PREY CONSUMPTION AND VARIATIONS IN LARVAL BIOLOGY OF *ENOCLERUS SPHEGEUS* (COLEOPTERA: CLERIDAE)

Gene D. Amman

Intermountain Forest and Range Experiment Station, Forest Service, Ogden, Utah

PREY CONSUMPTION AND VARIATIONS IN LARVAL BIOLOGY
OF *ENOCLERUS SPHEGEUS* (COLEOPTERA: CLERIDAE)

Gene D. Amman

Intermountain Forest and Range Experiment Station, Forest Service, Ogden, Utah

Abstract   *Can. Ent.* 102: 1374–1379 (1970)

Larvae of *Enoclerus sphegeus* Fabricius (Coleoptera: Cleridae) were separated into three groups for study. Throughout their development, the larvae in each group were fed mountain pine beetle larvae, *Dendroctonus ponderosae* Hopkins (Coleoptera: Scolytidae), of a specific size (small, medium, or large). Clerid larvae fed small *D. ponderosae* larvae generally completed three stadia, while the other two groups, which were fed medium-sized and large prey, respectively, usually passed through two larval stadia. The number of stadia a larva would have was determined by the amount of food consumed during the first stadium. The feeding period of larvae given small prey was considerably longer than that of those fed medium-sized or large beetle larvae, but the prepupal period was much shorter. The head capsules of second-instar larvae that passed through two stadia were distinctly wider than those of second-instar larvae that completed three stadia.

Introduction

Enoclerus sphegeus Fabricius is a predator of numerous species of bark beetles including: the mountain pine beetle, *Dendroctonus ponderosae* Hopkins, in ponderosa pine (Böving and Champlain 1920), in lodgepole and western white pines (DeLeon 1934), and in sugar pine (Struble 1942*a*); the Douglas-fir beetle, *D. pseudotsugae* Hopkins, in Douglas-fir (Cowan and Nagel 1965; Kline and Rudinsky 1964); and *Ips* sp. in lodgepole pine (Reid 1957). As presented in the literature, the larval biology of *E. sphegeus* is confusing. Cowan and Nagel (1965) reported that *E. sphegeus* larvae normally pupated after the second stadium, but that some small second-instar larvae had a third stadium. However, Kline and Rudinsky (1964) observed three instars and Reid (1957) recorded four. The purpose of this paper is to demonstrate the effect of food quantity on the biology of *E. sphegeus*.

Methods and Materials

Adult *E. sphegeus* were caught on beetle-infested trees in northwestern Wyoming and taken to the laboratory in Ogden, Utah. The sex of the beetles then was determined by observing sex-related differences in the sixth abdominal sternite, a method described by Cowan and Nagel (1965). In females, the sternite extends to the apex of the abdomen; in males, it is slightly shorter and leaves a portion of the copulatory organ exposed. Accuracy of the method was 100%.

Clerids were paired and each pair placed in a separate petri dish. Adult clerids were fed more adult mountain pine beetles each day than they could consume. A triangular piece of white crepe paper, rolled into a cylinder 2 in. long and ¼ in. in diameter, was laid in the petri dish as an oviposition site, a method used by Struble (1942*b*). Eggs were removed from the paper each day.

Eggs were kept in petri dishes at 72°F until they hatched. The newly hatched larvae were placed in individual plastic boxes (1-in. cubes). Three groups of 15 clerid larvae each were fed *D. ponderosae* larvae of a specific size: Group I was fed small larvae (wt. ≈ 4 mg); group II, medium-sized larvae (wt. ≈ 8 mg); and group III, large larvae (wt. ≈ 12 mg). Each clerid was given one larva per day. The clerids were kept at a constant temperature of 72°F and

at a constant relative humidity of 75% by keeping the boxes containing larvae in a closed desiccator over a saturated solution of NaCl (Wexler and Hasegawa 1954).

Mature larvae were put into 1-in.-long pieces of plastic straw or into cotton for pupation. The ends of the straws or a chamber in the cotton usually were closed or lined with a whitish material secreted from the mouth of the larva. When adults emerged following pupation, the sex of each individual was determined by means of the method described by Cowan and Nagel (1965).

