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# Fish and amphibians as bat predators

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**ABSTRACT**

Although bats (Chiroptera) belong to the most diverse mammalian orders, study of diversity of their natural predators has been seriously neglected for a long time. While some recent reviews contain comprehensive overviews of our recent knowledge on these phenomena for some animal groups, such work is still lacking for anamniotes - fishes and amphibians. Here, I am summarising bat predation incidences by anamniotes that were published in scientific journals and public web domains. I found out that at least 14 species of fishes and 14 species of frogs were observed as feeding on bats. Moreover, 7 and 16 species of bats were recorded as victims of hunting activity of fishes and frogs, respectively. Majority of localised incidences came from the New World; frog (between latitude 49°N to 28°S) attacks were distributed mainly in tropical or subtropical areas < 30° from equator (70% of all records), fish (44°N to 20°S) incidences reach same proportion in colder areas (> 30° from equator) and warmer areas. In some cases, these predators can regularly feed on bats, especially when hunting near roosting places of bats; however, with respect to number of recorded cases (21 for fishes and 37 for amphibians), bat predation by anamniotes seems to be very rare and opportunistic with only very limited influence on bat populations or their behaviour.

**KEYWORDS**

Amphibians – bats – diet – fishes – frogs – predation



## INTRODUCTION

Bats (Chiroptera) are among most taxonomically and ecologically diverse mammalian groups comprising more than 1200 recent species (Kunz & Fenton 2003; Gunnell & Simmons 2012). Although, they are the second largest mammalian order, several aspects of their life still remain only poorly understood. This particularly holds for predator–prey interactions; we had only limited knowledge on the spectrum of their natural predators over a long time (Allen 1940; Lima & Dill 1990). Nowadays, the knowledge on natural predators of bats is increasing due to several comprehensive reviews. However, these reviews include only few animal groups such as spiders (Nyffeler & Knörnschild 2013), some owls (e.g. Speakman 1991; Sparks, Roberts & Jones 2000; Roulin & Christe 2013) and diurnal birds (Mikula et al. forthcoming).

Traditionally, some life-history traits (e.g. long lifespan and small litter size) and agile flight of bats indicate successful predator avoidance by bats (Kunz & Fenton 2003). In fact, however, it appears that bats have a variety of natural enemies (Sparks et al. 2000; Nyffeler & Knörnschild 2013; Mikula et al. forthcoming). Probably the most important bat predators are birds and especially owls, which are preying upon bats during their coincidental activity time (Speakman 1991; Lesiński et al. 2009; Roulin & Christe 2013). On the other hand, diurnal birds can represent substantial danger for daytime flying bats (Mikula et al. forthcoming), snakes and arthropods seem to be successful bat predator in the vicinity of their roosting aggregations (e.g. caves) (Molinari et al. 2005; Esbérard & Vrcibradic 2007; Nyffeler & Knörnschild 2013). Mammalian predators are, moreover, able to detect bat-roosting places based on odour clues (Threlfall et al. 2013). On patterns of bat predation by fishes and amphibians, we, however, have only limited information.

Representatives of anamniotes, fishes and amphibians, belong to the most diverse groups of vertebrates representing with approximately 33,000 and 7500 recent forms, respectively, substantial part of vertebrate species diversity (Nelson 2006; AmphibiaWeb 2015a; FishBase 2015). Although, there are most probably no specialised fish or amphibian bat predators, diversity of their feeding strategies and wide geographical distribution indicates that bats can at least occasionally fall prey to them. Specially, if we consider the fact that numerous larger fishes and amphibians are known to supplement their diet by preying on terrestrial vertebrates such as lizards, birds and mammals (Gregg 1945; Lowe et al. 1996; Merritt 2014; O'Brien et al. 2014; Schalk et al. 2014). Moreover, some fishes are even able to catch flying vertebrates such as birds on wing when skimming over the water surface (O'Brien et al. 2014) and can thus represent risk for therein foraging or drinking bats. Predation on bats by anamniotes is, however, infrequently described in literature. According to my best knowledge, most comprehensive review on chiropterophagy by anamniotes was published by Sparks, Roberts & Jones (2000) that included only five and two species of North American fishes and frogs, respectively. It thus seems that bat predation events by anamniotes are rare. However, no review on global scale is available. The aim of this study is thus to comprehensively review and synthesise published information on bat predation by fishes and amphibians.

