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Frog-eating Spiders in the Afrotropics: An Analysis of Published and New Cases

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Abstract

We analyze a selection of new and published predation cases of spiders (Araneae: Ctenidae and Pisauridae) on Afrotropical anuran amphibians (Amphibia: Anura), including (re-)identifications of the predators and preys involved. Reported cases occurred in Cameroon, Democratic Republic of the Congo, Gabon, Ghana, Ivory Coast, Kenya, Madagascar, Mozambique, South Africa, Tanzania and Uganda. Various spider species of the pisaurid genus *Nilus* have been recorded to prey on *Leptopelis* sp. (Arthroleptidae), *Schismaderma carens* and *Sclerophrys regularis* (Bufonidae), *Hyperolius fusciventris*, *H. marmoratus*, *H. nitidulus, H. phantasticus*, *H. spinigularis* and *H. sylvaticus* (Hyperoliidae), *Phrynobatrachus* sp. (Phrynobatrachidae), *Xenopus laevis* (Pipidae), *Tomopterna cryptotis* (Pyxicephalidae) and *Amnirana albolabris* (Ranidae). *Afrixalus vibekensis*, *Heterixalus tricolor*, *Hyperolius argus* (Hyperoliidae) and *Xenopus mellotropicalis* (Pipidae) have been found to be prey of unidentified pisaurid spider species. *Leptopelis brevirostris* (Arthroleptidae) is a prey for the ctenid spider *Piloctenus* cf. *haematostoma*. *Hyperolius acuticeps* is the prey of an unidentified spider. The predator-prey interactions between spiders and frogs in the Afrotropics are probably much more varied, involving numerous taxa in both groups.

Keywords

Ecology, Arachnids, Fishing spiders, Wandering spiders, arachnology, batrachophagy, Clawed frogs, Reed frogs, Tree frogs, Puddle frogs, Toads, Tropical Africa

Introduction

Predation on fish by spiders, especially by the genera *Dolomedes* Latreille, 1804 and *Nilus* Pickard-Cambridge, 1876 (Pisauridae, often named fishing spiders), is well documented and occurs worldwide, mainly in the world's warmer areas (Nyffeler and Pusey, 2014). The role of spiders as predators of amphibians is less documented, more observations being known from the Neotropics (Menin et al., 2005) than from other geographic areas, especially tropical Africa. Although the first published observations on predation by spiders on Afrotropical amphibians are more than a century old, only a limited number has been recorded so far in a few compilations (Abraham, 1923; Bristowe, 1930; McCormick and Polis, 1982; Toledo, 2005; Barej et al., 2009) and occasional reports. Only a part of them is vouchered by photographs or preserved specimens. We perform herein a non-exhaustive review of published cases of predation by spiders on Afrotropical amphibians, with a re-evaluation of the identities of the prey and predators involved based on the available evidence, and we present new observations.

Results

Chubb (1913) reported observations made by Father P. Boneberg of the Marianhill Monastery in Natal, South Africa, of individuals of "*Thalassius spenceri*" "catching and devouring tadpoles of the toad *Bufo carens*, and adults of the little frog *Rappia marmorata*." Chubb mentioned that vouchers of these spiders were deposited in the collections of the Durban Museum, and that he examined them. Without referring to Chubb's paper, Abraham (1923) also reported Father Boneberg's observations, but in more details, identifying this time the spider as "*Thalassius fimbriatus*" and specifying that these observations took place under captive conditions. He reported that these spiders were observed feeding on an adult hyperoliid frog "*Rappia marmorata*" (now *Hyperolius marmoratus* Rapp, 1842) (snout–vent length 30 mm), a young individual of the bufonid "*Bufo regularis*" (now *Sclerophrys regularis* (Reuss, 1833)) (snout–vent length about 30 mm) and on tadpoles of the bufonid "*Bufo carens*" (now *Schismaderma carens* (Smith, 1848)) and of the pipid frog *Xenopus laevis* (Daudin, 1802). He mentioned that the spider's body measured 18 mm. Abraham (1923) illus-

