Observations of the oviposition behaviour of four species of Euphaea Selys (Zygoptera: Euphaeidae)

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Introduction
The calopterygoid family Euphaeidae contains eight Indomalayan genera and a single Palaeartic genus. The Indomalayan genus Euphaea is the most speciose in the family, comprising approximately thirty species (Schorr et al., 2009). Species of Euphaea typically inhabit clean, moderate to fast-flowing forest streams, and their robust larvae are found amongst coarse gravel, pebbles and cobbles on the stream bed, often in mid-channel, where the current is at its fastest (Brooks, 2002; Silsby, 2001; Reels & Dow, 2006). This presents adult females with a major problem: how to ensure their eggs are deposited within the larval habitat or as close to the larval habitat as possible?

It is not uncommon for the females of many coenagrionid and calopterygid species to alight on emergent vegetation and slowly submerge themselves by climbing down this support prior to ovipositing in, or very close to, the larval habitat (Brooks, 2002; Corbet, 1999; Silsby, 2001). In the family Chlorocyphidae, adult members of which are often found in the same fast-flowing stream habitats as adult Euphaea, females typically lay their eggs on waterlogged, semi-submerged logs and branches close to the larval habitat (leaf litter and gravel in backwaters; A.G. Orr, pers. comm.), usually (but not always) without needing to submerge.

As noted by Silsby (2001), there is little information in the published literature on the oviposition behaviour of euphaeids. What little information there is was reviewed by Reels & Dow (2006). This review indicated that adult Euphaea females frequently lay their eggs whilst submerged or highly exposed in the same high energy lotic habitats inhabited by the larvae. In some species, females have been observed to boldly dive head first into the water, in flight, in order to reach a suitable oviposition site.

Below, we present observations and remarks on the oviposition behaviour (real or inferred) of four Euphaea species, from Borneo, Thailand, Hainan and Hong Kong.

Observations
Euphaea subcostalis (Selys, 1873)
11 February 2008, Sungai Sbong, Kapit, Sarawak, Malaysia, 200m, N02º00.322 E113º06.287
At about 1110h, in bright but overcast weather, GTR saw a pair of Euphaea subcostalis in copula, flying low over a small (2 m wide) moderately fast-flowing forest stream in a shaded shallow cobble area, depth 5-10 cm. The pair settled on a leaf pack protruding from the mid-channel of the stream. After a minute or so, they broke tandem and the female commenced a rapid, low flight back and forth over the stream (5 cm above the water), with the male following close behind. The flight area covered approximately 3 m of stream length (= 6 m²). She repeatedly entered the water, by suddenly rising up to 30 cm above the surface then abruptly diving head first, at an angle of ca 70 degrees to the horizontal, very fast. The momentum gained easily permitted her to enter the water, although GTR was too far away from the behaviour to verify that her momentum always took her to the stream bed. All her dives were made at least 0.5 m in from the edge of the stream. She stayed submerged for one or two seconds each time, before re-emerging and resuming her rapid presumed ‘oviposition flight’. In total, she performed this diving submergence about 25 times in the space of three minutes. She also interrupted this pattern three times to alight on a semi-submerged twig in the mid-channel, about 50 cm long and 5 mm diameter, where she made brief unsubmerged oviposition movements.

Photo: 1. Female E. subcostalis with male in foreground, Sarawak, Malaysia. Photo by G.T. Reels
for up to five seconds before flying again. The male perched on the leaf pack in mid-channel on the occasions when she did this. After about three minutes, the female abruptly flew up to an overhanging perch some 2 m above the water. GTR left the scene thereafter. The substrate she had been diving onto was comprised of small cobbles. Aquatic vegetation, leaf litter and rotten wood were scarce in the stream bed and she did not appear to specifically target such substrates, aside from the occasions when she landed on the exposed twig.

_Euphaea ochracea ochracea_
_Selys, 1859_

10 April 2001 Khao Panom Bencha N.P., Thailand
At mid-day a female _Euphaea ochracea_ was observed by KDPW ovipositing in a fast flowing hillstream. The female had elected to oviposit into a sodden stick wedged between rocks in the splash zone of a torrential cascade section of the stream. The lower part of the stick, located just above the water level where the female had selected to oviposit, was continuously exposed to strong splashes and on occasions the female was completed submerged for short periods during surges of stream flow. Throughout the oviposition period an attendant male perched nearby, quite close to the female on the same stick, but sufficiently further up to avoid surge flows and most of the strong splashes.

_Euphaea ornata_ (Campion, 1924)

23 May 2007 Ganzaling, Hainan, China, 180m, N18º22 E109º38 (approx.).
At 1245h, in warm, sunny weather, GTR saw a female _Euphaea ornata_ dive into the water onto a submerged twig ca 1 cm underwater in the mid-channel of a fast-flowing shallow riffle of a small (3 m wide) shady cobble-boulder forest stream. It clung onto the twig for 30 s in the current before abruptly exiting the water. It was accompanied by a male which perched 10cm away on a leaf sticking out of the water, and flew off with her (not in tandem) when she exited. No oviposition movements were discernible during the female’s period of submergence.

