DIET AND ACTIVITY PATTERNS OF *LEOPARDUS GUIGNA* IN RELATION TO PREY AVAILABILITY IN FOREST FRAGMENTS OF THE CHILEAN TEMPERATE RAINFOREST

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Dedication

For all those who care and would preserve wildlife in harmony with the human society, especially for my son and husband.

Abstract

The güiña (*Leopardus guigna*) or kod kod is one of the least known wild cats in the world. It is classified as vulnerable by IUCN with the most restricted distribution of any felid species in the world. I recorded the activity patterns of güiñas, determined diet composition, and measured prey availability in four cover types in Pucón, La Araucanía Region. I captured and followed five güiñas with VHF radio-telemetry and collected 67 scats for diet analysis. Güiña presented nocturnal and crepuscular peaks of activity. The güiña diet was mainly based on the most abundant rodents in the study area in accordance with a rodent survey and the teeth and hair analysis of scats. The small mammals captured were *Oligoryzomys longicaudatus, Abrothrix longipilis, Abrothrix olivaceus,* and *Rattus rattus*. This study contributes to the understanding of the influence of a highly fragmented habitat in activity, diet and prey offer of güiña.

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Introduction

The güiña or kodkod cat (*Leopardus guigna*) is the smallest cat in the neotropical rainforest and among the least known of the wildcats. Güiña distribution is the most restricted in the world among felids, inhabiting just a narrow strip of land in Chile and Argentina (IUCN 2008, Iriarte, 2008). Güiña range varies from 70° to 75° W and 30° to 50°S latitude, in the center and south of Chile and a narrow strip of the Argentinean Andes foothills (Iriarte & Jacksic, 2012).

Habitat

The güiña is a native rainforest specialist associated with Nothofagus rainforest. The habitat preferred by güiña is characterized by a dense vertical vegetation of at least 1.5 m understory height and scrub-thicket-forest (Dunstone et al., 2002). Güiña may use different habitats for resting and for hunting. In part this is driven by prey availability in different habitats, but in some cases small mammal density is not different among forested areas and brushy areas that güiñas use (Freer, 2004). Dense understory could be a safer environment for güiñas that are hunting. Likewise güiñas avoid roads and pine plantations, possibly due to the human activity associated with these cover types (Acosta-Jamett & Simonetti, 2004).

In relation to the size of habitat patches used by güiñas, Acosta-Jamett & Simonetti (2004) proposed that large patches of rainforest were necessary to maintain güiña populations. Recently, Gálvez et al., (2013) suggested that smaller patch sizes of 20 to 40 ha would allow the long term survival of güiñas in a progressively fragmented landscape.

Activity

One of the major influences on activity patterns of carnivores is prey availability (Zielinski et al., 1983). Inconsistent conclusions have emerged from existing studies on güiña activity patterns. For example, one study found no differences in güiña activity patterns between day and night (Dunstone et al., 2002). Some studies suggest that güiña increase activity during crepuscular hours (Sanderson et al., 2002; Freer, 2004). Other studies show that güiña are more active during the night with a decrease in activity during the day (Sanderson et al., 2002; Hernández, 2010; Delibes-Mateos et al., 2014).

Earlier ecological studies on güiña have mainly been conducted in its coastal distribution in continuous rainforest (Dunstone et al., 2002; Sanderson et al., 2002). Since 2010, there have been research projects on the ecological aspects of güiñas in its distribution, in the foothills of Los Andes (pre-Andean) range (Hernández, 2010; Fleschutz 2013; Gálvez et al., 2013; Herrmann et al., 2013; Castro-Bustamante 2014), where this project occurred.

Diet

Some common conclusions are emerging from studies of güiña across its range that are consistent with other small wild cats. Small wild cats consume primarily rodents (Nowell & Jackson, 1996). Geoffroyi's cat (*Leopardus geoffroyi*) diet is more than 75% rodents (Napolitano et al. 2008; Bisceglia et al., 2008). Pampa's cat (*L. colocolo*) diet is about 92% rodents (García-Esponda et al., 2009), the oncilla (*L. tigrinus*) diet is about 66% rodents (Wang, 2002) and the margay (*L. wiedii)* diet is about 70% arboreal rodents, (de Oliveira, 1998; Nowell & Jackson, 1996). The Andean cat (*Oreailurus jacobita*) diet is highly specialized on just two Andean rodents; viscachas (*Lagidium* *viscacia*) and chinchillas (*Chinchilla chinchilla*) (Walker et al., 2007; Napolitano et al., 2008). Güiña are similar to other small felids in that about 70% of their prey species are rodents. Güiña's preferred prey species are cricetine rodents, with the species of rodents consumed varying with geographic location (Freer, 2004; Zúñiga et al., 2005).

Other small mammal species from different orders are consumed by small cat species when rodents are not available. The wildcat (*Felis silvestris*) is considered a rodent specialist, but also preys on rabbits (*Oryctolagus cuniculus*) (Malo et al., 2004). Güiña diet can include about 20% birds (Dunstone et al., 2002; Freer, 2004; Correa & Roa, 2005). Birds consumed by güiña include wild and domestic birds such as the austral thrush (*Turdus falklandii*), Southern lapwing (*Vanellus chilensis*), chucao (*Scelorchilus rubecula*) and huet-huet (*Pteroptochos tarnii*). Güiña may also prey on domestic poultry. Geese (*Anser domesticus*) and chicken (*Gallus domesticus*) are opportunistic dietary items (Sanderson et al., 2002).

Other alternative prey may include lizards (*Liolaemus pictus chiloeensis*), *Dromiciops gliroides*, in the order Microbiotheria, rabbits (*O. cuniculus*), vegetable matter, and insects. There is evidence of low occurrence of carrion in the diet of güiña, but the extent of prey-switching by güiña is unknown (Sanderson et al., 2002; Freer, 2004; Correa & Roa, 2005).

All the past studies done on the diet of güiñas were focused on their coastal distribution and all of the studies were located in protected areas. Practically nothing is known about the diet of güiña in areas like my study area, which is a more anthropogenic landscape in which fragmentation predominates.

Güiñas preys species

The small mammal species found in the study area, are in the orders Microbiotheria, Didelphimorphia, and Rodentia (Quintana, 2008; Iriarte, 2008). The Microbiotherid present is the colocolo opossum (*D. gliroides*). Didelphids include the mouse-opossum (*Thylamis elegans*), but the mouse-opossum is very rare (Quintana, 2008). Potential prey species of Rodentia are in the Cricetidae Family, including *Oligoryzomys longicaudatus*, *Abrothrix longipilis*, *A. olivaceus*, *Loxodontomys micropus* and *Irenomys tarsalis*. *L. micropus* are caught infrequently and are likely rare (Quintana, 2008; Iriarte, 2008).

Güiña may also prey on non-native species. Invasive fauna in the study area include the black rat (*Rattus rattus*), the Norway rat (*R. norvegicus*) and the common house mouse (*Mus musculus*). Two species of Lagomorpha, European rabbit (*O. cuniculus*) and hares (*Lepus europaeus*) are invasive species that could also be preyed upon by güiñas (Correa & Roa, 2005; Iriarte, 2008).

In this research I recorded the activity of güiñas from radio-telemetry data collected from September 2010 to April 2012. I also estimated diet composition from analysis of güiña scats. Diet composition from scat analysis was compared to prey abundance from small mammal trapping to make inferences about prey species preference and abundance.

Methods

Study Area

The study was conducted in the pre-Andean zone of the Araucanía (IX Region), which represents the northern limit of the temperate rainforest in Chile (39°15´S). Two national parks, one national reserve and two private land conservation sites are protected areas that surround the study site (Fig. 1). This site has a temperate climate with precipitation throughout the year. There is small variation in average temperatures among seasons, without marked seasonality. In the study area the annual mean temperature for the years that the study was made was 12°C (Red Agroclima FDF-INIA-DMC, 2010).

The pre-Andean valleys that form the study area are surrounded by mountains, lakes and volcanoes. The fragmented forest is divided into small (8-20 ha) and large (100-300 ha) fragments that are embedded within an agricultural matrix. The forest species dominant in Pucón shape the mixed deciduous forest that is an association of partially deciduous trees dominated by *Nothofagus obliqua* and other perennial species, including *N. dombeyi*, *Laureliopsis sempervirens, L. philippiana*, *Persea lingue, Aextoxicon punctatum* and *Saxegothaea conspicua* (Gajardo, 1994).

