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Diet of Two Sympatric Rocket Frogs (Amphibia, Anura, Ptychadenidae: *Ptychadena*) in the Disturbed Parts of a West African Rainforest

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Abstract – We studied the diet of two syntopic rocket frogs, *Ptychadena mascareniensis* and *P. pumilio*, in Banco National Park, south-eastern Ivory Coast. We determined the prey of juveniles, males and females of both species in order to understand the potential avoidance of food competition. Insects dominated (>77.9%) the general diet of both species. We determined insect prey items down to the level of the order. At this level the diet of both species were mostly represented by coleopterans, hymenopterans and orthopterans. However, whereas *P. mascareniensis* preyed mainly on orthopterans (36%, grasshoppers and crickets), the diet of *P. pumilio* was dominated by coleopterans (42%, beetles and lightning bugs). We could observe a seasonal change in the diet of *P. mascareniensis,* but not in *P. pumilio*. Juveniles of both species mainly fed on small beetles and ants, while adults consumed various prey up to larger prey item (e.g. amphibians). However, the large overlap in prey can be taken as a hint that competition for food does not play a major role between these two frogs. The slightly different diets are more likely the result of so far undetected differences in habitat preferences and / or activity patterns.

Keywords. Diet, Ivory Coast, *Ptychadena mascareniensis, P. pumilio*, syntopic occurrence.

Introduction

The genus *Ptychadena* Boulenger, 1917, family Ptychadenidae Dubois, 1987, currently comprises 49 species (Frost, 2015). These species are common and particularly species rich in open and drier lowland habitats, ranging south from Egypt through sub-Saharan Africa, excluding the south-western parts of Africa. They are also known from the Seychelles, the Mascarene Islands and Madagascar (Du Preez and Carruthers, 2009; Vences et al. 2004).

In West Africa, *Ptychadena mascareniensis* (Duméril and Bibron, 1841) and *P. pumilio* (Boulenger, 1920) are both believed to have a wide distribution, inhabiting a broad range of habitats and are presumed to be often locally very abundant (Barbault, 1972; Barbault and Trefaut Rodrigues, 1978; Rödel, 2000; Adeba et al. 2010). Both species are widespread in different savannah types and disturbed forest habitats (Rödel, 2000; Rödel and Branch, 2002; Nago et al. 2006; Hillers et al. 2008; Rödel and Onadeko, 2008).

In Ivory Coast both species have been reported to live in sympatry in the leaf-litter of degraded areas of the Banco National Park, a threatened rainforest situated in the midst of Abidjan (Assemian et al. 2006). Despite the considerable research activity on the West African amphibian fauna, the ecology and biology of these species is still poorly known. Publications on basic trophic ecological data so far are restricted to species occurring in Lamto (Barbault, 1974) and some further single species, such as two syntopic *Phrynobatrachus* species from the swamp parts of the Banco National Park (Kouamé et al. 2008), *Hoplobatrachus occipitalis* from this park (Tohé al. 2014) and northern Benin (Hirschfeld and Rödel, 2011) for older papers see species account in Rödel (2000). In this rainforest, *Ptychadena mascareniensis* and *P. pumilio* are extremely common in degraded, open parts of the “forest”, including anthropogenic habitats such as grassland close to shallow flowing or non-flowing waters, as well as in marshes (B. Tohé, pers. obs.). Herein, we aim to document the food habits for both species.

Materials and Methods

Study site*:* The Banco National Park (BNP, 5°21’–5°25’ N; 4°01’–4°05’ W) is a small rain forest park (3474 ha), located in the middle of Abidjan, the economic capital of Ivory Coast (Daget and Iltis, 1965). The climate of this Park is typical for an equatorial rain forest, comprising four seasons (Girard et al. 1971): a long dry season (December to March), a long rainy season (April to July), a short dry season (August to September) and a short rainy season (October to November). The mean annual temperature in Banco is 26–27°C and the mean annual precipitation sums to about 2000 mm. The river Banco crosses the entire reserve over approximately 9 km. The survey was conducted from April 2004 to March 2005. In BNP populations of *Ptychadena mascareniensis* and *P. pumilio* were mainly found in three sites: Fish Farm, Bay and Filtisac Factory, all being under active logging (Figure 1). Whereas the Fish Farm (05°23'N, 04°03'W) was characterized by a vast clearing with artificial large ponds for fish breeding, the Bay site (05°21'N, 04°02'W) which was located downstream comprised marshes, high grass, a permanent flowing stream. This site was under anthropogenic pressure because of heavily degraded and water polluted due to the “Fanico” launderers, people that use the river for religious rituals or car washing. A third site (Filtisac Factory, 05°24'N, 04°01'W) was localized near a textile factory in the north of the park (Figure

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1). This site comprised large puddles, stagnant ponds and was partly polluted by oil. We search for frogs at 24 days visiting each site twice a day, and each day for seven hours (08:00–11:00 & 18:00–22:00 GMT), thus covering the rainy and the dry seasons. The three sites were always examined by three people twice a month. The sampling effort thus was 21 person-hours per site and day. Our searching techniques included visual scanning of terrain and refuge examination through which frogs were captured by hand, sexed and measured. Snout-Urostyle-lengths (SULs) were taken with a dial calliper (accuracy ± 0.5 mm).

