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Diet of the Turtle *Phrynops rufipes* in Central Amazônia

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Phrynops rufipes is one of the least known Neotropical chelonians (Pritchard, 1984). Palm fruits constitute an important part of its diet in Colombia (Medem, 1973; Lamar and Medem, 1982). No information is available on the diet of the species in the eastern part of its range.

We investigated the diet of *P. rufipes* in the Reserva Florestal Adolpho Ducke (03°08′S, 60°04′W), central Amazônia, Brazil. This is near the eastern limit of its known range although studies of small forest streams have recently shown it to occur also in the state of Pará (INPA, Specimen number 1229). Initially, we tried to pump the stomach contents from individuals (Legler, 1977). However, we were unable to dislodge seeds that could be felt through the body wall, and one animal died as a result of puncturing the stomach wall (Museum of Zoology, University of São Paulo: Number 3059). Therefore, we used fecal analysis to evaluate the diet.

Materials and methods.—Animals were caught by hand or in funnel traps baited with raw chicken. All captures were made in a small stream, Igarapé Acará, and one of its unnamed tributaries. The study area has been described in detail by Magnusson and Lima (1991). Straight-line carapace length was measured with a tape accurate to 0.1 cm. Animals were marked with unique combinations of holes drilled in the marginal scutes. Turtles were retained for fecal analysis in the years 1992 (10), 1993 (15), and 1994 (21). Most of the 46 (61 including recaptures) were caught in the months of May (18), July (7), and September (6). None was caught in February.

Animals were maintained in captivity for two to four days in plastic basins and then released at the site of capture. Feces were collected daily. Usually the animals defecated only once, although the timing varied from the first to the fourth day in captivity. Of 61 attempts to obtain feces, only 39 were successful.

Items in the feces were identified to species (palm fruits), family (other fruits), or order (animals). The number present was the minimum number of prey that could have contributed to the collection of parts encountered. However, for most analyses, dietary items were grouped as palm fruits, other fruits, aquatic invertebrates, terrestrial invertebrates, or vertebrates.

Similarities between the diets of individual animals (only data from the first capture) were estimated by the Bray-Curtis (Czekanowski) index. This index was chosen because it is not affected by joint absences (Belbin, 1992) and is less affected by aliasing than most other multivariate distance measures (Mac Nally, 1994). Data on the frequency of occurrence of dietary items were range-standardized within individuals to give equal weights to different-sized individuals, which would otherwise differ in diet simply because larger animals produce more feces.

The diet categories are not independent of each other because time spent eating one item generally precludes the eating of another. Also, the general increase in quantity with size is expected for the obvious reason that larger animals have larger stomachs. To obtain a single index of diet, we used semistrong hybrid multidimensional scaling (SSH MDS) to create a single ordination representing covariation in the five major diet categories. All multivariate analyses were done using the PATN program (Belbin, 1992).

The distribution of captures was not ideal for examining seasonal variation in diets, but, as a first approximation, we looked for seasonal trends in diet by calculating the mean value for the five major categories and the compound index for each month. To test for serial correlations in the values for these indices, we used the mean square successive difference test (Zar, 1974:305).

Results.—The turtles ate a wide variety of foods (Tables 1–2). However, most of the fecal volume was palm seeds. The relationship between fecal volume and ingested volume is not known, but the proportions observed correspond to the relative proportions seen in the only animal dissected and in previous studies. Fruits of most of the palms that occur in the area were eaten. All of the palm fruits are drupes with large woody seeds and a thin covering of lipid-rich mesocarp. The mean lengths of seeds of species recovered from the feces are given in Table 1.

Larger animals tended to eat more items from each diet category except aquatic invertebrates (Fig. 1A–E). However, a significant relationship between size and frequency was found only for palms. The low probability of the null hypothesis for aquatic invertebrates ($P = 0.058$) suggests a reduction in this category for the largest size classes (Fig. 1A). All vertebrates that could be identified were lizards. Many spe-

TABLE 1. PLANT REMAINS FOUND IN THE FECES OF 39 *Phrynops rufipes*. Common names are given for two morphotypes of palms that could not be identified to species with certainty. Lengths represent the mean of seeds recovered from the feces.

