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**Observations on the Life Histories of Four Species of *Epeorus*
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A lack of basic biological information is a serious impediment to the study of aquatic insect ecology. A large percentage of the immature stages of Ephemeroptera cannot be identified to species and the life histories of most have not been studied (Berner, 1959). Except for notes in taxonomic treatments (Edmunds and Allen, 1964; Jensen, 1966) the biologies of the northwestern species of *Epeorus* Eaton are unknown.

Four of the eight species of *Epeorus* reported to occur in Oregon (Allen and Edmunds, 1956) are found in Oak Creek, 5 miles northwest of Corvallis, Benton County: *Epeorus (Iron) longimanus* (Eaton), *E. (Ironodes) nitidus* (Eaton), *E. (Iron) albertae* (McDunnough), and *E. (Iron) deceptivus* (McDunnough). I have reared the nymphs of the first three to the adult stage in the laboratory, but adults of *E. deceptivus* have not been reared from the study area. The nymph of the fourth has been determined to species by referring to the keys and descriptions provided by Edmunds and Allen (1964), and by comparing the nymph with material in the Oregon State University collection which was identified tentatively as *E. deceptivus* by R. K. Allen.

Oak Creek is a small woodland stream located in the eastern foothills of the Coast Range at an elevation of approximately 400 feet. The stream flow ranges from a minimum of 0.1-0.2 cfs during the dry summer and fall to over 20 cfs during winter freshets. The width ranges from 2 to 8 feet and may reach 15 feet during severe floods. In the study area, the substrate consists of gravel with many scattered 4-6-inch

stones. Little organic matter is present except at the time of leaf fall in October and November, and periphyton is sparse. The stream has a dense canopy of trees, and has sharp banks 3 to 4 feet high.

Monthly square-foot bottom samples were taken between October 1965 and September 1966. A modified Hess-type sampler was used (Lattin, 1963), which enclosed the area to be sampled. The collecting net had a mesh size of 0.116 mm. Air and water temperatures were monitored with a continuous recorder for one week during each month of the study. Water temperature data are summarized in Table 1. Additional field and laboratory observations on the period of adult emergence were made during the 1966-67 season. A representative collection of specimens has been deposited in the Oregon State University collection.

LIFE CYCLES

EPEORUS LONGIMANUS (Eaton)

Keys and descriptions of the adults and nymphs of *E. longimanus* were given by Edmunds and Allen (1964). They recorded the species in every western state. Figure 1 shows the seasonal development of *E. longimanus* in Oak Creek. The nymphs, even those under 1 mm in length, may be recognized by the following combination of characters: two caudal cerci (a character common to all *Epeorus*), a fuscous macula on each femur, and abdominal gills which extend anteriorly and meet beneath the body on segment one. Early instar nymphs were first found in the samples in September. The low number of specimens and the irregularity of the presence of size classes between October and January probably is due to the disturbing effects of the floods and freshets which occurred in the stream during this time (Anderson and Lehmkuhl, in press).

Adults were collected at the Oak Creek station from April to June. An emergence trap, covering an area of 4 ft², was placed over a riffle from March to July 1967. Based on trap records the peak of emergence occurred during the last 3 weeks of April. No other *Epeorus* were collected in the emergence trap even though the nymphs of other species were numerous in the stream.

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FIG. 1. Size-class distribution of *Epeorus longimanus* in monthly bottom samples from Oak Creek, Benton Co., Oregon. Bars represent per cent of total in each size class: body length in mm. Total number in samples in column at right (A indicates adults).

