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SHORT COMMUNICATION

Interannual variation in the activity patterns of kodkod (*Leopardus guigna*) in a peri-urban protected area of south-central Chile

Variación interanual en los patrones de actividad de la güiña (*Leopardus guigna*) en un área protegida periurbana del centro-sur de Chile

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ABSTRACT

The kodkod (*Leopardus guigna*) is a small felid dependent on forests. We studied the activity patterns of this felid during two years in a periurban protected area. We also compared its overlap with rodents and birds. During the first year, we detected it to be mainly nocturnal. In the second year, a non-significant diurnal activity was observed. During the first year overlap was higher with rodents, and lower with birds, but this reversed during the second year.

Keywords: camera traps, circadian rhythm, fragmentation, prey overlap, temporal flexibility.

RESUMEN

La guiña (*Leopardus guigna*) es un pequeño félido vinculado a bosques. Estudiamos sus patrones de actividad durante dos años en un área protegida peri-urbana. También comparamos su sobreposición con roedores y aves. Durante el primer año, detectamos una gran proporción de actividad nocturna. En el segundo año, se observó una mayor actividad diurna, pero ésta no fue significativa. La superposición fue mayor durante el primer año con los roedores y menor con las aves, pero esto se invirtió durante el segundo año.

Palabras clave: cámaras trampa, flexibilidad temporal, fragmentación, ritmo circadiano, sobreposición con presas.

Activity patterns constitute an adaptive trait of species, as it is modulated by the environment and the interacting species (Kronfeldt-Schor & Dayan 2003). In carnivores, activity could be linked to the predator's relationship with its prey, which would lead to a coupling dynamic for the interacting species (Sih 1984). This process can also present complex relationships, a consequence of variations in the availability of prey over time, leading to changes in the trophic responses of predators (Zúñiga *et al.* 2020). In this way, long-term studies in ecology are of great importance, as they consider these agents of variation in carnivore populations, thus allowing us to expand our knowledge of their structure (Smith *et al.* 2017).

In parallel with this situation, habitat loss is one of the main threats to carnivore diversity worldwide (Brook *et al.* 2008). This process is in line with the change in land use, whose trend is increasing across diverse ecosystems worldwide (Peng *et al.* 2018), limiting the availability of food and shelter for the species. Protected areas try to limit this impact, allocating areas of biological value for conservation purposes (Watson *et al.* 2014). However, in peri-urban protected areas, wildlife faces additional problems arising from the surrounding matrix and the intensity of urbanization (Gallo *et al.* 2022). These impacts are related mainly to changes in orey diversity and abundance (Cavia *et al.* 2009; Tapia-Ramírez *et al.* 2022), predator-prey dynamics (Zúñiga *et al.* 2022), and the presence of humans and its pets species, such as cats and dogs (Baker & Leberg 2018). Thus, given the direct and indirect effects human impacts, the activity patterns of wildlife can be affected (Gaynor *et al.* 2018). Therefore, to persist, the impacted wildlife needs to show flexibility in its behavior (Cox & Gaston 2024).

The kodkod (*Leopardus guigna*) is a small felid (2-4 kg), which lives in temperate forests of Chile and Argentina (Iriarte & Jaksic 2012). This cat has been recognized as a habitat specialist (Acosta-Jamett & Simonetti 2004; Dunstone *et al.* 2002a), although there are records of its occurrence in environments with low forest cover (Peckham 2023) or with high habitat disturbance (Gálvez *et al.* 2021). In this sense, changes of land use could constitute a threat for his survival (Echeverría *et al.* 2008), affecting its spatial dynamics (Acosta-Jamett *et al.* 2003; Napolitano *et al.* 2015). Knowledge about its temporal behavior is of special importance, as this largely correspond to adaptive responses in a context of habitats close to or modified by humans (Gaynor *et al.* 2018). Considered a habitat specialist, is an appropriate model species to understand the impacts derived from protected areas in localities close to urban settlements and thus, affected by their impacts. Although there are reports regarding the pattern of activity in continuous and fragmented forests (Zúñiga *et al.* 2017; Gálvez *et al.* 2021; Schüttler *et al.* 2017), their response in peri-urban environments is unknown and of interest due to the many types of existing matrix (mainly grasslands and bushes). The present study aims to compare the activity pattern of the kodkod in a protected area in central-southern Chile. We test the hypothesis of the stability of activity patterns of this felid between years, and we put it in perspective in relation to two of its main prey types. The working prediction is that this species will shift its activity pattern to match the most abundant prey type.