Larvae were examined daily during their feeding period and two to three times weekly thereafter. Data recorded were: number of prey consumed; date of molts; width of head capsules; length of larvae; and duration of stadia. Measurements were obtained by using a microscope fitted with an ocular micrometer.

Results and Discussion

Twelve clerids in group I, 12 in group II, and 10 in group III developed to the adult stage. The other 11 died. Approximately the same number of deaths occurred in each group, generally during the prepupal and pupal periods.

Prey Consumption and Larval Biology

The biology of clerid larvae was affected greatly by the quantity of prey received. Most larvae in group I had three instars; only one had two instars. Group II larvae generally had two instars; two individuals had three. On the other hand, all group III larvae had two instars. These differences were not sex-related. The sex ratios (females to males) for larvae completing development were as follows: Group I, 1:1; group II, 1:0.7; and group III, 1:0.7.

Bodenstein (1953) pointed out that molting can occur only after an insect has accumulated a certain nutritive reserve, and that a particular period of feeding is required to build up this reserve. In *E. sphegeus*, the amount of nutritive reserve accumulated during the first instar apparently determines whether a larva will be a small or large second instar and, hence, whether it will complete development after two or three stadia.

The single two-instar larva in group I consumed eight small pine beetle larvae in the first stadium, compared to an average of 6.2 eaten by the three-instar larvae within that group (Fig. 1). Two-instar larvae in group II ate an average of 6.1 prey during the first stadium, compared to an average of 4.5 consumed by the group's three-instar larvae. All larvae in group III had two larval stadia and consumed an average of 5.1 prey during the first stadium.

Clerids that were to terminate larval development after two stadia consumed many more prey during the second stadium than those that were to complete three stadia. The single two-instar clerid in group I ate 30 *D. ponderosae* larvae, compared to an average of 8.9 eaten by the three-instar clerids within the same group. Two-instar clerids in group II consumed an average of 14.7 prey, while the three-instar individuals within the group ate an average of only 6.0. All group III clerids had two instars and consumed an average of 10.4 prey during the second stadium (Fig. 1).

Group I larvae consumed about the same number of pine beetle larvae regardless of whether they completed two or three larval stadia (38 vs. 36). However, group II larvae ate fewer prey passing through two stadia than they did while completing three (21 vs. 30). Group III larvae consumed an average of 15.5 prey to complete the two larval stadia; none had three stadia.
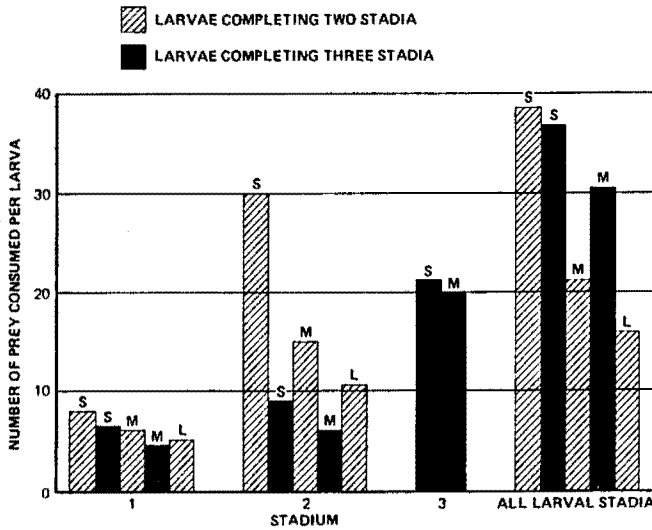
Fɪɢ. 1. Prey consumption by larvae of *Enoclerus sphegeus*. Letter over the bar indicates the size of *Dendroctonus ponderosae* larva fed to the clerids: S, small; M, medium; L, large.

Theoretically then, if small prey is abundant in either laboratory or field populations, the clerid probably could locate and consume several per day. If this were the case, the larval biology probably would not differ from that of a clerid eating large prey, but able to find only one pine beetle larva per day. Because all larvae observed by Kline and Rudinsky (1964) had three instars, it is assumed that prey was not abundant, particularly during the first stadium. In contrast, most of the larvae observed by Cowan and Nagel (1965) completed two instars and so probably had an abundance of prey.