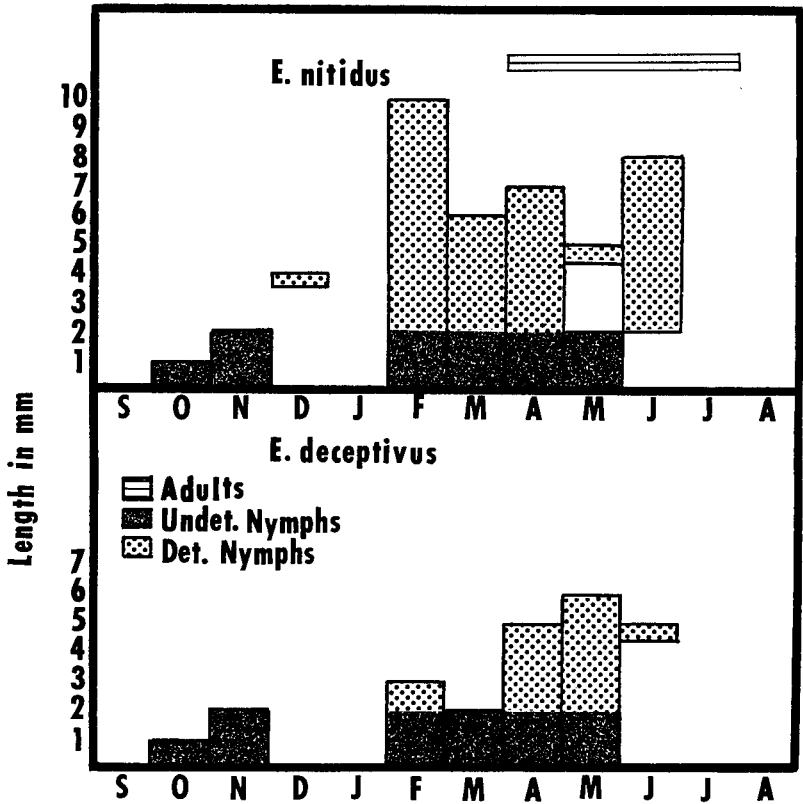


FIG. 2. Seasonal occurrence and size ranges of *Epeorus deceptiveus* and *E. ntidus* in Oak Creek, Benton Co., Oregon. The < 2 mm group was not identified to species and has been repeated for each.

Based on the occurrence of the 0–1 mm size group, the hatching period extends from September to May. The last adults were collected in June but no nymphs were present until September, suggesting that the eggs require several months to hatch.

EPEORUS DECEPTIVUS (McDunnough) and *E. NITIDUS* (Eaton)

Figure 2 shows the size range for the *E. deceptiveus* and *E. ntidus* nymphs collected in each month. Although the two species are in separate subgenera, nymphs under 2 mm long are difficult to separate to species. In figure 2, nymphs under 2 mm may be either species, and the < 2 mm size group has been repeated for each. Only size ranges are shown because the number of specimens in each sample was not

large (totals for year: Undet.—119; *E. nitidus*—23; *E. deceptivus*—34). Disturbing effects from flooding may be responsible for the lack of nymphs in the samples in December and January.

The adults and nymphs of *Epeorus deceptivus* are included in keys by Edmunds and Allen (1964). They report that the nymphs inhabit small- to medium-sized streams between 6500 and 10,000 feet in elevation in the Rocky Mountain region. Although adults of this species have not been collected from Oak Creek, nymphs from the samples agree closely with the description for *E. deceptivus* given by Edmunds and Allen (1964).

Nymphs over 2 mm were taken in the samples in February (fig. 2) and *E. deceptivus* may have been present in the small undetermined specimens in October and November. Nymphs over 4 mm were present from April to June but no nymphs were present in July. Based on the data, this species hatches in fall and winter, and the adults emerge before July.

Epeorus nitidus was described from adults taken in Oregon, and Day (1963) reported the species from California. Traver (1935), Day (1963) and Jensen (1966) include the species in keys to the nymphs but they are not, as yet, formally described.

Kraft (1963) reported the species from Berry Creek, near Corvallis, Oregon, where the adults emerged from March to July. He found that the nymphs fed mainly on detritus (97% of the gut contents) and that the adults emerged from water whose average velocity was 0.8 ft/sec.

In Oak Creek, the first recognizable nymphs (as determined by the tubercles on the dorsum of the abdominal segments) were over 3 mm in December (fig. 2). *E. nitidus* is comparatively large in size, the nymphs reaching 10 mm by February. Mature nymphs collected from Oak Creek transformed into adults in the laboratory from April to July. The cast nymphal skins of specimens that emerged in the laboratory were found floating free in the water. Since an object was provided for them to climb on, this suggests that the nymphs rise to the surface to emerge rather than climb out of the water. The subimaginal stage lasted from 3–4 days at outside temperatures (5–15° C).

This species follows the seasonal pattern of the previous two, with eggs hatching in fall and winter and the adults emerging in the spring and early summer.