MATERIALS AND METHODS

The Cerro Ñielol National Monument (MNCÑ; 38º 43’ S-72º 35’ W) is a state protected area adjacent to the city of Temuco, in the central valley of south-central Chile (Fig. 1). It has an area of 88 ha and a dry temperate rainy climate,

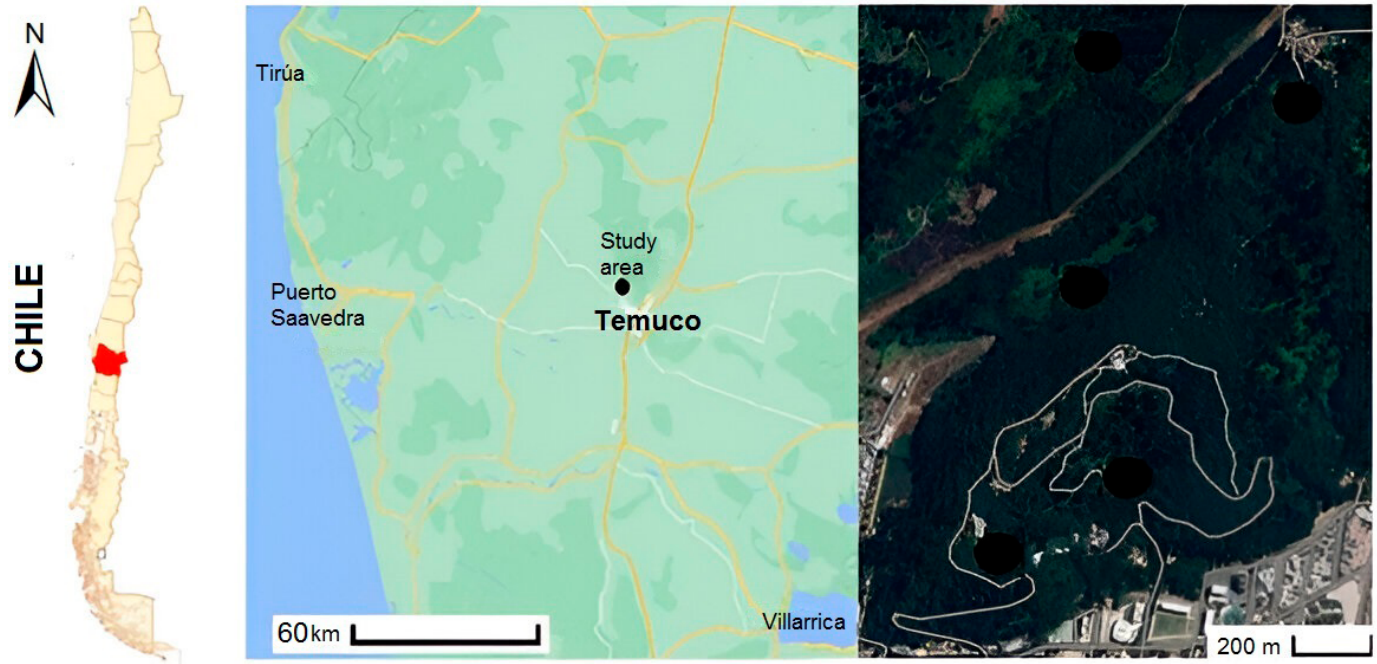

Figure 1. Study area. / Área de estudio.

with Mediterranean influence (Di Castri & Hajek 1976), with a maximum mean temperature of 22°C in summer and a minimum mean temperature of 4° C in winter (WeatherSpark 2024). Rainfall fluctuates between a minimum mean of 34 mm in summer and a maximum mean of 118 mm in winter (Weather Spark 2024). It belongs to the Huimpil-Ñielol mountain range, which corresponds to an elevation of the valley, with no connection with other mountain ranges (Ramírez *et al.* 1988). The vegetation of the MNCÑ is mainly comprised of deciduous forest, dominated by the roble-laurel-lingue formation (*Nothofago-Perseetum linguae*; Oberdorfer 1960), with an important presence of exotic species (Hauenstein *et al.* 1988).

To study the activity pattern of the kodkod camera traps were used. This is a non-invasive technique that allows recording pictures of individuals circulating in front of the device (Kays & Slauson 2008). The dates and time are recorded in each picture. Five Bushnell Trophy Cam (Bushnell Corporation, Overland Park, KS) camera traps were deployed throughout the protected area, having an average distance among cameras of 350 m to account for spatial independence of recordings and considering the size of the kodkod's home range (2,4 km^2 average; Sanderson *et al.* 2002). We used a time horizon of one hour for temporal independence between consecutive pictures (Lucherini *et al.* 2009).

