

Research Article

Tyto Furcata's Diet Analysis in Two Natural Protected Areas in the South of Santa Fe Province, Argentina

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Abstract

There is little background information on the trophic habits of *Tyto furcata* in the south of Santa Fe province. Based on the analysis of pellets, the diet of this raptor was characterized in two Natural Protected Areas (NPA) in the city of Casilda. The composition and diversity of prey items were documented. A total of 1342 pellets were recovered from the fieldwork and 3453 prey individuals were identified, distributed among 19 species of micromammals, mostly belonging to the Cricetidae family. According to the Shannon-Wiener index (H'), the ANP PE was the site with the highest dietary diversity ($H'=1.47$) with respect to the ANP FD ($H'=1.24$). These studies demonstrate that diet analysis of *Tyto furcata* can be considered a tool of high methodological value to mine the distribution of micro mammals avoiding other procedures (such as intensive trapping) potentially risky in terms of health and costly in time and effort.

Keywords: ANPs; Argentina; Micro mammals; *Tyto furcata*

Introduction

Pampas grasslands are considered to be one of the most modified natural ecosystems in the world [1,2]. According to its conservation status, the Pampas region has been categorized by the World Wildlife Foundation (WWF) as a "critically endangered/threatened" area, and is assigned the highest conservation priority due to its high biological diversity, its high degree of alteration and the scarce presence of protected natural areas [3-5].

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In the south of the province of Santa Fe, the region has been subdivided and its land use has changed its original appearance, being now a plain dominated by grain and oilseed crops. In this sense, agricultural activity brings with it a series of transformations that affect practically all ecological processes, from the behavior of individuals and population dynamics to the composition and structure of communities and the flow of matter and energy.

The barn owl (*Tyto furcata*) is distributed worldwide and in all types of environments except in the polar areas. Due to its specialized diet, it is one of the most important species in the regulation of rodent populations [6]. In the southern region of South America, the diet of this owl has been documented in numerous studies [7]. Most studies indicate that *Tyto furcata* consumes mainly rodents, opportunistically including other types of prey such as lagomorphs, marsupials, chiroptera, birds, reptiles, amphibians or insects [8-12].

Accordingly, and in order to expand the existing information in the southern part of the province, this research aims to analyze the composition of the diet of this raptor in two Natural Protected Areas (NPAs) to establish the main prey items and thus complete faunistic lists.

Materials and Methods

Study area

The study was carried out in the Casilda district, south of the province of Santa Fe, Argentina. The total area is 38,400 hectares (384 km²) of which 1,200 hectares correspond to urban area and the remaining 37,200 hectares to rural area, thus becoming the dominant matrix of the landscape (Figure 1).

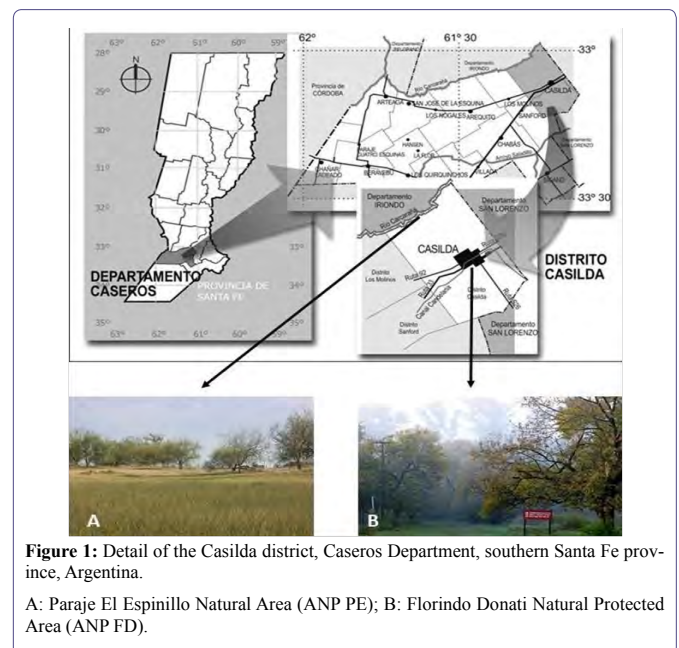


Figure 1: Detail of the Casilda district, Caseros Department, southern Santa Fe province, Argentina.

A: Paraje El Espinillo Natural Area (ANP PE); B: Florindo Donati Natural Protected Area (ANP FD).

Within this agricultural matrix there are two Natural Protected Areas (NPAs). According to the International Union for Conservation of Nature (IUCN), a protected area is understood as: "A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature and its ecosystem services and associated cultural values". In other words, protected areas are fundamental not only to the conservation of both natural and cultural biodiversity, but also to the environmental goods and services they provide to human communities. On the other hand, and according to the Convention on Biological Diversity, "protected area" means a geographically defined area that has been designated or regulated and managed to achieve specific conservation objectives.