EPEORUS ALBERTAE (McDunnough)

Adults and nymphs of *E. albertae* are included in descriptions and keys given by Edmunds and Allen (1964). *Epeorus albertae* occurs at

TABLE 1. Maximum and minimum water temperatures (Degrees C) at sample station in Oak Creek, Benton Co., Oregon. Recording thermometer operated for one week in each month. Thermometer probe placed on bottom in midstream.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Maximum	15	11	8	9	7	9	13	15	15	16	19	18
Minimum	10	7	6	5	2	5	7	10	8	9	14	13

elevations of 4000 to 7000 feet throughout the mountainous regions of the western United States and the nymphs usually are found under large rocks in rivers (Edmunds and Allen, 1964). Jensen (1966) reported that adults were collected in direct sunlight swarming 2 to 3 feet above riffles in July and August.

E. albertae was not found in the bottom samples, but a large number of nymphs were collected in Oak Creek in July in a wide sunlit riffle 100 feet upstream from the sample area (no other *Epeorus* were present in the stream at this time). Nymphs collected at the Berry Creek Fisheries Laboratory, 9 miles north of Corvallis, emerged as adults from 15–20 July 1967 and an adult was collected from Berry Creek on 7 August 1963 (Oregon State University collection). This species emerges several months later than the other *Epeorus* of Oak Creek.

DISCUSSION

The life cycles of the species of *Epeorus* in Oak Creek are similar in several respects. The data indicate that *Epeorus longimanus*, *E. nitidus*, and *E. deceptivus* are univoltine, but the information is insufficient to show this for *E. albertae*. Except for *E. albertae*, neither adults nor nymphs of *Epeorus* were present at the Oak Creek station in July and August. This indicates that the eggs require several months to hatch.

The results of the Oak Creek study are compared in Table 2 with data reported by Edmunds and Allen (1964) and Jensen (1966) for the Rocky Mountain populations of 3 of the 4 species discussed here. *E. nitidus* has not been reported from the Rocky Mountains. The life cycle of *E. albertae* is similar in both areas, with adult emergence occurring in July and August. The nymphs occur in water with temperatures up to 17–18° C.

Epeorus deceptivus and *E. longimanus* are found in approximately the same temperature ranges in the Rocky Mountains and in Oak Creek

TABLE 2. Comparison of the life cycles of three species of *Epeorus* in the Rocky Mountain region and in Oak Creek, Oregon. Data for the Rocky Mountain region obtained from Edmunds and Allen (1964) and Jensen (1966).

Species	Emergence Dates		Altitude Range		Temperature Range	
	Rocky Mountains	Oak Creek	Rocky Mountains	Oak Creek	Rocky Mountains	Oak Creek
<i>Epeorus albertae</i>	July-August	July-August	4-7000 ft.	400 ft.	9 -17 ° C	?-18° C
<i>Epeorus longimanus</i>	June-August	April-June	above 5000 ft.	400 ft.	5.5-14.5° C	5-15° C
<i>Epeorus deceptivus</i>	August-September	before July	6500-10,000 ft.	400 ft.	9 -15.5° C	5-15° C

(5–15° C), but adult emergence is completed several months earlier in Oak Creek (Table 2). These two may be cold water species which have been able to invade a region of high summer water temperatures by adjusting the life cycle to take advantage of the cooler winter and spring water temperatures. The life cycles of *E. deceptivus* and *E. longimanus* in Oak Creek are similar to that reported for *E. pleuralis* (Banks) in Kentucky (Minshall, 1964). *E. pleuralis* nymphs hatch from September to May and adults emerge from February to June. Minshall concludes that this is primarily a cold water species, and that temperatures of 17–18° C may be lethal to the nymphs.

One might surmise from Table 2 that temperatures of 15–16° C limit the occurrence of the nymphs of *E. longimanus* and *E. deceptivus* since in both the Rocky Mountains and in Oak Creek the nymphs do not occur above this temperature. The limitation of the period of adult emergence by water temperatures that kill the nymphs has been suggested by Macan (1960a, 1960b). *E. longimanus* nymphs ranging from 2.1–6 mm occurred in Oak Creek in June, while in July no nymphs were present (fig. 1). The rising water temperature in June or July could explain the rather sudden disappearance of the nymphs. However, this explanation is not supported by data presented by Hartland-Rowe (1964). Although he did not discuss the significance of the fact, he reported nymphs of *E. longimanus* in Alberta ranging from 2–10 mm during the last month of adult emergence. Temperatures in the stream did not exceed 12° C, and this appears to be well below the “lethal” temperature of the species. There is apparently some factor in addition to temperature which regulates the period of adult emergence. Since the “lethal” temperature hypothesis is not entirely satisfactory, other possibilities such as photoperiod or extremely rapid growth and development of the nymphs near the end of the emergence period should be investigated.

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