To estimate activity patterns, we tallied the independent photographic records as a frequency distribution within 24-hour daily cycle (Zúñiga *et al.* 2017). A niche breadth index was calculated to determine the species' extent of its time use as a function of the daily cycle (Levins 1968). We computed the standard deviation of this index using a Jackknife procedure (Jaksic & Medel 1987), by estimating subsamples obtained with one omitted observation for each case (Efron *et al.* 1981).

Probability density functions were generated for each sampled year (2022 and 2023), for which an overlap coefficient (Δ) was calculated by estimating the area under the curves of the two density functions. This was done using the ' OverlapEst' function in the 'overlap' R package (Ridout & Linkie and 2009; Meredith & Ridout 2021). We used the $\Delta 1$ estimator as it is better suitable for smaller data sets (Ridout & Linkie 2009). The 95% confidence intervals of the overlap for each year was obtained by running 5000 bootstrap iterations. To evaluate the significance of the differences between the curves, we used the Watson's U^2 statistic using 5000 permutations to obtain the p value to compare with (Agostinelli & Lund 2023; Barnes 2024). These iterations allow obtaining a greater number of observations through resampling. This test analyzes the probability that two circular data sets come from the same population (Jammalamadaka *et al.* 2021).

Concurrently, the periods of the day most used by the kodkod were compared based on the daily light availability, which were delimited as follows: dawn (6:00-7:59), day (8:00-17:59), dusk (18:00-19:59) and night (20:00-5:59; Fedriani 1997; Zúñiga *et al.* 2017). To test the observed against the expected proportions, Chi square's goodness-of-fit tests were used (Sokal & Rohlf 1995); here, the expected frequency was weighted according to the duration of each period. To estimate the detection rate of the kodkod in both sampling years, the number of independent events obtained per 100 days was calculated, which has been considered a proxy for abundance (Zúñiga & Jiménez 2018). The statistical significance of this parameter was calculated through the Mann-Whitney paired test (Sokal & Rohlf 1995), for which the abundance of records every 15 days of sampling effort was used (García-Solís *et al.* 2024).

To determine the effect of potential prey on the kodkod's activity, the density probability frequency obtained was compared with data from rodents (the murids black rat *Rattus rattus* and the Norvegian rat *Rattus norvegicus*; we obtained few records of native small mammals) and birds, which were estimated using the same camera traps in the MNCÑ, during the same period. Most common birds detected were the Chilean pigeon *Patagioenas araucana*, Austral thrush *Turdus falcklandii*, black-throated huet-huet *Pteroptochos tarnii* and green-backed firecrown *Sephanoides sephaniodes*. We tested the temporal overlap of the prey with the kodkod, during each year, as indicated above. The detection rate of both prey types was calculated in the same way as for the kodkod. The spatial pattern displayed by the kodkod and its prey was evaluated by Bray-Curtis analysis of similiarity (Brower & Zar 1984). Differences in the composition of sites of cameras were visualized through using non-metric multidimensional scaling, which was based on Euclidean distances (Clarke *et al.* 2014).

RESULTS

With a sampling effort of 3120 camera traps/night, a total of 47 independent records of *L. guigna* were obtained, 21 during 2022 and 26 in 2023. The recording rate for the first year was 1.42 camera trap records/night, while in the second year it was 1.64 camera trap records/night, with no significant differences found between these periods (Mann-Whitney test, U=206.5, p=0.20). Although the kodkod was detected throughout the day (Fig. 2), in the first year the activity was concentrated at night, having two large peaks, the highest before dawn (niche width, β=10.75 ± 0.87; Fig. 3A). This pattern contrasted with that of the second year, where a slight plateau was observed throughout the night hours (β=15.36 ± 0.00). The overlap coefficient between years was 74% (Confidence Intervals$_{95\%}$: 54.9-89.9). The distributions between years were not significantly different (Watson test U^2=0.12, p=0.12).

Regarding the daily activity of the kodkod based on the proportion of the periods of the day, we found differences between years, being in the first highest at night (χ^2=14.11, p=0.002, degrees of freedom=3; Fig. 4). During the second year, despite observing a greater activity during the day, the activity was not different from a random pattern distribution (χ^2=4.49, p=0.213), which implies that kodkod did not select any of the periods of the day.

The overlap of the prey activity with that of the kodkod was different for each prey types, being greater in the first year for rodents (76%; Confidence Intervals$_{95\%}$: 60-90), but not-

Figure 2. Records of the kodkod (*Leopardus guigna*) obtained with camera traps, during A) night, and B) day. / Registros de güiña (*Leopardus guigna*) obtenidos con cámaras-trampas, durante A) noche, y B) día.

