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Larvae of *Eurycnemus crassipes* (Panzer) (Diptera: Chironomidae) ectoparasitic on prepupae/pupae of *Hydropsyche siltalai* Döhler (Trichoptera: Hydropsychidae), with a summary of known chironomid/trichopteran associations

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Studies on the immature stages of *Eurycnemus crassipes* (Panzer) from Ireland suggest that larvae are obligate ectoparasites on the prepupae/pupae of *Hydropsyche siltalai* Döhler. An account is given of the larval ecology and distribution of the genus *Eurycnemus*. *E. crassipes* is recorded from Bosnia-Herzegovina, Slovenia and Switzerland for the first time. A literature survey reveals that known chironomid/trichopteran associations involve at least eleven chironomid genera, and such associations appear to be a much more widespread phenomenon than previously recognised.

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Introduction

Two species of *Eurycnemus* van der Wulp, 1874 are known: *E. crassipes* (Panzer, 1813) in Europe (Ashe & Cranston 1990) and *E. nozakii* Kobayashi, 1998 from Honshu, Japan. Published records of *Eurycnemus* from outside the Palaearctic have been regarded as erroneous (Ashe et al. 1987). When describing the immature stages of *E. crassipes*, Murray & Ashe (1981) indicated a possible association between its larva and a trichopteran species. Recent reports that larvae of *E. nozakii* are ectoparasitic on *Goera japonica* Banks (Trichoptera: Goeridae) (Kobayashi 1993, 1994a, 1995, 1998) suggest a generic association between larvae of *Eurycnemus* and prepupae/pupae of Trichoptera. This prompted the senior author to investigate more thoroughly the larval ecology of *E. crassipes* by searching a shallow riffle region of the River Flesk, S. W. Ireland. The present paper reports new findings on an association between *E. crassipes* and *Hydropsyche siltalai* Döhler (Trichoptera: Hydropsychidae), re-examines zoogeographical distribution data on *Eurycnemus*, and summarises known associations (commensal, phoretic and ectoparasitic) between Chironomidae and Trichoptera.

Methods and material

A shallow riffle site on the River Flesk, S. W. Ireland, was chosen for the investigation, and from the ecological data available on the immature stages of *Eurycnemus* (Murray & Ashe 1981) it was assumed for the purposes of the search that *E. crassipes* is ectoparasitic on *Hydropsyche* prepupae/pupae. By driving long, upright branches into the substrate, the riffle area was divided into three rectangular, box-like sections each about 1 m wide and 10 m long, the total area studied being about 30 square metres. Work began on the downstream end of each box and every stone likely to support *Hydropsyche* pupal cases was examined. Any such cases found were removed, opened and discarded if nothing was found. Suspect cases were placed in a tray of river water for further examination, and those which contained or were suspected of containing larvae or pupae of *E. crassipes* were preserved in 75% alcohol.

Material found: Ireland, Co. Kerry, River Flesk (Grid reference: V964893), 8.VIII.1994, leg. P. Ashe. 3 pupae and associated larval exuviae, 1 pupa and larval head capsule, 1 larval exuviae (pupa already emerged), 1 ?3rd instar larva, 2 mature (4th instar) larvae.

Abbreviations of museums: HNHM = Hungarian Natural History Museum, Budapest; IRSN = Institut Royal des Sciences Naturelles de Belgique, Bruxelles; NMI = National Museum of Ireland, Dublin; NHM = The Natural History Museum, London; NMW = Naturhistorisches Museum Wien, Vienna; NMSE = National Museum of Scotland, Edinburgh; MNHN = Museum National d'Histoire Naturelle, Paris; SMNH = Swedish Museum of Natural History, Stockholm; UMO = University Museum, Oxford,(England); UMZC = University Museum of Zoology, Cambridge (England).

Distribution of *Eurycnemus*

In addition to records from the Palaearctic (Ashe & Cranston 1990; present paper), occurrences of *Eurycnemus* have been reported for the Nearctic (Canada: Oliver et al. 1978; United States: Sublette 1970, Coffman 1978), the Neotropical (St. Vincent: Sæther 1981; Ecuador: Turcotte & Harper 1982), the Oriental (Japan – Nansei Islands: Sasa 1990, Sasa & Kikuchi 1995), and the Australasian region (Australia: Blyth et al. 1984). In Ashe et al. (1987) it was stated that "reports to date of the genus from the Nearctic, Neotropical and Australasian regions are erroneous", but this statement was not explained. Here, reasons are given for discounting each of these false records.