Taking this into account, the study areas in this research include

- Florindo Donati Natural Protected Area (ANP FD) (33° 03' 21" S, 61° 09' 11" W): With an area of approximately 240 hectares, the property constitutes a biogeographic island for the vertebrate fauna of the region, an effective conservation corridor for migratory birds, genetic flow between patches and ANP's of the Pampeana ecosystem. It has an important number of tree species that, although they are not native, serve as a refuge for wildlife [13] (Figure 1).
- Paraje El Espinillo Natural Area (ANP PE) (32° 55' 02" S, 61° 13' 27" W): The physiognomy of the landscape is characterized, by farmland but with notable variations in relatively small spaces. Which is crossed by the Carcarañá river, develops a valuable regional landscape with ecosystemic varieties, whose extension depends on the conjunction of several environmental factors, mainly the topography that frequently operates as a limiting factor for the agricultural activity (irregularities such as undulations of the land, hollows, hills, etc.) and consequently allows the survival of flora and fauna species in a more or less autonomous way, ensuring the preservation (although with certain limitations) of some structural and functional parameters of the native balanced ecosystem. The studied area is characterized by climax communities of Flechillas (*Stipa neesiana*, *Stipa papposa*) or *Piptochaetium montevidense*, which are frequently accompanied or complemented by other non-grass species (*Chevreulia sarmentosa*, *Berroa gnaphalioides*, *Bacharis articulata*, *Bacharis salicifolia*, *Bromelia sp.* etc.). The floodable depressions have a particular physiognomy in the landscape because they give rise to very interesting hydrophilic communities that develop in a transitory way accompanying the periods with permanence of water. There it is possible to find important extensions of *Eleocharis sp.*, *Sagittaria sp.*, *Scirpus sp.*, *Cyperus sp.* and even *Typha latifolia*. In spite of what has been described, one of the most important features of the place is the presence of woody species typical of the espinal. There are important specimens of Talas (*Celtis sp.*) that show an age structure typical of an expanding community, a phenomenon even more significant in the territorial occupation developed by the Chañar (*Geoffroea decorticans*). Both species are distributed mainly in the highest areas, very rarely associated with flooded depressions. Their forests, of different sizes, occupy the hills with a high population density (more of the Chañar than the Tala). Another well distributed species is the Sina-Sina (*Parkinsonia aculeata*) which accompanies other

species, the Sina-Sinas are more dispersed individuals but with a consistent and less concentrated distribution. The presence of specimens of Algarrobos (*Prosopis sp.*), is an interesting indicator that the formation maintains acceptable conditions even for this type of slow growing species. The invasion of woody exotics is visualized in specimens of *Morus alba*, *Melia azedarach*, *Gleditsia triacanthos* and *Ligustrum lucidum* (Figure 1).

Data collection

It has been possible to get a better understanding of the diversity, abundance, behavior and vulnerability of prey species by analyzing the content of pellets, which are non-digestible material regurgitated by birds of prey [14].

In this work, the diet analysis of *Tyto furcata's* is used as an indirect method, but with a high degree of reliability, to know the fauna present in the two NPAs in the south of the province of Santa Fe, Argentina.

Between January and December 2020, pellets were collected monthly at previously established points in the sampling sites. The pellets were placed in labeled paper bags and then in hermetically sealed polyethylene bags, respecting all Biosafety measures (use of latex gloves and surgical face mask) for the collection and the drying of the material, which was done in a laboratory with an oven at 70°C for 48hrs [15]. Each pellet was weighed on an analytical scale and its length and width were measured with a digital vernier. The pellets were then processed, using surgical instruments to extract the remains of the mandibles and skulls of the animals found.

The jaws and skulls of the captured prey were compared with samples which were identified in different osteological collections and specialized literature [16-19]. Pairs of mandibles of the same species and/or skull were considered as one individual.

Data analysis

The following were determined: (a) Species richness (S) understood as the number of species in a sample. (b) Relative abundance, understood as the percentage fraction of the total number of animals [17], which made it possible to identify species of low representativeness (low abundance). (c) Diversity α (intra-environment), considering specific richness and structure. The latter was determined according to the Shannon-Wiener diversity index, which quantifies the total diversity of a sample, being influenced by two fundamental components: richness and equity. It thus considers the importance value of each species and expresses the uniformity of importance values across all species in the sample.