Diet analysis: For the diet analysis, we used 217 specimens of *P. mascareniensis* (79 males, 116 females, and 22 juveniles) and 213 of *P. pumilio* (36 males, 105 females, and 72 juveniles), which were anesthetized in chlorobutanol solution and thereafter preserved in ethanol 70%. The vouchers are deposited in the Laboratory of Environment and Aquatic Biology, at the Nangui Abrogoua University (ex-University of Abobo-Adjamé), Abidjan. We extracted the stomachs through a ventral longitudinal incision and identified the prey categories at the order level, using a stereoscopic microscope. We determined and counted the prey items, and thereafter dried and weighed them (Sartørius scale; accuracy ± 0.0001g). To determine prey items, the keys of Dierl and Ring (1992) and Tachet *et al*. (2003) were used to distinguish between insect orders, arachnids (Arachnida), molluscs (Mollusca), earthworms (Annelida), vegetables (Macrophytes), other animal remains, and plant parts. Further unidentified material is also listed.

For a quantitative analysis of the frogs' diets, we calculated the Relative Importance Index

$$IRI \; (IRI = (N + P) \times F) \qquad (1)$$

Where: N = the numerical percentage of prey; P = the exact percentage of prey weight; F = the frequency of occurrence percentage. We used the index of shared prey $C\lambda$ according to Morisita (1959) modified according to Horn (1966) to evaluate the prey overlap between the two species.

$$C\lambda = \frac{2 \times \sum_{i=1}^{s} xi \cdot yi}{\sum_{i=1}^{s} xi^2 + \sum_{i=1}^{s} yi^2} \qquad (2)$$

Where: S = the total number of preys; xi = the proportion of prey i consumed by the species x; yi = the proportion of prey i consumed by the species y.

$C\lambda$ would be 0 if the prey composition in both species would be completely different; $C\lambda$ is 1 if the prey of both species is identical.

A value of *C*λ greater than 0.6 indicates a non-significant difference between trophic niches.

Results

Overall, we found prey items in 217 stomachs of *P. mascareniensis* and 213 stomachs of *P. pumilio* (Table 1). SULs of *P. mascareniensis* varied between 17 to 59 mm while sizes of *P. pumilio* ranged from 15 to 40 mm. Seven different major prey categories were consumed by each species. Concerning broad prey categories, both species fed on Insecta, Annelida, Arachnida, Mollusca, plant material and "other preys" (invertebrate debris and unidentified preys). Prey items such as Amphibians (*Phrynobatrachus latifrons* and juvenile *Ptychadena* sp.) were also observed in the diet of *P. mascareniensis* but not in this of *P. pumilio*. However, Crustacea (woodlice) were only consumed by the later species. Both species mainly preyed on insects, 78.0% and 79.5%, respectively. Orthopterans (36%) and coleopterans (42%) dominated the diet of these frog species respectively. Whereas *P. mascareniensis* mainly preyed on orthopterans (predominantly grasshoppers), *P. pumilio* seemed to prefer beetles (Table 1). The trophic niche of both species differed significantly (*C*λ > 0.60).

In all habitats, *P. mascareniensis* and *P. pumilio* mainly fed on insects (Table 2). Orthopterans (grasshoppers) were the dominant prey of *P. mascareniensis* at sites Bay, Fish Farm and Filtisac Factory, with 32.7%, 44.7% and 54.4%, respectively. In the same sites, *P. pumilio* preyed mainly on coleopterans (beetles and lightning bugs in majority) with 45%, 34.8% and 52.5% respectively. At Bay, both species preyed mostly on arachnids. Spiders were consumed as secondary prey by *P. mascareniensis* (25.6%) and *P. pumilio* (26.5%). In each site, the trophic niche of both species differed significantly (*C*λ < 0.60).

In Table 3 we summarize the prey (*IRI*) consumed by both species with respect to seasons. The diet of *P. mascareniensis* and *P. pumilio* in the rainy season, as well as in the dry season mainly consisted again of insects. Whereas *P. mascareniensis* mainly preyed on orthopterans (predominantly grasshoppers) and lepidopterans (butterflies), *P. pumilio* seemed to prefer beetles and lightning bugs. These coleopterans (especially lightning bugs) were important prey items for *P. pumilio* through both seasons. During the dry season arachnids became of increasing importance for *P. mascareniensis*. While the value of *C*λ between seasons was not significant for *P. mascareniensis* (*C*λ = 0.2601), it was in constrast significant for *P. pumilio* (*C*λ = 0.7909).