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trated these predation cases on amphibians with a black-and-white photograph showing a treefrog with a vertical pupil, a distinct tympanum, and the obvious general habitus of a *Leptopelis* (Arthroleptidae), which casts some doubts about his identification of "*Rappia marmorata*" (repeated in the literature, e.g., by McCormick and Polis, 1982, itself repeated by Toledo, 2005, and others). The photographed spider was on a leaf, head down, with its chelicerae inserted in the back of the frog. We re-identify here without doubt the treefrog illustrated by Abraham (1923) as a *Leptopelis* sp. (Arthroleptidae). The spider genus *Thalassius* Simon, 1885 is now treated as a junior synonym of the genus *Nilus*. *Thalassius spenceri* (Pickard-Cambridge, 1898) is a junior synonym of *Nilus curtus* Pickard-Cambridge, 1876. *Thalassius fimbriatus* is a synonym of *Nilus rubromaculatus* (Thorell, 1899), found in West and Central Africa but absent from southern Africa, and thus not a candidate species for these observations made in Natal. Based on the limited diagnostic characters visible on the photograph provided by Abraham, the spider can be identified as *Nilus* sp. Among the three *Xenopus* species found in South Africa, only *X. laevis* occurs near Durban (Minter et al., 2004). Last, due to the peculiar horseshoe-shaped skin flap on their head (Channing et al., 2012), the identification of the reported *Schismaderma* tadpoles can be trusted.

In addition, because the prey was an Afrotropical frog species, we mention here studies on predation on *Xenopus laevis* by the American pisaurid *Dolomedes triton* (Walckenaer, 1837) in laboratory conditions, reported by Bleckmann and Lotz (1987). These latter authors indicated that some of the prey items used in their experiments were "juvenile clawed frogs (*Xenopus laevis*, 2–3 cm) " but they did not specify if this length represented the total length of the frogs or their snout–vent length. The given size actually represented their snout–vent length (H. Bleckmann, pers. comm. to OSGP, Oct. 2018). *Xenopus laevis* is one of the most commonly used amphibians in laboratory studies (Evans et al., 2015).

Sierwald (1988: 245) included "tadpoles and toads" in the prey range of the spider "*Thalassius spinosissimus*" (now *Nilus curtus*) in Natal, South Africa, but she did not specify which tadpole or toad species was involved. However, in an earlier publication (Sierwald, 1983: 201) she reported that *Thalassius* spiders feed among others on tadpoles of "*Bufo* sp., *Xenopus* sp., *Phrynobatrachus* sp." "*Bufo* sp." might have been applied by Sierwald to species formerly included in *Bufo*, i.e., *Poyntophrynus* spp., *Schismaderma carens*, *Sclerophrys* spp. or *Vandijkophrynus* spp., so the exact bufonid genus involved is not established. In order to feed captive *Nilus* for her experiments, Sierwald used tadpoles found in unused swimming pools in Pietermaritzburg; unfortunately, no tadpole voucher was preserved (P. Sierwald, pers. comm. to OSGP, Jan. 2019).

In a field guide to the reptiles and amphibians of Madagascar, Glaw and Vences (1994: 22: Fig. 70) provided a black-and-white photograph of a spider with the caption "Frog-eating spider, Benavony." No more information is to be found in the book about this spider or which amphibian species it was consuming. On the basis of the characters visible on the photograph, the spider can at best be identified as a pisaurid. Benavony is located in Ambanja District in northern Madagascar.

Rödel (1998) mentioned pisaurid spiders as frequent predators of surfacing tadpoles at savanna ponds in Comoé National Park, Ivory Coast. In this park the same spiders were also often observed feeding on breeding *Hyperolius* and *Afrixalus* species (MOR, unpubl. obs.). Unfortunately, none of the spiders was collected, nor have the predation events been documented by photographs (exception see below).

McIntyre (1999) reported "*Thalassius spinosissimus* (or possibly *T. margaritatus*)" predating on tadpoles of the ranid frog "*Hylarana albolabris*" (now *Amnirana albolabris* (Hallowell, 1856)) in Kibale National Park, western Uganda. The observation was unfortunately not vouchered by photographs or a reference to preserved specimens, so the exact identity of the spider remains unknown, and it should best be regarded as a *Nilus* sp.

In a book on the amphibians of the West African savannas, one of us (Rödel, 2000: 208: Fig. 279) presented a color photograph of a pisaurid spider preying on an adult male hyperoliid frog *Hyperolius nitidulus* Peters, 1875. The spider, on a leaf, is facing the frog, and its head is positioned above the lower belly of the frog (with its chelicerae possibly inserted into it). The locality where this photograph was taken was not specified in Rödel's opus, but it actually happened in Comoé National Park, Ivory Coast, most likely in 1992 (MOR, unpublished data). Based on the photograph, we (RJ) identify here this spider more precisely, as a *Nilus* sp.

Glos (2003: 87) mentioned having observed six cases of predation by pisaurid spiders on the hyperoliid frog *Heterixalus tricolor* (Boettger, 1881) in Madagascar but he did not illustrate these cases and did not refer to voucher specimens, so the generic identity of the spiders remains unknown. He did not mention if the frogs were adult or tadpoles, but they were actually adult (J. Glos, pers. comm. to OSGP, Oct. 2018).