Family	Species	Number of items	Length (cm)	Percentage of turtles
VEGETABLE				
Palmae	*Euterpe precatoria*	26	0.8	56.5%
	Socratea exorrhiza	19	1.5	41.3%
	Irriartela deltoide	10	2.0	21.7%
	Oenocarpus bacaba	06	1.5	13.0%
	Jessenia batua	06	3.0	13.0%
	"Munbaca"	03	2.0	6.5%
	"Pupunharana"	01	1.5	4.3%
Leguminosae	?	02	—	4.3%
Euphorbiaceae	?	03	1.2	6.5%
Humiriaceae	?	01	2.0	2.1%
Anonaceae	?	01	1.0	2.1%
Unidentified algae	?	02	—	4.3%
Unidentified vine	?	02	—	4.3%
Unidentified seeds		12	—	26.1%

cies, including *Uranoscodon superciliosa*, *Neusticurus bicarinatus*, and *Kentropyx striatus*, live in and around the streams, but we could not make specific identifications based on the partly digested scales. No fish were detected.

The multivariate index of diet was significantly associated with size of the individuals (Fig. 1F), indicating a strong and continual ontogenetic shift in the diet. Analysis of covariance indicated no significant effect of sex on this relationship ($F_{1,30} = 0.08$, $P = 0.79$). No significant seasonal trend was detected ($P > 0.5$ in all

TABLE 2. ANIMAL REMAINS FOUND IN FECES OF 39 *Phrynops rufipes*.

Order	Taxa	Number of items	Percentage of turtles
ANIMAL			
Trichoptera	Calamoceridae	19	41.3%
	Odontoceridae	15	32.6%
	Helycopsychidae	10	21.7%
Hymenoptera	Formicidae	09	19.5%
Arachnida	Acarina	03	6.5%
Diptera	Sciaridae	02	4.3%
	Physicosidae	01	2.2%
Coleoptera	Scolitidae	02	4.3%
	Nitidulidae	04	8.6%
Odonata	Libellulidae	02	4.3%
Isoptera	?	03	6.5%
Orthoptera	Gryllidae	04	8.7%
	?	04	8.7%
Blattodea	Blattidae	01	2.2%
	Tridactylidae	01	2.2%
Annelida	Hirudinea	01	2.2%
Homoptera	?	01	2.2%
Isopoda	?	01	2.2%
Decapoda		09	19.5%
Vertebrata	Lacertilia	17	36.9%
Invertebrate Larvae		04	8.7%
Unidentified fatlike substances		02	2.2%
Unidentified insects		05	10.8%