Sublette (1970) transferred *Brillia annuliventris* (Malloch), known from the United States, to *Eurycnemus*, and this was the basis for the record in Coffman (1978), but Oliver (1981) reassigned this species to the genus *Euryhapsis* Oliver. Oliver et al. (1978) key an unnamed species of *Eurycnemus*, but Oliver (pers. comm.) declares this a misidentification of *Euryhapsis cilium* Oliver, and that *Eurycnemus* is not known from the Nearctic region. Turcotte & Harper (1982) report a single larval specimen of *Eurycnemus* from a stream in Ecuador. This specimen is apparently lost, its identity will thus remain unclear.

Sæther (1981) described a female imago, *Eurycnemus* sp., from the island of St. Vincent in the West Indies. However, our examination of the undescribed female genitalia of *E. crassipes* showed that the St. Vincent specimen is not a *Eurycnemus*. Sæther & Wang (1992) have since indicated that it belongs to *Irisobrillia* Oliver.

An Australian record of larval *Eurycnemus* is given in Blyth et al. (1984: "*Erycnemus* [sic.] sp. (69E)"), and other records are evidently the same or allied species (Marchant et al. 1984: "nr. *Eurycnemus* sp. 1"; Metzeling et al. 1984: "nr. *Eurycnemus* sp. 1", "?nr. *Eurycnemus* sp. 2"; Doeg 1984: "nr *Eurycnemus* sp (69E)"). This Australian material has been re-examined and identified as *Austrobrillia* Freeman (P. S. Cranston, pers. comm.).

The species *Eurycnemus amamiapiatus* Sasa from the Nansei Islands of Japan (Sasa 1990, Sasa & Kikuchi 1995), an area considered to be part of the Oriental Region, is now known to be a species of *Xylotopus* Oliver (Kobayashi 1994b). There is also a record of *Eurycnemus* from Asiatic Russia (Reiss 1977), the River Angara at Irkutsk, but Reiss later re-identified the adult male specimen as a *Euryhapsis* (M. Spies, pers. comm.).

Thus, the genus *Eurycnemus* is so far documented only from the Palaearctic, with the two species, *E. crassipes* from Europe (Ashe & Cranston 1990, Murray & Ashe 1981) and *E. nozakii* from Japan (Kobayashi 1998).

Distribution of *E. crassipes*

E. crassipes (Panzer) has been reported from Austria, Belgium, France, Germany, Hungary, Ireland, Netherlands, Russia, Spain, Sweden and the United Kingdom (England, Scotland), whereas mid 19th century records from Latvia require confirmation. Note that certain records from France (Massif Central and Pyrenees) are erroneous and refer instead to *Buchonomyia thienemanni* Fittkau (Serra-Tosio & Laville 1991).

The species is here recorded for the first time from three additional countries: Bosnia-Herzegovina: 17.VII.1909, Pale, leg. Czerny (NMW). Slovenia: 27.VII.-6.VIII.1973, "Bohinj, Riocev Laz" [= Bohinjska Bistrica, Ribcev Laz], 530 m, leg. A. E. Stubbs (NHM). Switzerland: 4.VII.1913, Schaffhausen, leg. A. E. Eaton (NHM).

The following list is based on published and unpublished (museum) records:

