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Diet of *Trachemys dorbigni* (Duméril & Bibron, 1835) (Testudines: Emydidae) in anthropic environments from southern Brazil

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Abstract. The objective of this study was to investigate the diet of *Trachemys dorbigni* in relation to two anthropic environments and the turtle's genders. The results suggest that *T. dorbigni* possesses a generalist opportunist diet, ingesting vegetal, animal and anthropic (synthetic and organic) food items. Vegetation was one of the items that contributed on the diet, mainly for the females with the food importance index (%IAi) > 40. Amongst the insects, larvae of Diptera were the most representative, with the frequency of occurrence (%F) > 90. The urban zone turtles ingested items of anthropic origin. We found significant differences on the diet volumes between rural and urban environments, but it didn't between both genders. Turtles from rural sites tend toward diet specialization, contrary to urban animals, which were more generalist.

Key words: D'Orbigny's slider, freshwater turtles, urban and rural areas, sexual variation on diet

Resumo: Dieta de *Trachemys dorbigni* (Duméril & Bibron, 1835) (Testudines: Emydidae) em ambientes antrópicos no extremo sul do Brasil. O objetivo deste estudo foi investigar a dieta de *Trachemys dorbigni* em relação a dois ambientes antrópicos e ao gênero sexual das tartarugas. Os resultados sugerem que *T. dorbigni* possui uma dieta generalista e oportunista, ingerindo itens alimentares vegetais, animais e antrópicos (sintéticos e orgânicos). A vegetação foi um dos itens que contribuiu na dieta, principalmente para as fêmeas com o índice de importância alimentar (%IAi) > 40. Entre os insetos, as larvas de Diptera foram as mais representativas, com a frequência de ocorrência (%F) > 90. As tartarugas da zona urbana ingeriram itens de origem antrópica. Diferenças significativas nos volumes de dieta entre ambientes rurais e urbanos foram observadas, mas não entre os gêneros sexuais. Tartarugas de áreas rurais tenderam a uma especialização na dieta, ao contrário dos animais urbanos, que foram mais generalistas.

Palavras-chave: tartaruga tigre d'água, tartarugas de água doce, área urbana e rural, variação sexual na dieta

Introduction

Studies on trophic ecology are an important tool to understand trophic interactions. Feeding may be seen as the main connection between an animal and its environment, and its knowledge provides basic information about the specie's biology (Schoener, 1974, Pough *et al*. 2008).

Turtles are important connection of trophic levels in marine and freshwater aquatic ecosystems, contributing for the energy flux, nutrients cycle, dispersion of riparian vegetation and water quality maintenance (Moll & Moll, 2004). The study on the diet of turtles may explain the variations in morphologic characteristics, habitat choice and composition patterns in riparian vegetation (Moll & Jansen 1995, Rhodin *et al*. 1984, Plummer & Farrar 1981).

Trachemys dorbigni (Duméril & Bibron, 1835) inhabits fluvial ecosystems as dams, rivers, lagoons and wetlands (Quintela & Loebmann 2009, Djik *et al*. 2014). In Brazilian territory it is considered one of the most abundant species in the state of Rio Grande do Sul (Bujes & Verrastro 2008, Fagundes *et al*. 2010). The diet of the species was studied on captivity (Lema & Ferreira 1990) and in natural environments (Pereira 1998, Bujes *et al.* 2007, Mascarenhas & Coimbra 2013, Hahn *et al*. 2013), but studies that describe the influence of anthropic environments in the diet of the species from southern of Brazil are still scarce.

The present study deals with the diet and feeding strategy of *Trachemys dorbigni* from southern Brazil populations in order to detect differences between two environments (i.e. urban and rural), and to the turtle's genders.

Material and Methods

Sixty specimens were collected in two anthropic environments in Rio Grande do Sul (Fig. 1). Twenty-eight individuals were collected (13 males: 15 females) in four lakes of the Centro Agropecuário da Palma, Universidade Federal de Pelotas (UFPel), in the rural area of Capão do Leão (31°48'01.1"S - 52°30'48.6"W). Other 32 individuals (14 males: 18 females) were collected in channels of the urban area of Pelotas (31°46'16.9"S - 52°18'45.9"W).

