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Flesh fly myiasis (Diptera, Sarcophagidae) in Peruvian poison frogs genus *Epipedobates* (Anura, Dendrobatidae)

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Myiasis – the invasion of fly larvae in vertebrate tissues – is a phenomenon well documented in many animals, predominantly mammals and birds, with the most frequent forms being wound and dermal myiasis (Zumpt 1965, Guimarães *et al*. 1983, Hall and Wall 1995, Hall and Farkas 2000). Amphibians world wide are also parasitized by larvae of numerous fly species, however this is a poorly studied area of amphibian biology. In Europe, North America and India, amphibians are commonly attacked by larvae of several species of blow flies (Calliphoridae), flesh flies (Sarcophagidae) and muscid flies (Muscidae) (James and Maslin 1947, Dasgupta 1962, Roy and Dasgupta 1977, Strijbosch 1980, Bolek and Coggins 2002, Bolek and Janovy 2004) while in Australia amphibians are infected with the larvae of grass flies (Chloropidae) in the genus *Batrachomyia* (Schell and Burgin 2001). In the Neotropics, dermal myiasis of amphibians by flesh flies has been reported from harlequin frogs (*Atelopus* spp.) in Costa Rica (Crump and Pounds 1985, Pounds and Crump 1987), from the granular toad (*Bufo granulosus*) in Venezuela (Lopes and Vogelsang 1953), from the bullfrog (*Rana catesbeiana*) in Brazil (Souza *et al.* 1990), and from leptodactylid frogs (*Eleutherodactylus* sp., *Proceratophrys* sp.) in Panama and Brazil (Dodge 1968, Lopes 1981). When fly identification was possible most of these cases have been attributed to *Notochaeta bufonivora* (Lopes and Vogelsang 1953).

Poison frogs of the family Dendrobatidae are small diurnal frogs of the Central and South American rainforests well known for their bright, aposematic coloration and extremely potent skin toxins (Daly 1978, 1995, Daly and Myers 1983, Schulte 1999, Summers and Clough 2001, Hagman and Forsman 2003). Because of their diurnal habits, these frogs overlap temporally in their habitat with myiasis causing flies, which are also diurnal in habit. To our knowledge no records of myiasis in poison frogs have been published. In this note we review records of

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myiasis in poison frogs collected in various locations in Peru during 1982-2005 and present evidence that larger and medium-sized poison frogs (*Epipedobates*) are infected with sarcophagid fly larvae. We hope that our observations will stimulate awareness of myiasis in poison frogs and stimulate more research on myiasis in amphibians.

One of us (RS) first observed myiasis in Peruvian poison frogs on two occasions in 1982 (Schulte 1984) and on three occasions during fieldwork with a Kansas University team headed by W. E. Duellman in 1989. Subsequent observations were made in 1998 and again in 2004 and 2005. These observations are summarized in Table 1. With the purpose of studying the prevalence of myiasis we sampled individuals of three species of poison frogs – *Epipedobates trivittatus* (n=111), *Epipedobates bassleri* (n=5) and *Epipedobates cainarachi* (n=1) – at six localities (the same localities as given in Table 1) from 27th February to 28th March of 2004. Only one individual (*E. cainarachi*) of the 117 frogs collected was infected. Eight maggots were retrieved after preservation. Maggots were preserved in 80% alcohol and identified as a species of flesh fly (Sarcophagidae, subfamily Sarcophaginae) due to the large size and characteristically recessed posterior spiracles. Species-level identification of flesh fly larvae, however, is still not possible. In June 2005 an infected *E. trivittatus* (Figure 1) was found near San Jose village (J. L. Brown, pers. comm.; Table 1). The frog, which died within hours after it was

Table 1 - Number of myiasis observations in poison frogs genus *Epipedobates* collected in various locations in Peru during 1982–2005. Data on maximum snout-vent length (SVL) include both sexes and were obtained from the literature (Schulte 1989, Haddad and Martins 1994, Walls 1994).