## 1. METHODS

To obtain relevant information on bat predation by fishes and amphibians, I started with an extensive study of bibliographic sources. Primarily, I included cases where predators (fishes or amphibians) were observed as consuming (or at least trying to consume) prey (bats) that was alive when the predator first attacked it (Begon et al. 2005). However, it cannot be ruled out with certainty that some records represent consumption of already dead bats (necrophagy) due to the fact that in many cases, fishes and amphibians were observed as already consuming bats with no information on manner how they got to their bat prey.

The internet-based search utilised mainly the Thomson-Reuters (Web of Science, Zoological Record) and Scopus databases, Google Scholar and Google Books. When a suitable paper was selected, its references (backward search) and citation records (forward search) were used to search for other relevant articles. Additionally, I included internet search mainly for images and videos carried by Google, Google images, Flickr and YouTube to obtain maximum information on such events. Search was hold not only in English, I also included some European (German, French, Spanish, Portuguese and Russian) and Asian languages (Chinese and Japanese) as languages used in scientifically well active countries or frequently covering large areas in species-rich regions of Central and South America, Africa and Asia. In general, my searching phrase contained Latin (e.g. *Hucho* or *Rhinella*) or national genus / family / order names (e.g. catfish and toad in English) of fishes and amphibians and one of the following word combinations 'bat' or 'bats' in each of the aforementioned languages. I was particularly careful when searching among fish and amphibian groups where, due to dietary demands and morphological and behavioural adaptations, there was increased probability of being bat predator. My search was, however, restricted by my knowledge of particular languages; this holds mainly for Asian languages. Whenever I found secondary report on this topic, I tried to get as near as possible to the primary source. If I was able to find the original source of report, secondary reports were not included in the review, which otherwise were treated similarly to the primary records. When it was very probable that multiple sources were describing the same predation event, I grouped them under a single case with several references. Moreover, to obtain data for natural predation as relevant as possible, I excluded cases where anamniotes, kept as pets, were fed by bats in captivity by their owners.

## 2. RESULTS

### 2.1. Fishes

Altogether, fish predation on bats was recorded in 21 cases. Bats were found as a prey of 13 identified Osteichtyes fish species from six families of Teleostei clade (Centrarchidae 2 spp., Ictaluridae 1 sp., Lutjanidae 1 sp., Osteoglossidae 3 spp., Salmonidae 5 spp., Serrasalmidae 1 sp.); in four cases, fishes were identified at least to order level; in one case, it was taxonomically unidentified (Table 1, Fig. 1). Most bat predation attempts were recorded for Salmonidae (39% of all taxonomically identified cases) and Centrarchidae (28%), followed by Osteoglossidae (17%), Ictaluridae, Lutjanidae and Serrasalmidae (5.5% in each case). Only one evidence for bat predation by Chondrichthyes fish included *Galeocerdo cuvier* (Carcharhinidae) (Table 1).

The vast majority of recorded bat-eating fishes live in limnetic ecosystems, only *G. cuvier* is mostly marine and other species, *Lutjanus griseus* (Lutjanidae), often penetrates from marine environment to brackish and fresh waters. Except for five records from Eurasia (24% of all records) and one from Australia (5%), all other records came from the New World (71%). All localised incidences occurred between the latitude 44°N to 20°S with approximately same proportion of incidences in colder areas (> 30° from equator) and tropical and subtropical areas. However, bat predation records for *Hucho taimen* and *Brachymystax lenok*, living in central and northern Asia, indicate that some records could come even from higher latitudes (Denisova 2004; Hogan & Jensen 2013; Froese & Pauly 2015). Northernmost record with given at least approximate position is reported by Kaimov & Gairabekov (2009) and included unidentified bat as a prey of *Salmo trutta* (Salmonidae) from Chechen Republic (43°18'N, 45°48'W), Russia. In Nearctic region, northernmost observation of fish predation on bats came from Ruby Mountains region (40°40'N, 115°31'W), Nevada, USA, where *Oncorhynchus mykiss* (Salmonidae) was preying upon dead or injured *Myotis lucifugus* (Vespertilionidae) (Borell & Ellis 1934). Most southward records from southern hemisphere were re-