The collecting was made on summer and spring of 2010, 2011 and 2012 with the help of a deep hand net (50cm). Two individuals were collected during winter, in July of 2010. The turtles were euthanized for helminthological studies under the license of the Instituto Chico Mendes de Conservação da Biodiversidade (23196 - ICMBio) and approved by the Research Ethics Committee of the Universidade Federal de Pelotas (3026 - CEEA/UFPel). After the collecting, the turtles were transported to the Laboratório de Parasitologia de Animais Silvestres (LAPASIL/UFPel), where they were sexed and necropsied. The stomach contents were fixed in AFA (70°GL alcohol, formol 37% and glacial acetic acid) and conserved in alcohol 70°GL.

Each stomach was observed under a stereomicroscope and feeding items were identified, when possible, to the lowest taxonomic level according to Needham & Needham (1978), Mugnai *et al.* (2010) and Menezes *et al.* (2010), and with the aid of specialists. The volume of each feeding item was estimated through the volume alteration of the water column in a measuring cylinder with precision of 100mL (Souza & Abe 2000, Bonino *et al*. 2009) and/or by using the area (mm^3) in a millimetric petri dish, and afterwards converted into volume (mL) (Hellawell & Abel 1971).

The percentage volume (%V) of each item was calculated as the volume of a determined prey in relation to the total volume of all preys. The frequency of occurrence (%F), which corresponds to the percentage of number of stomachs on which a determined prey was found in relation to the total of analyzed stomachs. Both variables were calculated for males and females of all sites. And employed to calculate the feeding importance index (%IAi); Kawakami & Vazzoler (1980):

$$IAi\ \% = \frac{F\% * V\%}{\sum (F\% * V\%)}$$

The diet's feeding strategy for male and females in their respective environments was analysed using the graphic method of Costello (1990). This method is based in the dispersion of values of volumes from the feeding item in "Y" axis and frequency of occurrence in the "X" axis. When the points are disposed next to 100% of frequency of occurrence and 1% of volume, it suggests that the predator consumes different feeding items in low quantity, being considered generalist. Otherwise, when we position next to 1% of frequency of occurrence and 100% of volume, it indicates that the predator is a specialist (Costello 1990, Corrêa & Silva 2010).

Significant sex differences between urban and rural environments were assessed using a non-parametric two-way ANOSIM for which the null hypothesis is the absence of significant difference between groups (environments and sexual gender), being used a matrix of square-root transformed values of percentage of volume of all feeding items. The p level we choose was < 0.05 (Clarke & Gorley 2006). The level of significance was tested through permutation amongst the groups with 10.000 replicas. The R statistic of ANOSIM is an indication

Figure 1. Anthropic environments where specimens of *Trachemys dorbigni* were sampled in Rio Grande do Sul, Brazil. **A-B.** Centro Agropecuário da Palma/UFPEL, rural area of Capão do Leão. **C-D.** Urban area of Pelotas.

of the difference between the formed groups, where there is total similarity amongst the groups when R global presents = -1, group formation at random when R global= 0 and full dissimilarity amid the groups when R global = 1 (Clarke & Gorley 2006). For evaluation of which feeding item obtained higher contribution in the dissimilarity amongst groups, similarity percentage analysis (SIMPER) was applied, where the analysis was carried out using the *Paleontological Statistics Analysis* PAST 3.0 software (Hammer *et al*. 2001).

Results

Thirty eight turtles (63.3%) showed stomach content, 12 from rural and 26 from urban environments. Items were of animal, vegetal and anthropic (synthetic and organic) origin (Table I). Diet from urban turtles was richer variety of feeding items in comparison to the consumed by the rural turtles. Nematoda, Odanata, Coleoptera, Blattodea and anthropic origin material were found in the urban zone turtles' diet, whilst algae, Gastropoda and Decapoda appeared in the rural zone turtles' diet. The other items were shared by turtles of both environments (Table I).

According to two-way ANOSIM, the turtles' diet differs significantly between these two particular environments (R: 0.32; p = 0.0041), however, there was no significant difference between sex (R: -0.05: p = 0.7277) and according to the SIMPER test, the main feeding items responsible for the dissimilarity between both environments, were fine particulate matter and vegetable remains, with a contribution of 25.18% and 24.32%, respectively. In relation to the plant rests, urban turtles consumed seeds, stems, roots, flowers, parts of leaves and fruits, with %IAi of 59.21 occurring in the female diets (Table I). In the urban turtles' diet, Insecta was the most diversified, where Diptera occurred with a %F of 78.57 in males and 83.33 in females, however, with a higher %IAi for males (8.38) (Table I). Anthropic materials (synthetic and

Table I. Composition of stomach contents of *Trachemys dorbigni* (Testudines, Emydidae) from the southern Brazil. Data refer to all stomach contents sampled (n= 60) and according to turtle's genders (Male and Female) and environment (Rural and Urban). %F, occurrence frequency; %V, volume and %IAi, feeding importance index.