Based on frogs' size (Figure 2A), SULs of young frog *P. mascareniensis* (n= 18) varied between 19 and 26 mm, while these of adults (n= 61) were comprised between 38 and 59 mm. Adults frogs were significantly larger than juveniles (Mann-Whitney *U*-test: $U = 0.00$; $Z = -6.41677$; $p < 0.001$). Beetles were the major prey of juveniles of *P. mascareniensis* (74.7%). Arachnida (28.2%) were consumed as secondary prey by young frogs.

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However, important prey of adults of *P. mascareniensis* comprised grasshoppers (29.9%), beetles (19.8%), and ants (14.8%). Within the species *P. pumilio*, size of juveniles (n= 5) ranged from 17 to 23 mm; size of adults (n= 57) varied between 38 and 57 mm. Juveniles were significantly less larger than adults (Mann-Whitney *U*-test: *U* = 0.00; Z = -3.68394; $p < 0.001$). Whereas juveniles mainly fed on beetles (57.1%), orthopterans (grasshoppers: 29.9%) and coleopterans (beetles and lightning bugs: 23.5%) were in total the major prey for adult frogs (Figure 2B). Likewise with respect to sex, the analysis of the diet of males and females of both species showed some variations. The size of male *P. mascareniensis* (n= 29) varied between 38 and 49 mm. These males mostly ate grasshoppers (41.7%) and ants (12.3%). Nevertheless, 10.6% of some plant materials were observed in their diet. Females (n= 32) of this species measured between 43.5 and 59 mm in SULs. Their stomachs mainly contained grasshoppers (42.1%) and some plant materials (19.4%). Beetles and lightning bugs (12.1%) were of secondary importance in term of abundance (Figure 2B). Females were significantly larger than males (Mann-Whitney *U*-test: *U* = 28.500; Z = -6.28940; $p < 0.001$). Within the species *P. pumilio*, males (n= 11) measured between 30 and 46 mm while SULs of females (n= 46) ranged from 45 to 57 mm. Likewise, female sizes were significantly larger than those of males (Mann-Whitney *U*-test: *U* = 19.500; Z = -4.72159; $p < 0.001$). Dominant prey for males comprised beetles and lightning bugs (27.7%), and grasshoppers (27.4%). Male *P. pumilio* also consumed ants (16.1%) and plant material (14%) secondarily. The diet of females was mainly characterized by orthopterans (40.6%) and hymenopterans (20.5%). Coleopterans (10.7%) and annelids became of increasing importance.

Discussion

Given the fact that various prey items were observed in their respective diet, *Ptychadena mascareniensis* and *P. pumilio* can be regarded as two generalist predators so far. This has also been shown in the prey composition of other anuran groups which were diverse and various (Barbault, 1974; Santos et al. 2004; Camera et al. 2014; Tohé et al. 2014). However, in the Banco National Park, the bulk of both rocket frogs was characterized by various insect orders. For the majority of anuran species, it has been reported that the best strategy for preying on arthropods is to adopt a sit-and-wait position (Toft, 1981). This behavioural strategy which was recently observed with *Hoplobatrachus occipitalis* (Tohé et al. 2014; own experience of the authors) may have also been used by *P. mascareniensis* and *P. pumilio* in the same degraded areas of the Banco National Park. Our results suggest that *P. mascareniensis* preyed on more grasshoppers while beetles and lightning bugs were the most abundant prey item in the diet of *P. pumilio*. As a previous survey on the dietary strategies of *Hoplobatrachus occipitalis* in the Fish Farm, Bay and Filtisac Factory area already revealed that these three sites comprised abundant arthropods (Tohé et al. 2014), it is not surprising to see insects representing the bulk of *P. mascareniensis* and *P. pumilio* within the same sites. The dominance of insects in the diet of the both *Ptychadena* species could be due to the fact that competition for food is of minor importance in anurans that usually feed on a huge variety of prey items (Barbault, 1974; Toft, 1980; Hofer et al. 2004). However, even if beetles and lightning bugs, grasshoppers and spiders were the most consumed prey items at the site Bay by both species, the diet of these amphibians may have profound differences with respect to prey availability in habitats, and differences in insect consumptions could be justified by environmental conditions (Inger and Marx, 1961; Toft, 1980; Aichinger, 1991). This statement has been shown by Legendre and Legendre (1998) who wrote that the taxonomic richness of a given habitat depends on the stability of the environment. In our study, the three studied sites which were under anthropogenic threats should be considered differently in prey availability. This is mainly due to the fact that the Fish Farm was located in the centre of the rainforest while the site Bay which was at nearby the main road was the most lightened area. As for the later site (Filtisac Factory area), its soil was more polluted by oil. All these different factors may influence prey availability in Banco National Park.