*Table 1. Reported cases of fish predation on bats based on literature and unpublished records. Question mark [?] represents cases where locality was uncertain.*

| Fishes Species | Family | Bats Species | Family | Country | Source |
|---|---|---|---|---|---|
| Chondroichtyes | | | | | |
| *Galeocerdo cuvier* | Carcharhinidae | Pteropus sp. | Pteropodidae | Australia | Simpfendorfer (1992) |
| Osteichthyes | | | | | |
| *Lepomis cyanellus* | Centrarchidae | *Tadarida brasiliensis* | Molossidae | USA | Jones & Hettler (1959) |
| *Micropterus salmoides* | Centrarchidae | *Myotis grisescens* | Vespertilionidae | USA | Dean (2008) |
| *M. salmoides* | Centrarchidae | *Pipistrellus hesperus* | Vespertilionidae | USA | Hermann (1950) |
| *M. salmoides* | Centrarchidae | Unidentified | Unidentified | No data | InTheory (2014) |
| *Ictalurus furcatus* | Ictaluridae | Unidentified | Phyllostomidae | Belize | National Geographic (2013) |
| *Lutjanus griseus* | Lutjanidae | *Erophylla sezekorni* | Phyllostomidae | Bahamas | Yager & Williams (1988) |
| *Osteoglossum bicirrhosum* | Osteoglossidae | Unidentified | Unidentified | Guyana | Lowe-McConnell (1964) |
| *Osteoglossum ferreirai* | Osteoglossidae | Unidentified | Unidentified | No data | Rechi (2014) |
| *Scleropages formosus* | Osteoglossidae | Unidentified | Unidentified | No data | Ford (2013) |
| *Brachymystax lenok* | Salmonidae | Unidentified | Unidentified | Russia? | Denisova (2004) |
| *Hucho taimen* | Salmonidae | Unidentified | Unidentified | No data | Hogan & Jensen (2013) |
| *Oncorhynchus mykiss* | Salmonidae | *Myotis lucifugus* | Vespertilionidae | USA | Borell & Ellis (1934) |
| *Hucho* sp. | Salmonidae | Unidentified | Unidentified | Russia? | Denisova (2004) |
| *Salmo gairdneri* | Salmonidae | Unidentified | Unidentified | USA | Ingles (1947) |
| *Salmo trutta* | Salmonidae | Unidentified | Unidentified | Russia | Kaimov & Gairabekov (2009) |
| *Pygocentrus nattereri* | Serrasalmidae | Unidentified | Unidentified | Brazil | Ferreira et al. (2014) |
| Bass | Centrarchidae | *M. lucifugus* | Vespertilionidae | USA | Barbour & Davis (1974); Merritt (2014) |
| Large trouts | Salmonidae | Unidentified | Unidentified | USA? | Murphy & Nichols (1913) |
| Catfish | Unidentified | Unidentified | Unidentified | No data | Smokeyrobot (2014) |
| Large fish | Unidentified | *Noctilio leporinus* | Noctilionidae | Costa Rica | Börk (2006) |

corded in Rio Negro Farm (19°35'S, 56°15'W), Pantanal, Brazil, where several unidentified bat individuals were found in the stomach of *Pygocentrus nattereri* (Serrasalmidae) (Ferreira et al. 2014). In the Old World, two *Pteropus* sp. (Pteropodidae) individuals were found in the stomach of shark *G. cuvier* living near Townsville (19°15'S, 146°50'E), Queensland, Australia (Simpfendorfer 1992).

