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Predation on amphibians by spiders (Arachnida, Araneae) in the Neotropical region

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Abstract

Predation on amphibians by spiders (Arachnida, Araneae) in the Neotropical region. Herein, we report observations about spider predation on anurans (adults and juveniles) in Central Amazonia and a literature review of spiders preying on amphibians in the Neotropical zoogeographic realm. We conducted field observations in Reserva Florestal Adolpho Ducke, Manaus, AM, and observed eight predation events on Bufonidae, Dendrobatidae, Hylidae, and Leptodactylidae frogs. The predators belong to the spider families Ctenidae, Pisauridae and Theraphosidae. Besides the families of spiders found in this study, two others – Lycosidae and Sparissidae - were found in literature. Frogs from families Centrolenidae and Microhylidae, and a caecilian (Gymnophiona, Caeciliidae) were found in literature also. There is a significant correlation between the length of the anuran (snout-vent length) and the length of spiders (cephalotorax and abdomen length). The size of the spider is similar or slightly lesser than the anuran prey. In general, the spiders preyed on adult and juvenile frogs in the breeding season. Spiders are opportunistic predators and prey on small frogs. Theraphosidae prey upon sub adults of large anurans and caecilians. As spiders can reach high densities on the forest floor - especially species of the genera *Ctenus* and *Ancylometes* - this interaction may be ecologically important for breeding anurans. Our reports and literature data provide evidence that spiders commonly prey on amphibians in Neotropic, but the impact of predation on populations of amphibians is unknown.

Keywords: Anura, Gymnophiona, predator-prey interaction, Amazonian, Neotropical region, intraguild predation.

Introduction

Small vertebrates such as gekkonid lizards (see Bauer 1990 for review) and amphibians (Duellman and Trueb 1994, Rubbo *et al.* 2003) are prey for a great variety of vertebrate and arthropod predators, and it is apparent that some arthropods may cause significant mortality among some vertebrate populations (review in McCormick and Polis 1982). According to McCormik and Polis (1982), representatives of four classes of Arthropoda are predators of vertebrates: Arachnida, Insecta, Crustacea, and Chilopoda. Despite the fact that the reports of

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attacks by arthropods on small vertebrates are numerous, it is difficult to assess the impact of arthropod predators on their vertebrate prey (McCormick and Polis 1982). Detailed studies have been made about predation by aquatic insects on larval amphibians (Heyer *et al.* 1975) and by insect larvae on non-aquatic eggs (Villa *et al.* 1982, Menin and Giaretta 2003).

Among small vertebrates, adult and juvenile amphibians are preyed upon by aquatic insects, such as water bugs (Hinshaw and Sullivan 1990, Toledo 2003, Giaretta and Menin 2004), and arachnids, such as scorpions (Villanueva-Rivera *et al.* 2000) and spiders (Goin 1943, Formanowicz *et al*. 1981), which are considered important predators of terrestrial frogs (Hayes 1983). Although most examples of spider attacks on amphibians are based on fortuitous observations of single events, spiders were observed preying upon and eating a great variety of frogs in different places around the world (Goin 1943, McCormick and Polis 1982, Mitchell 1990, Raven 1990, Owen and Johnson 1997, Blackburn *et al.* 2002). Besides this, the small leaf-litter dwelling species, such as most leptodactylids and dendrobatids, are well within the size range of prey of many spiders.

Herein, we report our own observations about events of predation by spiders on adult and juvenile frogs in Central Amazonia and undergo an extensive literature review of spiders preying on amphibians in the Neotropical zoogeographic realm.

Material and Methods

We conducted field observations in Reserva Florestal Adolpho Ducke - RFAD (02º55'– 03º01' S, 59º53' – 59º59' W), in the municipality of Manaus, state of Amazonas, Central Amazonia, northern Brazil, between January and May 2004 and in January 2005. Seven observations were made at night in a temporary pond (ca. 6 x 6 m) and along trails in terra-firme forest. All observations were occasional and realized during surveys of nocturnal anurans. Only one observation was made in the afternoon in a trial. The measures of the body size represent the cephalotorax and abdomen length to spiders and snout-vent length (SVL) to frogs. Measures were made with vernier calipers to the nearest 0.01 mm. The relation between the size of frogs and spider was analyzed by the Pearson Correlation test (r) (Zar 1999) using data from this study and cases in literature for which sizes of both predator and prey were available. The size data were log-transformed (base 10) prior to analysis. Spiders were preserved in 70% alcohol and deposited in the Invertebrate Collection of the Instituto Nacional de Pesquisas da Amazônia (INPA). Frogs were deposited in the INPA Herpetological Collection (INPA-H 11891, 11898, 11899).

