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Caddisfly larvae (Trichoptera: Phryganeidae) as scavengers of carcasses of the common frog *Rana temporaria* (Amphibia: Ranidae)

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Insects may use carcasses for oviposition as well as for nutrition, and non–aquatic larvae of Hexapoda, especially of Diptera and Coleoptera, play an important role in the composting of carcasses, but also aid in timing the post-mortem interval in forensic entomology (e.g., Byrd & Castner 2001, Amendt et al. 2004). Reports on the aquatic larvae of caddisflies (Trichoptera) as scavengers on vertebrates (Holzer 1939), such as dead fish (e.g., Brusven & Scoggan 1969, Kline et al. 1997, Walter et al. 2006), have been sporadic. Other reports refer to the predation of newt and frog eggs by larval limnephiid (Gall et al. 2011), phryganeid (Rowe et al. 1994, Richter 2000), and leptocerid caddisflies (Wilson et al. 2014). Here we report an incident of scavenging of caddisfly larvae on carcasses of the European common frog *Rana temporaria* from a pond.

Four carcasses of *Rana temporaria* including attached caddisfly larvae were retrieved on 15 March 2009 from a 40 cm deep pond located near Jena-Cospeda, State of Thuringia, Germany (50°57'25.48" N, 11°32'19.60" E, ca. 300 m a.s.l.). The frogs were fixed in 70% ethanol. Snout–vent lengths were measured with a digital calliper as the distance between snout and posterior edge of the urostyl to the nearest 0.01 mm. The frog specimens (herpetology collection SMNS 14463–14466), and a caddisfly larva (aquatic insects collection SMNS TRI 002418 A) were deposited at the State Museum of Natural History Stuttgart. Caddisfly larvae were examined with a stereomicroscope (Leica MZ8) and identified following Solem (1971) and Waringer & Graf (2011). Photographs were taken with a Leica DFC490 digital camera through a Leica Z16 Apo Macroscope. The digital photographs were processed with the Leica Application Suite Version 3.1.8 to obtain stacked photographs with extended depths of field.

All four adult common frogs *Rana temporaria* were female (88.82 ± 4.75 mm SVL, range 81 to 93.5 mm) as identified by a lack of nuptial pads and the presence of ovarian egg masses.

The frog carcasses showed multiple traces on various parts of the body of having been scavenged on by caddisfly larvae (Figs 1A–D). In two cases the larvae were still attached (Figs 1B, C). Most obvious were various perforations in the skin of the carcasses, which clearly were evidence of penetration by caddisfly larvae. Penetration holes were present on the dorsum, in the thoracic region, on the axillae, and on the groins (Figs 1A–D). A larva lacking a case was found emerging from a thigh (Fig. 1A), likely feeding on decaying muscle tissue, as three of the four frogs lacked the thigh muscle tissue and the femur appeared flat as a result (Fig. 1 D). However, other larvae directly fed on the tongue and exposed egg masses.

The caddisfly larvae were identified as *Agrypnia varia* (Trichoptera: Phryganeidae) (Figs 2A–D). Among other genera, the genus *Agrypnia* is characterised by an eruciform shape (Fig. 2A), the presence of a prosternal horn, an orthognathous head capsule with a dark medial stripe (Fig. 2B), and a small triangular plate between the foreleg coxal cavities. Within the genus, *A. varia* is well distinguishable by its colour pattern on the pronotum (Fig. 2B)

and the specific arrangement of microtrichia rows on the ventral sides of pro- and mesocoxae (Fig. 2 C).

To the best of our knowledge it has never before been reported that trichopteran larvae would feed on amphibian carcasses whereas instances of the predation of frog (Richter 2000, Wilson et al. 2014) and newt eggs (Gall et al. 2011) by caddisfly larvae have been documented. As all adult *Rana temporaria* bodies were found in the pond in early March we expect that they likely died during hibernation, which is not uncommon in temperate regions, as both sexes will often approach the spawning sites already in autumn and stay under water for hibernation (e.g., Verrell & Halliday 1985, Schlüpmann & Günther 1996).

Caddisflies usually deposit their eggs in water and their larvae are obligatorily bound to freshwater. Larvae of Phryganeidae are generally limnobiont, and *A. varia* prefers the littoral zones of lentic sites such as lakes and ponds from planar to montane regions (Pitsch 1993). *Agrypnia varia* has a wide dietary spectrum, including as predator of other freshwater invertebrates such as mayflies (Wiggins 1998). Evidently, here they used the frog carcasses as a food source. Apparently the larvae consumed frog skin, muscle and other soft tissues, but also directly fed on ovarian egg masses. As *A. varia* has an univoltine life cycle and imagines can be found from spring to autumn, but because larval development and growth continues throughout winter, it is most likely that the use of