Feeding item	Rural						Urban					
	Males (n=13)			Females (n=15)			Males (n=14)			Females (n=18)		
	%F	%V	%IAi	%F	%V	%IAi	%F	%V	%IAi	%F	%V	%IAi
Algae	7.69	34.19	15.57	13.33	36.46	21.68						
Vegetation remnants	15.39	10.26	9.34	20.00	4.38	3.90	64.29	13.12	15.51	83.33	44.62	59.21
NEMATODA							50.00	0.43	0.40	22.22	0.02	0.01
GASTROPODA				6.67	0.05	0.01						
ARACHNIDA												
Acari	7.69	0.01	<0.00	13.33	<0.00	<0.00	21.43	0.01	<0.00	16.67	<0.00	<0.00
Aranae				6.67	0.02	0.01	14.29	0.03	0.01	16.67	0.02	0.01
CRUSTACEA												
Cladocera	7.69	0.68	0.31	13.33	21.00	12.47	7.14	4.57	0.60	16.67	10.56	2.80
Ostracoda	7.69	0.003	0.01	6.67	0.01	<0.00	14.29	0.14	0.04	11.11	0.03	0.01
Decapoda				13.33	3.74	2.22						
INSECTA												
Diptera (larva, pupa, adult)				26.67	0.47	0.56	78.57	5.80	8.38	83.33	3.08	4.09
Hemiptera (egg, nymph, adult)				13.33	0.93	0.55	28.57	4.79	2.52	27.78	0.66	0.29
Odonata (nymph)										5.56	0.01	<0.00
Hymenoptera (adult)	7.69	0.003	0.01				42.86	0.29	0.23	33.33	0.09	0.05
Coleoptera (adult)							14.29	0.06	0.02	38.89	0.28	0.17
Blattodea (ooteca)							7.14	0.14	0.02	11.11	0.52	0.09
Unidentified	7.69	0.10	0.05	6.67	0.19	0.05	78.57	0.94	1.35	55.56	0.94	0.38
ANTHROPIC MATERIAL												
Paper and plastic							35.71	5.76	3.78	44.44	0.44	0.31
Watermelon, fish* and bean										11.11	10.15	1.80
OTHERS												
Thin particulate matter	23.08	54.71	74.71	40.00	32.81	58.54	57.14	63.92	67.15	66.67	28.59	30.35

*Scales and muscle of *Mugil liza* Valenciennes, 1836 (Mugilidae)

organic) were consumed only by urban turtles, where paper and plastic rests had a %F of 35.71 in males and 44.44 in females; and beans, seeds, watermelon remains, scales and parts of fish tissue (*Mugil liza*) were also verified, with a %F of 11.1 (Table I). In the rural area, females turtles consumed mainly algae (%IAi = 21.68). The most important animal item consumed by rural turtles was Cladocera (%IAi = 12.47) and with higher volume (%V = 21.00) in relation to females (Table I). From the graph proposed by Costello (1990) it was determined that urban turtles presented a more generalist feeding strategy, however, Crustacea, Arachnida and Nematoda had a low importance, while vegetal remains with had a strong tendency to dominance in the females' diet (Fig. 2). Rural males and females tended to a more specialist feeding strategy in relation to the ingestion of vegetation, while items of animal origin had a low contribution (Fig. 3).

Discussion

The results suggest that *T. dorbigni* is a generalist opportunist turtle, which consumes both animal and vegetal items. Previous studies on the diet of the species agree with the data presented here about a generalist feeding pattern (Lema & Ferreira 1990, Pereira 1998, Bujes *et al*. 2007, Mascarenhas & Coimbra 2013, Hahn *et al*. 2013). In other *Trachemys* species, was also observed the ingestion of a diversity of feeding items (Dreslik 1999, Batistella 2008, Veléz 2009). The opportunism in the *T. dorbigni*, in relation to the ingestion of items anthropic, was observed in captivity as well as in natural environments (Lema & Ferreira 1990, Pereira 1998, Bujes et al. 2007). Bujes et al. (2007) registers the species as a predator to *Limnoperma fortunei* (Dunker, 1857) (golden mussel), an exotic bivalve mollusk, that way verifying the opportunism in the species. Even though *T. dorbigni* being considered a generalist species, vegetable items contribute considerably in the diet, as observed by Hahn et al. (2013), where vegetable items were registered with a contribution of 85.3% of the volume of all ingested feeding items.