Six species of bats from four families (Noctilionidae 1 sp., Molossidae 1 sp., Phyllostomidae 1 sp., Vespertilionidae 3 spp.) were identified as prey of Osteichtyes fish predation (Table 1). In 60% of the reported cases, the captured bats remained completely unidentified. Majority of identified bats belonged to family Vespertilionidae (50%), Phyllostomidae (25%), followed by Molossidae and Noctilionidae (both 12.5%).

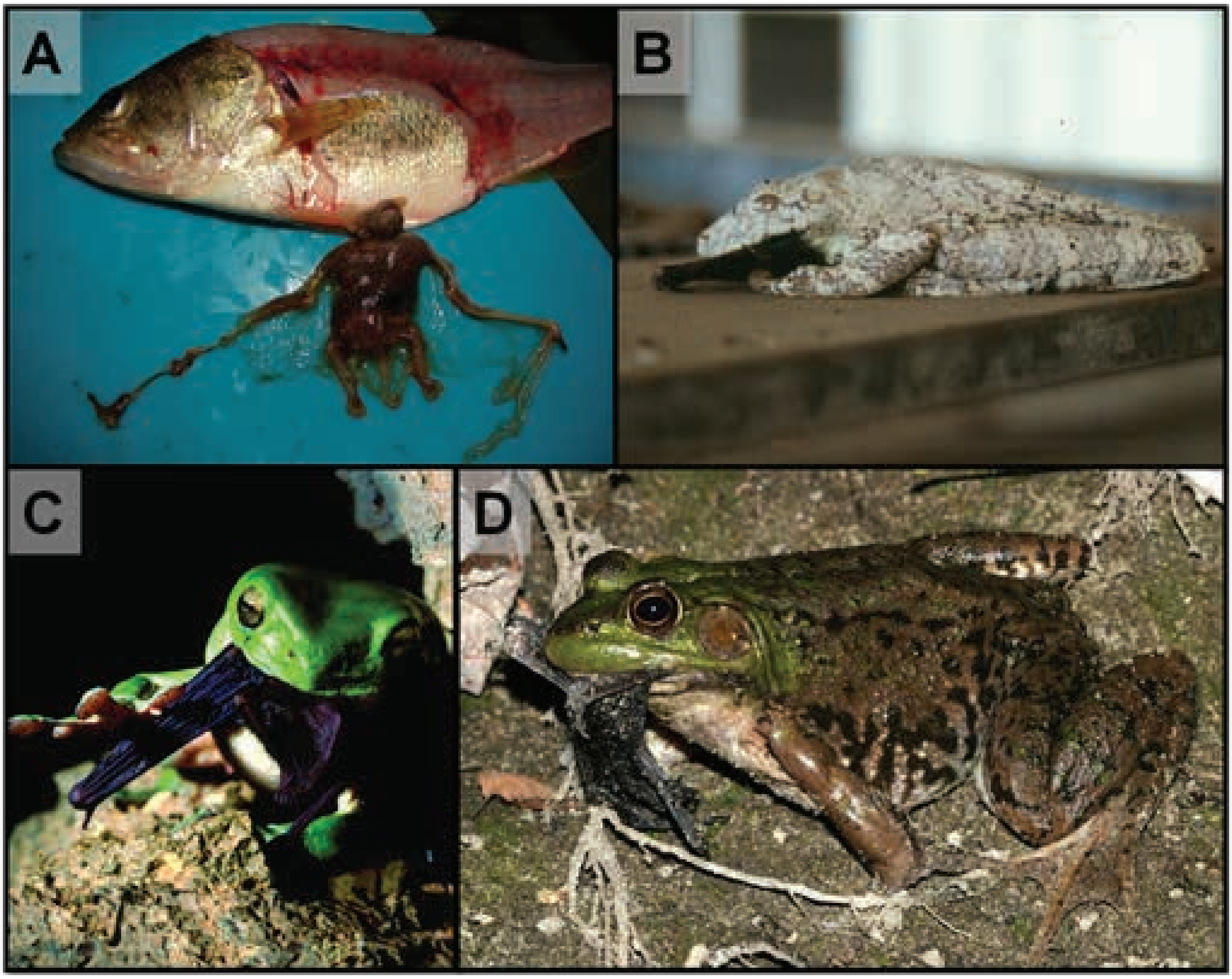


*Figure 1. Examples of bat captures by fishes and amphibians. A - Stomach content of Micropterus salmoides included one partially digested individual of Myotis grisenscens, which was caught in Lick Creek conservation area, USA (Photo credit: Colby Wrasse; Dean 2008). B - Partial ingestion of unidentified bat by Hyla boans in Parque Nacional Cinaruco-Capanaparo, Venezuela (Photo credit: Albrey Arrington & Jennifer Arrington; Arrington & Arrington 2000). C - Litoria caerulea feeding on Miniopterus australis in a cave in Mt. Etna, Queensland, Australia (Photo credit: Bruce Means; Means 2003). D - Rana catesbeiana consuming one unidentified bat in the bank of the Nashua River in Lancaster (Massachusetts), USA (Photo credit: Tom Murray; Murray 2004). Reproduced with permission from all authors of original photographs.*

In addition, at least one *Pteropus* species (Pteropodidae) was found as prey of Chondroichtyes fish. Altogether, identified bats made only 0.6 and 26% of global diversity of bat species and families, respectively.

