Food habits of *Anilius scytale* (Serpentes: Aniliidae) in the Brazilian Amazonia

Gleomar F. Maschio; Ana Lúcia da C. Prudente; Francílio da S. Rodrigues & Marinus S. Hoogmoed

Laboratório de Herpetologia, Museu Paraense Emílio Goeldi. Avenida Perimetral 1901, Terra Firme, 66077-530 Belém, Pará, Brazil.

Corresponding Author. E-mail: gleomarmaschio@yahoo.com.br

ABSTRACT. Information on the diet of *Anilius scytale* is provided based on the analysis of 162 specimens from the Brazilian Amazonia. Amphibians (*Aulura anomala* Barbour, 1914; *Leposternon polystegum* [Duméril, 1951] and *Amphisbaena* sp.), which are highly specialized for a fossorial life, accounted for 81.25% of the recorded items, followed by snakes – *Anilius scytale* (Linnaeus, 1758), and *Tantilla melanocephala* (Linnaeus, 1758): 12.5% – and caecilians – *Caecilia* cf. *gracilis* Shaw, 1802: 6.25%. We found a positive, although not significant, relationship between the snout-vent length of *A. scytale* and the total length of the prey and a tendency for smaller specimens to ingest proportionately larger prey. *Anilius scytale* forages mainly on the ground, at night, as well as in aquatic environments. The non-selective capture of either proportionately large or small prey by *A. scytale* may reflect the opportunistic nature of the encounters. A tendency of the juveniles of this species to ingest proportionately larger prey may be associated with either a low availability of prey with a size compatible to that of the juveniles, or with their inexperience in selecting prey. Ingestion of prey headfirst may be an attempt to minimize the risk of injury the prey could cause through their rigid, pointed and sharp structures or powerful bites.

KEY WORDS. Basal snakes; diet.

Nevertheless, knowledge about the diet of this species is based on anecdotal information, which records as food items amphisbaenians, small snakes and, occasionally, fish such as *Synbranchus marmoratus* Bloch, 1795 (*Beebe* 1946, *Cunha* & *Nascimento* 1981, 1993, *Martins* & *Oliveira* 1998, *Dixson* & *Soini* 1986, *Duellman* 1978, *Dixon* & *Soini* 1977, *Silva Jr* 2001). The scarce information available indicates that *A. scytale* has fossorial habits and can occasionally be seen both on the ground and in aquatic environments, where it forages mainly at night. It can also be active during the day, but this habit has been observed less frequently (e.g. *Beebe* 1946, *Cunha* & *Nascimento* 1978, *Duellman* 1978, *Dixon* & *Soini* 1986, *Vanzolini* 1986, *Martins* & *Oliveira* 1998). Recently, *Maschio et al.* (2007) observed that females of *A. scytale* in Eastern Amazonia have seasonal reproduction, with developed follicles recorded mainly from the end of the dry season (May to October) to the middle of the rainy season (November to April). Newborns were recorded mainly in the rainy season.
The diet of a species is one of the most important aspects of its ecology and detailed information about dietary habits are, in most cases, necessary for understanding environmental and/or behavioral issues (Clark 2002). Moreover, these aspects can underpin our understanding of trophic relationships in different ecological communities (Rodríguez-Robles 2002). Thus, the present study provides information on the dietary habits of *A. scytale* in Brazilian Amazonia, namely: 1) the composition of its diet; 2) the variation in the absolute frequency of items in the dry season and months with higher rates of annual precipitation in the Amazonia; 3) the relationship between size of predator and that of prey; and 4) the level of behavioral specialization with respect to the environment and the ingestion prey.

**MATERIAL AND METHODS**

We analyzed 162 specimens (79 males and 83 females) from the Brazilian Amazonia, deposited in the Herpetology Collection of the Museu Paraense Emílio Goeldi (MPEG) between 1971 and 2007 (Appendix 1). Females and males with SVL greater than 515 and 430 mm, respectively, were considered as sexually mature (Maschio et al. 2007).