With respect to seasons there seem to be some differences in the food preference of the two species. However, the large overlap in prey can be taken as a hint that competition for food does not play a major role between *P. mascareniensis* and *P. pumilio*. Welcomme (1985) and King (1989) showed that food resources were usually more abundant during the rainy season than the dry season. In Banco National Park, Kouamé et al. (2008) showed that differences in the prey composition of two syntopic anurans from the genus *Phrynobatrachus* with respect to seasons were even larger, although not significant. In our study, differences between seasonal diet in both species could be due to prey availability with respect to seasons. These reflected the fact that many insect species mostly reproduce during the rainy season (Dietoa, 2002).

From a qualitative point of view we also observed differences between ingested prey with respect to size and sex (Figure 2). Juveniles of both species mainly feed on small beetles and ants while adults consume various prey up to larger prey item (e.g. amphibians, Figure 2A). In rice fields at nearby Ranomafana National Park (Madagascar), the investigations of Fatroandrianjafinonjasolomiovazo et al. (2011) on the food habits of *P. mascareniensis* revealed a positive correlation between prey size and frog size, and a significant negative correlation between the number of prey consumed and size of prey ingested. According to these authors, adult *P. mascareniensis* could also prey on froglets. There is hence, a general agreement that larger frogs are able to feed on the largest prey in comparison to smaller frogs that may be limited by their size and eat smaller prey. Thus, usually larger frogs have an advantage in prey capture because they are more experienced than smaller, younger frogs (Camera et al. 2014). Qualitatively, males and females of both *Ptychadena* species in Banco National Park mainly consumed different prey. However, female *P. mascareniensis* were significantly larger than males but consumed similar prey in Madagascar (Fatroandrianjafinonjasolomiovazo et al. 2011). With the exception of *P. pumilio*, our results confirm a kind of cannibalism in the diet of *P. mascareniensis*, particularly in males' diets, from which amphibians were observed.

Although it is believed that frogs do not normally feed on plants, it is known that some frogs may have considerable amounts of plant material in their stomachs. This item was the most important food category found in stomachs of individuals of *Leptodactylus mystaceus* (Leptodactylidae) around the farmhouse of the Florentino farm, in Novo Progresso, Brazil (Camera *et al*., 2014). In our survey, we detected more plants in adult individuals than juveniles. This is also illustrated during the dry season (Table 3). Hence, we could not *a priori* exclude the possibility that some plants are devoured deliberately less favourable periods and were not only swallowed randomly. This possibility is further supported by the fact that the high percentage of plant material in the dry season diet of *P. mascareniensis* was due to some stomachs completely filled with plants (for frogs that deliberately feed on plants compare Da Silva and De Britto-Pereira, 2006 and other literature cited therein). The ability of the *Ptychadena* spp. to digest plant matter is completely unknown.

Insects in general, and grasshoppers, beetles, lightning bugs and ants in particular were the dominant prey of *Ptychadena mascareniensis* and *P. pumilio* in the disturbed areas of Banco National Park. The dominance of ants and beetles in the diet was also revealed in two *Phrynobatrachus* species from the swamp parts of Banco National Park by Kouamé et al. (2008). Even though we have not simultaneously recorded the availability of the respective prey, we can however presume that the food choice in the two *Ptychadena* species most likely is attributable to differences in the availability of the various arthropod taxa encountered in the survey area. The differences in the consumption of ants and beetles as dominant food may hence reflect some so far undetected differences in the frogs' micro-habitat choice and / or activity patterns, rather than being the result of current competition for food. Further in-detail-analyses of the habitat requirements and the species' behaviour may help clarifying this point.