Vonesh (2003, 2005) studied predation by pisaurid spiders, "*Thalassius* sp." (thus currently *Nilus* sp.) on the hyperoliid reed frog *Hyperolius spinigularis* Stevens, 1971 in Tanzania. He mentioned that these spiders prey upon both metamorph and adult frogs, but unfortunately did not illustrate any predation case that would allow further identification of the spider species involved. Vonesh (2003) provided several photographs of *Hyperolius spinigularis*, allowing a confirmation of the identification of the amphibian prey.

Channing (in Minter et al., 2004: 322) noted, about the pyxicephalid frog *Tomopterna cryptotis* (Boulenger, 1907) that "fishing spiders and terrapins prey upon the tadpoles." No more precise information was provided in the frog species account on the spider species involved, but the introduction to the genus mentions that they belong to the genus "*Thalassius*," thus now *Nilus*. Within the same opus, P. J. Bishop (loc. cit.: 136) mentioned, based on his personal observations, that the predators of *Hyperolius acuticeps* Ahl, 1931 include, among others, spiders, without more precision. About *Hyperolius pusillus* (Cope, 1862), G. J. Alexander (in Minter et al., 2004: 147) noticed, based on unpublished observations made by two other frog specialists (A. Turner and L. R. Minter): "The call sites favoured by this species make it particularly vulnerable to predation by

Figure 1. A pisaurid spider eating a tadpole of *Xenopus mellotropicalis* in Cap Esterias, Estuaire Province, northwestern Gabon. Photograph by B. Gratwicke.

pisaurid spiders," implying that adult frogs are involved. In tree holes in Ivory Coast where *Phrynobatrachus guineensis* Guibé & Lamotte, 1962 (Phrynobatrachidae) breed, Rödel et al. (2004: 39) found spiders "large enough to be potential predators of both metamorphosing and adult frogs."

Barej et al. (2009) reported a case of predation by a wandering spider (Ctenidae) on an arthroleptid tree frog *Leptopelis brevirostris* (Werner, 1898) in southern Cameroon; the frog's snout–urostyle length was 33.6 mm. The spider was photographed along with the frog but unfortunately the spider escaped during the observation and could not be identified with more precision. Based on the photograph, we identify it here as a *Piloctenus* cf. *haematostoma* Jocqué & Henrard in Henrard and Jocqué (2017) (Ctenidae).

In December 2009, Brian Gratwicke photographed a pisaurid spider eating a tadpole of *Xenopus mellotropicalis* Evans, Carter, Greenbaum, Gvoždík, Kelley, McLaughlin, Pauwels, Portik, Stanley, Tinsley, Tobias & Blackburn, 2015, in Sahoué (0°36'47.6"N, 9°19'14.3"E) in Cap Esterias, Komo-Mondah Department, Estuaire Province, northwestern Gabon (Figure 1). The spider was not collected but voucher *Xenopus* material (USNM 578211-578212) from the same site was deposited in the National Museum of Natural History in Washington. The photograph does not allow to decide if the spider is a *Dolomedes* or a *Nilus*, the latter being much more probable being more common in Africa.

Channing et al. (2012: Fig. 62) provided a photograph of a "Fishing spider eating *Hyperolius nasutus* metamorph." In fact, it is not a metamorph of *Hyperolius nasutus* Günther, 1865, but rather a tadpole of *Xenopus* (our re-identification of the prey was confirmed by Alan Channing, pers. comm. to MB, Nov. 2018). The locality where this photograph was taken is unknown (A. Channing, pers. comm. to MB, Nov. 2018). Based on the photograph, the spider can be identified as a *Nilus* sp.

Portik et al. (2018: 401: Fig. 9A) provided a photograph of a "*Nilus* cf. *curtus*" preying on an adult female *Hyperolius fusciventris* Peters, 1876 near Mount Kupe in Cameroon. We (RJ)

Figure 2. *Nilus* spider preying upon an adult *Hyperolius marmoratus* in Gorongosa National Park, Mozambique. Photograph by M.-O. Rödel.

agree with the identification of the spider, which had been originally made by the spider specialist Sarah C. Crews. It will be possible to further verify the identification of the predator and of the prey, as they were both preserved in the collections of the California Academy of Sciences.