The formula for this function is:

$$H' = -\sum p_i \ln p_i$$

Where p_i is the proportion of the total number of individuals in the sample that corresponds to the species, whose values are displayed between zero and the logarithm of S when there is only one species. To test the null hypothesis that the diversity H' of both PNAs are equal, the procedure of Hutcheson (1970) described in Zar was followed, consisting of a t-test calculating the weighted diversity index ($H_p = (N \log N) - (\sum f_i \log f_i) / N$) [20]. The percentage contributed to the diet in terms of biomass by each species was calculated as $n_i w_{pi} 100 / \sum (n_i w_{pi})$, where n_i is the number of individuals of prey i and w_{pi} is the average weight of prey i . The average prey weights were taken from specialized literature [18,21,22].

Finally, Jaccard's Coefficient of Similarity was used to express the degree to which two samples, in this case PNAs, are similar in terms of the species present in them, and are therefore an inverse measure of diversity, which refers to the change in species between two stations [23,24]. The range of values for Jaccard's index goes from 0, when there are no shared species between both stations, to 1, when two stations have the same species composition. This coefficient was obtained according to the following expression:

$$I_j = C / A + B - C$$

Where a = number of species present at site A, b = number of species present at site B and c = number of species present at both sites A and B.

Because a significant proportion of the birds of prey could not be determined to genus or species level and the contribution of amphibians and reptiles was negligible, only the contribution of micromammals was estimated.

Results

A total of 1342 barn owl pellets were recovered in the two Natural Protected Areas and 3491 prey individuals were identified. For the ANP PE, a monthly average of 53.16 pellets was collected (SD= 16.83) with an average number of prey per pellet of (n = 2.8 individuals). The average weight of the pellets was 3.27gr. In the ANP FD, the average monthly number of pellets collected was 58.66 (SD=19.97) with an average number of prey per pellet of (n = 2.5 individuals). The average weight of the pellets was 2.78gr.

The trophic habits of the barn owl for the two NPAs showed a diet based mainly on small mammals (98.91%), followed by birds (0.97%) and finally amphibians and reptiles (0.11%).

The richness of micromammals that make up the diet is distributed in 19 species, mostly belonging to the Cricetidae family (Table 1).

In ANP FD, the most consumed prey item was one of the two species of the genus *Calomys* (50.32%), while in ANP PE the dominant prey item was *Akodon azarae* (35.17%).

In terms of biomass, *Akodon azarae* is the species that contributed most to the diet of *Tyto furcata* in ANP PE with 31.39%, followed by *Oligoryzomys flavescens* 18.98% and the two species of the genus *Calomys* with 14.5%. In the ANP FD this trend is reversed and the two species of the genus *Calomys* dominate the biomass contribution. It is in this area where commensal mice make an important contribution, especially *Rattus rattus* with 14.5%.

According to the Shannon-Wiener index (H'), the ANP PE was the site with the highest dietary diversity (H' = 1.47) regarding the ANP FD (H' = 1.24). In terms of diversity (H') there are significant differences between the richness and evenness of prey consumed in both environments ($t_{0,05(2) 3440} = 1.96$). These data are again confirmed from the results obtained by Jaccard's Coefficient of Similarity, which yields a similarity (Ij) = 0.36.

Discussion

The results of this study made it possible to compare the diet of *Tyto furcata* in two NPAs in the south of the province of Santa Fe, where previous data were practically non-existent.

Species	ANP PE			ANP FD		
	ni	pi (%)	B%	ni	pi (%)	B%
Didelphimorphia						
Didelphidae						
<i>Lutreolina crassicaudata</i>	2	0,11	1,32	-	-	-
<i>Monodelphis dimidiata</i>	1	0,06	0,13	-	-	-
Chiroptera						
Molossidae						
<i>Eumops bonariensis</i>	1	0,06	0,02	2	0,12	0,05
<i>Tadarida brasiliensis</i>	2	0,11	0,04	2	0,12	0,04
<i>Molossus molossus</i>	1	0,06	0,02	-	-	-
Rodentia						
Cricetidae						
<i>Akodon azarae</i>	612	35,17	31,39	480	28	26,2
<i>Oligoryzomys flavescens</i>	483	27,76	18,98	280	16,4	11,9
<i>Oligoryzomys nigripes</i>	27	1,55	1,74	-	-	-
<i>Calomys cf. C. laucha - C. musculus</i>	497	28,56	14,5	862	50,3	26,8
<i>Calomys venustus</i>	17	0,98	1,14	-	-	-
<i>Holochilus chacarius</i>	22	1,26	8,05	-	-	-
<i>Necomys lasiurus</i>	24	1,38	2,03	16	0,93	1,44
<i>Oxymycterus rufus</i>	15	0,86	2,54	-	-	-
<i>Graomys cf. Chacoensis</i>	20	1,15	3,18	-	-	-
Caviidae						
<i>Cavia aperea</i>	14	0,8	11,14	13	0,76	11
Muridae						
<i>Rattus norvegicus</i>	-	-	-	6	0,35	4,52
<i>Rattus rattus</i>	-	-	-	28	1,63	14,5
<i>Mus musculus</i>	-	-	-	24	1,4	0,9
Lagomorpha						
Leporidae						
<i>Lepus europaeus</i>	2	0,11	1,59	-	-	-
Total Number of Individuals (N)	1740			1713		
Total Number of Species (S)	16			10		