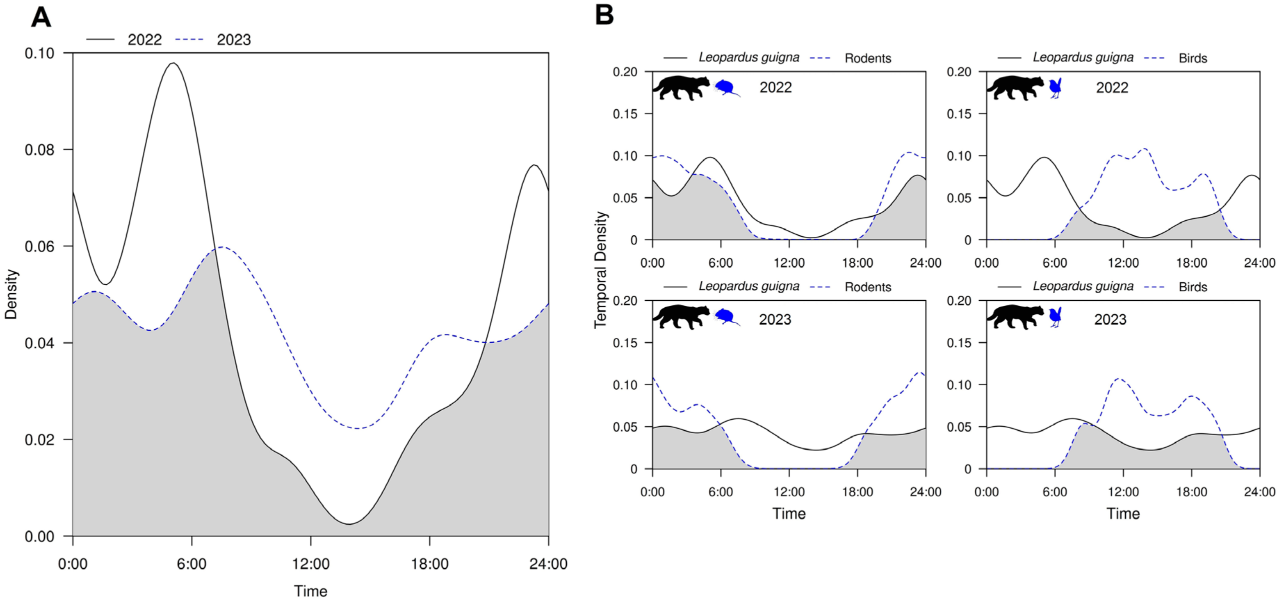

Figure 3. Activity pattern of *L. guigna* and overlap A) for the two years of the study (2022 and 2023), and B) overlap with birds and rodents during the same period in the study area. / Patrón de actividad de *L. guigna* y sobreposición A) para los dos años de estudio (2022 y 2023) y B) con aves y roedores durante el mismo periodo en el área de estudio.

significant (U^2=0.1337, p=0.1402; Fig. 3B), while birds had a low co-use of time activity (26%; Confidence Intervals$_{95\%}$: 12,42; U^2=1.2559, p=0.0002). This pattern changed in the second year, where a decrease in overlap was obtained for the rodents (60%; Confidence Intervals$_{95\%}$: 44,75; U^2=0.4844, p=0.0004), while with birds it increased twice as much (51%; Confidence Intervals$_{95\%}$: 36-67; U^2=0.7702, p=0.0002). The detection rate of rodents was 72.30 in the first year, and 27.94 in the second year (U=185, p=0.05). For birds, the detection rate was 50.34 in the first year, and 30.52 in the second year (U=270.5, p=0.10). Regarding the spatial relationship between kodkod and their prey, it was observed that both bird and rodents were present in a similar way at the sites where this felid is present (Fig. 5), which suggests a weak effect in their respective recording rates.

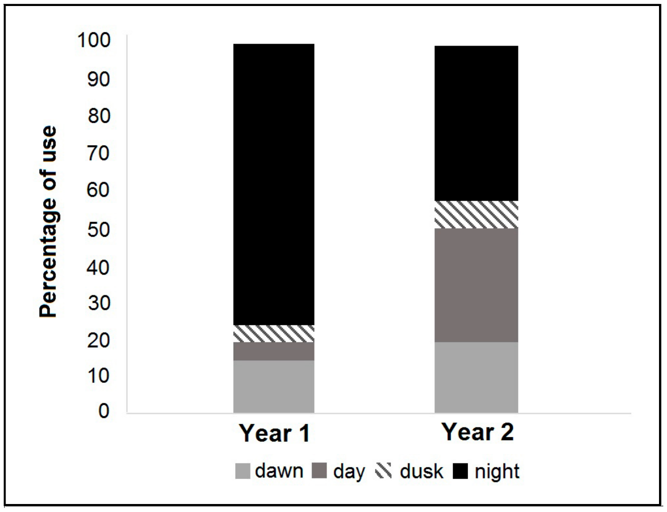

Figure 4. Proportion of kodkod daily activity in the two years of study, according to the light periods in the 24-hour cycle in south-central Chile. / Proporción de la actividad diaria de la güiña en los dos años de estudio, de acuerdo a los periodos de luz en el ciclo de 24 horas en el centro-sur de Chile.