AUSTRIA (all NMW): "Austria" (leg. Schiner); "Austria Inf. Alpen" (leg. Schiner); Frankenfels (leg. Bergenstamm); Hainfeld (leg. Mik); Wiklina (?) (leg. Bergenstamm); BELGIUM: Brabant: Bueken (Goetghebuer 1911); Namur: Eprave (Goetghebuer 1922) – IRSN; Sy (leg. Goetghebuer) – IRSN; BOSNIA-HERZEGOVINA: Pale (leg. Czerny) – NMW; ENGLAND: Devon: River Exe, near Bridgetown (Murray & Ashe 1981); Bickleigh (?leg. Verrall) – UMO; Hampshire: Brockenhurst Heath (Curtis 1825); River Itchen (Langton 1984); Shropshire: Longner Hall, Shrewsbury (Edwards 1929) – NHM, NMSE, UMO, UMZC; Westmorland: Rydal (Edwards 1929); Yorkshire: Ilkley (Edwards 1929); FRANCE: "De France. Cabinet de M. Percheron" (Macquart 1834); "environs de Paris" (leg. Macquart) – MNHN; Rhône: Lyon (Winthem Coll., det. Meigen) – NMW; GERMANY: Baden-Württemberg: Mülheim (Meigen 1818); Bayern: Würzburg (Winthem Coll., det. Meigen) – NMW; River Inn, upstream of Mühldorf (leg. C. Orendt); Hessen: Neuwied (Meigen 1818); Uerdingen (Kieffer 1923) – HNHM; Nordrhein-Westfalen: (not stated, ?Aachen) (Panzer 1813); Bonn (Wiedemann Coll.) – NMW; Köln (leg. A. E. Eaton) – NHM; Sachsen: Dresden (det. Kuntze) – NMW; HUNGARY: Budapest (Thalhammer 1899; Kieffer 1923); Kecskemét (Thalhammer 1899); IRELAND: Co. Carlow: River Slaney, New Bridge, Kildavin (Grid Ref. S899597); River Slaney, Kilcarry Bridge (Grid Ref. S893624); Co. Cork: River Ilen, Madore Bridge (Grid Ref. W103419); River Ilen, bridge near Hollybrook (Grid Ref. W117363); Co. Kerry: Killarney, (leg. J. N. Halbert) – NMI; Killarney, River Flesk (leg. P. S. Cranston) – NHM; River Flesk (Murray & Ashe 1981); River Flesk (several sites, Grid references: V9643885, V964893, V987900, W084814, W114826, W048790, leg. P. Ashe) – NMI; River Laune, Beaufort Bridge (Grid Reference V8892); Co. Laois: River Nore, Athanagh (Grid Ref. S423763); Co. Mayo: Ballylahan Bridge, River Moy (Grid Ref. M277992); Co. Meath: River Boyne, Ardsallagh (Grid Ref. N894640); River Boyne, Kilcarn Bridge (Grid Ref. N8865); Co. Offaly: River Shannon, Shannonbridge (Grid Ref. M967254); Co. Roscommon: River Suck, Castlecoote (Grid Ref. M809627); River Suck, Mount Talbot (Grid Ref. M813531); River Suck, Newtown Bridge (Grid Ref. M844346); Co. Sligo: Easky River, Easky Bridge (Grid Ref. G377378); outflow of Glencar Lake (Grid Ref. G734430); Co. Waterford: River Blackwater, Ballyduff (Grid Ref. W964992); River Blackwater, Lismore, (Grid Ref. X047988); Co. Wexford: River Slaney, Ballycarney Bridge (Grid Ref. S967488); NETHERLANDS: Gelderland: Arnhem (van der Wulp 1877); Heelsum (leg. Snellen van Vollenhoven) (van der Wulp 1874a, b); RUSSIA: River Neva, near Leningrad [= St. Petersburg] (Pankratova 1968); River Mezen, Timan Ridge (Komi Region) (leg. Y. Kuzmina); SCOTLAND: Inverness: Boat of Garten, [River Spey, near Nethysbridge] (leg. Francis Jenkinson) – UMZC; near Tulloch Glen stream (Evans 1915) – NMSE; SLOVENIA: Bohinjska Bistrica, Ribcev Laz (leg. A. E. Stubbs) – NHM; SPAIN: "Hispania" (Thalhammer); Provinces of La Coruña, Lugo, Pontevedra, Teruel (Soriano et al. 1997): SWEDEN: no locality specified (Peter Wahlberg) – SMNH; Bohuslän: no locality specified (Carl Bohemann) – SMNH; no locality specified (Peter Wahlberg) – SMNH; Östergötland: "Ostrogoth. ad Gusum" (Zetterstedt 1850, Wahlgren 1919); "ad Börshult in paroecia Ekeby" (Zetterstedt 1852); Skåne: "Årup Scaniae borealis" [= Årup, 18 km east of Kristianstad] (Zetterstedt 1855); no locality (Wahlgren 1919); Småland: Örsled, near Växjö (Brundin 1947); SWITZERLAND: Schaffhausen (leg. A. E. Eaton) – NHM.

The following 19th century records require confirmation: LATVIA: "Curland" (Gimmerthal 1842, 1845); "Livland" (Gimmerthal 1842, 1845); Russia: "Umgegend von Treparewo" [= near Mozhaisk, about 100 km WSW of Moscow] (Fedcenko 1891).

In the new River Flesk survey, only eight trichopteran pupal cases were found to contain immature stages of *E. crassipes*. All were *H. siltalai*, although there are three species of *Hydropsyche* recorded from the studied section of the river.