**2.2. Amphibians**

Altogether, 37 cases of bat predation by amphibians were recorded. I found that at least 14 species of frogs (Anura) from five families were recognised as bat consumers (Bufonidae 3 spp., Conrauidae 1 sp., Hylidae 2 spp., Leptodactylidae 4 spp., Ranidae 4 spp.) (Table 2, Fig. 1). Highest prevalence of bat hunting records was in family Ranidae (27% of all records), followed by Leptodactylidae, Bufonidae (both 24%), Hylidae (22%) and Conrauidae (3%). I was not able to find any literature records of bat predation in Caudata and Apoda clade.

Most reports were localised in Neotropical (43% of all cases), Australian (24%) and Nearctic (22%) regions. Such records were very rare in Europe (8%) and Africa (3%) and completely absent in Asia. Incidences were found between latitude 49°N and 28°S with ~70% of cases within warmer areas (< 30° from equator). The northernmost observation of bat predation by amphibians was published by Országhová, Mikulíček & Pachinger (2003) who reported an observation of *Rana esculenta* (Ranidae) feeding on *Myotis mystacinus* (Vespertilionidae) in Šajdíkove Humence (48°39'N, 17°16'E), Slovakia. In North America, such observation was recorded in Botany Glen (40°33'N, 85°40'W), Indiana, USA, where *Eptesicus fuscus* (Vespertilionidae) was observed protruding from the mouth of *Rana catesbeiana* (Ranidae). In Neotropics, the southernmost observation came from Curitibanos (27°17'S, 50°37'W), Brazil where one individual from *Rhinella marina* complex (Bufonidae) was filmed on video as eating unidentified bat (Petris 2011). From the Old World, the southernmost record came from the vicinity of Mt. Etna (23°10'S, 150°29'E),

*Table 2. Reported cases of amphibian predation on bats based on literature and unpublished records. Question mark [?] represents cases where species identification was uncertain.*