Güiña trapping and activity

Wooden and Tomahawk® live traps, (*n*=30) were set in forest fragments where the presence of güiña had been confirmed with photos, sightings or scat. We used wildcat lure odor attractants in the surrounding area 2 meters from each trap. *Valeriana officinalis* extract and dried *Nepeta cataria* were attached to the traps. We stopped using wildcat lure after 11 trapping sessions to avoid attracting bigger species which could trigger the avoidance of traps by güiñas. Once the animals were captured, their weight was visually estimated to calculate the dose of the anesthetic. The anesthetic protocol that was followed in the first two güiñas was ketamine-xylazine through intramuscular injection using yohimbine as the antagonist (Acosta et al., 2007). The anesthetic protocol was then switched to ketamine-dexomedetomidine and atipamezole as the antagonist. The ketamine-dexomedetomidine protocol diminishes secondary effects as myoclonic twitching, and apnea in anesthetized animals compared to the ketamine-xylazine protocol (Verstegen et al., 1991; Selmi et al., 2003).

Anesthetized animals were sexed, weighed, and marked with a subcutaneous microchip with a unique identification number. VHF radio collars with mortality switches were attached. We trapped and radio-collared five güiñas that were followed in sessions of 1 to 4 hours. We used a hand-held flexible 3-element Yagi antenna and receiver (Model Silka, Biotrack, UK.) to locate each güiña. Each data collection event consisted of recording information from the location (proximity to water sources, habitat use, existence and distance to human dwellings), weather (clouds, rain), behavior and strength of the received signal. Behavior was classified active or inactive based on pulse rate of the VHF transmitter. Inactivity was represented by constant pulses and the pulse rate became irregular when the animal was active.

Radio-telemetry data were collected at least 15 days in every month for each güiña captured. Every location was estimated from triangulations of three bearings. Each bearing was taken pointing the antenna to the strongest reception of the signal from the transmitter, recording the UTM, the local time and the compass direction. To minimize location bias, only azimuths with an angular difference between 60° and 120° were used (White & Garrot, 1990). In order to avoid error due to the animal movements, locations for triangulation were taken within a 10 minute interval. The time between one location and the next location in the same session was at least 15 minutes whenever possible and the time between consecutive sessions of locations was at least 8 hours.

Activity analysis

Whether güiñas were active or inactive during sunrise, day, sunset, and night periods was tested. Sunrise and sunset occurred when the sun was 6 degrees below horizon. The period called sunrise was established from 1 hour before sunrise to 1 hour after sunrise, and the period called sunset was from 1 hour before sunset to 1 hour after sunset (Ridpath, 2012).

The day was divided into four stages, and I assumed that sunrise and sunset lasted 120 minutes. Day length varied depending on the time when the sun set or rose (this corresponds to civil twilight). Night began one hour after sunset and ended one hour before sunrise. From spring 2010 (22 September 2010) to fall 2012 (19 June 2012) the day length varied from 7 hours 24 minutes in winter on the shortest day of the year, to 12 hours 56 minutes in summer on the longest day of the year, averaging 11 hours 50 minutes from December 21st to March 20th (spring to summer) and 8 hours 26 minutes from March 21st to June 20th (fall to winter). Night lasted an average of 8 hours and 10 minutes from December 21st to March 20th and 11 hours 33 from March 21st to June 20th.

I compared the number of inactive and active bearings to assess if they were evenly distributed in different time periods. I also compared activity between males and females and among seasons.

Dietary analysis

We collected scats opportunistically during field work from September 2010 to May 2012. We also searched habitats which were frequently used by güiñas based on the radio-telemetry data. Scats were collected near water courses and native forest patches, stored in a paper bag labeled with the georeference of the location (WGS 1984 UTM Zone 19S) where the scat was found, and date. Assignment of the scats to *L. guigna* was based on the morphology keys described for this species (Freer, 2004) and then confirmed through microscopic analysis of hair contained in the samples originating from grooming. The sample was considered confirmed if it was collected from a trap or if a güiña's hair was present. If the scat was morphologically consistent with güiña, but hair was not found, the sample was classified as probably from güiña.

The dried scats were segmented and then broken apart to obtain the indigestible prey remains. The remains retrieved (hairs, feathers, bones, nails, teeth) were compared with reference keys from known prey species (Reise, 1973; Pearson, 1995; Fernández et al., 2011). Prey items were classified to the lowest taxonomic resolution possible for that sample as small mammals, birds, fish, vegetable matter, and invertebrates. Mammals were identified to the species level while birds were considered a single class. The relative importance of every dietary item was expressed by different indices of occurrence.

Bones, teeth, and hairs were used to identify mammals. The hairs were collected, placing all the hairs retrieved from one sample above a 1 cm side grid and then from 10 random squares subsamples of the scat were picked to analyze them in the microscope (40Xmagnification power). All the hairs retrieved from the scat were analyzed in their cuticle characteristics and compared with local keys (Chehébar, 1989; Freer, 2004). In order to make the hair impressions, one slide was painted with clear nail polish and left to dry for about 5 minutes, then the hairs were put over the polish layer and another slide was placed on top, compressing the hair in between the two slides with the nail polish to generate a cuticle impression. After five minutes, the slides were separated and the hairs were gently removed from the nail polish (Quadros & Monteiro-Filho, 2006).

Contributions to the diet made by each prey category were expressed by different indices of prey occurrence. The percentage of occurrence of each food item (RF) is the frequency of one dietary item compared to all the prey items present. The percentage biomass of a prey item is a measure of the importance of every prey item in the diet. It is calculated by multiplying the average body mass of one prey item, according to the literature and field collection, by the number of individuals found. For estimating the weight of the prey items contained in each scat, I assumed the presence of one individual of each species found if I found its presence in the hair analysis in the scat, but in the teeth analysis if I found more than 2 jaws from the same species I assumed presence of more than one individual for that species. The percentage occurrence of the dominant item (largest volume class) is the most frequent prey item found and it is calculated by dividing the number of times that a prey item is found by the total number of prey items.

Rodent capture and manipulation

We assessed the relative abundance of rodents from April 2011 to July 2011 by live trapping with grids of Sherman traps. Grids were placed in patches of native rainforest, corridor, meadow, and forest plantation (Table 1) within the study site with three replicates of each cover type. We did not use some cover types because güiña were not expected to be present. Cover types not used included glaciers and permanent snow, paved and dirt roads, shrubland, urban and industrial areas, watercourses, wetlands, lava flow, dumps, and rocks which covered 15% of the study area (Servicio Aerofotométrico de la Fuerza Aérea de Chile, 2007; Fig. 2).

The trap grid covered 1,250 m^2 and was arranged in 5 columns and 10 rows. Each trap was 5 meters from the previous trap. The trap grid was set for 5 consecutive nights (250 trap nights). Traps were baited with a mix of oatmeal and peanut butter. They were checked early every morning because all rodents present in the study area were nocturnal or crepuscular (Quintana, 2008).

Trapped animals were identified to species level (Iriarte, 2008). Body mass was determined using an Electronic LCD Balance. Each individual was marked with a unique numbered ear tag in the left ear to permit the recognition of recaptured animals, and was then released at the site of capture.

Results

Güiña trapping and activity

Two male güiña and three female güiña were trapped between September 2010 and April 2012 (a total of 3,323 trap nights). We monitored the locations of güiña from September 2010 to April 2012. We collected 3,388 bearings to calculate 1,153 locations (Table 2). We had from 37 to 466 locations per individual (Table 3) in 21 months of tracking.

The active bearings in the five güiñas sampled were not evenly distributed among 24 hours for any individual (F01 χ^2_3 = 293.36, P< 0.05; F03 χ^2_3 = 283.45, P< 0.05; M01 χ^2_3 = 456.92, P< 0.05, and M02 χ^2_3 = 130.71, P< 0.05). The bearings of most güiñas were not evenly distributed between active and inactive behavior throughout the 24hours (χ^2_3 = 91.8, P< 0.05; Fig. 3). For F01 there were no differences between inactive and active bearings, being active 50% of the times it was sampled (χ^2_3 = 1.7, P= 0.65). F03 had more active bearings at dusk and was slightly more active at sunrise. M01 was more active at night and sunrise (χ^2_3 = 9.7, P= 0.02), (χ^2_3 = 99.3, P< 0.05), and M02 had more inactive bearings than the theoretical expected over the 24 hours, and it presented more activity at dusk and at night (χ^2_3 = 80.8, P< 0.05). F02 was not used in this analysis because only 37 locations were collected (Table 4).

There were two peaks of activity each day according to the percentage of active bearings per hour of all the güiñas. Peaks were between 4:00 and 6:00, when 60% (182 of 304) of bearings were active and between 20:00 to 23:00, when 64% (302/471) were active (Fig. 3).

During the day 36% of the bearings indicated activity, at dusk 58% of the bearings indicated activity, and at night and sunrise about the 50% of bearings indicated activity (Fig. 4). Comparing between sexes, females were more active than males during the day, dusk and sunrise periods. At night both female and male were active about 50% of the time. Females were active around 50% of the time in day and night, and active more than 60% in dusk and sunrise. Males were active about 50% of the time in dusk and night, about 40% in the sunrise period and about 20% during day.