Nothing as yet is known of the 1st and 2nd instar larvae of *E. crassipes* and whether or not an association exists between these and *H. siltalai*. In Ireland, prepupae/pupae of the latter occur between April and September, pupal exuviae of *E. crassipes* have been found in the drift from May to September. In the material examined, several 4th instar larvae and pupae of *E. crassipes* have been found in the *H. siltalai* pupal cases, but a smaller and probable 3rd instar was also collected inside one pupal case. The precise habitat of the earlier *E. crassipes* instars is unknown. Larvae of *H. siltalai* are caseless but construct a fixed, funnel-shaped net used to gather suitable suspended particulate food matter. The Japanese species, *E. nozakii*, is associated with the case-bearing caddis *Goera japonica*, but again nothing is known of the early instars although Kobayashi (1998) also reported finding 3rd and 4th instar larvae and pupae within *Goera* pupal cases.

When the final instar trichopteran larva constructs its pupal case, a 3rd or 4th instar *Eurycnemus* larva manages to remain inside with its host. Once the host enters the prepupal/pupal stage the chironomid can commence feeding on it. Infested or parasitized *H. siltalai* pupal cases, when viewed through the clear membrane on the underside of the case (attachment point), have a greyish appearance from the partially consumed body components. Movement of the *E. crassipes* larva or pupa may be observed through the same membrane.

The prominent blunt projection on the antero-dorsal margin of the *Eurycnemus* pupal scutum (Murray & Ashe 1981, Kobayashi 1998) can be hypothesized to help the pupa escape by forcing an opening through the stony trichopteran pupal case. Similar structures are reported in the pupae of some chironomids which are also ectoparasitic on Trichoptera, e.g. *Cardiocladius albiplumus* Sæther (Oliver & Bode 1985) and *Collartomyia hirsuta* (Goetghebuer) (Amakye & Sæther 1992).The pupa of *Buchonomyia thienemanni* Fittkau also possesses chitinised projections (on the bases of the antennal sheaths) and it is also believed to be associated in some way with a trichopteran species (Ashe 1995), but since this has not been proven the species is excluded from Table 1.

Table 1. Summary of known chironomid/trichopteran associations (commensal, phoretic and ectoparasitic).

Chironomid taxon	Trichopteran host	Distribution	Reference
Commensal species			
Corynoneura sp.	*Glossosoma intermedium* (Glossosomatidae), *Hesperophylax designatus* (Limnephilidae)	Nearctic (USA)	Vinikour & Anderson (1981)
Cricotopus sp.	*Glossosoma intermedium* (Glossosomatidae)	Nearctic (USA)	Vinikour & Anderson (1981)
Dratnalia potamophylaxi	*Potamophylax cingulatus*, *P. nigricornis* (Limnephilidae)	Palaearctic (Europe)	Cranston et al. (1983), Dratnal (1979), Lellák (1971), Schnell (1991), Sæther & Halvorsen (1981)
"*Eukiefferiella*" sp.	*Brachycentrus occidentalis* (Brachycentridae)	Nearctic (USA)	Gallepp (1974)
Eukiefferiella sp.	*Glossosoma intermedium* (Glossosomatidae), *Hesperophylax designatus* (Limnephilidae), *Neophylax concinnus* (Limnephilidae)	Nearctic (USA)	Vinikour & Anderson (1981)