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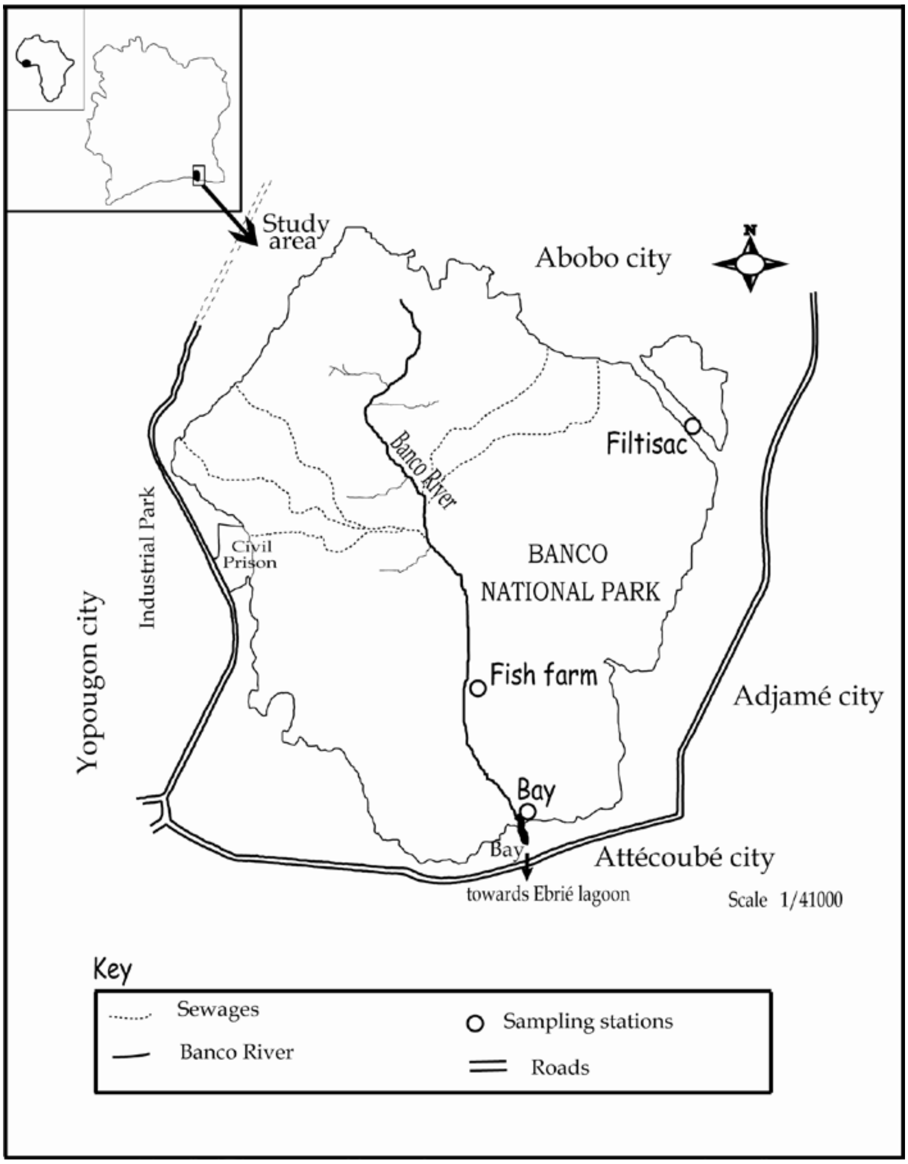

Fig. 1: Map of the Banco National Park showing the sampling stations (inlet: Africa with the position of Ivory Coast and the position of Banco National Park within Ivory Coast).

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Table 1: Summary of the diet of *Ptychadena mascareniensis* and *P. pumilio* in Banco National Park: n = total number of stomachs examined.

Prey category	Relative Importance Index (%)	
	Ptychadena mascareniensis (n = 217)	*P. pumilio* (n = 213)
Blattoptera	0.2	0
Coleoptera	20	42
Diptera	1.2	1.3
Heteroptera	0.6	0.3
Hymenoptera	12	17
Lepidoptera	7.8	4.9
Odonata	0.2	0
Orthoptera	36	14
INSECTA (Σ)	78	79.5
AMPHIBIANS	0.5	0
ANNELIDA	1.9	1.6
ARACHNIDA	5.8	9.9
CRUSTACEA	0	0.6
MOLLUSCA	0.1	0.3
PLANT MATERIAL	11.3	8.7
OTHER PREYS		
Invertebrate debris	2.6	0.2
Unidentified	0.3	0.2

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Table 2: Relative importance index (%) of prey items with respect to three different sites where specimens of *Ptychadena mascareniensis* and *P. pumilio* were collected. n = number of stomach contents, B = Bay, FF = fish farm, Fi = filtisac.

Prey category	*P. mascareniensis*			*P. pumilio*		
	B n = 48	FF n = 127	Fi n = 42	B n = 48	FF n = 124	Fi n = 41
Blattoptera	0.7	0.1	0.6	0	0	0
Coleoptera	20.5	11.7	19.8	45	34.8	52.5
Diptera	0	1.1	0	1.8	0.8	0.8
Heteroptera	0.4	0.9	0.7	0	0,4	0
Hymenoptera	5.4	8.9	6.5	14.9	17.1	15.1
Lepidoptera	7.8	8.7	0.6	3	5.5	1
Odonata	0	0	3.2	0	0	0
Orthoptera	32.7	44.7	54.4	3.3	20.3	0
INSECTA (Σ)	67.5	76.1	85.8	68	78.9	69.4
AMPHIBIANS	0	0.6	0	0	0	0
ANNELIDA	0	2.4	0	0	0,7	0
ARACHNIDA	25.6	6.3	3	26.5	8.3	28.5
CRUSTACEA	0	0	0	0.6	0	0
MOLLUSCA	0.7	0	0	0	0.7	0
PLANT MATERIAL	4.5	11.9	5.9	3.6	11	0.6
OTHER PREYS						
Invertebrate debris	1.1	2.3	4.7	0.6	0.3	0.9
Unidentified	0.6	0.4	0.6	0.7	0.1	0.6

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Table 3: Relative Importance Index (%) of the diet of *Ptychadena mascareniensis* and *P. pumilio;* with respect to season in Banco National Park: n = total number of stomachs analyzed.