23rd April 2008 Wuzhishan, Hainan, China, 500m, N18º58.305 E109º40.654
At ca 1100h, GTR was on a small (1 m wide) sunlit cobble-boulder tributary in secondary forest, when a tandem pair of _E. ornata_ came down to the water at a semi-submerged leaf pack in the mid-channel. The male alighted on the above-water part of the leaf pack; the female in the water. The female broke tandem and quickly submerged herself beneath the leaf pack. The water depth was 8 cm. She stayed submerged (and out of sight) for about 3 minutes before she was inadvertently disturbed, whereupon

**Photo 2:** Female _E. ochracea ochracea_ ovipositing into sodden stick at the splash zone in a fast-flowing stream, with guarding male perched nearby, Thailand. Photo credit: K.D.P. Wilson

**Photo 3:** Male _E. ornata_, Hainan, China. Photo credit: G.T. Reels
she flew out of the water and settled on nearby vegetation. The male moved to a boulder about 30 cm from the presumed oviposition site until similarly disturbed.

**Euphaea decorata Selys 1853**

23 July 2008 Hok Tai, Hong Kong, China, 150m, N19º19.341 E122º56.603

At 1035h at a small (2 m wide) open aspect boulder stream in secondary forest, GTR observed a pair of *Euphaea decorata* in the wheel, perched on a sunlit boulder in mid-channel. After two minutes the pair broke tandem and the female flew low over the water about 1m upstream to a point where some *Acorus* was growing in a short cascade section. The uppermost leaves were intermittently breaking the surface of the water. The female flew upstream slowly, about 5 cm above the water, until reaching the *Acorus*. She then alighted on the semi-submerged leaves, clinging on against the stiff current and commencing oviposition movements. This behaviour was photographed. The male initially accompanied her in flight, then settled on a nearby (50 cm away) perch. The female was observed clambering over the intermittently submerged leaves and ovipositing for ca 10 minutes, before GTR was unfortunately obliged to move on. The female actually disappeared from view for about three minutes, and was presumably completely submerged and beneath the leaves at this point. The male made two short patrol flights over the oviposition site during the ten minutes in which observations were made.

**Remarks**

Unfortunately, GTR was unable to photograph the spectacular diving behaviour exhibited by the female *E. subcostalis* (which was observed through binoculars at a distance of about 5 m), and could not determine whether the female was able to reach the stream bed (up to 10 cm below the surface). It seems likely, however, that the female repeated her diving behaviour so many times for either (or both) of two reasons: she was trying unsuccessfully to reach the stream bed, or she was reaching the stream bed but repeatedly encountering a substrate unsuitable for oviposition. The force with which the female was striking the water, and the shallow depth, suggests that the latter explanation may be the more probable, particularly bearing in mind the observation by Choong (2005) of a female *Euphaea impar* Selys diving into water of similar depth to oviposit on slime-covered rocks and roots. This very dynamic method of submergence and very abrupt re-emergence contrasts with observations of *E. subcostalis* oviposition made by Reels & Dow (2006), in which the female dove into very shallow water (ca 3 cm) from an adjacent low perch, and stayed submerged, apparently ovipositing into dead leaves, for 20-25 s.

In the case of *E. ochracea*, a sodden stick was observed to be used as a substrate for oviposition, which was located in a torrential section of stream and involved exposure to strong splashes and occasional passive submergence.

The two brief observations of submergence by female *E. ornata* from Hainan represent the first records of this style of (presumed) oviposition-related behaviour for this species. It is unfortunate that actual oviposition was
not observed, but it is reasonable to suppose that this was the reason for the submergence in both cases.

Underwater oviposition by *E. decorata* into *Acorus* leaves, as described above, is a behaviour which was also observed by Reels & Dow (2006), who noted this was apparently the first observation of *Euphaea* ovipositing into living green vascular plant tissue. It noteworthy the additional record described here also involves the same oviposition substrate.

Females of *Euphaea* spp. are very stout. Their robust build undoubtedly helps several species within this genus to withstand the severe physical stresses encountered during oviposition in cascades and riffles, either from diving headlong into riffle sections and struggling against the current, or from exposure at torrential splash zone sites. The larvae of many oriental euphaeids inhabit fast flowing sections of steep gradient hill streams. This contrasts slightly with *Epallage fatima*, the type species for the family, which frequents riffle sections of streams generally located in areas with moderate gradients and relatively slower current flows. The other notable difference is the males of *Epallage fatima* often remain attached, in tandem, to ovipositing females. The oviposition substrate for *Epallage* is floating vegetation, living or dead. This type of substrate is frequently absent from many oriental, steep gradient hill streams.

**References**


