg)	G	< B > (mg/m ²)	P (mg/m ²)
6 Jun	0.14	0.1	0.92	4.3	4.0
6 Jul	8.5	0.25	1.57	18.0	28.3
8 Aug	27.6	1.20	0.25	26.0	6.5
10 Sep	24.3	1.54	1.36	55.6	75.6
22 Oct	86.8	6.03	0.60	95.1	57.1
24 Nov	103.4	11.00	0.47	121.0	56.9
31 Dec	138.6	17.54	0.16	194.9	31.2
27 Jan	251.1	20.58	0.42	306.2	128.6
24 Feb	361.3	31.42	0.02	216.1	4.3
28 Apr	70.8	32.20	0.08	35.4	2.8
Production =					395.3