Aquatic Insects
2004, Vol. 26, No. 2, pp. 123–129

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Description of the Nymph and Drumming Calls of *Megaleuctra complicata* Claassen (Plecoptera: Leuctridae); Evolution of Drumming in Leuctridae

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Abstract

The immature stages, life histories and behaviors of the six North American species of *Megaleuctra* Neave are little known. Only the nymph of *Megaleuctra kincaidi* has been well described, and there are no published accounts of *Megaleuctra* nymphal biology or adult drumming or other behaviors.

We and Bill P. Stark collected nymphs and adults of *M. complicata* in spring seeps near Marion Forks in Linn County, Oregon, May 17, 2001. Nymphs are described; their diagnostic morphological features conform to generic characters proposed by Stewart and Stark (2002). Nymphs were found only on loosely imbedded pieces of decaying wood where their color-blending and immobility at being disturbed is a crypsis adaptation.

Twenty-two call signals were recorded from field collected males. Calls were composed of 2–23 grouped vibrational signals having an average of 2.7 ± 0.5 beats per group with average intra-group intervals of 30.3 ± 4.4 msec. The single field collected female never answered calls. The evolution of drumming in Leuctridae is discussed, from the ancestral calls of *Zealeuctra* to the derived types of calls of *M. complicata* and European *Leuctra pseudosignifera*.

Keywords: Plecoptera, *Megaleuctra*, nymph, description, drumming.

Introduction

The immature stages, life histories, and behavior of the six North American species of the stonefly genus *Megaleuctra* are little known (Stewart & Stark, 2002). All species are considered rare, perhaps a reflection of low collection success due to their habitat specialization. Adults typically occur at low densities on ground cover, emer-

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DOI: 10.1080/01650420412331325855

gent objects and vegetation in the immediate vicinity of seeps and springs or their outflows.

Relatively few nymphs of any of the six species have been collected, presumably because of their occurrence and development in the debris-choked surface layers of their shallow spring-seep habitats, or in subterranean cavities. Only the nymph of *M. kincaidi* Frison has been correlated and described, and there are no published accounts of *Megaleuctra* nymphal biology or adult drumming or other behaviors (Stewart & Stark, 2002).

Stoneflies of the suborder Arctoperlaria typically communicate for mate-finding with substrate-borne vibrational signals, and have evolved one of the most diverse and complex systems of calls and male–female dueting known in insects that utilize vibrational communication (Stewart, 1997). Stewart (2001) proposed an evolutionary paradigm for drumming in Plecoptera that describes ancestral and derived signals. The drumming signals of only two of the eight genera of the subfamily Leuctrinae have been reported: those of four species of *Zealeuctra* (Zeigler & Stewart, 1977; Snellen & Stewart, 1979; Stewart et al., 1995), and *Leuctra pseudosignifera* Aubert (Rupprecht, 1977), and drumming in the other subfamily Megaleuctrinae is unknown.

The objectives of this study were: (1) to collect and describe the nymph of *M. complicata* Claassen and determine if it conforms to the generic characters proposed by Stewart and Stark (2002) based on only one species, and (2) to record for the first time its drumming signals as representative of the genus, and to evaluate how this increases the knowledge of drumming in the Leuctridae and Plecoptera.

Material and Methods

Nymph collection and description

An intense half-day search was made by B.P. Stark and us for live nymphs at a known locality of *M. complicata* in spring-seeps feeding Willis Creek, 2.1 km southeast of Marion Forks on Marion Forks Road in Linn County, Oregon, on 17-V-2001. Mosses, wood, and other submerged vegetation and detritus were sorted through in white enamel pans. There was insufficient flow for kick-net collection. Our original intent was to attempt to rear nymphs, but because of the small number of three successfully collected, we decided to preserve them in 80% EtOH for later measurement and description using a drawing attachment on a Wild M-5 stereomicroscope. The gut contents from a single female nymph were removed by dissection and mounted on microscope slides using CMC-9 mounting media.

Adults and drumming

Ten adult males and one female were field-collected from foliage immediately surrounding the Willis Creek seeps, with beating sheets. These were kept alive in cotton-stoppered vials held and transported in an ice chest to keep them cool.