The comparison of active bearings between sexes did not show differences overall (χ^2_3 = 0.51, P = 0.92). However the two males appeared to be less active during the day than the two females (25% and 49%, respectively; Fig. 5). At dusk both females and males were active at least half of the time. At night, both sexes were active about

50%, although one of the males had lower activity. At sunrise activity was above 50% for all güiña with >30 locations (Table 4).

There were differences in activity in fall, spring, and summer (fall χ^2_3 = 8.6, P< 0.05, spring χ^2_3 = 20, P< 0.05, summer χ^2_3 = 63.8, P< 0.05), but activity was evenly distributed in winter χ^2_3 = 0.7, P=0.12. In each season night was the period when there were more active records. In fall there were more active bearings in dusk and sunrise, in spring güiñas had more active bearings at sunrise, and in summer there were more active bearings at dusk.

Rodent trapping

A total of 113 rodents were captured during 3000 trap-nights. Rodents captured included *O. longicaudatus, A. longipilis, A. olivaceus,* and *R. rattus.* The average number of captured individuals for 100 trap nights was variable among sites and within cover types. Each cover type had 1 or 2 sites with high capture success, and other sites with lower capture success. The success order of captures from higher to lower averages was forest plantation > corridor > native forest > meadow (Table 5).

In native forest, meadow, and corridors the most common rodent captured was *O. longicaudatus.* Half of the captures were *O. longicaudatus* in native forest and meadow. In the forest plantation cover type half of the captures were *A. longipilis* (Table 6).

The species varied in capture rate relative to cover type. *O. longicaudatus* (χ^2_3 = 10, P= 0.02) and *A. olivaceus* (χ^2_3 = 11.18, P= 0.01) had more captures in native forest and corridor, *R. rattus* (χ^2_3 = 12.26, P= 0.01) had more captures in native forest and forest plantation, and *A. longipilis* (χ^2_3 = 36.17, P< 0.05) had more captures in forest plantation (Table 5).

Scat Analysis

I collected 67 scats, 81% of which were confirmed to be güiña based on presence of güiña hair. Thirty five scats were found in latrines, which are areas where deposit of scats are left by an animal, five scats were inside the trap at capture, and 27 scats were at other locations which were close to water bodies. Scats confirmed to be from güiña were in latrines (52%), outside of latrines (38%), and in the trap at capture (10%).

From the 67 scats, 4 were too degraded to be analyzed, 2 were not within standard measurements of güiña scat and therefore were discarded from the analysis, 51 were confirmed as belonging to güiña, and 10 were considered unconfirmed.

Weight, diameter, and length were measured to compare the confirmed and unconfirmed scats. The confirmed (47 measurable samples) and unconfirmed scats (9 measurable samples) were not different in weight (t_{15}=0.84, P= 0.41), length (t_{17}=0.83, P= 0.42), or diameter (t_{13}=1.31, P= 0.21). The percentage of scats with hairs, bones, or feathers also was not different between the confirmed and unconfirmed scats, (Fig. 6; t_{11}=0.31, P= 0.76, t_{17}=1.12, P= 0.28, t_4=0.43, P=0.69).

Güiña diet in the region consisted predominantly of mammals based on hair and bones in scats. Vegetable matter, birds, insects and fish were present in low percentages (Fig. 7). Identifiable remains of teeth and mandibles in scats (43% of the confirmed samples) were from *A. olivaceus*, *R. rattus*, *A. longipilis*, *O. longicaudatus* and *D. gliroides* (Table 7). The same prey species were identified by analysis of hair, as well as the European rabbit (*O. cuniculus*).

Frequency of occurrence

Sixty one scats were analyzed for hair content, of which 51 samples were confirmed and 10 unconfirmed. From the unconfirmed scats there were 5 that did not have güiña hair and were discarded from further analysis. Mass, length and diameter of these discarded scats were consistent with güiña scats, but they were not found in latrines, the remaining 5 unconfirmed samples were included in prey content analysis because they were consistent with the measures of güiña scats and also were found in latrines where confirmed scats were found. The most common prey species found were *O. longicaudatus, A. longipilis*, *R. rattus*, and *A. olivaceus* (Table 8).

Percentage occurrence of the dominant item

From analysis of hairs from each scat, about half of the scats had two prey species. About half of the scats had a single prey species, and only five scats had more than 2 prey species (Table 9). *O. longicaudatus* was the main prey found in confirmed scats and the second most frequent prey in unconfirmed scats (Table 8). *R. rattus* was the second most common species, being present in one third of the confirmed scats, *A. longipilis* was the third most common species in both confirmed and unconfirmed scats, and *O. cuniculus* was present in about one fifth of the confirmed scats while it was the most common species in unconfirmed scats. The least frequent prey species were *A. olivaceus* and *D. gliroides.*

Discussion

Small mammals were the most important item in the güiñas' diet. Almost all scats had one or two prey species (average prey range range 27-188 g). Over 80% of the diet was comprised of small mammals based on frequency of occurrence. The most consumed species were *O. longicaudatus, A. longipilis,* and *R. rattus.* The second most consumed prey species, *A. longipilis*, was the most consumed prey in El Maule, central Chile (373 km to the north of my study area) and also in Rucamanque, La Araucanía region (98 km north of my study area) (Zúñiga et al., 2005; Correa & Roa, 2005). *A. olivaceus* was one of the less preferred prey species in the pre-Andean zone of La Araucanía region. Is important to consider that preferences for rodent species vary according with the distribution of güiñas (Freer, 2004; Zúñiga et al., 2005).

Even though I found feathers in several scats, birds are a secondary item in the güiña diet. Feathers were found in 15 of 65 samples (23%), but they were only 3% of the scat composition. These findings are consistent with previous studies on the Chilean north Patagonian rainforest where avian remains were in less than 20% of the samples and in Rucamanque, La Araucanía region (Freer, 2004; Zúñiga et al., 2005).

Similarly, I found presence of fish in a very low percentage (2%). Fish was documented for the first time as part of the diet of güiña from two confirmed scats. The fish could be attributed to scavenging on remains of fishing activity, because these samples were collected where human fishing occurred. Freer (2004) observed one individual attempting to prey on fish, although no evidence of fish was found in the scat analysis. It is very unlikely that the samples came from a predator different from güiña because the size and shape of the sampled scats were different from scats of other potential predators, dogs, foxes or pumas (Iriarte et al., 1991). Güiña hairs were also present in the samples that contained fish scales.

The insects found in the scats may have entered the sample after deposition. Leaves and some of the vegetable matter also could have become attached after deposition, or they could be from incidental ingestion.

The prey availability in the four land uses showed that *R. rattus, O. longicaudatus, A. longipilis* and *A. olivaceus* were the rodent species present in the study area based on trapping. If we compare with the scat analysis findings, it is evident that other small mammal species are present in the area, although in lower abundance. Small mammal species in güiña scat in very low percentages included, *D. gliroides,* and at a higher percentage*, O. cuniculus.*

About 60% of the unconfirmed samples were taken from latrines where other samples were confirmed to be of güiña, which might have increased the possibility of belonging to güiña. Because they did not have güiña hair, I did not include them in the analysis. From the remaining 6 unconfirmed samples which were not found in latrines, 5 contained rabbit as prey item. It was very difficult to find güiña hairs in samples that contained rabbit hairs, and it is likely these scats were not from güiña, but came from another carnivore. For future studies genetic analysis of the epithelial cells left in the surface of the scat would help confirm assignment of the scats to güiña.

The three most frequent species in the güiña diet were the three most common small mammals in the trap survey, all of them reported to have nocturnal behavior (Quintana, 2008). The dominant cover type among the home ranges of the güiñas in the study area was native forest. Native forest was the cover type where güiña were found most of the time (Castro_bustamante, 2014), also this cover type had higher *O. longicaudatus* abundance, and this species was the most common prey species in güiña diet. Meadow was the second most common cover type in the home range of güiña, but the highly fragmented landscape composition inside the home ranges and in the study area in general make meadow cover type less available. The trap sessions for capturing güiñas were in fragmented native forest embedded within an agricultural matrix which implies that güiñas captured in those fragments would have at least these two types of land uses in their home ranges (Castro-Bustamante, 2014).

If the landscape were less fragmented we could expect that home ranges would have included more native forested shrubland (Acosta-Jamett & Simonetti, 2004). One other factor to be considered is that the home ranges represent areas that could probably be used based on locations, but field observations revealed that meadow was not frequently used. Meadows had the lowest captures of small mammals among the four surveyed cover types, with just one *O. longicaudatus* caught.

Among the most common cover types in the home range of güiñas were lava streams and shrublands (Castro-Bustamante, 2014). Lava streams are overrepresented because just one güiña frequented this cover type about half of the recorded time. Shrubland was variable among individuals. These two cover types were not sampled for rodent abundances because we prioritized the most preferred cover type described for güiña in order to optimize the field work and at the same time to focus on the differences between native and non-native landscapes (Acosta-Jammet & Simonetti, 2004).