Prey category	*P. mascareniensis*		*P. pumilio*	
	dry season n = 76	rainy season n = 145	dry season n = 66	rainy season n = 147
Blattoptera	0.5	0.1	0	0
Coleoptera	5.5	22.7	42.3	29.5
Diptera	0.6	1.2	0	2.2
Heteroptera	1.1	0.5	0.3	0.1
Hymenoptera	4.8	8.5	12.7	20.9
Lepidoptera	33.5	2.5	9.7	2.1
Odonata	5.3	0	0	0
Orthoptera	7.8	49.9	14.4	13.9
INSECTA (Σ)	59.1	85.4	79.4	68.7
AMPHIBIANS	0.7	0.2	0	0
ANNELIDA	0	2.5	11.9	0
ARACHNIDA	20.8	2.5	3.1	25.7
CRUSTACEA	0	0	0.3	0.2
MOLLUSCA	1.1	0	0	1.9
PLANT MATERIAL	16.6	7.3	4.8	2.6
OTHER PREYS				
Invertebrate debris	0.7	1.9	0	0.7
Unidentified	1	0.2	0.5	0.2

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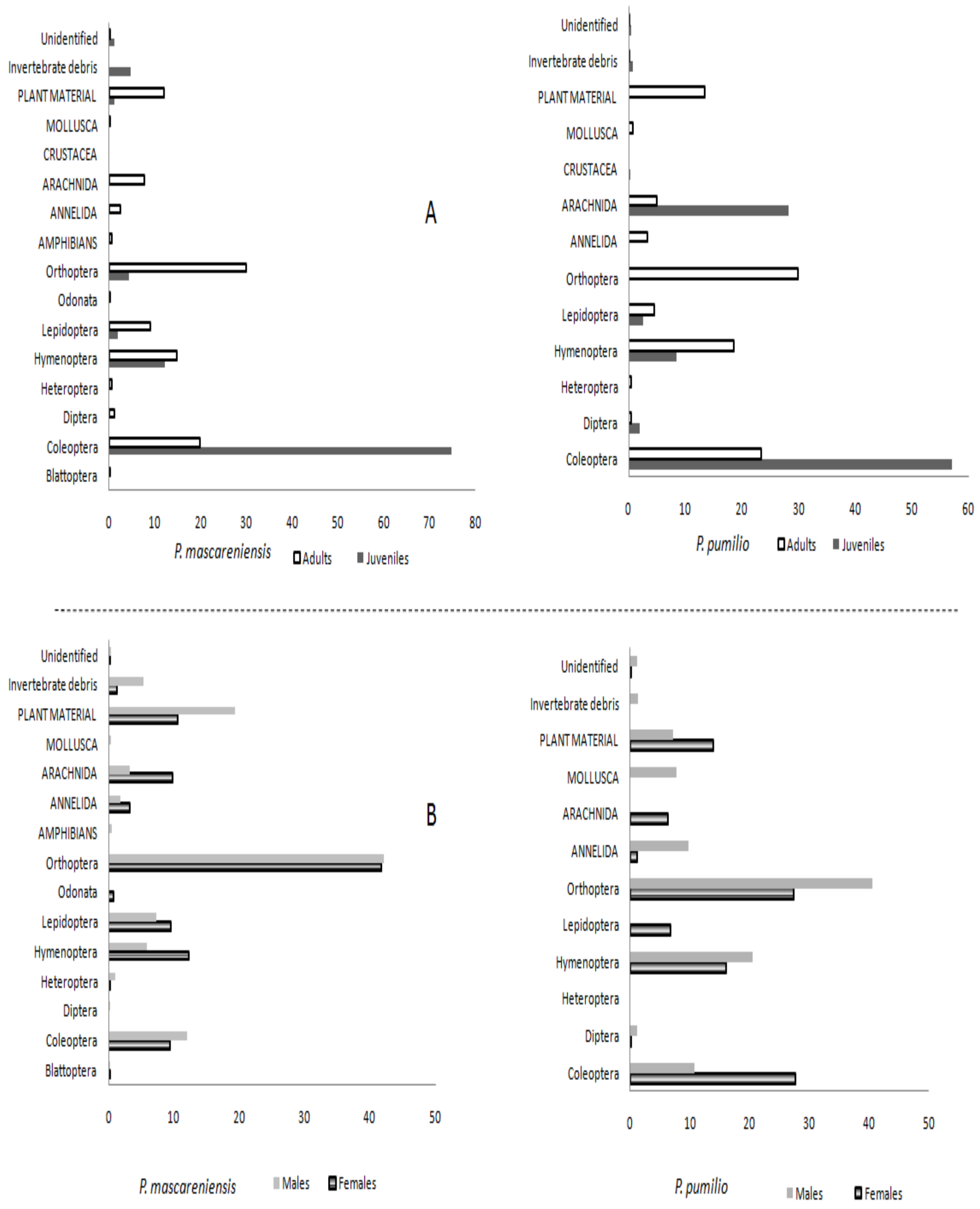