Different males were paired with the female in a two-compartment, glass-covered field recording chamber (Fig. 1), and their drumming signals recorded on separate channels with a Sony® WALKMAN portable Minidisk recorder (Model MZ-R37) and Optimus® model 33-3013 (100 Ohm, 70–1600 Hz) omnidirectional microphones. The recording chamber dimensions were 265 mm square ×70 mm high, and it had a 6 mm thick plate glass cover. The male and female were housed within their respective compartments, each in a small manila file folder box with a thin plastic lid; these boxes were connected only by a small wooden rod running through a felt-sound-damped hole in the chamber partition. Recordings occurred on May 18 in an Oregon motel in darkness at 21.1°C and May 19–20 in a room under incandescent light near

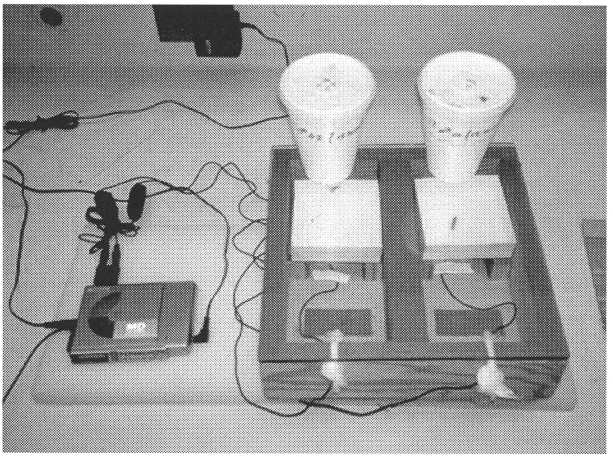

Figure 1. Portable stonefly drumming chamber with digital recorder and microphones under manila folder boxes with plastic lids.

a sunlit window in a house in Redmond, Washington, at 22.2–23.3°C. Signal analyses were accomplished using digital audio WAV files by methods described by Sandberg and Stewart (2001).

Results

Nymph morphology, habitat and food

(Based on one pre-emergent male, one pre-emergent female, and one immature female collected; description and illustration format following Stewart & Stark, 2002). Robust body, length <8 times pronotal width. Body length of pre-emergent male 12 mm (Fig. 2A), pre-emergent female 13 mm, immature female 8 mm. Color reddish-brown with lighter legs. Head uniform brown, except light ecdysial sutures and anterior M-mark (Fig. 2A); antennal segments pre-emergent male 54, pre-emergent female 58, immature female 46. Pronotum about same width as head, with complete anterior and lateral fringe of short hairs (Fig. 2A). Front legs bear several short to medium length bristles over surfaces and a few fine fringe hairs on outer margin of the femur, tibia and tarsus (Fig. 2C). The mesosternal Y-ridge is stout, with a prominent stem and arms reaching the posterior corners of the furcal pits (Fig. 2B). Abdominal segments 1–7 bear a membranous pleural fold (Fig. 2E); abdominal terga have a posterior fringe of short setae (Figs. 2A, D), and are covered with short, stiff surface hairs, with longer lateral hairs on segments 7–10 (Fig. 2A). Tergum 10 and fused subanal lobes of male produced posteriorly between the cerci, and sternum 9 bears a median, posterior lobe (Figs. 2D, F). Female terminalia not produced as in male, and the developing subgenital plate of abdomnal segment 8 is produced (Fig. 2G). Cercal segments with posterior circlet of 10 or more bristles and no intercalary hairs (Fig. 2H); cercal segments of male 18, immature female 12. The pre-emergent