As for the urban environments, macrophyte, possibly, constituted the most part of vegetable remnants, exactly because of their ability to be excellent colonizers of lotic and lentic aquatic ecosystems (Esteves & Camargo 1986), besides providing habitats for macroinvertebrates (Esteves & Camargo 1986) birds (Voltz 1995) and fishes (Delariva *et al*. 1994, Nakatani *et al*. 1997, Weaver *et al*. 1997). Environment characteristics, like the degradation of the habitat may influence in the freshwater turtles diet as observed for the *Phrynops geoffroanus* (Schweigger 1812) in anthropic environments (Souza & Abe 2000, Deconte 2012). Souza & Abe (2000) verified a great quantity of larvae and pupae of Chironomidae (Nematocera), as well as meat and rice in the feeding. Deconte (2012) observed that the frequency de items commonly ingested by the *P. geoffroanus* decreased as that the frequency of garbage increased.

Aquatic environments rich in organic matter in decomposition originated from anthropic actions, favor the development of insects as well as of other invertebrates (Connell 1978, Townsend & Scarsbrook 1997). The Chironomidae (Diptera), for example, are considered bio-indicators for constituting a group of bentonic macroinvertebrates more tolerant to adverse conditions on the water quality (Callisto *et al.* 2001). Besides, intrinsic and extrinsic factors, like temperature, presence of riparian forest and photoperiod, interfere in the presence and dispersion of prey, especially land-air insects, contributing to the occurrence of a diversity of insects in the urban area (Randal *et al.* 2000, Deconte 2012).

In this context, the diet composition of *T. dorbigni* may reflect the characteristics of the urban environments, as the insects represent the most diversified group among the items of animal origin found in the stomach contents of urban turtles (Table I). The presence of anthropic items in the urban area animal diet, the same way associates to anthropic actions of aquatic ecosystems degradation, for example, garbage disposal and sewage. These results were similar to Pereira (1998) and Bujes *et al.* (2007), which have found anthropic materials (paper and fishing line) in the *T. dorbigni* diet. Other fact that could be noted was the occurrence of Nematoda in the diet of urban area specimens, what may be related to the ingestion of these helminths along with the thin particulate material (sand and sediment), of which was consumed by turtles in periods of drought given the shortage of feeding resources. In the rural environment, the plant rests were the second most important item (%IAi), emphasizing principally the algae, that reached very high volumes in both sexes. It may probably be associated to the abundance of algae in eutrophic rural lakes, where high nutrient availability (Wetzel 1993). Rural turtles did not consume anthropic material. However, it is not possible to state that it is an environment with no pollution, given that it may show itself in other way,