In May 2013 MOR photographed a *Nilus* sp. spider predating an adult reed frog *Hyperolius marmoratus* in Gorongosa National Park, Mozambique. The spider, head down on a reed, was holding the frog with its chelicerae inserted in the posterior part of the body of the frog, itself head down (Figure 2). Bishop (in Minter et al., 2004: 139) listed spiders, without further details, among the predators of *Hyperolius marmoratus*, referring to personal observations and to Channing (2001: 165, who mentioned "fishing spiders" as predators for this frog species).

MOR and Raffael Ernst (unpublished data) observed several times pisaurid spiders preying on adult individuals of the hyperoliid frog *Afrixalus vibekensis* Schiøtz, 1967 in Taï National Park in Ivory Coast. These observations, unfortunately not photographed, took place when the *Afrixalus* were gathering during the breeding period, and represent the first known case of predation by spiders on this frog species.

Benaglia (2017) provided photographs of a "*Dolomedes*" fishing spider predating an "Argus reed frog" on Diani Beach, Kwale County, in coastal Kenya (see Figure 3). We confirm the identification of the frog as an adult female *Hyperolius argus* Peters, 1854. The structure of the eyes allow to distinguish the genus *Nilus* from the genus *Dolomedes*, which both occur in Africa, although the latter is much rarer (in *Nilus* the anterior eye row is almost as wide as the posterior one; in *Dolomedes* the anterior eye row is much narrower). The spider observed by Benaglia probably belongs to the genus *Nilus*, but without

Figure 3. Pisaurid spider (probably *Nilus* sp.) eating an adult female *Hyperolius argus* on Diani Beach in Kenya. Photograph by A. Benaglia.

absolute certainty, since its eyes are not clearly visible on the photographs he took. The genus *Dolomedes* is not known from Kenya. Bishop (in Minter et al., 2004: 139) had mentioned spiders, without more precision, among the predators of *Hyperolius argus*.

On 23 July 2017 MB photographed a pisaurid spider eating a young post-metamorph *Hyperolius sylvaticus* Schiøtz, 1967 in Bobiri Forest Reserve (ca. 6°40'40.8"N, 1°19'12"W) in southern Ghana. The spider, head down, was suspended to a stem with the help of its hind legs and a silk string (Figure 4). It was biting the posterior part of the body of the dead frog, which was already damaged due to the histolysis following the envenoming. The frog and the spider were not collected. Based on the diagnostic characters available on the photographs taken by MB, the spider can be identified as a *Nilus* sp. This represents the first record of predation by a spider on *Hyperolius sylvaticus*.

On 19 May 2018 at 21:49, in the course of an inventory of the amphibian diversity in the Kokolopori Bonobo Nature Reserve in Tshuapa Province, located south of the Congo River in the Democratic Republic of the Congo, GBB observed a spider killing a reed frog (Figure 5). They were found on a leaf about 1.3 m above the ground on the bank of Sondo River near the village of Yambimbo (0°13'47.5"N, 22°51'43.3"E). The spider was above the frog, and had its chelicerae inserted in the back of the frog. The frog showed a snout–vent length of 32.9 mm, a horizontal pupil, an indistinct tympanum, no black canthal stripe, a uniformly orange-brown dorsum, partly deep black ventral sides of body and limbs, and can be identified as an adult male *Hyperolius phantasticus* (Boulenger, 1899) of the F coloration phase. This color phase was already documented for Kokolopori (Schiøtz, 2006) and is locally common, according to Schiøtz's and our observations. The frog was already dying when found. The frog's back around the spider's bite was damaged because of a histolysis following the envenoming. Based on Blandin (1979), the spider is identifiable as a *Nilus* sp. Five *Nilus* species are known to inhabit Central Africa, but the fact that the individual involved in our observation is a subadult male prevents its identification at the specific level. The frog and the spider were preserved in ethanol and deposited in the reference collections of the *Centre de Surveillance de la Biodiversité* of the University of Kisangani. This represents the first record of predation by a spider on *Hyperolius phantasticus*.

Figure 4. *Nilus* spider eating a juvenile *Hyperolius sylvaticus* in Bobiri Forest Reserve, Ghana. Photograph by M. Burger.

Conclusion

After verifications and corrections, the *in situ* predation cases treated here involve at least one ctenid spider genus (*Piloctenus*) and at least one pisaurid spider genus (*Nilus*). Afrotropical *Nilus* species globally prey on at least 13 amphibian species of seven anuran families: one arthroleptid, two bufonid, six hyperoliid, one phrynobatrachid, one pipid, one pyxicephalid and one ranid.

Figure 5. *Nilus* spider eating an adult male *Hyperolius phantasticus* in Kokolopori Bonobo Nature Reserve, Democratic Republic of the Congo. Photograph by G. Badjedjea Babangenge.