Table 1: List of micro mammals surveyed in two NPAs of southern Santa Fe province and their relative abundance. References: ANP PE: Natural Protected Area "Paraje el Espinillo"; ANP FD: Natural Protected Area "Florindo Donati". ni: number of individuals of species i, pi (%): proportion corresponding to species i, B%: percentage represented in the diet by each species in terms of biomass.

Diet, from an ecological point of view, refers to the trophic margin of all food categories that are consumed by an animal. Available information on the feeding habits of the barn owl in Argentina suggests that prey consumption patterns are aimed in active searches for small mammals, preying mainly on rodents [17,25-28]. The results of this research agree with this pattern, as the presence of small mammals (98.91%) in the pellets of barn owls corroborates this trend.

In terms of richness and relative abundance, the structure of the predatory micromammal assemblage in the ANP FD seems to respond similarly to patterns found in other areas of the Pampas ecoregion [17,25-30] among others, since the community was dominated by *Calomys cf. C. laucha - C. musculus*. The reason for the existence of species typical of agroecosystems lies in the fact that the ANP FD is located in a peri-urban area where it can be considered a transition zone between the urban center and the agricultural fields.

This is also in line with the presence of rodents of the Muridae family such as *Rattus rattus*, *Rattus norvegicus* and *Mus musculus*, which are closely related to humans (commensal rodents) and are particularly recognized for their impact on public health because they are natural reservoirs of various pathogenic microorganisms. For example, *Rattus rattus* and *Rattus norvegicus* are vector species of the bacteria *Salmonella typhimurium* and *Leptospira interrogans* and are involved in the biological cycle of the parasite *Trichinella spiralis*. Another commensal species of potential health risk for humans is *Mus musculus*, since it has domiciliary and peridomiciliary nesting habits and is the main reservoir of the lymphocytic choriomeningitis virus.

The species *Akodon azarae* comes to dominate the assemblage to the detriment of the genus *Calomys* in the ANP PE. *Oligoryzomys flavescens* also increases its proportion in this environment in relation to the rest of the species studied, demonstrating that both species (*Oligoryzomys flavescens* and *Akodon azarae*) prefer more stable habitats as mentioned by Bellocq, 1988; Guidobono, 2013; Massa, 2015 covered with high vegetation cover [25].

As the ANP PE is a complex (vertical variation) and heterogeneous (horizontal variation) environment which contains a greater diversity of microhabitats that can be occupied by species with different requirements, a greater diversity of species is observed. Examples of these include *Holochilus chacarius* and *Oxymycterus rufus*, which are species, associated with riparian environments, and *Graomys chacoensis*, which prefers forests and shrublands, among some of the species present in this type of environment.

Some more information about the ANP PE is the presence of *Lutreolina crassicaudata* and *Monodelphis dimidiata* as part of the diet of *Tyto furcata*. Although the number of specimens is low, the results are relevant because these species have been little studied in Argentina and there are few or no records in the area. The transformation and degradation of the natural habitat due to the advance of the agricultural boundary is the main threat to these species. In this work, the records were presented in the ANP PE, which agrees with what has been mentioned by several authors that in the Pampean region some populations have been fragmented, occupying isolated patches of native vegetation or with low intensity of use.

In this research it is likely that the relative abundance and available biomass of the two species of the genus *Calomys*, *Akodon azarae*, *Oligoryzomys flavescens* and *Rattus rattus* explain why the diet of this predator concentrates its foraging activities on these rodents, making them a more profitable hunting target (in terms of energy compensation) than other predatory species.

This contribution demonstrates the importance of the natural relicts that still exist for the fauna in a purely agricultural area. However, the advance of cultivated areas in recent years could contribute to reduce the areas studied in this work, so we recommend the development of actions aimed at increasing research on key, threatened and ecologically relevant species present in the area, in order to incorporate effective strategies in the conservation proposals that lead to the sustainable management of resources in the region.

Another point to highlight is the importance of the study of micromammal communities based on *Tyto furcata*'s diet analysis, since it can be considered a tool of high methodological value to

determine the distribution of micromammals at low densities, avoiding other procedures (such as intensive trapping) that are potentially risky in terms of health and costly in terms of time and effort.

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