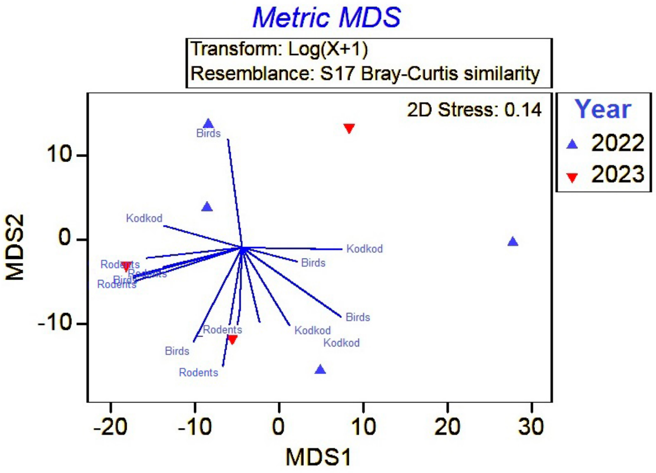

Figure 5. Non-metric multidimensional scaling based on the coverage of the sites where the kodkod and their prey (rodents and birds) were recorded. / Escalamiento multidimensional no métrico basado en la cobertura de los sitios donde la güiña y sus presas (roedores y aves) fueron registrados.

DISCUSSION

The variation observed in the activity pattern between both years made it possible to visualize the existence of responses by the kodkod to environmental stimuli. The predominance of the nocturnal activity in the first year was linked to the activity pattern of murids, whose activity focuses exclusively in this period (Salgado *et al.* 2022). This group of rodents benefited with the environmental conditions generated in peri-urban landscapes (Fernández & Simonetti 2013), which allows them to reach high densities (Feng & Himswoth 2014). In this way, it is expected that the kodkod use this temporal spectrum to prey on them, which agrees with previous reports (Escobar & Jackson 2023). The relatively high temporal overlap of the kodkod with exotic rodents (>0.5), suggests a moderate strength in the predator-prey interaction (Monterroso *et al.* 2014). Rodents have been reported as the most common type of prey captured by the kodkod (Palomo-Muñoz *et al.* 2023), suggesting a behavioral adaptation for this purpose. However, the absence of statistical significance in this comparison would result from a recent link between a native predator and an exotic prey, a process that deserves more studies (Carlsson *et al.* 2009). On the other hand, the decline in overlap in the second year could be explained by the decrease in rodent abundance. This fact would be explained by interannual variations related to density dependence

(Feng & Himswoth 2014). As this is only correlational, it is an area worth examining in the future, as it may reflect a quick response regarding the type of prey available.

Regarding the overlap of the kodkod with birds, our low first year value of monitoring suggests a low level of interaction (Monterroso *et al.* 2014), due to its preference for rodents. Considering the relevance of the birds in the diet of the kodkod (Freer *et al.* 2004), it is expected that occasionally there will be variations in their activity pattern to improve its predation, considering that the birds are mainly diurnal (Fontúrbel *et al.* 2021). Given the decline in rodent abundance in the second year, we interpret the response of the kodkod as a change in prey selection (Lazzeri *et al.* 2024), which is reinforced by its ability to use the vertical profile of the trees (Altamirano *et al.* 2013). Birds differ in their use of microhabitats from rodents (Murúa 1982; Díaz *et al.* 2005), which leads to the use of different strategies for their capture. This is another aspect of the kodkod's behavior that should be analyzed in future research.

The lack of spatial association between the kodkod and their prey could be explained by the high frequencies of exotic species, which would have a diffuse effect on predation, mainly during the first year. This fact would be explained by the dietary flexibility of this cat, that it would not specialize in specific types of prey but would consume them based on their abundances (Jaksic 1989; Peckham 2023), which can result in different types of these. Thus, the link between the kodkod and exotic rodents suggests an adaptation of the latter to urbanized environments, where changes in abundance could result in the use of alternative prey by the predator.