Fig. 2: Prey composition of *Ptychadena mascareniensis* and *P. pumilio* with respect to size (A) and sex (B).

References

1. Adeba, P.J., Kouassi, P. and Rödel M.-O. (2010) Anuran amphibians in a rapidly changing environment – revisiting Lamto, Côte d'Ivoire, 40 years after the first herpetofaunal investigations. African Journal of Herpetology, **59**: 1–16.

2. Assemian, N.E., Kouamé, N.G., Tohé B., Gourène G. and Rödel M.-O. (2006). The anurans of the Banco National Park, Côte d'Ivoire, a threatened West African rainforest. Salamandra, **42**: 41–51.

3. Aichinger, M. (1991) Faunal deficit of anurans in tropical farmland of Amazonian Peru. Alytes, **9**: 23–32.

4. Barbault, R. (1972) Les peuplements d'Amphibiens des savanes de Lamto (Côte d'Ivoire). Ann. Univ. Abidjan, serie E, V (1): 59–142.

5. Barbault, R. (1974) Le régime alimentaire des amphibiens de la savane de Lamto (Côte d'Ivoire). Bulletin de l'Institut Fondamental d'Afrique Noire, Série A, 36: 952–972.

6. Barbault, R. and Trefaut Rodrigues M. (1978) Observations sur la reproduction et la dynamique des populations de quelques anoures tropicaux. II: *Phrynobatrachus plicatus* (Günther). Geo-Eco-Trop, **2**: 455–466.

7. Camera, B.F., Krinski D. and Calvo I.A. (2014) Diet of the Neotropical frog *Leptodactylus mystaceus* (Anura: Leptodactylidae). Herpetology Notes, **7**: 31–36.

8. Da Silva, H.R. and De Britto-Pereira, M.C. (2006) How much fruit do fruit-eating frogs eat? An investigation on the diet of *Xenohyla truncata* (Lissamphibia: Anura: Hylidae). Journal of Zoology, **270**: 692–698.

9. Daget, J. and Iltis, A. (1965) Poissons de Côte d'Ivoire. Eaux douces et saumâtres. Institut Fondamental d'Afrique Noire, Dakar, **74**: 324–366.

10. Dierl W. and Ring, W. (1992) Guide des insectes: description, habitat, moeurs. Paris (Edition Delachaux et Niestlé).

11. Dietoa, Y.M. (2002) Entomofaune et stratégie alimentaires des poissons du genre *Brycinus* (Characidae) en milieux fluviatiles et lacustres (Bassins Bia et Agnébi; Côte d'Ivoire). Thèse de doctorat de l'Université d'Abobo-Adjamé, Côte d'Ivoire, 261 pp.

12. Du Preez, L.H. and Carruthers, V.C. (2009) A complete guide to the frogs of southern Africa. 488 pp. Cape Town, Struik Nature.

13. Fatroandrianjafinonjasolomiovazo, T.N.L., Rasoamampionona, N.R., Vieites D.R. and Vences, V. (2011) Diet of the Mascarene grass frog, *Ptychadena mascareniensis*, in Madagascar. Malagasy Nature, **5**: 68–74.

14. Frost, D.R. (2015) Amphibian species of the World: an Online Reference. Version 6.0 (last checked on 29 May, 2015). Electronic Database accessible at http://research.amnh.org/vz/herpetology/amphibia/: American Museum of Natural History, New York, USA.

15. Girard, G. Sircoulon J. and Touchebeuf, P. (1971). Aperçu sur les régimes hydrologiques. In: Avenard J.M., Eldin M., Guillaumet J.L., Adjanohoun E. & Perraud A. (eds.), Milieu naturel de la Côte d'Ivoire. Mémoire ORSTOM, **50**: 109–155.

16. Hillers, A., Loua N.S. and Rödel M.-O. (2008) A preliminary assessment of the amphibians of the Fouta Djallon, Guinea, West Africa. Salamandra, **44**: 113–122.