We assessed rodent abundances in non-native forest plantation, even though it was not a common cover type, in order to compare differences in prey availability for güiña compared to native forest. Density of the invasive species *R. rattus* was highest in forest plantations. *R. rattus* was present in about a third of the scats and it was also was one of the three most preferred prey species. The most abundant species found in forest plantation was *A. longipilis,* one of the two most common species in the güiña diet. Corridors were less than 0.02% of the study area, and they had the 4 captured species in the rodent survey with *O. longicaudatus* as the most frequent captured species and also the most preyed upon. Despite being a rare cover type in the landscape, 11% of the güiña locations were in corridors (Castro-Bustamante, 2014).

Güiña are preying on animals that are more abundant (Table 5). In order to better describe availability of potential prey species in the study area it would be beneficial to incorporate arboreal sampling, and to use shrublands as a cover type. There are at least two arboreal species that have been identified in the güiña diet (Freer, 2004; Zúñiga et al., 2005). Beside these native species, it would be useful to assess the abundance of some introduced species of lagomorphs such as rabbits, which in this study are a part of güiñas diet in confirmed scats. Another way to improve the prey availability estimate is sampling in all the seasons with more repetitions in the main cover types (Murúa et al., 1987).

It is worthy to take into account that in the temperate Chilean native forest rodent abundances have seasonal increases with the maximum number of individuals for *A. olivaceus* and *O. longucaudatus* in fall and winter (March to September), *A. longipilis* (May to December) fluctuations in abundances are related to availability of resources and also to above average rainfall (Murúa et al., 1987; Jaksic & Lima 2003). These species have similar microhabitat utilization and high home range overlap (González et al., 2000). Interactions have been reported by means of rodent removal experiments in Chilean temperate rainforest that showed that *O. longicaudatus* have unpredictable population increases and *A.longipilis* showed significant increase when the removal of *A. olivaceus* occurred. *O. longicaudatus* and *A. olivaceus* are highly synchronic in their abundance fluctuations (Murúa et al., 1987). The scat analysis findings could be influenced by rodent abundance fluctuations. The trapping months in the present study coincided with the higher abundances reported for the most common species in the native forest (Murúa 1987).

The prey available in home ranges of güiña would determine in part the scat composition of güiña (Sanderson et al., 2002; Freer, 2004; Castro-Bustamante, 2014). In the case of this study as it was located inside a very fragmented landscape, the composition of the home range was composed by several cover types which had multiple prey species. I cannot attribute the prey present in the scat to one specific cover type in which güiña could have hunted.

In the activity analysis my results suggest that güiñas have the tendency towards crepuscular and nocturnal behavior with lower activity in day light hours. I found two marked peaks of activity, one near crepuscular hours increasing the activity in the first hour of the sunrise, and at dusk after the first hour of sunset, and at night at least 2 hours after the beginning of the night. I also found increases in activity before midday. The lowest percentages of activity in the 24 hours were during the day. My findings are similar to those made in the same region and also with those found 360 km south from my study site in the continental fjords of the Chilean Patagonia using a camera trap survey (Hernández, 2010; Delibes-Mateos et al., 2014).

There was variability in activity between females and males, with females more active than males in the day. It is probable that female güiñas as well as other wildcats are more active because they must spend more time alert and obtaining food, which means less time for resting (Geertsema, 1985).

One of the radio-collared females (F02) was a kitten güiña who had very few bearings in comparison with the other cats and we did not have records of her at either dusk or night hours. This female probably moved out of radio-telemetry range, because she was captured in a forest fragment and then she moved 7 km from the capture site towards continuous rainforest with very limited access.

Some findings depicted in the present study can be improved by repeating the small mammal survey throughout the year and in the most preferred cover types for güiña. It also could be improved by capturing more güiñas, but because trapping and radio-telemetry is difficult, an alternative would be to complement our current data with other non-invasive techniques such as a camera trap survey.

This study is one of the first studies on this vulnerable and cryptic small wild cat in the pre-Andean zone of Araucanía region, and in a highly anthropogenic fragmented landscape where güiña is found. Other studies have been associated mainly with continuous native forest (Sanderson et al., 2002; Acosta-Jamett & Simonetti, 2004). We established that güiñas are mostly active at night with a crepuscular tendency, and that small mammals are the main part of güiña diet here also. One explanation of the differences between the present study and the studies where güiña was found to have arrhythmic activity patterns in continuous rainforests is that güiña could be avoiding human presence in fragmented landscapes (Hernández, 2010; Delibes-Mateos et al., 2014), shifting their behavior from arrhythmic towards nocturnal hours when human activity decreases. This behavior has been documented for bobcats (*Felix rufus*) and coyotes (*Canis latrans*) in southern California, United States where their activity diminished in day hours in fragmented landscapes in order to avoid human presence (Tigas et al., 2002).

Table 1. Cover type composition of the 2,269 km^2 study area, the 170 km^2 of home range areas, and frequency güiñas were found in each cover type. Data were collected from radio-telemetry locations of five güiñas, home ranges were calculated using the Brownian Bridge Kernel 90% from September 2010 to April 2012 in Pucón, La Araucanía region, Chile (Castro-Bustamante, 2014).

Cover Type	Güiña locations	Study area	Home-range	Güiña locations
Native forest	622	68%	38%	56%
Meadow	168	15%	17%	15%
Wetland	160	1%	1%	14%
Corridor	117	<1%	<1%	10%
Forest plantation	19	<1%	1%	2%
Lava flow, dump and rocks	18	5%	27%	2%
Shrubland	6	6%	13%	1%
Dirt roads	3	<1%	1%	<1%
Water courses	0	3%	3%	<1%
Major roads	0	<1%	1%	<1%
Glacier and permanent snow	0	<1%	<1%	<1%
Urban and industrial areas	0	<1%	<1%	<1%
Total	1113	100%	100%	100%

Table 2. Total of number of bearings per hour per güiña in Pucón, pre-Andean zone of the Araucanía region of southern Chile (IX región) in the Cautín province, from September 2010 to April 2012.

	Number of Bearings per güiña						
Hours/ID	F01	F02	F03	M01	M02	Total	%bearings
0:00	41	-	22	37	9	109	3
1:00	37	-	24	42	28	131	4
2:00	45	-	24	33	29	131	3
3:00	35	-	18	33	22	108	3
4:00	28	2	15	35	14	94	4
5:00	31	7	18	46	17	119	6
6:00	22	-	16	56	6	100	6
7:00	24	-	29	47	16	116	6
8:00	29	10	18	60	8	125	3
9:00	36	33	19	67	37	192	4
10:00	43	15	25	69	65	217	5
11:00	57	11	22	83	25	198	4
12:00	27	-	19	50	20	116	6
13:00	11	-	20	78	40	149	6
14:00	55	-	16	56	31	158	5
15:00	29	3	23	40	34	129	4
16:00	45	12	33	76	29	195	4
17:00	65	18	29	71	25	208	3
18:00	40	-	24	86	36	186	3
19:00	28	-	18	61	29	136	3
20:00	28	-	18	44	22	112	4
21:00	7	-	12	56	23	98	3
22:00	13	-	21	51	29	114	3
23:00	40	-	24	52	31	147	4
Total	816	111	507	1329	625	3388	100

Table 3. Number of radio-telemetry locations per güiña in Pucón, pre-Andean zone of the Araucanía region of southern Chile (IX región) in the Cautín province, from September 2010 to April 2012.

	Number of locations per individual					
Month/year	**F01**	**F02**	**F03**	**M01**	**M02**	**Total**
Sept 2010	-	-	-	44	-	44
Oct 2010	-	-	-	87	-	87
Nov 2010	-	-	-	56	12	68
Dec 2010	-	-	-	36	53	89
Jan 2011	-	-	-	72	73	145
Feb 2011	-	-	-	28	71	99
March 2011	-	-	-	27	0	27
Apr 2011	-	-	-	18	0	18
May 2011	-	-	-	36	0	36
June 2011	9	-	-	27	0	36
July 2011	56	-	-	18	0	74
Aug 2011	66	-	-	1	0	67
Sept 2011	46	-	-	17	0	63
Oct 2011	36	13	-	0	0	49
Nov 2011	49	24	-	0	0	73
Jan 2012	10	0	-	0	0	10
Feb 2012	0	0	56	0	0	56
March 2012	0	0	56	0	0	57
Apr 2012	0	0	57	0	0	56
Total	272	37	169	466	209	1153

Table 4. Number of radio-telemetry bearings and percentage of active bearings in day, dusk, night and sunrise periods for each güiña, Pucón, pre-Andean zone of the Araucanía region of southern Chile (IX region) in the Cautín province, from September 2010 to April 2012.