The stomachs and intestines of all specimens were analyzed by making a longitudinal ventral incision to verify the presence or absence of contents. The direction of ingestion (antero-posterior or postero-anterior) was determined by observing the position of the prey’s head in relation to that of the predator. All items were removed, identified to the lowest possible taxonomic level, weighed, measured, and deposited in the MPEG collection (Appendix 2).

We measured the snout-vent length (SVL), total mass and largest diameter of all specimens of *A. scytale* (TLPr = total length of predator, MPr = mass of predator, DPr = diameter of predator) as well as that of the food items (TLPy = total length of prey, MPy = mass of prey, DPy = diameter of prey) where possible. Partially digested items were identified and compared with a sample of complete specimens of the same species from the MPEG collection, from which we took the same measurements.

To test the normality of the analyzed data, we used the D’Agostino test (D’Agostino et al. 1990). We then applied Spearman’s linear correlation (Zar 1996) to verify the correlation between the SVL of *A. scytale* and the TLPr and the correlation between the SVL of *A. scytale* with the proportion TLPy versus SVL. The software used was Statistica 6.0. (StatSoft 2001).

**RESULTS**

Of the 162 specimens analyzed, only 21 (12.9%) had some type of food item in the digestive tract. Of these, we were able to identify the content up to the genus level of 16 (76%; 12 females and 4 males) specimens and we found only scales in the digestive tract of the other five. Of the 16 identified prey specimens, 13 (81.2%) were amphibiaenians, two (12.5%) were snakes and one (6.2%) was a caecilian. Among the amphibiaenians, specimens of *Amphibiaena* Linnaeus, 1758 were the most consumed items (n = 7, 43.75% of all items recorded: *Amphibiaena amazonica* Vanzolini, 1951 [n = 2], *A. mitchelli* Procter, 1923 [n = 1], and four undetermined specimens), followed by specimens of *Aulura anomala* Barbour, 1914 and *Leposternon polystegum* (Duméril, 1851) (n = 3 for both; 18.8% of the recorded items) (Tab. I). The two snakes, *A. scytale* (n = 1) and *Tantilla melanocephala* (Linnaeus, 1758) (n = 1), and the caecilian, *Caecilia cf. gracilis* Shaw, 1802 (n = 1), each accounted for 6.3% of the total items recorded (Tab. I).

The direction of ingestion of all the food items that were in adequate conditions for analysis (intact or only partially digested) was antero-posterior.

Of the specimens containing food items, 81% were collected in the dry season (May to October), while 19% were collected in months with higher rates of annual precipitation (November to April) (Fig. 2).

There was no correlation between the SVL of *A. scytale* and the total length of the prey (rS = 0.08, t = 0.2654, p = 0.8) (Fig. 3). But a tendency for smaller specimens to ingest propor-
Figures 3-4. Relation between snout-vent-length of *A. scytale* and the: (3) total length of its items; (4) proportion of the total length of the prey in relation to the snout-vent length of *A. scytale* in Brazilian Amazonia.

Table I. Preys and their frequency in the diet of 16 specimens of *A. scytale*, in Brazilian Amazon. (SVLPr) snout-vent length of predator (mm), (DPr) diameter predator (millimeters), (%) the percentage which each group of prey items represents of the total number of food items analyzed, (MPy) weight of prey (g), (TLPy) total length of prey in millimeters, (DPy) diameter of prey (mm), (DPy/Pr) proportional diameter of prey in relation to diameter of predator, (SVLPy/Pr) proportion total length of prey in relation to snout-vent length of predator.