Afrotropical ctenid spiders prey on at least one amphibian genus (Arthroleptidae: *Leptopelis*). Although not yet documented, Afrotropical caecilians (Amphibia: Gymnophiona) are also potential prey of spiders, as was already documented for caecilians in the Neotropics (see among others Boistel and Pauwels, 2002). Other spider genera and families found in tropical Africa are candidate predators of frogs. Nyffeler et al. (2017: 240) indicated that the largest jumping spiders (Salticidae) found in Africa, such as *Hyllus* spp., would possibly be able to consume small frogs. Our compilation of observations is certainly by far incomplete, nevertheless it already allows concluding that predation by spiders on frogs and tadpoles is a common event in the Afrotropics, and we can predict very varied predator-prey interactions, involving diverse taxa in both groups.

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Table 1. Predator-prey interactions between spiders and amphibians in the Afrotropics

Predator spider	Amphibian prey	References
Ctenidae		
Piloctenus cf. *haematostoma* (Cameroon)	*Leptopelis brevirostris* (Arthroleptidae); obs. *in situ*	Barej et al. (2009), this work
Pisauridae		
Dolomedes triton (USA)	Juv. *Xenopus laevis* (Pipidae); all obs. in captivity	Bleckmann and Lotz (1987)
Nilus cf. *curtus* (Cameroon)	Adult *Hyperolius fusciventris* (Hyperoliidae), obs. *in situ*	Portik et al. (2018)
Nilus sp. (Uganda)	*Amnirana albolabris* tadpoles (Ranidae), obs. *in situ*	McIntyre (1999)
Nilus sp. (South Africa)	(Sub)adult *Leptopelis* sp. (Arthroleptidae), *Schismaderma carens* tadpoles, young *Sclerophrys regularis* (Bufonidae), *Xenopus laevis* (Pipidae), all obs. in captivity	Chubb (1913), Abraham (1923), this work
Nilus sp(p). incl. *N. curtus* (South Africa)	Bufonidae, *Phrynobatrachus* sp. (Phrynobatrachidae), *Xenopus* sp. (Pipidae), obs. *in situ*	Sierwald (1983, 1988)
Nilus sp. (Ivory Coast)	Adult *Hyperolius nitidulus* (Hyperoliidae), obs. *in situ*	Rödel (2000), this work
Nilus sp. (Tanzania)	Metamorph and adult *Hyperolius spinigularis* (Hyperoliidae), obs. *in situ*	Vonesh (2003, 2005)
Nilus sp. (southern Africa)	*Tomopterna cryptotis* tadpoles (Pyxicephalidae), obs. *in situ*	Channing (in Minter et al., 2004)
Nilus sp. (Mozambique)	Adult *Hyperolius marmoratus* (Hyperoliidae), obs. *in situ*	This work
Nilus sp. (Ghana)	Metamorph *Hyperolius sylvaticus* (Hyperoliidae), obs. *in situ*	This work
Nilus sp. (Democratic Republic of the Congo)	Adult *Hyperolius phantasticus* (Hyperoliidae), obs. *in situ*	This work
Nilus sp.? (Kenya)	Adult *Hyperolius argus* (Hyperoliidae), obs. *in situ*	Benaglia (2017), this work
Nilus sp. (country?)	*Xenopus* sp. tadpole	Channing et al. (2012: Fig. 62), this work
Pisauridae gen. et spp. (Ivory Coast)	Unidentified tadpoles, adult *Afrixalus* sp., adult *Hyperolius* sp. (Hyperoliidae), obs. *in situ*	Rödel (1998), this work
Pisauridae gen. et sp. (Ivory Coast)	Adult *Afrixalus vibekensis* (Hyperoliidae), obs. *in situ*	This work
Pisauridae gen. et sp(p). (Madagascar)	Adult *Heterixalus tricolor* (Hyperoliidae), obs. *in situ*	Glos (2003), this work
Pisauridae gen, et sp. (southern Africa)	Adult *Hyperolius pusillus* (Hyperoliidae), obs. *in situ*	Alexander (in Minter et al., 2004)
Pisauridae gen. et sp. (Gabon)	*Xenopus mellotropicalis* tadpole (Pipidae), obs. *in situ*	This work
Araneae		
Araneae gen. et sp. (southern Africa)	*Hyperolius acuticeps* (Hyperoliidae), obs. *in situ*	Bishop (in Minter et al., 2004)
Araneae gen. et sp. (southern Africa)	*Hyperolius argus* (Hyperoliidae); obs. *in situ*	Bishop (in Minter et al., 2004)

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