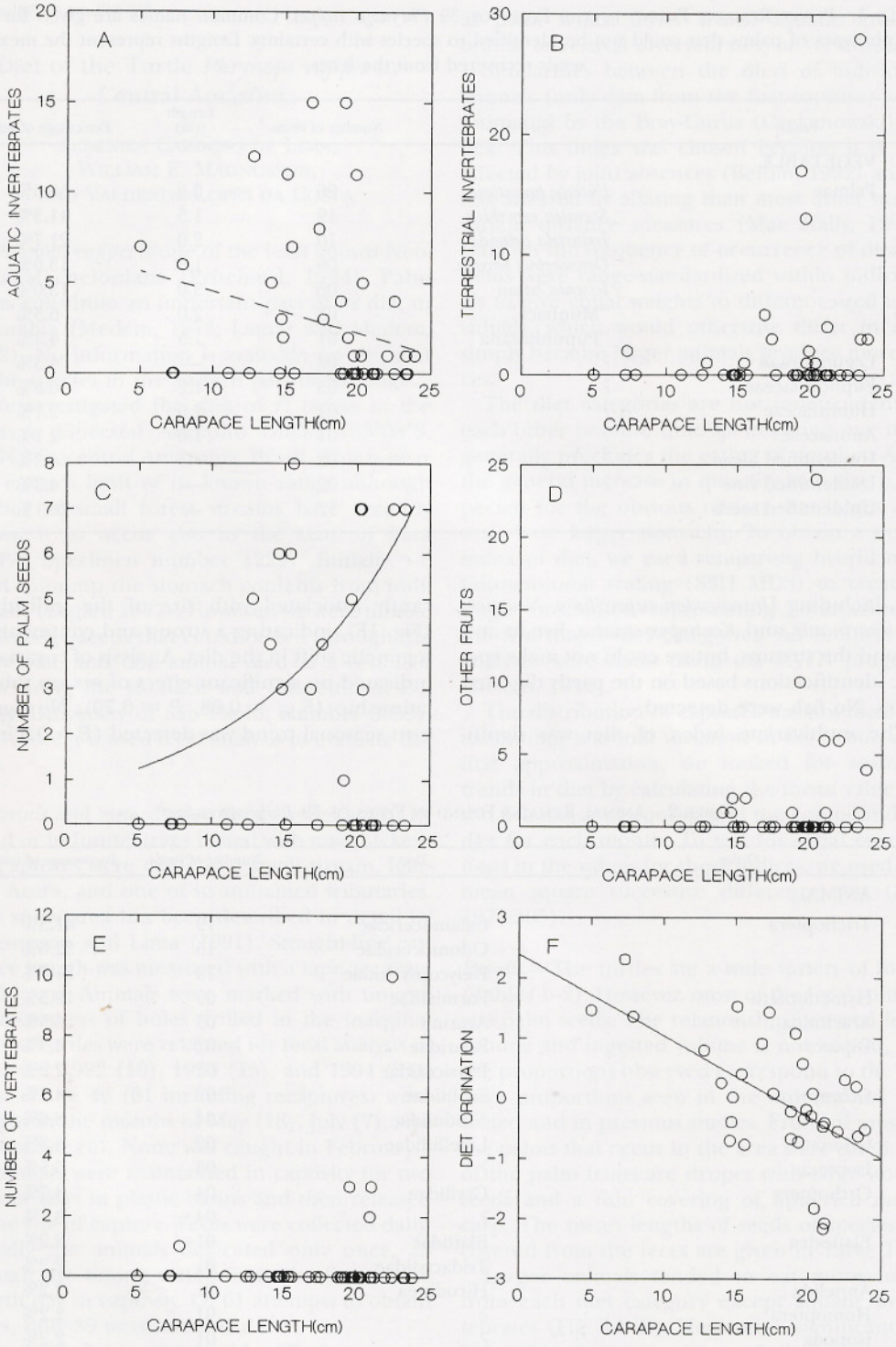

Fig. 1. Relationships between the carapace length (CL-cm) of 39 *Phrynops rufipes* and; (A) the number of aquatic invertebrates (AI) (AI = 6.78–0.23 CL, $r^2 = 0.06$, $P = 0.096$); (B) the number of terrestrial invertebrates ($r^2 = 0.04$, $P = 0.171$); (C) the number of palm seeds (PS) (PS = $-0.33 + 0.09\log_e$CL, $r^2 = 0.10$, $P = 0.03$); (D) the number of non–palm fruits ($r^2 = 0.03$, $P = 0.28$); (E) the number of vertebrates ($r^2 = 0.03$, $P = 0.25$); (F) scores for an ordination of the previous five diet categories by multidimensional scaling (DO) (DO = 2.40–0.14CL, $r^2 = 0.38$, $P = 0.000$), based on fecal analysis.

cases). This did not appear to be a result of lumping diet categories. Most of the lowest diet categories occurred throughout the year or too infrequently to analyze for seasonal trends. The only exception was a palm species (*Oenocarpus bacaba*), which occurred in every month between December and May except April and was absent from June to November.

Discussion.—This study confirms the results of Lamar and Medem (1982) that *Phrynops rufipes* is a palm specialist. Animals form a greater proportion of the diets of the smaller size classes. The presence of shrimp is to be expected because these are the most common large-bodied invertebrates in the streams. They may be an important source of protein for the species. It is not clear how the turtles catch lizards when they do not generally appear to be capable of catching fish. However, many lizard species, such as *U. superciliosa* and *N. bicarinatus*, take refuge in streams when threatened by predators. Lizards hiding on the bottoms of streams may be vulnerable to turtles.

It may be that *P. rufipes* eats mainly palm fruits simply because they are the most common foods available in the forest. However, its apparent dependence on palms, at least for the larger size classes, may explain its restriction to small streams and lakes within closed-canopy rainforest. This habitat covers the greater part of the Amazon basin and, despite the species' rarity in museum collections (Pritchard, 1982), *P. rufipes* may be one of the most abundant South American chelonians. Palm fruits appear to be less available outside the forest and constitute a negligible proportion of the foods of turtles from large rivers in the Amazon basin (Almeida et al. 1986; Fachin Teran, 1992; Fachin Teran et al., 1995). Deforestation, and the concomitant loss of palm species, is likely to exclude the species from many areas in the near future.

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