We conducted an extensive literature review on spiders preying on amphibians (adults and juveniles, not larvae) in the Neotropical zoogeographic realm. In addition, we contacted other researchers that conducted works in Central Amazonia, which made their unpublished data available. We considered as 'predation' those events for which the capture of prey was reported or when the capture was not observed but the prey was still alive.

Results

Observed Events

Bufo marinus - on 16 April 2004 a theraphosid spider *Theraphosa blondi* (84.12 mm) was observed eating a juvenile *B. marinus* (90.52 mm). The spider was standing over the toad with its chelicerae in the head of the frog. There was a hemorrhage around the bite, and another bite was observed in the gular region. The frog was still alive but motionless when the spider was captured. After two hours, the frog was still alive but the left eye and the right hind limb were paralyzed.

Dendrophryniscus minutus – on 12 January 2005 a male pisaurid spider *Ancylometes rufus* (ca. 30 mm) was observed capturing a passing

female *D. minutus* (ca. 22 mm) on leaf-litter. After 15 minutes, the frog was still alive, but after its death, the right leg and part of the belly were deformed, probably due to the removal of liquefied internal tissues.

Colostethus stepheni – on 18 May 2004 a juvenile male ctenid spider *Ctenus amphora* (16.4 mm) was observed eating an adult female *C. stepheni* (18.4 mm) on a leaf from a shrub about 0.30 m above the ground (Figure 1A).

Dendropsophus minutus - on 6 March 2004 a juvenile male pisaurid spider *Ancylometes rufus* (26.1 mm) was observed eating an adult *D. minutus* (ca. 22 mm) (Figure 1B). The spider was found perched on a leaf 0.50 m above the water surface of a temporary pond. The right side of the body, head and trunk of the frog had been eaten; the left hind and fore limbs were intact, but it was impossible to determine the sex of the frog. On 7 March 2004, in the same pond, a male *A. rufus* (31.0 mm) was observed about 0.05 m above water surface on a leaf preying on a gravid female *D. minutus* (24.5 mm). The spider was holding the hylid with its pedipalps and first pair of legs, and the chelicerae penetrated the side of the frog. The spider released the frog when disturbed. The frog was still alive, but floated motionless in the water.

Adenomera andreae – on 14 January 2004 a male *A. rufus* (ca. 30 mm) was observed eating a female leptodactylid *A. andreae* (ca. 24 mm) on the leaf-litter (Figure 1C). The spider held the hylid with its pedipalps and the chelicerae penetrated the head of the frog. The frog struggled briefly and was completely immobilized. On 15 March 2004 a juvenile ctenid spider *Ctenus villasboasi* (18.5 mm) was observed eating an adult male *A. andreae* (20.9 mm). The spider was perched on a shrub's leaf about 0.50 m above the ground, with its chelicerae in the head of the frog. At the time, the frog was still alive and completely immobilized. About one hour later, the frog was dead with the region of the head partially eaten. On 1 May 2004 a juvenile ctenid spider *Ctenus* sp. (8.0 mm) was observed capturing a juvenile *A. andreae* (11.5 mm) on the leaf-litter at afternoon. The frog struggled briefly, but was completely immobilized after about 60 seconds.

Literature Data

We collated published data on 16 articles or notes. In the 16 articles or notes, 21 reports were found, in eight predation were observed and in ten feeding were observed. In three reports this information was not available.

A total of 15 species of frogs belonging to four families (Centrolenidae, Dendrobatidae, Hylidae, and Leptodactylidae) and one species of caecilian (Caeciliidae), were preyed upon by 13 species of spiders belonging to five families (Ctenidae, Pisauridae, Theraphosidae, Lycosidae and Sparassidae) (Table 1).

In general, the reports of spider attacks on amphibians are based on observations of single events; only one study showed experimental data and the impact of predations on a species of *Eleutherodactylus* (Formanowicz *et al.* 1981).

Discussion

The majority of reports found in the literature of predation on amphibians in the Neotropical realm were about anurans; only one report was found on a caecilian (Table 1), probably due to the fossorial habits of this taxon. Often the size of the predator and prey were not available in the original reference, and the actual evidence of predation (from capture to consume) was observed in few events. In much of them the authors observed the spiders eating their prey after the capture. There are some reports that spiders will scavenge dead insects (Cangialosi 1990, Sandidge 2003). However, a few spiders scavenge dead individuals encountered in the search for live prey, and these spiders are generally opportunistic feeders and not obligate scavengers (Wise 1993). In addition, the spiders are primarily predators and most of them remain motionless for a long time, sitting on the ground or on low plants waiting for their prey (Wise

Figure 1 - Spider *Ctenus amphora* eating a female *Colostethus stepheni* (A); *Ancylometes rufus* eating an adult *Dendropsophus minutus* (B), *Adenomera andreae* (C) and *Hypsiboas geographicus* (D); *Ancylometes* sp. eating an adult *Hamptophryne boliviana* (E); theraposid spider eating an adult *Phyllomedusa vaillanti* (F). Photos: M. Menin (A and B), A. P. Lima (C), W. E. Magnusson (D) and W. Hödl (E and F).