The detection rate of kodkods was similar to that observed in larger protected areas (Zúñiga *et al.* 2017), where the kodkod coexists with other predators. This suggests that its presence in the study area would not be negatively affected by the exotic carnivores (dogs and cats) that we detected making it possible to persist. The kodkod persists in this landscape plagued with a high level of direct (many visitors on foot and on vehicles that visit the area) and indirect human disturbances (high frequency of human pets, exotic birds and small mammals, noise, etc.; Fleschutz *et al.* 2016), where this species can tolerate the agricultural matrix close to forest patches. This situation is especially relevant due to its presence in forest patches close to the study area (Zúñiga *et al.* 2009), where kodkods could move and persist in a metapopulation dynamics (Acosta-Jamett *et al.* 2003; Schüttler *et al.* 2017). Considering the scarcity of forest patches in the central valley, maintaining a fluid dispersal of kodkod among patches is vital. Monitoring is required in the near future to determine the conservation status of their populations. This is another avenue for future research on this species.

In conclusion, we found that the kodkod was active mainly at night, however it presented a degree of flexibility to use other periods of the daily cycle, which could be linked to changes in the availability of its prey and potential interaction with other exotic and felids. Although we recorded several potential relationships to interpret the kodkod behavior, more questions emerged from this pioneer research in a highly disturbed environment that could be tested using more mechanistic approaches.

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REFERENCES

Acosta-Jamett, G., Simonetti, J.A. 2004. Habitat use by *Oncifelis guigna* and *Pseudalopex culpaeus* in a fragmented forested landscape in Central Chile. Biodiversity and Conservation 13: 1135-1151.

Acosta-Jamett, G., Simonetti, J.A., Bustamante, R.O., Dunstone, N. 2003. Metapopulation approach to assess survival of *Oncifelis guigna* in fragmented forests of central Chile: A theoretical approach. Mastozoología Neotropical 10: 217-229.

Agostinelli, C., Lund, U. 2018. Package "CircStats". https://cran.r-project.org/web/packages/CircStats/CircStats.pdf.

Altamirano, T.A., Hernández, F., De la Maza, M., Bonacic, C. 2013. Güiña (*Leopardus guigna*) preys on cavity-nesting nestlings. Revista Chilena de Historia Natural 86: 501-504.

Baker, A., Leberg, P.L. 2018. Impacts of human recreation on carnivores in protected areas. PlosOne 13: e0195436.

Barnes, C. 2024. AS.circular: ArchStats: circular functions. R package version 0.9. https://github.com/clairbarnes/AS.circular

Brook, B.W., Sodhi, N.S., Bradshaw, C.J.A. 2008. Synergies among extinction drivers under global change. Trends in Ecology and Evolution 23: 453-460.

Brower, J.E., Zar, J.H. 1984. Field and laboratory methods for general ecology. Wm. Brown. Co. Dubuque, Iowa.

Carlsson, N.O.L., Sarnelle, O., Strayer, D.L. 2009. Native predators and exotic prey – an acquired taste? Fontiers in Ecology and Evolution 7: 525-532.

Cavia, R., Cueto, G.R., Suárez, O.V. 2009. Changes in rodent communities according to the landscape structure in an urban ecosystem. Landscape and Urban Planning 90: 11-19.

Clarke, K., Gorley, R., Somerfield, D., Warwick, R. 2014. Changes in marine communities: an approach to statistical analysis & interpretation. Primer-E Ltd. Lutton, UK.

Cox, D.T., Gaston, K.J. 2004. Cathemerality: a key temporal niche. Biological Reviews 99: 329-347.

Di Castri, F., Hajek, E. 1976. Bioclimatología de Chile. Ediciones Universidad Católica de Chile, Santiago de Chile.

Díaz, I.A., Armesto, J.J., Reid, S., Sieving, K.E., Willson, M.F. 2005. Linking forest structure and composition: avian diversity in sucessional forests of Chiloé Island, Chile. Forest Ecology and Management 123: 91-101.

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

Dunstome, N., Freer, R., Acosta-Jamett, G., Durbin, L., Wyllie, I., Mazzolli, M., Scott, D. 2002b. Uso del hábitat, actividad y dieta de la güiña (*Oncifelis guigna*) en el Parque Nacional Laguna San Rafael, XI Región, Chile. Boletín del Museo Nacional de Historia Natural 51: 147-158.

Echeverría, C., Comes, D., Hall, M., Newton, A. 2008. Spatially explicit models to analyze forest loss and fragmentation between 1976 and 2020 in southern Chile. Ecological Modelling 212: 439-449.

Efron, B. 1982. The jackknife, the bootstrap, and other resampling plans. Society for Industrial and Applied Mathematics. Philadelphia, PA.

Escobar, A., Jackson, D. 2023. Presencia de *Rattus norvegicus* (Rodentia: Muridae) en la dieta de *Leopardus guigna* (Carnivora: Felidae), en una zona suburbana del sur de Chile. Mammalogy Notes 9: 1-5.