ID	Day	Dusk	Night	Sunrise	Day % active	Dusk % active	Night % active	Sunrise % active
F01	335	128	290	63	48	53	49	59
F03	239	40	190	38	47	80	48	66
M01	711	105	429	84	27	50	68	54
M02	367	51	193	14	20	49	30	29

Table 5. Success and number of each species captured in 0.125 ha sampling areas, corrected by number of traps closed and without bait by habitat type in Pucón, La Araucanía region, Cautín province, Fall & Winter 2010.

Habitat type	Trap effort corrected	Capture s	Trap success	Captures per 100 trap nights (number of captures)				
				Ollo	*Abol*	*Rara*	*Ablo*	total
Forest Plantation								
1	239	23	10%	1	0	3	5	10
2	241	20	8%	2	1	0	5	8
3	234	4	2%	0	0	2	0	2
Corridor								
1	240	31	13%	5	4	0	3	13
2	244	5	2%	0	0	1	0	2
3	248	2	1%	1	0	0	0	1
Native forest								
1	238	20	8%	4	3	1	1	8
2	250	3	1%	0	0	1	0	1
3	240	1	0%	0	0	0	0	0
Meadow								
1	249	3	1%	0	0	0	0	1
2	248	1	0%	0	0	0	0	0
3	250	0	0%	0	0	0	0	0

Ollo: Oligorysomys longicaudatus

Abol: Abrothrix olivaceus

Rara: Rattus rattus

Ablo: Abrothrix longipilis

Table 6. Number and percentage of capture of rodents (N=113) by means of live trapping with 5x10 grids by species in different cover types (4 cover types with 3 repetitions for each one) in Pucón, X region La Araucanía, Chile, April 2011 to July 2011.

Species/Land cover	N	Native forest %	N	Meadow %	N	Forest plantation %	N	Corridor %
Oligoryzomys longicaudatus	11	46	2	50	8	17	15	39
Abrothrix olivaceus	7	29	0	0	3	6	10	26
Rattus rattus	4	17	1	25	12	26	4	11
Abrothrix longipilis	2	8	1	25	24	51	9	24
Total	24	100	4	100	47	100	38	100

Table 7. Frequency of occurrence of prey species in confirmed güiña scats based on teeth (N=22) and hair remains (N=51) present. The percentages represent the number of individuals found in the total number of scats analyzed in each method.

Species	Teeth based analysis	Hair based analysis
Dromiciops gliroides	5%	4%
Oligoryzomys longicaudatus	27%	47%
Abrothrix longipilis	32%	39%
Abrothrix olivaceus	55%	29%
Rattus rattus	45%	37%
Oryctolagus cuniculus	-	20%

Table 8. Frequency of occurrence and percentage of occurrence of the dominant item (POD) of prey species found in confirmed (51) and unconfirmed (5) güiña scats through hair identification.

Species	Frequency of occurrence in confirmed scats	Frequency of occurrence in unconfirmed scats	POD confirmed scats	POD unconfirmed scats
Dromiciops gliroides	4%	0%	4%	0%
Oligoryzomys longicaudatus	47%	40%	37%	40%
Abrothrix longipilis	39%	20%	25%	20%
Abrothrix olivaceus	29%	20%	14%	20%
Rattus rattus	37%	0%	33%	0%
Oryctolagus cuniculus	20%	60%	18%	60%

Table 9. Number and percentage of güiña scats containing one to four prey species, weight average (g) and standard deviation based on teeth (N=22) and hair analysis (N=51) from confirmed scats.

Prey found per scat	Scats teeth based	Scats hair based	% Teeth based	% Hair based	Weight average ± sd in grams teeth based (range)	Weight average ± sd in grams hair based (range)
1	10	19	45	37	84±47(27-131)	221±383 (33-1,300)
2	10	26	45	51	131±45 (71-188)	355±500 (71-1,431)
3	2	5	9	10	165±52(128-202)	530±639 (202-1,488)
4	0	1	0	2	-	229

Figure 1. Study Area, Pucón city, province of Cautín, La Araucanía region, Chile. The map displays from right to left, red colored the location of La Araucanía region in Chile, and framed in a squared area the study area inside Pucón. The different cover types and the protected areas are represented by different colors.

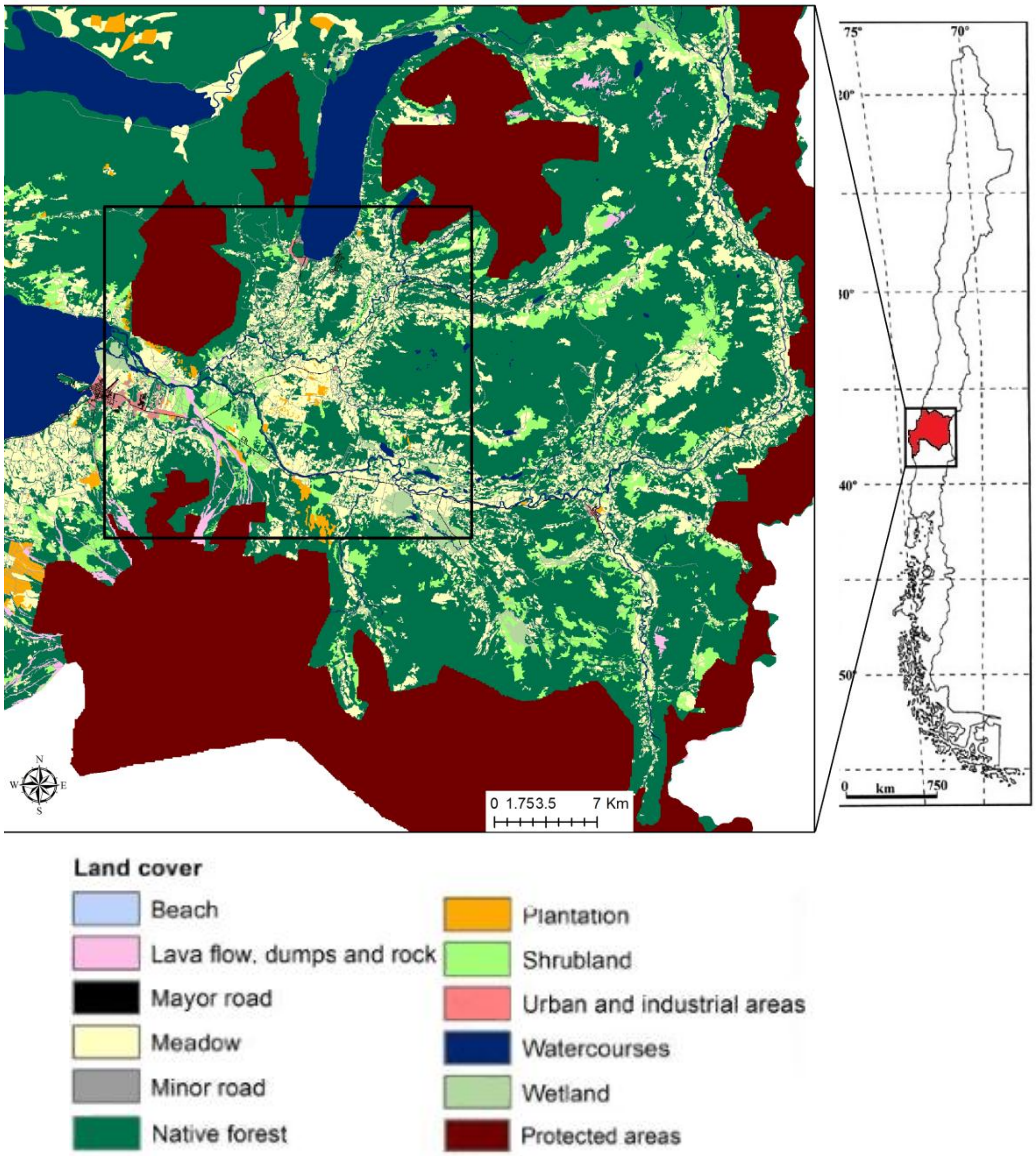


Figure 2. Rodent survey grids, locations and güiña home ranges in Pucón, Cautín Province, La Araucanía region, Chile, September 2010 to April 2012 (Castro-Bustamante 2014). The map displays the distribution in the study area of rodent surveys in 4 cover types with 3 repetitions within each, (circles) completed in fall and winter 2011, and its relation with güiña home ranges calculated through Brownian Bridge Kernel 90% (black frames) based on 1153 locations of five güiñas (blue small circles) monitored from September 2010 to April 2012 in Pucón, La Araucanía region, Chile