1993, Höfer *et al.* 1994). Although most reports on attacks of amphibians by spiders in literature do not show the capture of the prey, our observations and those of other researchers indicate that predation is an important source of mortality for amphibians. Therefore, it is very probable that reports in literature where the capture of amphibians was not observed are actual events of predation.

The predaceous spiders that feed on

Table 1 - Neotropical amphibian species preyed upon by spiders. J, juvenile; A, adult (unidentified sex); SVL, snout-vent length. Spider size represents the cephalotorax + abdomen length.

Order: Family/Species	Sex	SVL (mm)	Spider species	Spider size (mm)	Predation observed	Source
Anura: Bufonidae						
Bufo marinus	J	90.5	*Theraphosa blondi*	84.1	Yes	This study
	J	90.0	*Theraphosa blondi*	–	Yes	J. Zuanon (unpubl.)
Dendrophryniscus minutus	A	22.0	*Ancylometes rufus*	–	Yes	This study
	A	15.8	*Ancylometes rufus*	9.0	Yes	V. F. V. Pazin (unpubl.)
Anura: Centrolenidae						
Centrolene prosoblepon	♂	–	*Cupiennius* sp.	–	Yes	Hayes 1983
Hyalinobatrachium fleischmanni	–	–	*Cupiennius* sp.	–	No	Hayes 1983
Anura: Dendrobatidae						
Colostethus stepheni	♀	18.4	*Ctenus amphora*	16.4	No	This study
Dendrobates auratus	♂	–	*Sericopelma rubronitens*	–	Yes	Summers 1999
Anura: Hylidae						
Dendropsophus ebraccatus	–	–	*Cupiennius coccineus*	–	–	Szelistowski 1985
Dendropsophus minutus	♀	21.0	*Ancylometes rufus* (= *A. gigas*)	30.0	No	Bernarde *et al.* 1999
	A	22.0	*Ancylometes rufus*	26.1	No	This study
	♀	24.5	*Ancylometes rufus*	31.0	Yes	This study
	♂	29.0	*A. concolor* (= *A. vulpes*)	30.0	No	Bernarde *et al.* 1999
	A	20.0	*Ancylometes* sp.	–	No	Bernarde *et al.* 1999
	J	–	*Dolomedes* sp.	15.3	No	Bastos *et al.* 1994
Dendropsophus nanus	J	10.0	*Thaumasia* sp.	12.0	No	Pramuk and Alamillo 2002
Dendropsophus sanborni	♂	18.3	*Diapontia* cf. *uruguayensis*	9.5	Yes	Del–Grande and Moura 1997

Table 1. *Continued.*

Order: Family/Species	Sex	SVL (mm)	Spider species	Spider size (mm)	Predation observed	Source
Hypsiboas geographicus	–	50.0	*Ancylometes rufus*	–	Yes	W. E. Magnusson (unpubl.)
	–	–	*Ctenus* sp.	–	Yes	D. M. M.Oliveira (in prep.)
Hypsiboas sp.	–	–	*Theraphosa blondi*	–	Yes	W. E. Magnusson (unpubl.)
Phyllomedusa vaillanti	–	–	Theraphosidae	–	Yes	W. Hödl (unpubl.)
Scinax alter	A	27.3	*Ancylometes rufus*	23.0	No	Prado and Borgo 2003
	J	11.5	*Thaumasia* sp.	10.2	No	Marra *et al.* 2003
Scinax cruentommus	A	25.0–31.0	Lycosidae	–	No	Aucone and Card 2002
Scinax elaeochrous	–	–	*Cupiennius coccineus*	–	–	Szelistowski 1985
Anura: Leptodactylidae						
Adenomera andreae	♀	24.0	*Ancylometes rufus*	30.0	Yes	A. P. Lima (unpubl.)
	♂	20.9	*Ctenus villasboasi*	18.5	No	This study
	J	11.5	*Ctenus* sp.	8.0	Yes	This study
Eleutherodactylus coqui	J	6.0–21.0	*Olios* sp.	–	Yes	Formanowicz *et al.* 1981
	–	–	*Oligoctenus ottleyi*	–	–	Formanowicz *et al.* 1981
Eleutherodactylus spp.	–	–	*Cupiennius coccineus*	–	Yes	Szelistowski 1985
Hylodes phyllodes	J	17.2	*Trechalea keyserlingi*	13.8	Yes	Schiesari *et al.* 1995
Leptodactylus knudseni	J	90.0	*Theraphosa blondi*	–	Yes	Boistel and Pauwels 2002b
Physalaemus pustulosus	A	–	*Sericopelma rubronitens*	–	Yes	Gray *et al.* 1999
Anura: Microhylidae						
Hamptophryne boliviana	A	–	*Ancylometes* sp.	–	Yes	W. Hödl (unpubl.)
Gymnophiona: Caeciliidae						
Oscaecilia zweifeli	–	–	*Theraphosa blondi*	–	No	Boistel and Pauwels 2002a