Fedriani, J.M. 1997. Relaciones interespecíficas entre el lince ibérico, *Lynx pardinus*, el zorro, *Vulpes vulpes*, y el tejón, *Meles meles*, en el Parque Nacional de Doñana. Tesis de doctorado, Universidad de Sevilla, Sevilla, España.

Feng, A.Y.T., Himsworth, C.G. 2014. The secret life of the city rat: a review of the ecology of urban Norway and black rats (*Rattus norvegicus* and *Rattus rattus*). Urban Ecosystems 17: 149-162.

Fernández, I., Simonetti, J.A. 2013. Small mammal assemblages in fragmented shrublands of urban areas of Central Chile. Urban Ecosystems 16: 377-387.

Fleschutz, M.M., Gálvez, N., Pe'er, G., Davies, Z.G., Henle, K., Schüttler, E. 2016. Response of a small felid of conservation concern to habitat fragmentation. Biodiversity and Conservation 25: 1445-1463.

Fontúrbel, F.E., Orellana, J.I., Rodríguez-Gómez, G.B., Tabilo, C.A., Castaño-Vila, G. 2021. Habitat disturbance can alter forest understory bird activity patterns: A regional-scale assessment with camera-traps. Forest Ecology and Management 479: 118618.

Freer, R. 2004. The spatial ecology of güiña (*Oncifelis guigna*) in Southern Chile. Ph. D. Thesis. University of Durham. Durham, UK.

Gallo, T., Fidino, M., Gerber, B., Ahlers, A.A., Angstmann, J.L., Amaya, M., Concilio, A.L., Drake, D., Gay, D., Lehner, E.W., Murray, M.H., Ryan, T.J., St Clair, C.C., Salsbury, C.M., Sander, H.A., Stankowich, T., Williamson, J., Belaire, J.A., Simon, K., Magle, S.B. 2022. Mammals adjust diel activity across gradients of urbanization. eLife 11: e74756.

Gálvez, N., Meniconi, P., Infante, J., Bonacic, C. 2021. Response of mesocarnivores to anthropogenic landscape intensification: activity patterns and guild temporal interactions. Journal of Mammalogy 102: 1149-1164.

García-Solís, F., Zúñiga, A.H., Rau, J.R., Garcés, C. 2024. Interannual activity pattern of the European hare (*Lepus europaeus*) in the coastal foothills of southern Chile. Gayana 88: 17-21.

Gaynor, K.M., Honojowski, C.E., Carter, N.H., Brashares, J.S. 2018. The influence of human disturbance on wildlife nocturnality. Science 260: 1232-1235.

Hauenstein, E., Ramírez, C., Latsague, M. 1988. Evaluación florística y sinecológica del Monumento Natural Cerro Ñielol (IX Región, Chile). Boletín del Museo Regional de la Araucanía 3: 7-32.

Iriarte, A., Jaksic, F. 2012. Los carnívoros de Chile. Flora and Fauna/CASEB Ediciones, Santiago de Chile.

Jaksic, F. 1989. Opportunism vs selectivity among carnivorous predators that eat mammalian prey: a statistical test of hypotheses. Oikos 56: 427-430.

Jaksic, F.M., Medel, R. 1987. El acuchillamiento de datos como método de obtención de intervalos de confianza y de prueba de hipótesis para índices ecológicos. Medio Ambiente 8: 95-103.

Jammalamadaka, S.R., Guerrier, S., Mangalam, V. 2021. A two-sample nonparametric test for circular data-its exact distribution and performance. Sankhya B 83: 140-166.

Kays, R., Slauson, K.M. 2008. Remote cameras. In: Long, R., Mackay, P., Zielinski, W., Ray, J. (Eds.) Non invasive survey methods for carnivores: 110-140. Island Press, Washington.

Kronfeld-Schor, N., Dayan, T. 2003. Partitioning of time as an ecological resource. Annual Review of Ecology, Evolution and Systematics 34: 153-181.

Lazzeri, L., Pacini, G., Belardi, I., Fini, G., De Lillo, C., Ferretti, F. 2024. Switch or perish? Prey-predator interactions in a Mediterranean area. Animal Conservation 27: 830-850.

Levins, R. 1968. Evolution in changing environments. Princeton University Press, New Jersey.

Lucherini, M., Repucci, J.L., Walker, R.S., Villalba, M.L., Wursten, A., Gallardo, G., Villalobos, R., Perovic, M. 2009. Activity pattern segregation of carnivores of the High Andes. Journal of Mammalogy 90: 1404-1409.