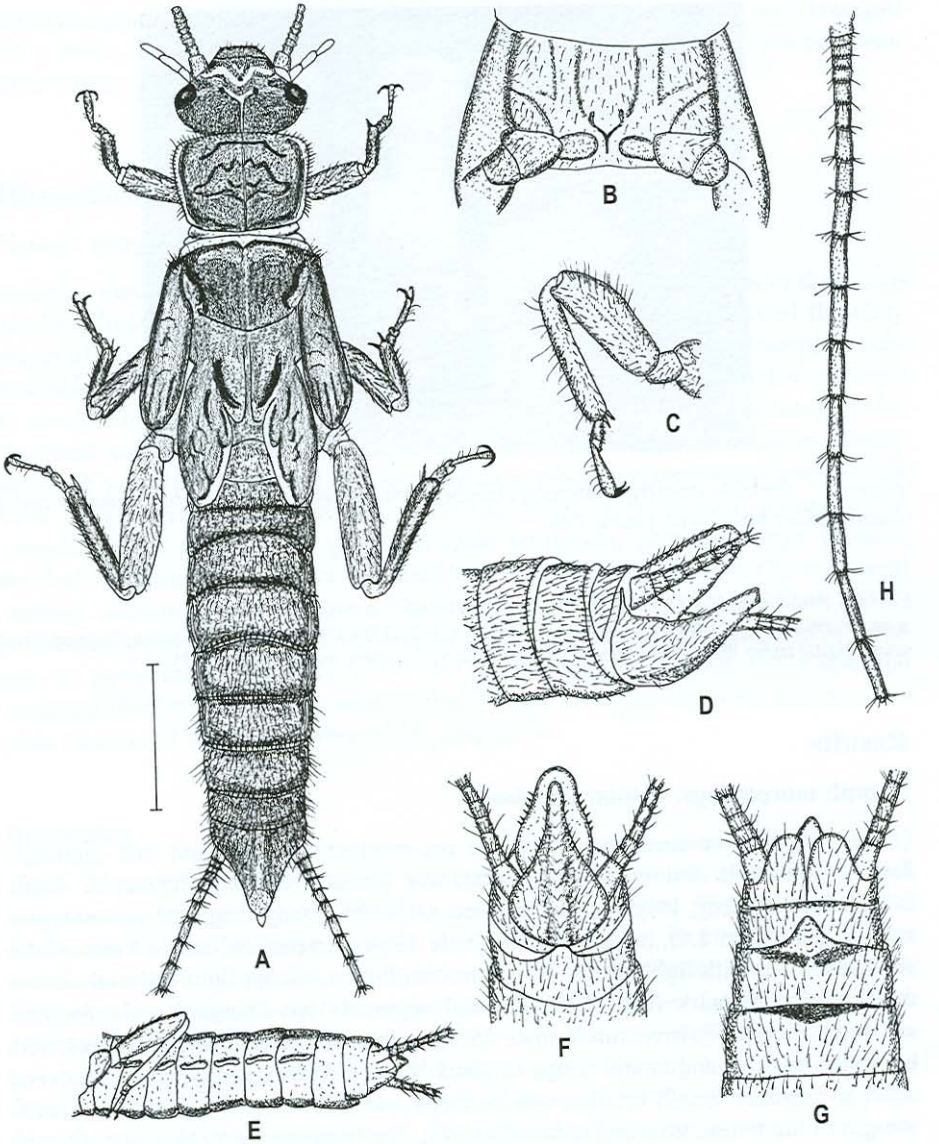

Figure 2. Megaleuctra complicata, nymph characters. (A) Habitus. Bar = 2mm. (B) Mesosternum. (C) Right front leg, dorsal. (D) Male terminalia, oblique lateral. (E) Membranous pleural folds. (F) Male terminalia, ventral. (G) Female terminalia, ventral. (H) Right cercus, lateral.

female gut contents included small (0.1–0.5 mm) leaf and wood fragments and a few alga filaments probably from conditioned material.

Drumming

Twenty-two call signals were successfully recorded from two of the ten field-collected males (1–3 days old) both in darkness and daytime room light. They called with 2–23 grouped signals having an average of 2.7 ± 0.54 beats per group with overall average intra-group (time interval within groups) intervals of 30.3 ± 4.43 ms (Fig. 3, Table 1); intra-group intervals decreased slightly from $\bar{x}$ = 31.8 ± 4.34 ms (1st interval) to $\bar{x}$ = 28.5 ± 3.82 ms (2nd interval). The $\bar{x}$ inter-group interval (time between groups) was variable, ranging from 234.8 to 452.7 ms (Table 1). Total call duration