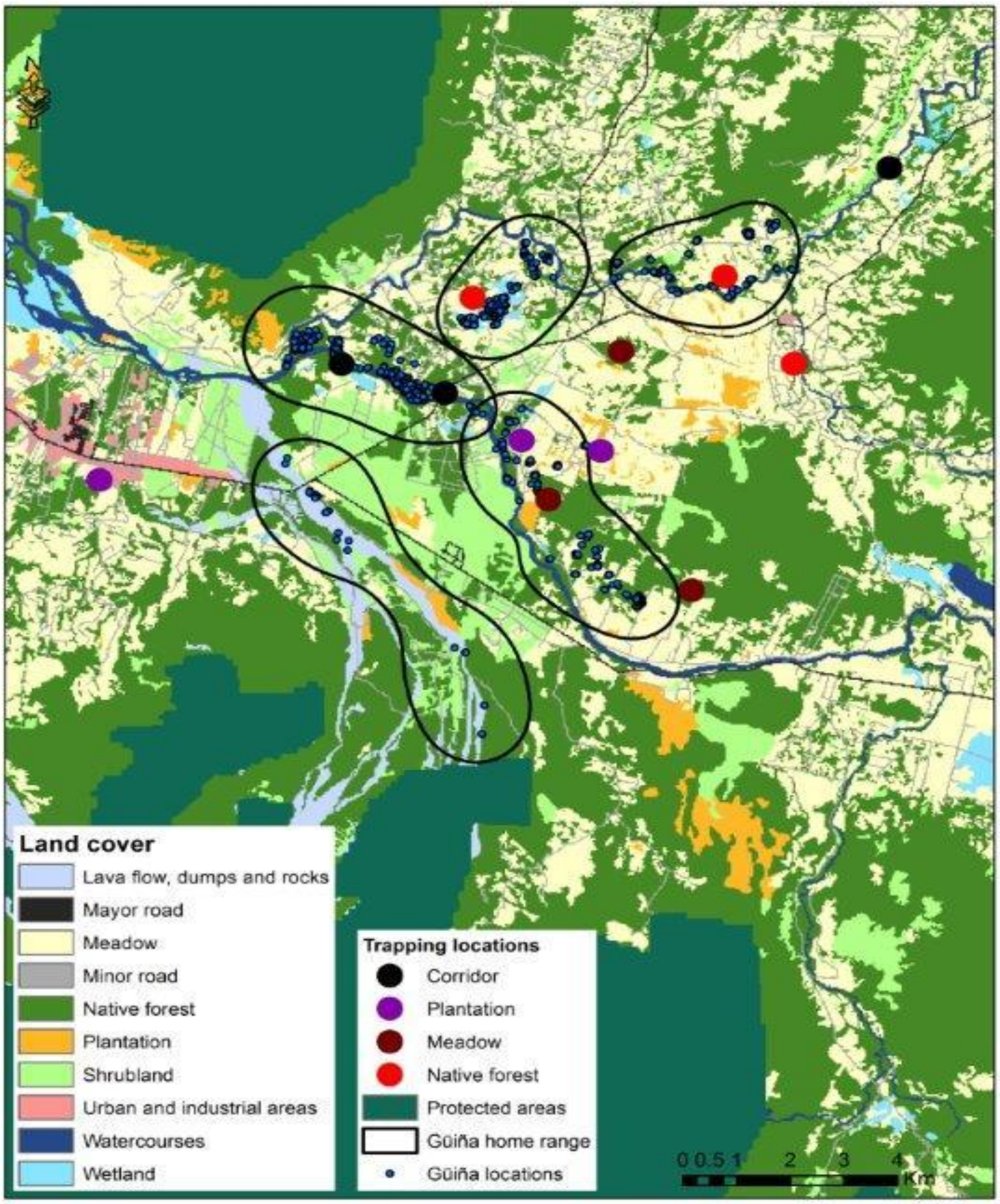


Figure 3. Percentage of active bearings in 24 hours of five güiñas in Pucón, La Araucanía X region in September 2010 to April 2012 period. The solid line represents the percentages of bearings when güiñas were active distributed among 24 hours and grouped by hour. The total number of bearings was 3388 where 1473 were active.

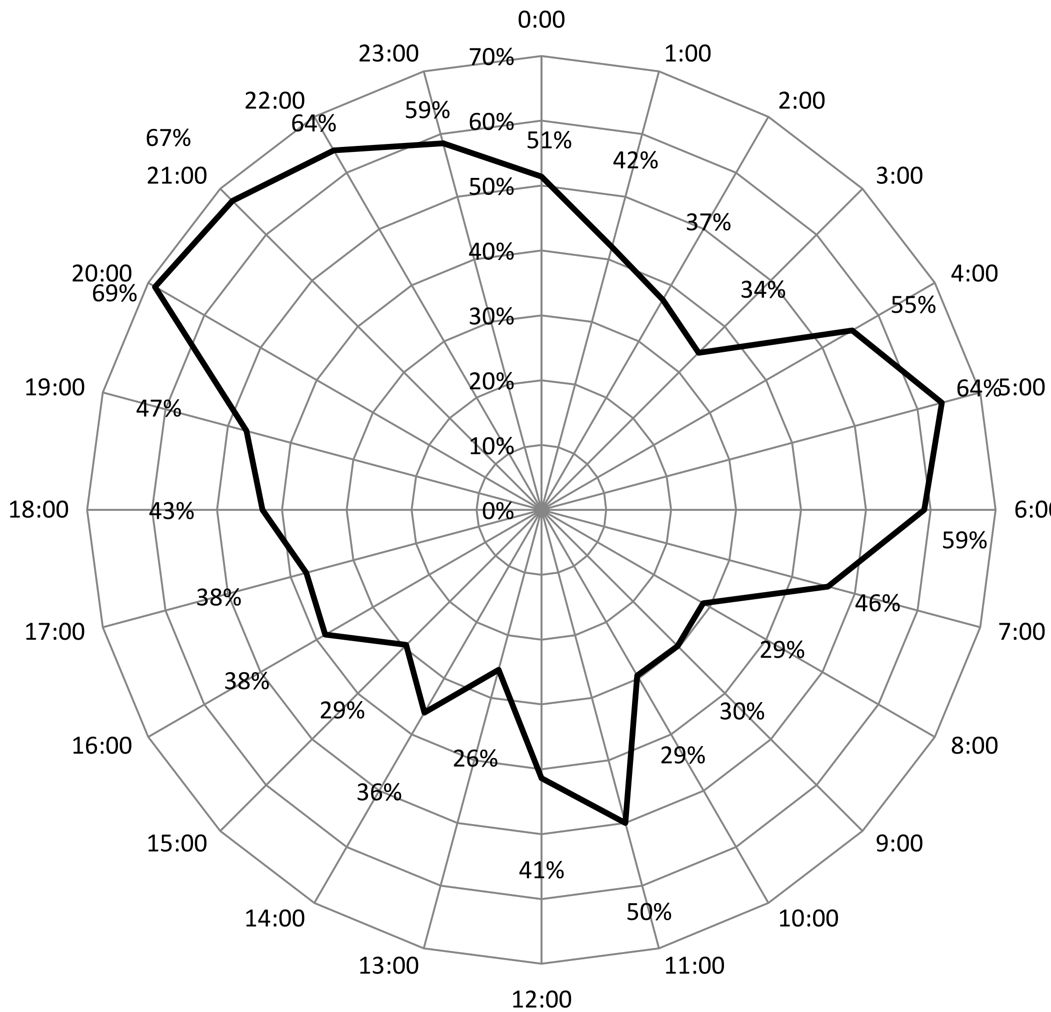


Figure 4. Percentages of active bearings of four güiñas in day, dusk, night, and sunrise periods, Pucón, La Araucanía region, September 2010 to April 2012. The bars represent the percentages of active records with standard error of the mean for four güiñas tracked. The total number of bearings was 3277, where 1410 were active.

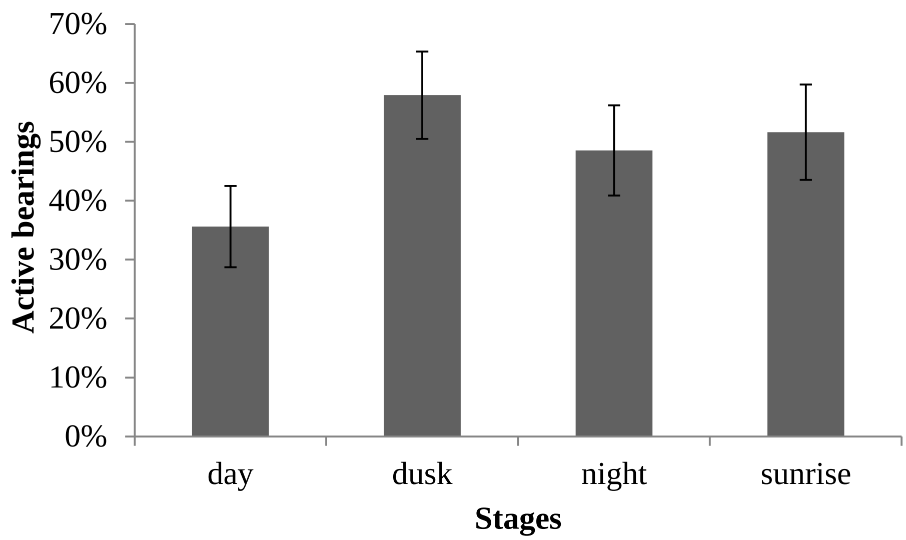


Figure 5. Percentages of active bearings by sex of four güiñas in day, dusk, night and sunrise periods, Pucón, La Araucanía region, September 2010 to April 2012. The light grey bars represent the percentages of active bearings in females (N=2), with their standard error of the mean and the dark grey represent the percentage of active bearings for males (N=2) with their standard error of the mean in the four stages of the 24 hours.