Locality	Year	Species	Max. SVL (mm)	N Sampled	N Infected	Note
Central Alto Caynarachi Valley	1982	*E. bassleri*	40.0	1	1	Found in water of roadside drain
Yurimaguas Road (at 6 km)	1982	*E. trivittatus*	49.5	1	1	Found in water of artificial quebrada
Chumilla River, Huallaga	1989	*E. trivittatus*		~20	~10	Most of the infected frogs found in water
Chumilla River, Huallaga	1989	*E. cainarachi*	31.0	1	1	Found in water of artificial quebrada
Chumilla River, Huallaga	1989	*E. bassleri*	40.0	1	1	Found near water of a creek
West Flank, Uruhuasha	1998	*E. bassleri*		1	1	Found in shallow margins of a river
South Carrachamera	2004	*E. bassleri*		1	1	Found in shallow margins of a river
Upper Alto Caynarachi Valley	2004	*E. bassleri*		1	1	Found among leaf litter on ground
Yurimaguas Road (at 34 km)	2005	*E. trivittatus*	49.5	1	1	Found in a shallow pool of water

Figure 1 - *Epipedobates trivittatus* parasitized by larvae of *Sarcodexia lambens* (Sarcophagidae). This specimen (SVL > 45mm) was found in a small water pool near San Jose village, Peru, in June 2005.

collected, was placed in a ventilated container. Within a week thirty larvae had emerged from the dead frog, and about three weeks later three adults (two males, one female, all = *Sarcodexia lambens* (Wiedemann, 1830) and deposited in the Zoological Museum, Copenhagen) hatched from their puparia. Unfortunately, wasps of an unknown species had parasitized the remaining larvae.

S. lambens is widely distributed in the New World, from the south-eastern US to northern Argentina and Paraguay (Pape 1996). This species has been bred from dead bird nestlings, snails, dead and living (but probably often injured or otherwise weakened) insects and scorpions, and vertebrate carrion, and it is known from cases of human myiasis (Townsend 1893, Almeida 1933, Callan 1946, Parker *et al.* 1953, Harrison 1963, Stegmaier 1972, Cornaby 1974, Jones 1988, Fessl *et al.* 2001, Janzen and Hallwachs 2005). With such diversity of breeding habits, a record of amphibian myiasis would seem at first to be no surprise. Still, it is noteworthy that no records exist of *S. lambens* involved in amphibian myiasis outside Peru, and the pattern of infection in the poison frogs is here considered as indicative of a specialised predator. Precautions were taken to avoid contamination of the infected frog after being brought to the laboratory, but clearly the small parasitic wasps (1.5-2.0 mm) could penetrate the fine nylon mesh covering the breeding container. Some flesh flies will larviposit on the mesh without direct contact with the bait (Bänziger and Pape 2004), but with only one breeding event giving adult flies, and thereby a reliable identification, data does not allow a clearcut answer.

The present records represent the first evidence of myiasis on frogs from Peru as well as the first evidence of fly larvae parasitizing poison frogs. Most of the infected frogs that have been found are the larger species *Epipedobates trivittatus*, and a few are from the medium-sized species *E. bassleri* and *E. cainarachi* (see Table 1 for data on body size). No maggot infections have been recorded from any of the smaller sympatric species *E. hahneli* (maximum SVL = 23.0 mm; Haddad and Martins 1994) and *E. pongoensis* (max. SVL = 26.0 mm; Schulte 1999). It is unclear if these flies can infect small *Epipedobates* species. Other studies on fly larvae that cause myiasis in amphibians clearly show that smaller frogs under 30 mm die quicker and get consumed within one to three days of infection (Bolek and Coggins 2002, Bolek and Janovy 2004), suggesting that small frogs also may be infected but that they are less likely to be found by researchers due to the rapid death and consumption by fly maggots.

Most of the infected frogs collected have been found sitting in water (Table 1). Poison frogs normally do not sit in water and in fact seldom enter water except for short visits to deposit their tadpoles (Heselhaus 1992, Walls 1994). Infected frogs usually are motionless, probably due to extensive destruction of the muscular tissues in later stages of myiasis. Infected frogs die within a few days after capture, suggesting that the larvae kill their host quickly and that the larvae have a rapid growth and development. Crump and Pounds (1985)

observed larvae of *Notochaeta bufonivora* parasitizing *Atelopus varius* in Costa Rica, and they reported that all hosts died within four days after they were found. Maggots that crawled out from the dead frogs pupated within 48 hours and eclosion occurred in 17 to 30 days. *Notochaeta bufonivora* is the only fly species known to parasite diurnal, toxic frogs in the Neotropics (*A.varius*; Crump and Pounds 1985). Although not closely related, harlequin frogs (*Atelopus*) and poison frogs (Dendrobatidae) have similar life-history traits and are often found living sympatrically. Like poison frogs, harlequin frogs are small, diurnal and have noxious toxins. Crump and Pounds (1985) reported a SVL range of 25.0 – 29.5 mm for male *A. varius* and 30.0 – 41.0 mm for females. Interestingly, male *A. varius* were more common in their study location, although females were more commonly infected (Crump and Pounds 1985).

Note: the area where we made our observations is under heavy pressure of illegal collecting. We have therefore omitted latitude and longitude coordinates for our study sites. We will provide them to researchers on request.

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