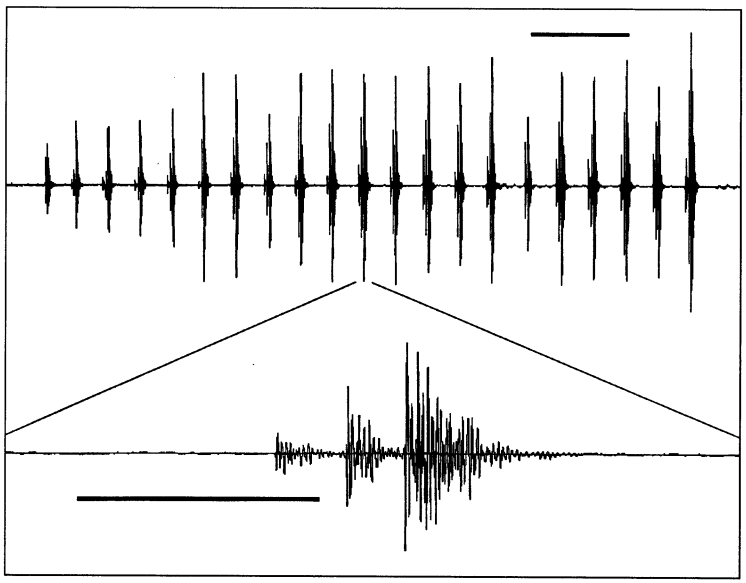

Figure 3. *Megaleuctra complicata*, typical male-call signal. Twenty-one grouped call above. Bar = 1000 msec. Detailed 25× horizontal zoom of call group 11 showing three beats. Bar = 100 msec.

Table 1. Megaleuctra complicata drumming data summary.

Signals, ♂	Individuals, ♂	Beats/group, ♂ Range (mode)	Beats/group, ♂ $\bar{x}$ ± SD	Beat intervals, ♂ (ms) ($\bar{x}$ ± SD)	Intra-group intervals, ♂ (ms) ($\bar{x}$ ± SD)
22	2	1–3 (3)	2.74 ± 0.54	30.29 ± 4.43	326.7 ± 43.18

was greatly variable depending on the number of groupings of call, and averaged 3.5 ± 2.29 s. The female never answered either male and we presumed she had been field-mated.

Discussion

Nymph morphology, habitat and food

Nymphs were very difficult to find in the debris-choked surface layers of their seep habitat, although the number and sex ratio of adults collected indicated the early stages of an emergence in progress. About 12 man-hours of intensive gleaning of substrates in white pans was required to collect the three nymphs, all of which were found in crevices of loosely imbedded pieces of decaying wood. Their color-blending with the wood background, and immobility at being disturbed, is apparently a crypsis adaptation. Whether early nymphal development takes place in subterranean seep cavities or in surface layers remains unknown. The diagnostic morphological features of *M. complicata* are robust body, produced male terminalia, pronotal fringe setation, number of abdominal segments separated by a ventrolateral membrane (7), and cercal setation, conform closely to generic characters proposed by Stewart and Stark (2002) then based mainly on congener *M. kincaidi*. The pre-emergent body length of *M. complicata*, particularly the female, is 3–7 mm smaller than *M. kincaidi*. Other potential species differences include the shorter bristle length of cercal segments and the complete M-band of the head pattern of *M. complicata*.

Drumming

These *M. complicata* call signals interestingly represent the third type of call now known from reports of only three genera of Leuctridae. The four species of *Zealeuctra* (*Z. arnoldi* Ricker & Ross, *Z. claasseni* (Frison), *Z. hitei* Ricker & Ross and *Z. warreni* Ricker & Ross; (Zeigler & Stewart, 1977; Snellen & Stewart, 1979; Stewart et al., 1995)) all call with monophasic signals and their females answer with monophasic signals. *Leuctra pseudosignifera* calls with a highly complex diphasic call with the first phase consisting of about 15 groups having 1–3 beats each, and females answer with a monophasic signal (Rupprecht. 1977). It therefore appears from the study of only two Leuctrinae genera that drumming has evolved in that subfamily in a fashion agreeing with the paradigm of Stewart (2001) from ancestral, monophasic calls (*Zealeuctra*, four spp.) to derived diphasic calls with multi-beat groups composing the first phase (*L. pseudosignifera*). Any inference on drumming evolution in the subfamily Megaleuctrinae will require the discovery of male and female signals of other species of *Megaleuctra*. Additional studies of leuctrid drumming are needed to determine how consistent these patterns are within genera and the two subfamilies, and if other derived types of signals are represented in the family.

Acknowledgements

We wish to give thanks to Bill Stark who graciously provided transportation to the study sites and helped collect specimens. Also to Bill Stark and Boris Kondratieff, for providing suggestions to the manuscript.

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