Reid (1957) stated that most prey were consumed during the second stadium. However, in my study this occurred only when a two-instar clerid in group I consumed 30 larvae, compared to the 21 averaged by three-instar clerids of the same group. As noted in Fig. 1, more prey were consumed in the third than in the second stadium by both group II larvae (19 vs. 15) and three-instar group I larvae (21 vs. 9). However, second-instar larvae always consumed more prey than first-instar larvae.

Developmental Time

The feeding periods of three-instar group I, two-instar group II, and group III clerids averaged 51, 33, and 22 days, respectively (Table I). The total developmental period (larva to adult), however, averaged 134, 148, and 149 days, respectively. Although the group II and group III clerids completed feeding an average of 18 and 29 days, respectively, ahead of the group I clerids, they remained in the prepupal period (cessation of feeding until pupation) an average of 20 and 43 days longer. Average pupal periods for the three groups were essentially the same: 13.6, 14.2, and 13.6 days, respectively. The physiological processes responsible for differences in developmental time were not determined.

The single two-instar clerid of group I' developed to the adult stage in 83 days — 38 days faster than the average three-instar clerid of that group. The two three-instar clerids of group II required an average of 165 days to complete development — 45 days longer than the two-instar individuals of the group.

TABLE I
Developmental time (days) for larvae of *Enoclerus sphegeus* fed different sizes of *Dendroctonus ponderosae* larvae

D. ponderosae larvae	Larvae (no.)	Larval instars (no.)	Larval stadium						Prepupal period		Larval period (total)		Pupal period		Larval + pupal period	
			1		2		3									
			Av.	R.	Av.	R.	Av.	R.	Av.	R.	Av.	R.	Av.	R.	Av.	R.
Small	1	2	13.0	—	42.0	—	—	—	28.0	—	83.0	—	10.0	—	93.0	—
	11	3	11.5	11–13	14.0	9–17	25.1	20–34	70.2	32–135	120.7	83–186	13.6	8–21	134.3	97–197
Medium	10	2	11.8	11–13	21.3	10–34	—	—	90.0	45–154	134.0	90–179	14.2	9–21	148.2	101–199
	2	3	12.0	11–13	11.5	10–13	24.5	24–25	117.0	60–174	165.0	107–223	34.0	21–47	199.0	154–244
Large	10	2	11.3	10–14	11.1	10–14	—	—	113.2	57–155	135.6	83–179	13.6	8–18	149.2	98–190

Abbreviations: Av. – average; R. – range.

TABLE II
Larval measurements (mm) of *Enoclerus sphegeus* fed different sizes of *Dendroctonus ponderosae* larvae

D. ponderosae larvae	Larvae (no.)	Larval instars (no.)	Head capsule width						Larval length (maximum)					
			Instar 1		Instar 2		Instar 3		Instar 1		Instar 2		Instar 3	
			Av.	R.	Av.	R.	Av.	R.	Av.	R.	Av.	R.	Av.	R.
Small	1	2	0.70	—	1.50	—	—	—	10.0	—	20.0	—	—	—
	11	3	.65	0.6–0.75	1.13	1.0–1.3	1.60	1.5–1.7	8.1	7.5–9	14.1	12–16	19.1	17–21
Medium	10	2	.68	.6–.75	1.44	1.3–1.6	—	—	10.0	9–11	19.7	18–21	—	—
	2	3	.60	.6–*	1.00	.9–1.1	1.55	1.5–1.6	*	*	15.0	14–16	22.5	22–23
Large	10	2	.68	.6–.70	1.48	1.3–1.6	—	—	12.0	11–14	20.4	20–22	—	—

*Failed to measure.

However, these apparently unusual developmental periods do not differ greatly from some observed for individual group I and II larvae (see ranges, Table I).