| Sex  | Predator       | SVLPr | DPr  | Prey             | %   | MPy | TLPy | DPy | DPy/Pr | SVLPy/Pr |
|------|----------------|-------|------|------------------|-----|-----|------|-----|--------|----------|
| Female | Caeciliidae    |       |      |                  |     |     |      |     |        |          |
|       | *Caecilia cf. gracilis* | 635   | 18.04|                  | 6.25| 8.5 | 350  | 7.06| 0.39   | 0.55     |
| Female | Squamata       |       |      |                  |     |     |      |     |        |          |
|       | *Leposternon polystegum* | 560 | 14.32| *Amphibia*       | 35.0| 480 | 12.03| 0.84| 0.86   |          |
| Female | *Leposternon polystegum* | 527 | 13.87| *Amphibia*       | 37.0| 425 | 11.16| 0.80| 0.81   |          |
| Female | *Leposternon polystegum* | 678 | 14.89| *Amphibia*       | 19.0| 315 | 10.22| 0.69| 0.46   |          |
| Female | *Aulura anomala* | 515 | 13.68| *Amphibia*       | 13.0| 290 | 9.81 | 0.67| 0.56   |          |
| Female | *Aulura anomala* | 514 | 12.24| *Amphibia*       | 14.0| 260 | 10.03| 0.82| 0.51   |          |
| Female | *Aulura anomala* | 590 | 13.51| *Amphibia*       | 7.5 | 205 | 7.61 | 0.56| 0.35   |          |
| Female | *Aulura anomala* | 586 | 12.86| *Amphibia*       | 6.4 | 192 | 8.06 | 0.63| 0.33   |          |
| Male   | *Amphiboida fuliginosa* | 700 | 19.21| *Amphibia*       | 6.0 | 188 | 7.01 | 0.36| 0.27   |          |
| Female | *Amphiboida mitchelli* | 360 | 8.84 | *Amphibia*       | 2.5 | 172 | 4.59 | 0.52| 0.48   |          |
| Female | *Amphiboida sp. (und.)* | 631 | 14.40| *Amphibia*       | 14.0| 255 | 9.13 | 0.63| 0.40   |          |
| Female | *Amphiboida sp. (und.)* | 610 | –    | *Amphibia*       | –   | –   | –    | –   | –      |          |
| Male   | *Amphiboida sp. (und.)* | 535 | –    | *Amphibia*       | –   | –   | –    | –   | –      |          |
| Male   | *Amphiboida sp. (und.)* | 802 | –    | *Amphibia*       | –   | –   | –    | –   | –      |          |
| Aniliidae |                   | 6.25 |       |                  |     |     |      |     |        |          |
| Male   | *Anilis scytale* | 445 | 19.21| *Colubridae*     | 11.0| 315 | 9.17 | 0.48| 0.71   |          |
| Female | *Tantilla melanocephala* | 370 | –    | *Colubridae*     | 3.0 | 253 | –    | –   | 0.68   |          |

**Total** 100
tionately larger prey was detected, although this relationship was also not significant (*rs* = -0.53, *t* = -2.11, *p* = 0.057) (Fig. 4). We observed a preference of *A. scytale* to feed on elongated vertebrates with a diameter less (36-84%) than the diameter of their body (Tab. 1).

**DISCUSSION**

The frequency of specimens with food items found in studies of snake diets is usually low, varying between 14% and 30% (Rodríguez-Robles & Greene 1999, Shewchuk & Austin 2001, Clark 2002, Ruffato et al. 2003, Gregory & Isacc 2004, Hartmann et al. 2005, Balestrin et al. 2007, Leite et al. 2007, Prudente et al. 2007). This result may be related to the time of the year in which the analyzed specimens were collected, as suggested by Gregory & Isacc (2004). Reading & Davies (1996) observed extended periods of “fasting” in gravid females of *Natrix natrix* Linnaeus, 1758, with the resumption of feeding after the reproductive period, and Shine (1987) suggests that female snakes in general tend to reduce the consumption of food during the gestation period. Females with some type of food item were recorded only in the months between June and October, a period with low frequency of embryos. The low frequency of food items observed in *A. scytale*, mainly in the months of November to April, the period in which there are records of gravid females (see figure 5 in Maschio et al. 2007) may be a strong indication that females tend to reduce the consumption of food during the gestation period. Thus, future studies involving the analysis of a larger number of specimens collected throughout all the seasons of the year are necessary to reach more conclusive results.