Meredith, M., Ridout, M. 2014. Overlap: Estimates of coefficient of overlapping for animal activity patterns. R package version 0.3.4. https://cran.r-project.org/web/packages/overlap/overlap.pdf

Monterroso, P., Alves, P.C., Ferreras. P. 2018. Plasticity in circadian activity patterns of mesocarnivores in southwestern Europe: implications for species coexistence. Behavioral Ecology and Sociobiology 68: 1403-1417.

Murúa, R. 1982. Características de las huellas de roedores cricétidos del bosque valdiviano. Boletín de la Sociedad de Biología de Concepción 53: 78-86.

Napolitano, C., Gálvez, N., Bennett, M., Acosta-Jamett, G., Sanderson, J. 2015. *Leopardus guigna*. The IUCN Red List of Threatened Species 2015: eT15311A50657245

Oberdorfer, F. 1960. Pfanzensociologische Studien in Chile. Ein Vergleich mit Europa. Flora et Vegetatio Mundi, 2: Weinheim. Cramer, Germany.

Palomo-Muñoz, G., Gálvez, N., Alarcón, V., Minte, E., Gallardo, B., Kramer, T. 2023. Straight from the Guiñas mouth: diet of a Neotropical carnivore documented by camera traps. Food Webs 36: e00296.

Peckham, C. 2023. *Leopardus guigna* (Carnivora: Felidae). Mammalian Species 55: 1-18.

Peng, X., Hansen, M.C., Stehman, S.V., Potapov, P.V., Tyukavina, A., Vermote, E.F., Townshend, J.R. 2018. Global land change from 1982 to 2016. Nature 560: 639-643.

Ramírez, C., San Martín, J., Hauenstein, E.W., Contreras, D. 1988. Estudio fitosociológico de la vegetación de Rucamanque (Cautín, Chile). Studia Botanica 8: 91-115.

Ridout, M.S., Linkie, M. 2009. Estimating overlap of daily activity patterns from camera trap data. Journal of Agricultural, Biological and Environmental Statistics 14: 322-337.

Salgado, R., Barja, I., Hernández, M., Lucero, B., Castro-Arellano, I., Bonacic, C., Rubio, A. V. 2022. Activity patterns and interactions of rodents in an assemblage composed by native species and the introduced black rat: implications for pathogen transmission. BMC Zoology 7: 48.

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

Schüttler, E., Klenke, R., Galuppo, S., Castro, R.A., Bonacic, C., Laker, J., Henle, K. 2017. Habitat use and fragmentation in America's smallest wildcat. Mammalian Biology 86: 1-8.

Sih, A. 1984. The behavioral response race between predator and prey. American Naturalist 123: 143-150.

Smith, J.E., Lehmann, K.D.S., Montgomery, T.M., Strauss, E.D., Holekamp, K.E. 2017. Insights from long-term field studies of mammalian carnivores. Journal of Mammalogy 98: 631-641.

Sokal, R.R., Rohlf, F.J. 1995. Biometry. WH. Freeman and Company, New York.

Tapia-Ramírez, G., Lorenzo, C., Carrillo-Reyes, A., Navarrete, D., Retana, Ó. 2022. Effect of an urban area in the distribution pattern and diversity of Neotropical rodents. Therya 13: 183-193.

Watson, J.E.M., Dudley, N., Segan, D.B., Hockings, M. 2014. The performance and potential of protected areas. Nature 515: 67-73.

Weather Spark. 2024. El clima promedio en todo el año en Temuco. https://es.weatherspark.com/y/25123/Clima-promedio-en-Temuco-Chile-durante-todo-el-a%C3%B1o Accessed: December 2, 2024.

Zúñiga, A.H., Jiménez, J.E. 2018. Activity patterns and habitat use of pudu deer (*Pudu puda*) in a mountain forest of south-central Chile. Journal of Natural History 52: 2047-2054.

Zúñiga, A., Muñoz-Pedreros, A., Fierro, A. 2009. Habitat use for four terrestrial carnivores in southern Chile. Gayana 73: 200-210.

Zúñiga, A.H., Jiménez, J.E., Ramírez de Arellano, P. 2017. Activity patterns in sympatric carnivores in the Nahuelbuta Mountain Range, southern-central Chile. Mammalia 81:445-453.

Zúñiga, A.H., Rau, J.R., Fuenzalida, V., Fuentes-Ramírez, A. 2020. Temporal changes in the diet of two sympatric carnivorous mammals in a protected area of south-central Chile affected by a mixed-severity forest fire. Animal Biodiversity and Conservation 43: 177-186.

Zúñiga, A.H., Rau, J.R., Sandoval, R., Fuenzalida, V. 2022. Landscape use and food habits of the chilla fox (*Lycalopex griseus*, Gray) and domestic dog (*Canis lupus familiaris*) in a peri-urban environment of south-central Chile. Folia Oecologica 49: 159-167.

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