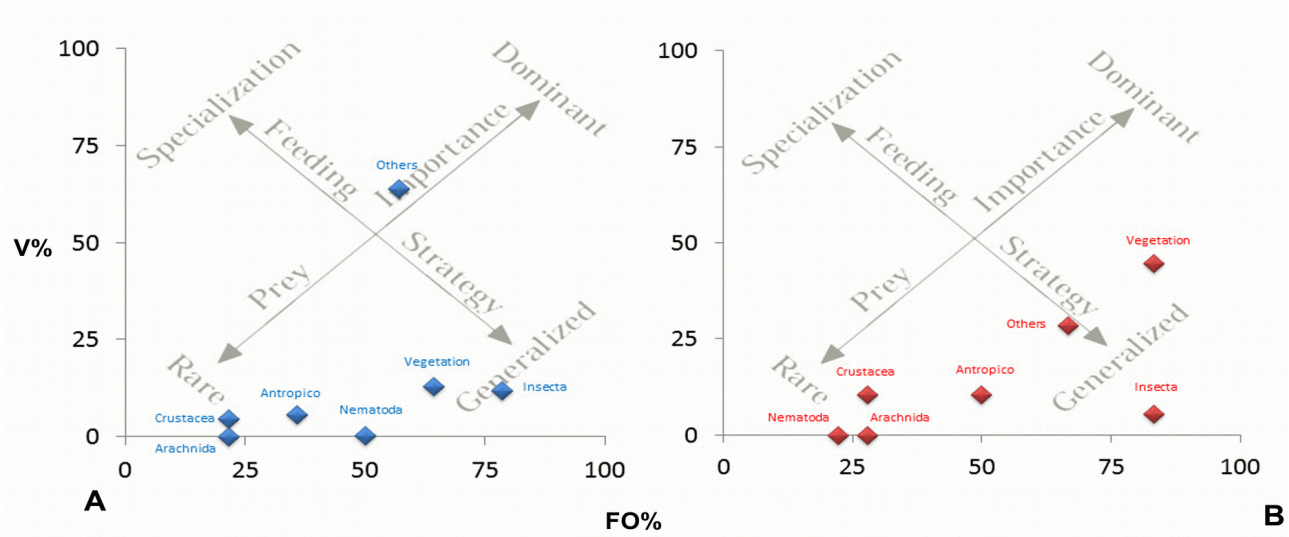

Figure 2. Graph Costello (1990) from the frequency of occurrence (%F) and volume percentage (%V) of large groups of feeding items found in male diet (A) and female (B) *Trachemys dorbigni* in urban environment from southern Brazil.

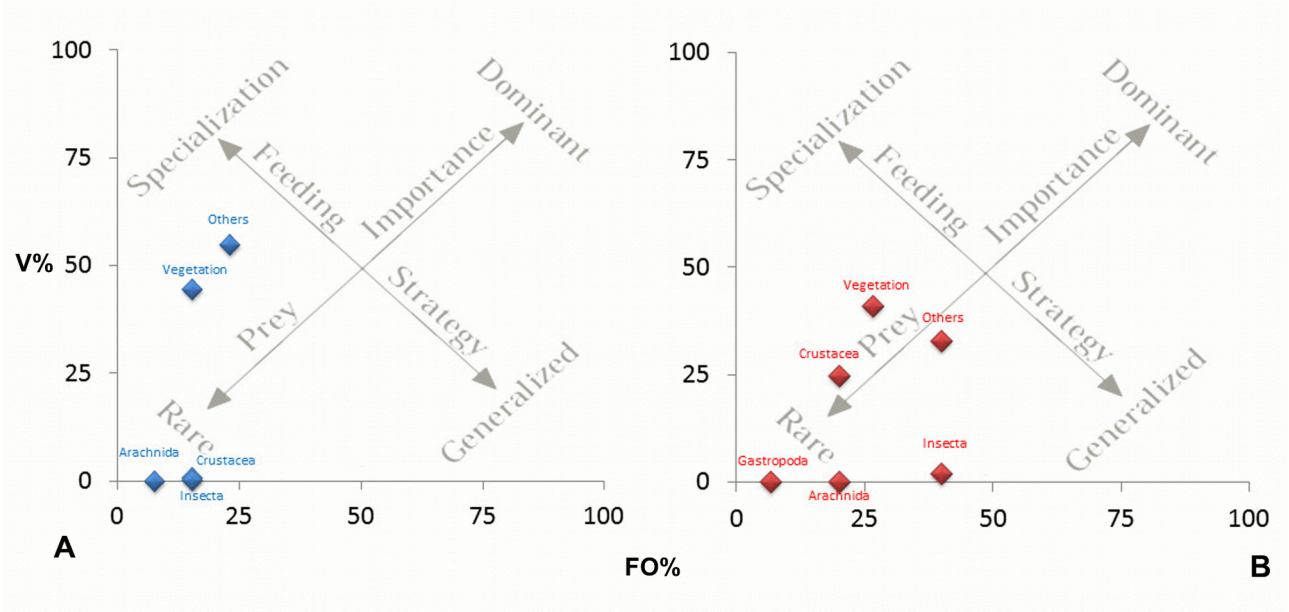

Figure 3. Graph Costello (1990) from the frequency of occurrence (%F) and volume percentage (%V) of large groups of feeding items found in male diet (A) and female (B) *Trachemys dorbigni* in a rural area from southern Brazil.

through agrochemicals used in plantations and the production of animals in confinement, which in turn make available nitrogen and phosphorus in great quantity, that way favoring, high primary activity (Merten & Minella 2002).

Even though no difference in the diet of males and females occurred in the tested environments, it was possible to notice that females tend to herbivory more than males. Similar results were observed for other freshwater turtles species (Moll, 1990, Teran *et al*. 1995). Besides, it is necessary to point out that the period of collecting (spring and summer) also comprehends the period of development of insects, which were the main feeding items consumed. In synthesis, *Trachemys dorbigni* has a generalist opportunist diet, consuming items from vegetable, animal and anthropic origins. Males and females present a similar diet, however, females from both environments, presented greater diversity of items of animal origin and used primarily vegetable material as an important feeding resource.

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