17. Hirschfeld, M. and Rödel M.-O. (2011) The diet of the African Tiger Frog, *Hoplobatrachus occipitalis* in northern Benin. Salamandra, **47**: 125–132.

18. Hofer, U., Bersier, L.F. and Borcard, D. (2004) Relating niche and spatial overlap at the community level. Oikos, **106**: 366–376.

19. Horn, H.S. (1966) Measurement of overlap in comparative ecological studies. – American Naturalist, **100**: 419–424.

20. Inger, R. and Marx, H. (1961) The food of amphibians. – In: Mission G.F. de Witte: Exploration du Parc National de l'Upemba, Institut des parcs nationaux du Congo et du Ruanda-Urundi, Fasc. 64: 1–86.

21. King, R.P. (1989) Distribution, abundance, size and feeding habitat of *Brienomyrus brachyisttius* (Gill, 1862) (Teleostei: Mormyridae) in a Nigerian rain forest stream, Cybium, **13**: 25–36.

22. Kouamé, N.G., Tohé, B., Assemian, N.E., Gourène, G. and Rödel, M.-O. (2008) Prey composition of two syntopic *Phrynobatrachus* species in the swamp forest of Banco National Park, Ivory Coast. Salamandra, **44**: 177–186.

23. Kpan, T.F., Adeba, P.J., Kouamé, N.G., Koné I., Kouassi, K.P. and Rödel, M.-O. (2014) The anuran fauna of a Volunteer Nature Reserve: the Tanoé-Ehy Swamp Forests, south-eastern Ivory Coast, West Africa. Zoosystematics and Evolution **90**: 261–270.

24. Legendre, P. and Legendre, L. (1998) Numerical ecology. 2nd English edition. Elsevier Science BV, Amsterdam, 853 pp.

25. Morisita, M. (1959) Measuring of interspecific association and similarity between communities. Memories of the Faculty of Sciences Kyushu University, Ser E, **3**: 65–80.

26. Nago, S.G.A, Grell, O. Sinsin, B. and Rödel, M.-O. (2006) The amphibian fauna of Pendjari National Park and surroundings, northern Benin. Salamandra, **42**: 93–108.

ISSN 2348 – 7968

27. Onadeko, A.B. and Rödel, M.-O. (2008) Anuran surveys in south-western Nigeria. Salamandra, **44**: 153–167.

28. Rödel, M.-O. (2000) Herpetofauna of West Africa Vol. I Amphibians of the West African Savanna. Edition Chimaira, 333pp.

29. Rödel, M.-O. and Branch, W.R. (2002) Herpetological survey of the Haute Dodo and Cavally forests, western Ivory Coast, Part I: Amphibians. Salamandra, **38**: 213–232.

30. Rödel, M.-O., Largen, M., Minter, L., Howell, K., Nussbaum, R., Vences, M. and Baha El Din, S. (2009) *Ptychadena mascareniensis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 03 February 2014.

31. Santos, E.M., Almeida, A.V. and Vasconcelos, S.D. (2004) Feeding habits of six anuran (Amphibia: Anura) species in a rainforest fragment in Northeastern Brazil. Iheringia, Série Zoologia, **94**: 433–438.

32. Tachet, H., Richoux, P., Bournaud, M. and Usseglo-Polatera P. (2003) Invertébrés d'eau douce: systématique, biologie, écologie. – Paris (Editions du Centre National de la Recherche Scientifique).

33. Toft, C.A. (1980) Seasonal variation in population of Panamanian litter frogs and their prey: a comparison of wetter and drier sites. Oecologia, **47**: 34–38.

34. Toft, C.A.,(1981) Feeding ecology of Panamanian litter anurans: Patterns in diet and foraging mode. Journal of Herpetology, **15**:139–144.

35. Tohé, B., Kouamé, N.G., Assemian, N.E., Gourène, G. and Rödel, M.-O. (2014) Dietary Strategies of the giant swamp frog *Hoplobatrachus occipitalis* in degraded areas of Banco National Park (Ivory Coast). International Journal of Scientific Research and Reviews, **3**: 34–46.

36. Vences, M., Kosuch, J., Rödel, M.-O., Lötters, S., Channing, A., Glaw, F. and Böhme, W. (2004) Phylogeography of *Ptychadena mascareniensis* suggests transoceanic dispersal in a widespread African-Malagasy frog lineage. Journal of Biogeography, **31**: 593–601.

37. Warkentin, I.G, Bickford, D., Sodhi, N. and Bradshaw, C.J.A. (2009) Eating frogs to extinction. Conservation Biology, **23**: 1056–1059.

38.Welcomme, R.L. (1985) River fisheries. FAO fisheries technical paper 262. Rome, 330 pp.

39. Zaret, T.M. and Rand, A.S. (1971). Competition in tropical stream fishes: support for the competitive exclusive principle. Ecology, **52**: 336–342.