Chironomid taxon	Trichopteran host	Distribution	Reference
Phaenopsectra sp.	*Hydropsyche* spp., *Cheumatopsyche* spp. (Hydropsychidae)	Nearctic (Canada)	Rutherford & Mackay (1986)
Polypedilum sp.	*Glossosoma intermedium* (Glossosomatidae) *Hesperophylax designatus* (Limnephilidae)	Nearctic (USA)	Vinikour & Anderson (1981)
Polypedilum sp.	*Hydropsyche* spp. *Cheumatopsyche* spp. (Hydropsychidae)	Nearctic (Canada)	Rutherford & Mackay (1986)
indet. Orthocladiinae	*Hydropsyche pellucidula* (Hydropsychidae)	Palaearctic (?Italy)	Corallini Sorcetti & Moretti (1987)
indet. Orthocladiinae	*Anabolia* sp. [?*nervosa*] (Limnephilidae)	Palaearctic (?Czech Rep.)	Lellák (1966)
Phoretic species			
Rheotanytarsus sp.	*Nectopsyche exquisita* (Leptoceridae)	Nearctic (USA)	White et al. (1980)
Ectoparasitic species			
Cardiocladius albiplumus	*Hydropsyche bronta, H. morosa, H. slossonae, H. sparna, Cheumatopsyche* spp. (Hydropsychidae)	Nearctic (Canada)	Rutherford & Mackay (1986)
Cardiocladius albiplumus	*Hydropsyche incommoda, H. venularis, Cheumatopsyche* spp. (Hydropsychidae)	Nearctic (USA)	Parker & Voshell (1979), Oliver & Bode (1985)
Collartomyia hirsuta	*Amphipsyche scottae, Cheumatopsyche thomasetti* (Hydropsychidae)	Afrotropical	Amakye & Sæther (1992), Borkent (1984)
Eurycnemus crassipes	*Hydropsyche siltalai* (Hydropsychidae)	Palaearctic (Ireland)	present paper
Eurycnemus nozakii	*Goera japonica* (Goeridae),	Palaearctic (Japan),	Kobayashi (1993, 1994a, 1995, 1998)
Parachironomus sp.	eggs of *Phryganea* sp. (Phryganeidae)	Palaearctic (Russia, Germany)	Chernovskii (1932), Lenz (1951)
Polypedilum fallax	*Potamophylax cingulatus* (Limnephilidae)	Palaearctic (Sweden)	Otto & Svensson (1981)
indet. Tanypodinae	?	Nearctic (USA)	Wisseman & Anderson (1984)
indet. Chironomidae (several genera)	*Ecclisocosmoecus scylla, Pseudostenophylax edwardsi* (Limnephilidae)	Nearctic (USA)	Wisseman & Anderson (1984)

The pupal exuviae of *E. crassipes* vary greatly in size, the smallest measured being 4.96 mm and the largest 11.8 mm (138% larger than the former). This large variation is postulated to be a consequence of ectoparasitism, with the adult size of *E. crassipes* depending on the size of the trichopteran host at the time of infestation.

All records to date indicate that *Eurycnemus* is confined to lotic waters, primarily the middle and lower reaches of rivers.

Summary of chironomid/trichopteran associations

Steffan (1967), in a review of ectosymbiosis in aquatic insects, listed only two cases involving associations of chironomids with Trichoptera. A summary of chironomid/trichopteran associations – phoretic, commensal and ectoparasitic – is given in Table 1, which shows that the phenomenon is much more common than is generally recognised.

There are some clues in the physical features of some chironomid larvae and pupae, which give a strong indication of such species being associated with Trichoptera. For pupae see the discussion under 'Ecology', in the larval stage such features are:

(i) Body colour pure white or off-white (e.g. *Eurycnemus*, *Buchonomyia*). In *Collartomyia hirsuta* the larva is pinkish red (Borkent 1984) probably due to the presence of haemoglobin to ensure adequate uptake of oxygen in the higher water temperatures of tropical Africa. Chironomid larvae vary greatly in colour from whitish to yellowish, brownish, greenish, purplish, pinkish and bright red, but white is very rarely encountered.

(ii) Posterior parapods reduced and apparently incapable of normal use for gripping the substrate, often smaller than the enlarged anal gills. In *Collartomyia* and *Buchonomyia* the posterior parapods project laterally from the body rather than ventrally as in most chironomid larvae.

In Table 1, apart from one phoretic genus, all species associated with Trichoptera have been assigned to either the commensal or the ectoparasitic category. If the relevant reference states that the chironomid is feeding on trichopteran tissue then it has been assigned to the ectoparasitic category. Species appearing to feed on other sources are assigned to the commensal category, along with those whose mode of feeding is unclear. However, the example of *Dratnalia potamophylaxi* (Fittkau & Lellák) shows the potential problems with such assignments. Dratnal (1979, sub *Eukiefferiella szczensnyi* Dratnal) stated that the immature stages of the host caddisfly were not injured by the chironomid larvae, indicating a commensal relationship between the two species. However, Schnell (1991) found one of six observed *D. potamophylaxi* larvae in a small wound on the last abdominal segment of a larva of *Potamophylax cingulatus* (Stephens), "indicating that the chironomid larvae actually feed on their hosts" (op. cit.).

All the reports to date, apart from *Collartomyia hirsuta* from the Afrotropical Region, are confined to the Palaearctic and Nearctic regions with, respectively, four and seven named and several undetermined genera (Table 1). Many further discoveries are likely to be made, and all zoogeographical regions (except Antarctica) are likely to contain several genera and species associated with Trichoptera.

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