Head Capsule Widths

As shown in Table II, the average head capsule width of first-instar larvae was 0.65 mm (range 0.60–0.75 mm), which is in accord with the average 0.69 mm (range 0.64–0.72 mm), reported by Kline and Rudinsky (1964) and the 0.74 mm average (standard error (S.E.) = 0.06) of Cowan and Nagel (1965). Head capsule width of second-instar larvae depended on whether the larvae terminated development after the second stadium or passed through a third. Head capsules of larvae that completed a third stadium averaged 1.11 mm (range 0.90–1.30 mm) compared to the 0.99-mm average (range 0.80–1.02 mm) observed by Kline and Rudinsky. Head capsules of two-instar larvae averaged 1.46 mm (range 1.3– 1.6 mm). This average agrees closely with the 1.45 mm (S.E. = 0.21 mm) of Cowan and Nagel. Third-instar clerids had head capsules that averaged 1.59 mm (range 1.5–1.7 mm), a figure close to the 1.53-mm average reported by Kline and Rudinsky.

Reid (1957) gave a range in head capsule widths of 0.51 to 0.55 mm for the first instar and 0.56 to 0.66 mm for the second. His second-instar data would partially overlap the range observed in my study, but his first-instar measurements would not. My measurements for second-instar larvae that were to complete three instars were similar to Reid's measurements for third-instar larvae (0.9– 1.3 mm vs. Reid's 1.0–1.4 mm). However, my measurements for larvae completing development after two instars were considerably larger (1.3–1.6 mm) than Reid's measurements for third-instar larvae. Head capsules of my third-instar clerids were larger than those reported for third and fourth instars by Reid (1.5–1.7 mm vs. Reid's 1.0–1.4 mm).

Larval Length

The maximum length of Reid's (1957 first-instar larvae (7 mm) is similar to that of my three-instar larval group, which was 8 mm, as shown in Table II. The length of second-instar larvae given by Reid is about the same as the larvae within my two-instar group (20 mm vs. Reid's 21 mm). However, Reid did not have measurements in the 12- to 16-mm class, and 12–16 mm was the length of second-instar larvae requiring three stadia to complete development. My measurements for group II third-instar larvae were about the same as Reid's (22.5 mm vs. Reid's 23.0 mm). However, his measurement of 24 mm for fourth-instar larvae exceeded any recorded in my study.

The differences noted between Reid's and my data are difficult to resolve. They may be related to the prey species (*Ips*) used by Reid, to prey quantity and the rate at which prey were consumed, or perhaps represent clinal variation in size between Alberta and Wyoming. In any case, the number of instars observed in my study was related to the quantity of prey received during the first stadium.

References

Bodenstein, D. 1953. The role of hormones in molting and metamorphosis, pp. 879–931. *In* K. D. Roeder (Ed.), Insect physiology. Wiley, New York; Chapman and Hall, London.
Böving, A. G., and A. B. Champlain. 1920. Larvae of North American beetles of the family Cleridae. *Proc. U.S. natn. Mus.* **57**: 575–649.
Cowan, B. D., and W. P. Nagel. 1965. Predators of the Douglas-fir beetle in western Oregon. *Ore. agric. Exp. Stn Tech. Bull.* 86, 32 pp.

DeLeon, D. 1934. An annotated list of the parasites, predators, and other associated fauna of the mountain pine beetle in western white pine and lodgepole pine. *Can. Ent.* **66**: 51–61.

Kline, L. N., and J. A. Rudinsky. 1964. Predators and parasites of the Douglas-fir beetle: description and identification of the immature stages. *Ore. agric. Exp. Stn Tech. Bull.* **79**, 52 pp.

Reid, R. W. 1957. The bark beetle complex associated with lodgepole pine slash in Alberta. III: Notes on the biologies of several predators with special reference to *Enoclerus sphegeus* Fab. (Coleoptera: Cleridae) and two species of mites. *Can. Ent.* **89**: 111–120.

Struble, G. R. 1942*a*. Biology of two native coleopterous predators of the mountain pine beetle in sugar pine. *Pan-Pacif. Ent.* **18**: 97–107.

—— 1942*b*. Laboratory propagation of two predators of the mountain pine beetle. *J. econ. Ent.* **35**: 841–844.

Wexler, A., and S. Hasegawa. 1954. Relative humidity–temperature relationships of some saturated salt solutions in the temperature range 0° to 50°C. *J. Res. natn. Bur. Stand.* **53**: 19–26.