| Frogs | | Bats | | Country | Source |
|---|---|---|---|---|---|
| Species | Family | Species | Family | | |
| *Bufo viridis* | Bufonidae | *Pipistrellus pipistrellus* | Vespertilionidae | Russia | Denisova (2004) |
| *Rhinella jimi* | Bufonidae | *Molossus molossus* | Molossidae | Brazil | da Silva, dos Santos & de Amorim (2010) |
| *R. jimi* | Bufonidae | *Pteronotus personatus* | Mormoopidae | Brazil | Gouveia et al. (2009) |
| *Rhinella marina* | Bufonidae | *M. molossus* | Molossidae | Venezuela | Gonzalez-Fernandez (2013) |
| *R. marina* | Bufonidae | *M. molossus*? | Molossidae | Peru | Torres (2013) |
| *R. marina* | Bufonidae | Unidentified | Unidentified | Australia | Bierly (1998) |
| *R. marina* | Bufonidae | Unidentified | Unidentified | Australia | Richards & Hall (2012) |
| *R. marina* group (*icterica*?) | Bufonidae | Unidentified | Molossidae | Brazil | Srpimentelbio (2015) |
| *R. marina* group (*icterica*?) | Bufonidae | Unidentified | Unidentified | Brazil | Petris (2011) |
| *Conraua goliath* | Conrauidae | Unidentified | Unidentified | No data | San Diego Zoo (2015) |
| *Hyla boans* | Hylidae | Unidentified | Unidentified | Venezuela | Arrington & Arrington (2000) |
| *Litoria caerulea* | Hylidae | *Miniopterus australis* | Vespertilionidae | Australia | Means (2000, 2003, 2008) |
| *L. caerulea* | Hylidae | *M. australis* | Vespertilionidae | Australia | Cray (2007) |
| *L. caerulea* | Hylidae | *M. australis* | Vespertilionidae | Australia | Parer & Parer-Cook (n.d. b) |
| *L. caerulea* | Hylidae | Microbat | Unidentified | Australia | Macdonald (2010) |
| *L. caerulea* | Hylidae | Unidentified | Unidentified | Australia | Richards & Hall (2012) |
| *L. caerulea* | Hylidae | Unidentified | Unidentified | Australia | Davis (n.d.) |
| *L. caerulea* | Hylidae | Unidentified | Unidentified | Australia | Parer & Parer-Cook (n.d. a) |
| *Leptodactylus fallax* | Leptodactylidae | Unidentified | Unidentified | Dominica | Schwartz & Henderson (1991) |
| *Leptodactylus labyrinthicus* | Leptodactylidae | *Anoura caudifer* | Phyllostomidae | Brazil | Esbérard et al. (2006) |
| *Leptodactylus pentadactylus* | Leptodactylidae | *Carollia perspicillata* | Phyllostomidae | Brazil | Castro et al. (2011) |
| *Leptodactylus vastus* | Leptodactylidae | *P. personatus* | Mormoopidae | Brazil | Gouveia et al. (2009) |
| *L. vastus* | Leptodactylidae | *Natalus stramineus* | Natalidae | Brazil | Gouveia et al. (2009) |
| *L. vastus* | Leptodactylidae | *Glossophaga soricina* | Phyllostomidae | Brazil | Filho, Feijó & Rocha (2014) |
| *L. vastus* | Leptodactylidae | *Lonchophylla mordax* | Phyllostomidae | Brazil | Filho, Feijó & Rocha (2014) |
| *L. vastus* | Leptodactylidae | *Tonatia bidens* | Phyllostomidae | Brazil | Filho, Feijó & Rocha (2014) |
| *L. vastus* | Leptodactylidae | *Myotis nigricans* | Vespertilionidae | Brazil | Filho, Feijó & Rocha (2014) |
| *Rana blairi* | Ranidae | *Pipistrellus subflavus* | Vespertilionidae | USA | Creel (1963) |

continued *Table 2. Reported cases of amphibian predation on bats based on literature and unpublished records. Question mark [?] represents cases where species identification was uncertain.*

| | | | | | |
|---|---|---|---|---|---|
| *Rana catesbeiana* | Ranidae | *Eptesicus fuscus* | Vespertilionidae | USA | Kirkpatrick (1982) |
| *R. catesbeiana* | Ranidae | *Lasiurus borealis* | Vespertilionidae | USA | Jones (1961) |
| *R. catesbeiana* | Ranidae | *L. borealis* | Vespertilionidae | USA | Korschgen & Baskett (1963) |
| *R. catesbeiana* | Ranidae | *Myotis austroriparius* | Vespertilionidae | USA | Lee (1969) |
| *R. catesbeiana* | Ranidae | Unidentified | Unidentified | USA | Murray (2004) |
| *R. catesbeiana* | Ranidae | Unidentified | Unidentified | USA | Schwalbe (2015) |
| *Rana esculenta* | Ranidae | *Myotis mystacinus* | Vespertilionidae | Slovakia | Országhová, Mikulíček & Pachinger (2003) |
| *Rana pipiens* | Ranidae | *Myotis* sp. | Vespertilionidae | USA | Kinsey (1961) |
| *Rana* sp. | Ranidae | Unidentified | Vespertilionidae | France | Leblanc (2005) |