Species of *Leposternum* Wagler, 1824, *Aulura* Barbour, 1914 and *Amphisbaena*, the most frequent items in the diet of *A. scytale*, are highly specialized for a fossorial life (Zug 1993, Kearnney & Stuart 2004) and forage on the soil surface during the night, according to Kearnney (2003). This fact, added to the records of *Caecilia cf. gracilis*, *Atractus torquatus* Duméry, Bibron and Duméry, 1854 (see Martins & Oliveira 1998) and *Tantilla melanoccephala* as food items of *A. scytale*, suggest that the species forages mainly on the ground. In addition to these observations, records of *A. scytale* in water bodies (Martins & Oliveira 1998, G.F. Maschio pers. obs.) and the presence of *S. marmoratus* as a food item of *A. scytale* (Martins & Oliveira 1998) are also evidence of the use of the aquatic environment as a foraging site.

The assumption that *A. scytale* forages on the ground can be reinforced by observations made by Marques & Sazima (2008), which showed a behavior similar to constriction: if *A. scytale* does indeed subdue its prey by using a type of constriction behavior, this would only be possible on the soil surface, given that it is not feasible in underground galleries. But the possibility of *A. scytale* foraging and subduing its prey in galleries cannot be discarded, and more observations are needed to safely conclude whether *A. scytale* really subdues its prey on the ground, as suggested by the present study.

Regardless of the substrate used by *A. scytale*, the records of cannibalism observed by Maschio et al. (2005), the predominant presence of Amphisbaenidae in the stomach contents, recorded in this study, as well as the records of intake of other elongated vertebrates such as *Caecilia cf. gracilis* and *T. melanoccephala* (this study), *S. marmoratus* and *A. torquatus* (see Martins & Oliveira 1998) suggest that *A. scytale* does not discriminate between snakes and other small elongated vertebrates.

The direction of prey ingestion probably depends on the morphological characteristics of both the prey and the predator, as well as the behavioral characteristics that they exhibit during the different stages of their interactions (Gregory & Isacc 2004). The antero-posterior direction observed in all *A. scytale* is a pattern commonly observed in several species of snakes (Diefenbach & Emslie 1971, Ashton 2002). This pattern is related mainly to the type of prey ingested, that usually shows rigid, pointed or sharp structures that could cause physical damage to the predator. Several species of *Amphisbaena* are able to inflict powerful bites, different to species of *Leposternon* that have an anti-predatory repertoire limited to flight and cloacal discharge (Marques & Sazima 1997). The fact that some Amphisbaenidae produce strong bites is enough to ensure that they are ingested headfirst, thereby decreasing the potential harm they could cause (see Greene 1976), and thus justifying the constriction behavior of *A. scytale*, as observed by Marques & Sazima (2008).

According to Shine (1987), the energetic cost of capturing and ingesting small prey is less than the energetic cost of predation of large prey, and the risks of injury are also lower with small prey. However, the theory predicts that foraging predators with access to prey of varying sizes will select larger prey, thus maximizing the foraging efficiency (Schoener 1972). On the other hand, the optimization of energy in an environment with low prey availability could also explain both the ingestion of prey with relatively large total lengths by adults and the inclusion of relatively small prey in the diet of large snakes (Shine 1991). The indiscriminate capture of both proportionately large and small prey by *A. scytale* may reflect its opportunistic behavior. However, the tendency for juveniles of *A. scytale* to eat proportionately larger prey (Fig. 3) may be associated with both the low availability of prey of a size compatible to that of the juveniles, as well as the inexperience of the juveniles in selecting their prey (see Sazima & Martins 1990).

Basal Alethinophidia, which include the Neotropical *Anilius* and the Asiatic *Cylindrophis*, present a series of cranial modifications that are related to their adaption as burrowing snakes: skull of compact structure with leveled surface, and the snout characterized by a firm maxillary arch formed by the premaxilla, the maxilla and the ectopterigoid that is solidly united to the palate (Rieppel 1977), among others. These characteristics limit the cranial kinesis of the basal Alethinophidia compared with Macrostomata, and the ability to consume prey with larger diameter or similar to the diameter of their body, which in theory would limit the selection of prey. Therefore,
these cranial modifications could explain the preference of *A. scytale* for feeding on elongated vertebrates with a diameter less than the diameter of their body.