anurans in the Neotropical region include species from the families Pisauridae (genera *Ancylometes*, *Dolomedes*, *Thaumasia*, and *Trechalea*), Ctenidae (genera *Ctenus*, *Cupiennius* and *Oligoctenus*), Lycosidae (genus *Diapontia*), Sparassidae (genus *Olios*), and Theraphosidae (genera *Theraphosa* and *Sericopelma*). These spiders feed primarily on adults engaged in reproductive activity and juvenile frogs (Figure 1) (e.g. Del-Grande and Moura 1997, Pramuk and Alamillo 2002, this study). There is a significant correlation between anuran SVL and spider body size ($r = 0.892$; $P < 0.001$, $N = 15$) (Figure 2), specifically, the size of the spider is similar or slightly lesser than the anuran prey.

Spiders of the family Pisauridae are opportunistic predators that prey on small frogs, fishes and tadpoles (Bastos *et al.* 1994, Azevedo and Smith 2004). Members in the genera *Ancylometes*, *Dolomedes*, and *Thaumasia* were observed preying on small frogs (between 10 – 30 mm SVL), which were mainly hylid frogs (Table 1). *Dendropsophus minutus* was the species with the highest number of reports. It is a common hylid frog that reproduces in temporary and permanent ponds (Lutz 1973), and the pisaurid spiders are commonly found near aquatic environments during the night (Höfer and Brescovit 2000, Azevedo and Smith 2004). The results of our study support the conclusion of Bernarde *et al.* (1999) that these spiders can be important predators of adults in breeding activity and metamorphosing *D. minutus* (Bastos *et al.* 1994).

The wandering spiders of the genus *Ctenus* are very similar in behavior and microhabitat use because they forage in and on the leaf-litter (Höfer *et al.* 1994, Gasnier and Höfer 2001). Diet of most species consists predominantly of invertebrates, but they occasionally prey on small lizards (Gasnier 1996) and frogs (*C. stepheni* and *A. andreae*, this study).

Sub adults of large amphibians, such as the bufonid *B. marinus* (this study), the leptodactylid *L. knudseni* (Boistel and Pauwels 2002b) and caecilians (Boistel and Pauwels 2002a) are

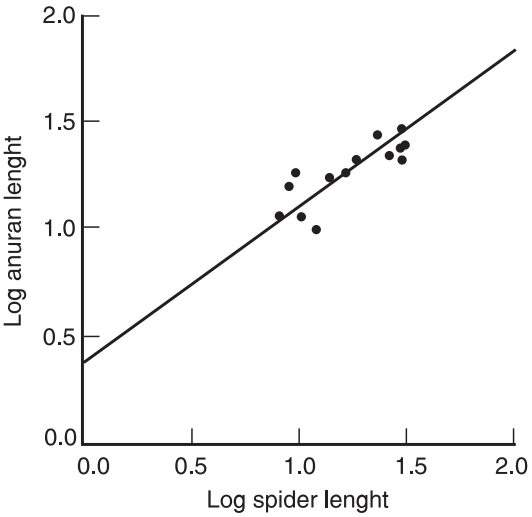

Figure 2 - The size relationship between spiders and anurans. Data from this study and cases for which both size of predator and prey were available are in Table 1.

preyed upon by large spiders. The giant tarantula *Theraphosa blondi*, and probably the tarantula *Sericopelma rubronitens*, eat a wide range of prey types. *Theraphosa blondi* is known to prey on skinks, snakes, mice (Azevedo and Smith 2004) and earthworms (Nyffeler *et al.* 2001) as well as frogs. *Sericopelma rubronitens* eats medium sized frogs (about 30–40 mm) (Gray *et al.* 1999, Summers 1999).

According to McCormick and Polis (1982), many vertebrates in the diet of arachnid predators are smaller than the predator. The presence of venoms, specialized trophic structures and the ability to make webs are foraging adaptations that allow many arthropod predators to capture similarly sized or even slightly larger prey (McCormick and Polis 1982). Conversely, the diet of anurans generally includes small spiders. Therefore, in some cases, the interaction between these taxa may represent intraguild predation (McCormick and Polis 1982, Rubbo *et al.* 2003). As spiders can reach high densities on the forest floor, especially species

of the genera *Ctenus* and *Ancylometes* (Gasnier 1996), this interaction may be ecologically important for breeding anurans. This study provides evidence that spiders commonly prey on amphibians, but the impact of predation on populations of amphibians remains unknown.

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