Australia where individuals of *Litoria caerulea* (Hylidae) were photographed as eating *Miniopterus australis* (Vespertilionidae) (Means 2000, 2003; Cray 2007).

I was able to find information on 16 bat species from five families (Molossidae 1 sp., Mormoopidae 1 sp., Natalidae 1 sp., Phyllostomidae 5 spp., Vespertilionidae 8 spp.) that were identified as prey of frogs. More than 32% of all records included bats unidentified at least on family level. The majority of identifiable bats were members of family Vespertilionidae (52%), Phyllostomidae (20%) and Molossidae (16%) whereas only small number of records existed for Mormoopidae (8%) and Natalidae (4%). Identified bat taxa represent 1.3 and 26% of global diversity of bat species and families, respectively.

## 3. DISCUSSION

I found that the occurrence of bats in the diet of fishes and amphibians was very low, especially when compared to main bat predators such as owls, small carnivores and other bats, snakes and diurnal birds (Schätti 1984; Speakman 1991; Esbérard & Vrcibradic 2007; Sparks et al. 2000; Mikula et al. forthcoming). For instance, Mikula et al. (forthcoming) reviewed > 1500 such records for almost 240 species of diurnal birds (however, unlike actual paper, one case included multiple observations with several bat individuals and species there; the total number of such records for diurnal birds will be thus much higher) that were obtained by similar searching methodology. However, diurnal birds are not main bat predators due to different activity time, number of incidences for more important bat predators such as owls, small mammalian carnivores, and, in some regions, snakes should be thus higher (Speakman 1991; Sparks et al. 2000; Denisova 2004; Esbérard & Vrcibradic 2007). Although, according to my knowledge, no exhaustive global overview on bat predation by these animal groups has been published up to date. Comparable number of incidences (52) and species spectra (14) was recorded during global survey on bat-catching spiders that are, however, mainly passive bat hunters using their nets for bat catching (Nyffeler & Knörnschild 2013). Low number of recorded incidences for anamniotes thus indicates that bat predation by fishes and amphibians is probably very rare event occurring only in restricted number of species. Below, I discuss the most significant findings that shed light on patterns of anamniotic predation on bats.

Majority of bat predation records by anamniotes came from the New World; however, there was not such strong pattern of tropical distribution of predation attempts as in spiders (Nyffeler & Knörnschild 2013). In fishes, almost all records were located in North and South America, two regions with the highest global diversity of freshwater fishes (Pelayo-Villamil et al. 2015). Similarly, majority of bat-hunting incidences by amphibians were from Neotropical, Australian and Nearctic regions, which are again characterised by really high diversity of amphibians (AmphibiaWeb 2015b). In addition, the aforementioned regions belong to the areas with the highest global microchiropteran diversity (Hutson et al. 2001), a bat group where vast majority of identified bat victims belonged. The predominant distribution of bat-hunting attempts in these regions suggested that observed bat-hunting pattern could simply be a result of random predation, which just included predator species that on the basis of morphological and dietary characteristics are able to consume bats. There are, however, only few such incidences for African anamniotes, although there is relatively high diversity of bats and their predators. Very limited study efforts compared with areas in the New World and Australia where lots of researchers and naturalists are present could be a probable justification of this geographical bias.