Since both the density and availability of prey may influence the selection of prey with particular sizes (Plummer & Goy 1984; Shine 1987, 1991), the reason why *A. scytale* includes both large and small prey in its diet is still inconclusive, due to lack of information on the actual abundance of different species recorded as food items of *A. scytale*.

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Appendix 1. Specimens of *Anilius scytale* analized (Herpetological Collection of the Museu Paraense Emílio Goeldi – MPEG).

Brazil, *Amazonas*, Manaus: MPEG 16402 (June, 1980). Marañá: MPEG 16782 (November/1983). Caracará: MPEG 17299 (March/1986). Presidente Figueiredo: MPEG 17382, 17428, 17433, 17518, 17547 (April/1988). Tefé: MPEG 17505, 17547 (April/1988). Ourém: MPEG 1662 (June/1972), 4247 (August/1973), 7006 (August/1974). Paragominas: MPEG 18846 (July/1974), 16965, 17083 (May/1985). Maracanã: MPEG 5802 (March/1974). Mosqueiro: MPEG 16823 (July/1981). Gurupá: MPEG 15443 (April/2006). Igarapé-açú: MPEG 858, 859, 860, 861, 876, 877, 878, 892 (September/1971). Marabá: MPEG 7452 (July/1974), 16950 (May/1985). Curuçá: MPEG 4062, 4873, 4892 (July/1973), 7110 (July/1974), 5362, 5363 (October/1975), 6493, 6664, 6669 (March/1974), 8993, 9995, 9086, 9087 (March/1975), 10002 (June/July/1974), 10721, 10722, 10723, 10724 (October/1975), 12452, 12453 (June/1976). Belém: MPEG 259, 764 (August/1971), 5362, 5363 (October/1975), 6319 (March/2006), 11304, 11307 (November/2006). Canãá dos Carajás: MPEG 20627 (April/2008). Capitão Poço: MPEG 2132 (September/1979), 4925 (October/1973), 6057, 6088, 6090 (March/2006), 7243 (March/1974), 9678, 9679 (March/1975), 9680 (June/1975), 10655 (October/1975), 12191, 12192 (June/1976), 12981 (October/2006), 13042, 14050, 14058 (October/1997), 15402 (November/1975). Castanhal: MPEG 12602 (September/1976). Conceição do Araguaia: MPEG 16950 (May/1985). Curuçá: MPEG 4062, 4873, 4892 (July/1973), 7110 (July/1974), 5788, 5789, 5792, 5799, 7603 (October/1974). Gurupá: MPEG 15443 (April/2006). Igarapé-açú: MPEG 858, 859, 860, 861, 876, 877, 878, 892 (September/1971). Marabá: MPEG 7452 (July/1974), 16965, 17083 (May/1985). Maracanã: MPEG 5802 (March/1974). Mosqueiro: MPEG 16823 (July/1981). Ourém: MPEG 1662 (June/1972), 4247 (August/1973), 6193 (March/1974), 7006 (August/1974). Paragominas: MPEG 18846 (July/1994). Porto Jarbas Passarinho: MPEG 12949 (June/1976). Santa Rosa: MPEG 4011 (July/1973), 4666, 4691 (October/1973), 5673 (March/1974), 6906 (June/1974), 7484, 7486, 7511, 7531 (September/1974), 8484, 8489 (February/1975), 11833 (May/1976), 12591 (September/1976). Santarém: MPEG 19101 (April/1995). Viseu: MPEG 1073 (November/1971), 7667 (July/1974), 12326 (June/1976), 15982, 15983 (August/1979), 16004 (August/2006).
Appendix 2. Prey of A. scytale analyzed (Herpetological Collection of the Museu Paraense Emílio Goeldi – MPEG).

Caecilia cf. gracilis (MPEG 17382); Amphisbaena amazonica (MPEG 843, 16965); Amphisbaena mitchelli (MPEG 7667); Amphisbaena sp. (MPEG 2249, 4666, 8259, 15982); Aulura anomala (MPEG 876, 7452, 9680); Leposternum polystegum (MPEG 5336, 9993, 12026); Anilius scytale (MPEG 7243); Tantilla melanocephala (MPEG 12326).