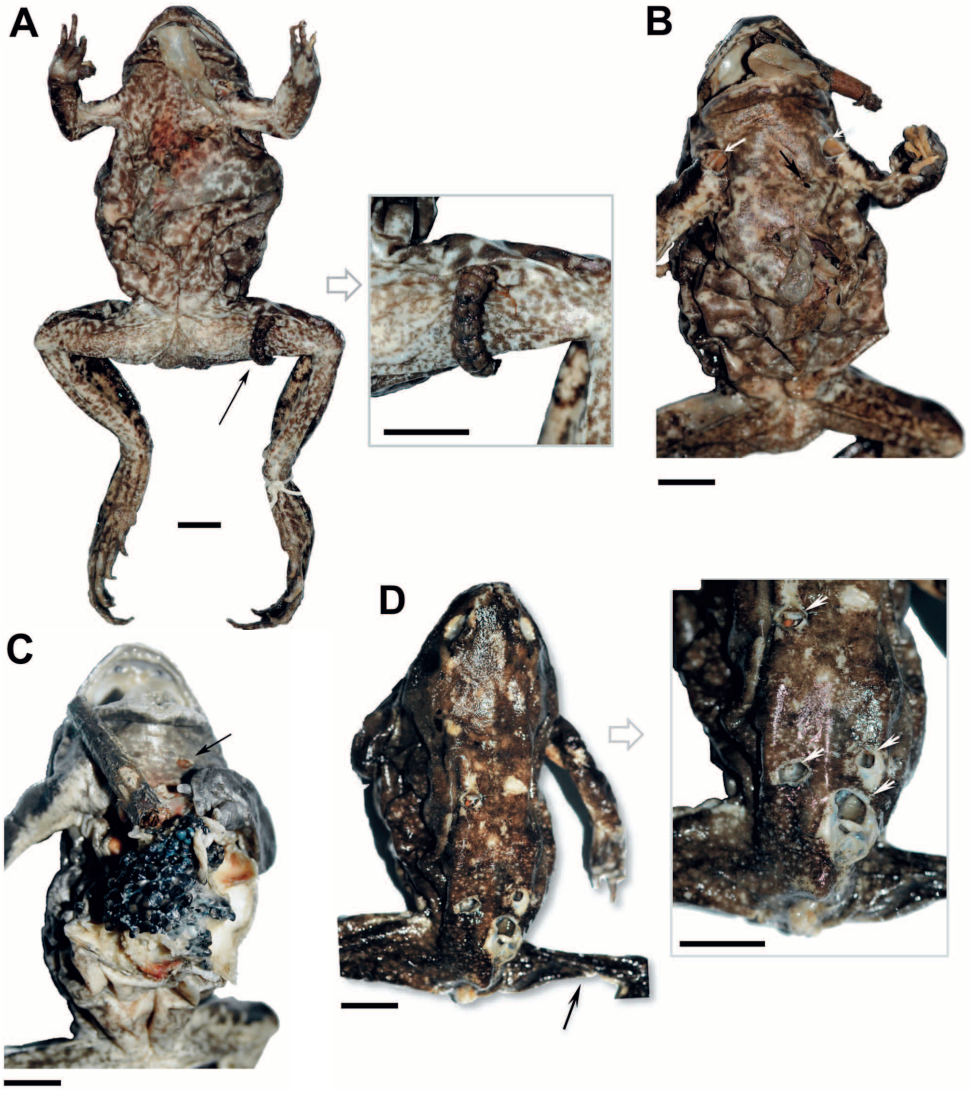

Figure 1. Caddisfly larvae scavenging on *Rana temporaria*: (A) female SMNS 14463 in ventral view with a larva emerging from the frog's thigh (indicted by arrow) and detail of thigh; note that the caddisfly larva lacks a case; (B) female SMNS 14465 in ventral view with a caddisfly larva attached to the tongue; arrows indicate penetration holes in the axilla; (C) ventral view of female SMNS 14466 with a caddisfly larva feeding on the ovarian egg mass; arrows indicate penetration holes; (D) dorsal view of female SMNS 14466 with penetration holes on the dorsum pointed out (white arrows); note the thin femur that apparently lacks the muscle tissue (indicated by black arrow). All scale bars 10 mm.

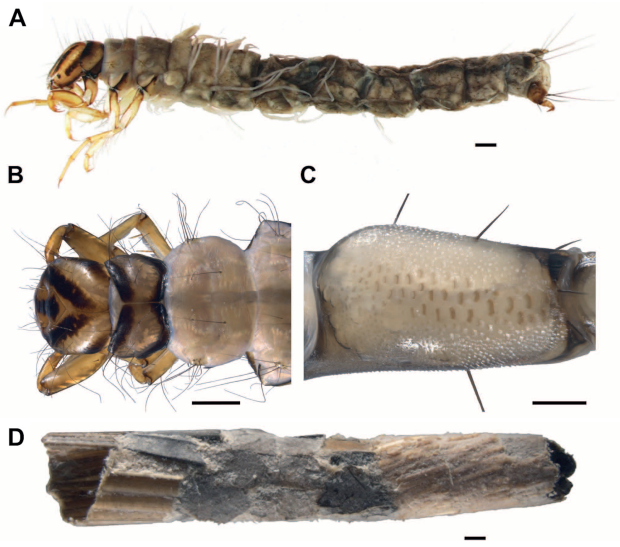

Figure 2. Details of the scavenger, larval *Agrypnia varia*. (A) lateral view of a larva with its case removed; (B) detailed dorsal view of larval caput and thorax; (C) rows of microtrichia on larval coxa allowing species identification; (D) case in lateral view. All scale bars 1 mm (except C with scale bar = 0.2 mm).

frog carcasses as a food source positively influences larval development.

Future studies should reveal whether amphibian carcasses are consumed as an occasional food source or whether this is a common feeding strategy. Furthermore it would be worth studying how such feeding regimes influence larval growth rate and developmental time in the laboratory (see also Ito et al. 2005, Niederegger et al. 2013). Dedicated field studies at the overwintering sites of amphibians could also demonstrate if carcasses of other species are used for nutrition purposes as well. Another future study aspect would be estimating the trophic level of carnivorous caddisfly larvae within lentic aquatic food webs via stable isotope analysis (see also Kupfer et al. 2006).

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