Majority of bats recorded as victims of predation by fishes are known to live or forage in the vicinity of water bodies. *Erophylla sezekorni* (Phyllostomidae) roosts in hot caves, sometimes overhanging over the water surface (Yager & Williams 1988), *Myotis grisescens* and *M. lucifugus* forage over water surface when looking for insects (Harriman 2003; Havens 2006), and *Noctilio leporinus* (Noctilionidae) is known for its fish-eating habits (Börk 2006). In truth, there are not exceptional predation attempts by fishes on vertebrates, especially birds living or hunting near water sources (e.g. Glegg 1945; Oatley 1960). O'Brien *et al*. (2014) reported 20 cases of successful predation on swallow *Hirundo rustica* by tigerfish *Hydrocynus vittatus*. Among bats, similar case of predation was described by Börk (2006) who observed one attempted capture of large fish on *N. leporinus* when skimming over water surface. Additional case of fish predation on bats involved large trouts (Salmonidae) and probably low-flying drinking bats (Murphy & Nichols 1913; Allen 1940). Although, I was not able to find any direct observations on similar hunting behaviour in other fish groups, it is very probable that it occurs also in Osteoglossidae family in which members are known as regular aerial feeders (Lowry et al. 2005). Predation on bats by fishes is, however, rarer than on birds, most probably due to the fact that even bats living near water are in direct contact with water only for short time unlike birds that are capable of swimming on water surface, diving or rising their juveniles there.

Several bat species recognised as amphibian prey are known to feed near to the ground or water surface (e.g. *Myotis austroriparius* and *M. mystacinus*) (Jones & Manning 1989; Tamling 2004), roosting in caves in large aggregations (e.g. *M. australis*, *Pteronotus personatus*) (Means 2003; de la Torre & Medellín 2010) or in human buildings (*Molossus molossus*) (Kunz & Reynolds 2003). There are observations of bat catching by frogs when bat foraged very close to the ground surface (Torres 2013), near roosting places of bats such as caves (Means 2000, 2003; Cray 2007; Richards & Hall 2012) or consuming them in the vicinity of buildings (Petris 2011; Srpimentelbio 2015). Many bat species were, however, attacked when caught in mist nets; several frugivorous and nectarivorous bats, otherwise presumably immune to predation by amphibians, were thus attacked (*Carollia perspicillata* and *Anoura caudifer*, *Glossophaga soricina*, *Lonchophylla mordax*) (Ésberard et al. 2006; Castro et al. 2011; Filho et al. 2014). Majority of bat catches involved larger and considerably opportunistic frog species. It is interesting to note that bat-hunting records for invasive *R. marina* and *R. catesbeiana* (http://www.invasive.org/species/amphibians.cfm, accessed 8 October 2015) represented one-third of all incidences for amphibians. It is assumed that invasive species of frogs can have broader trophic niche than native species (San Sebastián et al. 2015) with capacity to exploit more diverse dietary resources. Relatively high frequency of bats in their diet compared to other frogs can thus reflect their highly opportunistic nature of hunting.

It is noteworthy to say that not all cases of bat predation were completely accidental; some populations of anamniotes are probably able to regularly feed on bats. Among fishes, individuals of *L. griseus* were observed as systematically waiting under maternal colony of *E. sezekorni* for falling bats near the entrances of Lucayan cavern (26°36'N, 78°24'W), Bahamas (Yager & Williams 1988). In addition, frogs *R. marina* and *L. caerulea* were described as sitting around cave entrances in Australia and waiting for bats knocked to the ground by collision when emerging (Richards & Hall 2012). However, even in these cases where fishes and frogs catch bat relatively often, they predominantly prey upon few bat individuals only, including mainly fallen bats.

Finally, I can state that bat predation by anamniotes is rare, including only very limited number of fish, amphibian and bat species worldwide (> 1% of global diversity in majority of cases). There were only few cases where these predators were observed as systematically waiting for bats around their roosting sites. In these cases, long-term research may help us to understand potential effects of anamniotic predations on bats. However, with respect to the total number of recorded cases, bat-hunting activity of fishes and amphibian has most probably only very limited influence on bat populations and their behaviour in general.

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