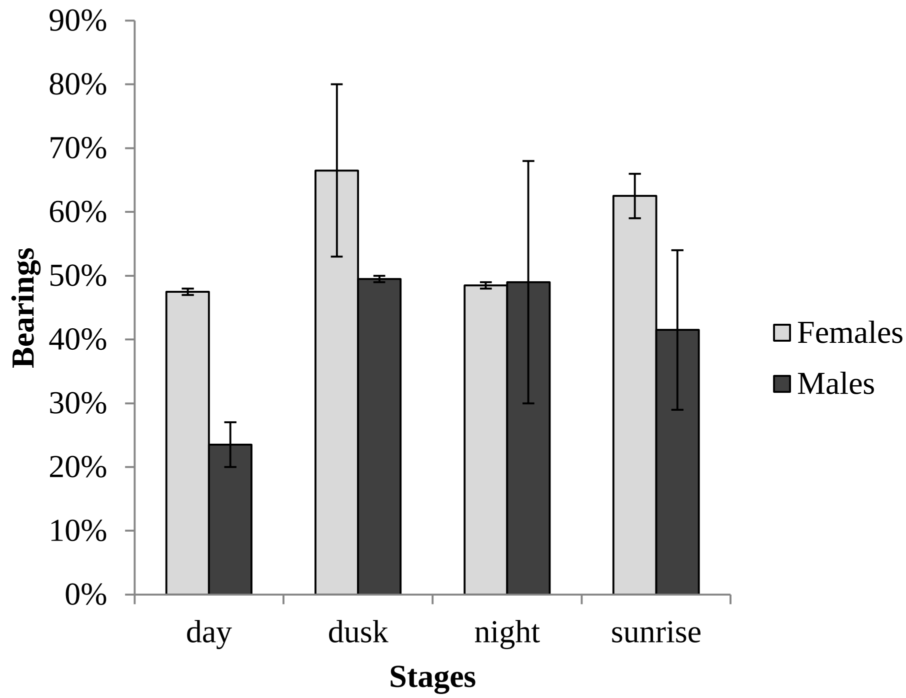
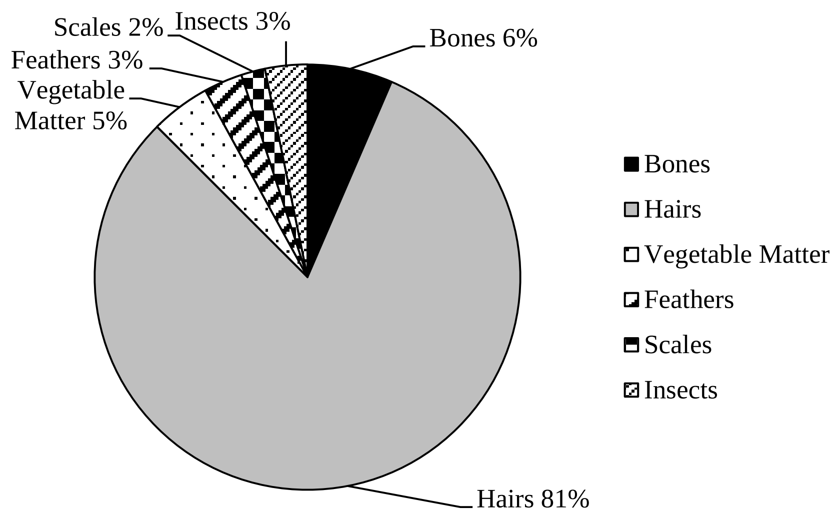


Figure 6. Composition of güiña scat in confirmed and unconfirmed samples. The obtaining of the percentages results from the analysis of 65 scats which were manually segregated and torn apart, the components of each scats were visually estimated in percentages and classified into 6 main different categories. The percentages of the composition of 47 of 51 confirmed and 9 of 14 unconfirmed scats were averaged, 4 and 5 samples respectively were discarded from the analysis for being too degraded, therefore misrepresenting the different categories in the scat composition**.**



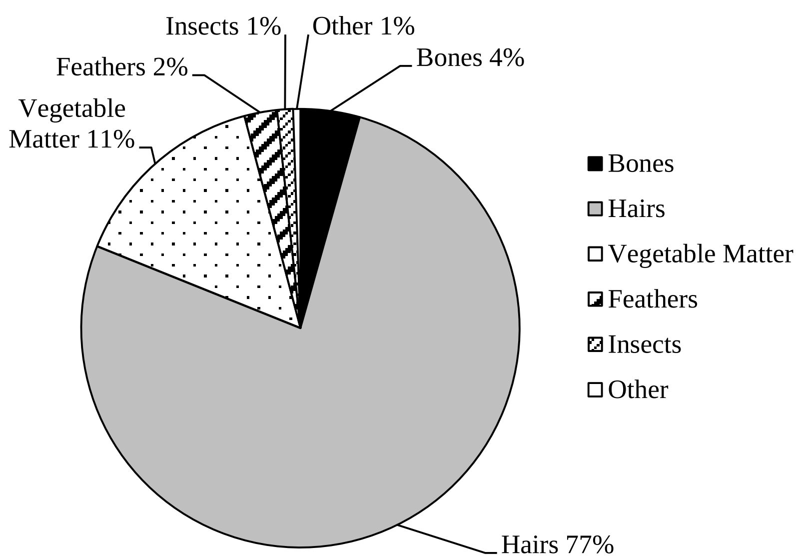
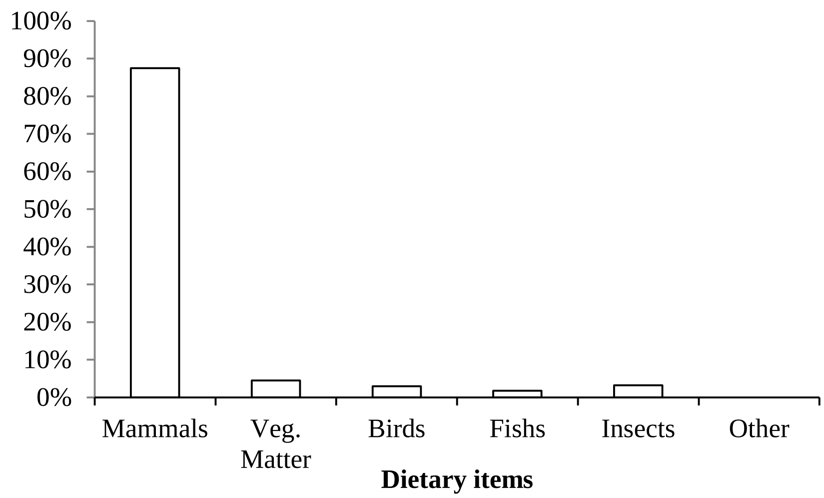


Figure 7. Percentages of the components of güiña's confirmed scats. Dietary items found in 47 of 67 collected güiña scats. From those 67 scats 4 were not possible of analyze, 2 were outliers in their measurements and 10 couldn't be confirmed, This scats were collected in field during years 2010 to 2012 and they were analyzed by means of manual segmentation and classified in coarse categories before the microscopic analysis. The percentages above the bars represent the proportion that each item was represented in the scat.



Bibliography

Acosta-Jamett, G. & Simonetti, J.A. (2004) Habitat use by *Oncifelis guigna* and *Pseudalopex culpaeus* in a fragmented forest landscape in central Chile. *Biodiversity and Conservation* 13, 1135-1151.

Acosta, G., Funk, S.M. & Dunstone, N. (2007) Inmovilización de la güiña (*Leopardus guigna*) en estado silvestre con la asociación anestésica ketamina-xilacina. *Avances en Ciencias Veterinarias* 22, 1-2.

Bisceglia, S.B.C., Pereira, J.A., Teta, P. & Quintana, R.D. (2008) Food habits of Geoffroy's cat (*Leopardus geoffroyi*) in the central Monte desert of Argentina. *Journal of Arid Environments* 72, 1120-1126.

Castro-Bustamante, R. (2014) *Comparing methods for assessing habitat connectivity: a case study of güinas (Leopardus guigna) in a fragmented Chilean landscape*. MSc thesis, University of Minnesota, Minnesota, USA.

Chehébar, C. & Martín, S. (1989) Guía para el reconocimiento microscópico de los pelos de los mamíferos de la Patagonia. *Doñana Acta Vertebrata* 16, 247-291.

Correa, P. & Roa, A. (2005) Relaciones tróficas entre *Oncifelis guigna*, *Lycalopex culpaeus*, *Lycalopex griseus* y *Tyto alba* en un ambiente fragmentado de la zona central de Chile. *Mastozoología Neotropical* 12, 57–60.

Delibes-Mateos, M., Díaz-Ruiz, F., Caro, J.& Ferreras, P. (2014) Activity patterns of the vulnerable guiña (*Leopardus guigna*) and its main prey in the Valdivian rainforest of southern Chile, *Mammalian Biology*.

de Oliveira, T.G. (1998) *Leopardus wiedii*. *Mammalian species*, 1-6.

Dunstone, N., Durbin, L., Wyllie, I., Freer, R., Acosta, G., Mazzolli, M. & Rose, S. (2002) Spatial organization, ranging behavior and habitat use of the kodkod (*Oncifelis guigna*) in southern Chile. Journal of Zoology 257, 1-11.

Fernández, F., Ballejo, F., Moreira, G., Tonni, E. & De Santis, L. (2011) Roedores cricétidos de la provincia de Mendoza: *Guía cráneo-dentaria orientada para su aplicación en estudios zooarqueológicos*. Sociedad Argentina de Antropología and Universitas Sarmiento, La Plata, Argentina.

Fleschutz, M.M. (2013) *Impact of fragmentation on Leopardus guigna in the Chilean temperate rainforest.* PhD thesis, Johannes Gutenberg University, Mainz, Germany.

Freer, R., (2004) *The spatial ecology of the güiña (Oncifelis guigna) in southern Chile*. PhD thesis, University of Durham, Durham, UK.

Gajardo, R. (1994) *Clasificación de la vegetación natural de Chile*. Editorial Universitaria. Santiago de Chile.

Gálvez, N., Hernández, F., Laker, J., Gilabert, H., Petitpas, R., Bonacic, C., Gimona, A., Hester, A. & MacDonald, D.W. (2013) Forest cover outsides protected areas plays an important role in the conservation of the vulnerable guiña *Leopardus guigna*. Oryx 47, 251–258.

García-Esponda, C.M., Carrera, J.D., Moreira, G.J., Cazón, A.V. & De Santis, L.J.M. (2009) Microvertebrados depredados por *Leopardus pajeros* (carnivora: felidae) en el sur de la provincia de Mendoza, Argentina. *Mastozoología Neotropical* 16, 455-457.

Geertsema, A. A. (1985) Aspects of the ecology of the serval *Leptailurus serval* in the Ngorongoro Crater, Tanzania. Netherlands journal of zoology, 35, 527-610.

González, L. A., Murúa, R., & Jofré, C.(2000) Habitat utilization of two muroid species in relation to population outbreaks in southern temperate forests of Chile. *Revista Chilena de Historia Natural*, 73, 489-495.

Herrmann, T.M., Schüttler, E., Benavides, P., Gálvez, N., Söhn, L. & Palomo, N. (2013) Values, animal symbolism, and human-animal relationships associated to two threatened felids in Mapuche and Chilean local narratives. *J Ethnobiol Ethnomed*, 9, 41-56.

Hernández, F.A. (2010) *Antecedentes de historia natural, ocupación y percepción social de Leopardus guigna en un ambiente fragmentado de bosque templado en la zona andina de la Araucanía, Chile (39º15´S, 71º48´O)*. MSc thesis. Faculty of Agriculture and Forestry, Pontificia Universidad Católica, Santiago, Chile.

Iriarte, J. A., Johnson, W. E., & Franklin, W. L. (1991) Feeding ecology of the Patagonia puma in southernmost Chile. *Revista Chilena de Historia Natural*, 64, 145-156.

Iriarte, A. (2008) *Mamíferos de Chile*. Lynx editions, Barcelona, Spain.

Iriarte, A. & Jaksic, F. (2012) *Los Carnívoros de Chile.* Flora y Fauna Chile and CASEB editions, Pontificia Universidad Católica de Chile Press, Santiago, Chile.

IUCN (Red List of Threatened Species) (2008) http://www.iucnredlist.org [Acceced 21st July 2014]

Jaksic, F. M., & Lima, M. (2003) Myths and facts on ratadas: bamboo blooms, rainfall peaks and rodent outbreaks in South America. *Austral Ecology*, 28, 237-251.

Malo, A. F., Lozano, J., Huertas, D. L., & Virgós, E. (2004) A change of diet from rodents to rabbits *(Oryctolagus cuniculus).* Is the wildcat *(Felis silvestris)* a specialist predator? *Journal of Zoology* 263, 401–407.

Murúa, R., Meserve, P. L., González, L. A., & Jofré, C. (1987) The small mammal community of a Chilean temperate rain forest: lack of evidence of competition between dominant species. *Journal of Mammalogy*, 729-738.

Napolitano, C., Bennett, M., Johnson, W.E., O'brien, S.J., Marquet, P.A., Barría, I., Poulin E. & Iriarte, I. (2008) Ecological and biogeographical inferences of two sympatric and enigmatic Andean cat species using genetic identification of faecal samples. *Molecular Ecology* 17, 678–690.

Nowell, K. & Jackson, P. (1996) *Wild cats: status survey and conservation action plan*. The Burlington Press, Cambridge.

Pearson O. (1995) Annotated keys for identifying small mammals living in on near Nahuel Huapi National Park or Lanin National Park, southern Argentina. *Mastozoología Neotropical* 2, 99-148.

Quadros, J. & Monteiro-Filho, E.L.A. (2006) Coleta e preparacão de pêlos de mamíferos para identificacão em microscopia óptica. *Revista Brasileira de Zoología* 23, 274–278.

Quintana, V. (2008) Diversidad de micromamíferos de la región de la Araucanía, sur de Chile. *Gestión Ambiental* 16, 41-52.

Red Agroclima FDF-INIA-DMC (2010) *Boletín Agroclimático Regional. Región de la Araucanía, September 2010 to April 2012*, Ministerio de Agricultura de Chile, Gobierno de Chile.

Reise D. (1973) Clave para la determinación de los cráneos de marsupiales y roedores chilenos. *Gayana, Zoología* 27, 1-20.

Ridpath, I. (Ed.) (2012) *A dictionary of astronomy*. Oxford reference online Oxford University Press. http://www.oxfordreference.com

Servicio Aerofotométrico de la Fuerza Aérea de Chile (2007) Aerial Images of the year 2007. Chile LPT-UCT (2009): Geographic Information System for the Villarrica Catchment. Information provided by the Land-use Laboratory (LPT) of the Catholic University of Temuco (UCT), Chile.

Sanderson,J., Sunquist, M.E. & Iriarte, A.W. (2002) Natural history and landscape-use of guignas (*Oncifelis guigna*) on Isla Grande de Chiloé , Chile. *Journal of Mammalogy,* 83, 608–613.

Selmi, A.L., Mendes, G.M., Lins, B.T., Figueiredo, J.P. & Barbudo-Selmi, G.R. (2003) Evaluation of the sedative and cardiorespiratory effects of dexmedetomidine, dexmedetomidine-butorphanol, and dexmedetomidine-ketamine in cats. *Journal of the American Veterinary Medical Association*, 222, 37-41.

Tigas, L. A., Van Vuren, D. H., & Sauvajot, R. M. (2002) Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation*, 108, 299-306.

Verstegen, J., Fargetton, X., Donnay, I. & Ectors, F. (1991) An evaluation of medetomidine/ketamine and other drug combinations for anaesthesia in cats.*Veterinary Record*, 128, 32-35.

Walker, R.S., Novaro, A.J., Perovic, P., Palacios, R., Donadio, E., Lucherini, M., Pia, M. & López, M.S. (2007) Diets of three species of Andean carnivores in high altitude deserts of Argentina. *Journal of Mammalogy* 88, 519-525.

Wang, E. (2002) Diets of ocelots (*Leopardus pardalis*), margays (*L. wiedii*), and oncillas (*L. tigrinus*) in the atlantic rainforest in southeast Brazil. *Studies on Neotropical Fauna and Environment* 37, 207-212.

White, G.C. & Garrott, R.A. (1990) *Analysis of Animal Radio-tracking Data.* Academic Press, Inc. New York, New York.

Zielinski, W.J., Spencer, W.D. & Barrett, R.H. (1983) Relationship between food habits and activity patterns of pine martens. *Journal of Mammalogy* 64, 387-396.

Zúñiga, A., Quintana, V. & Fierro, A. (2005) Trophic relations among predators in a fragmented environment in southern Chile. *Gestión Ambiental* 11, 31–42.