FOLIA OECOLOGICA – vol. 52, no. 1 (2025), doi: 10.2478/foecol-2025-0002

Short communication

Temporal interactions among carnivores in an anthropized landscape of the coastal mountain range in southern Chile

Fernando García-Solís[1], Alfredo H. Zúñiga[1,2,3,*], Jaime R. Rau[1], Francisco Encina-Montoya[4], Cristóbal Garcés[5]

[1]Laboratorio de Ecología, Departamento de Ciencias Biológicas and Biodiversidad, Universidad de Los Lagos, Osorno, Chile
[2]Departamento de Ciencias Agronómicas y Recursos Naturales, Universidad de La Frontera, Temuco, Chile
[3]Departamento de Gestión Agraria, Universidad de Santiago, Chile
[4]Núcleo de Ciencias Ambientales, Universidad Católica de Temuco, Temuco, Chile
[5]Programa de Doctorado en ciencias, mención Ecología y Evolución, Escuela de Graduados, Facultad de Ciencias, Universidad Austral de Chile, Valdivia, Chile

Abstract
García-Solís, F., Zúñiga, A.H., Rau, J.R., Encina-Montoya, F., Garcés, C., 2025. Temporal interactions among carnivores in an anthropized landscape of the coastal mountain range in southern Chile. *Folia Oecologica*, 52 (1): 14–21.

The structuring of carnivore assemblages is based on the partitioning of niche axes, where the activity pattern is relevant for their coexistence. However, the continuous degradation of habitats, and the human presence (and exotic species) limit the availability of resources. Therefore, these species must readjust their requirements to minimize interactions derived from competition. For two years, activity patterns of two native carnivores (the cougar *Puma concolor* and the chilla fox *Lycalopex griseus*), one exotic carnivore (the domestic dog *Canis lupus familiaris*) and people were evaluated in an anthropogenic landscape in southern Chile. A differentiation was observed in the circadian cycle of the species, where the fox was predominantly nocturnal, while the cougar maintained a random activity pattern, in contrast to the dog and humans, which were the most diurnal. The ecological implications derived from the observed patterns are discussed, mainly in relation to the interference exerted by the exotic species.

Keywords
activity pattern, exotic species, niche breadth, overlap, segregation

Introduction

Carnivorous mammals are a widely distributed group, with a great diversification of species across different biomes (Gittleman, 1989). The role of this group is of special relevance in ecosystems, due to the control that they exert on herbivorous species through predation (Hairston et al., 1960). However, carnivores are exposed to various threats globally, due to the progressive loss of their habitats, such as the growing conflict with humans (Fernán

*Corresponding author:
e-mail: alfredo.zuniga@ufrontera.cl

dez-Sepúlveda and Martin, 2022). These threats, combined with their large spatial needs (Carbone and Gittleman, 2002), means that many carnivore populations are currently in decline, elevating the risk of stochastic local extirpation (Ripple et al., 2014).

The structuring of carnivore assemblages is manifested through a combination of elements that include the size of the species and their morphological and behavioral adaptations (Gittleman. 1985; Hunter and Caro, 2008), as well as other ecological niche axes (Fedriani et al., 1999). This last issue implies the decrease in the co-use of niche axes between species to limit competition (Morin, 2011). Of these, temporal partitioning differentiation is a common mechanism of ecological differentiation, since it involves the use of space through different periods within a 24-hour period, thus minimizing the probability of encounters between individuals (Kronfeld-Schor and Dayan, 2003).

The native forest of southern Chile is characterized by its biogeographic isolation in relation to the rest of the continent (Mella et al., 2002), which is reflected in the richness of species and endemism (Murúa, 1996). However, the progressive fragmentation and alteration of the natural habitat has resulted in changes in the landscape configuration (Echeverría et al., 2008), which is likely to affect both the distribution of carnivores and their potential interaction (Crooks, 2002). Knowledge regarding the responses of species to these impacts is important for the implementation of conservation measures, which would be applied at the landscape scale (Carroll et al., 2001). Among the species present in this ecosystem is the cougar (*Puma concolor*), which is a large felid, widespread throughout the Americas, in which it acts largely as a top predator, selecting prey of intermediate to large size (Iriarte et al., 1990). Nevertheless, in anthropized environments it can prey on domestic animals, which can generate conflicts with humans (García-Solís et al., 2023). On the other hand, the chilla fox (*Lycalopex griseus*) is a small-sized canid, present in much of the Chilean territory, with great plasticity in the use of habitats (Iriarte and Jaksic, 2012). On the other hand, the domestic dog (*Canis lupus familiaris*) is one of the most widespread exotic species in the world (Boitani et al., 2017), with a generalist trophic spectrum (Butler and Du Toit, 2002; Krauze-Gryz and Gryz, 2014). Their impact on native fauna has been widely reported on various ecosystems (Vanak and Gompper, 2002; Zapata-Ríos and Branch, 2016), mainly by feral individuals that roam natural habitats, which generate pressure on native carnivore assemblages (Rodríguez et al., 2022). Thus, better understanding about its interaction with native species is needed for its eventual control. The aim of this study is to compare the activity patterns of two native carnivores and one exotic carnivore and humans in an anthropized landscape in southern Chile. The hypothesis of variation in the use of resources between species is tested during two years.

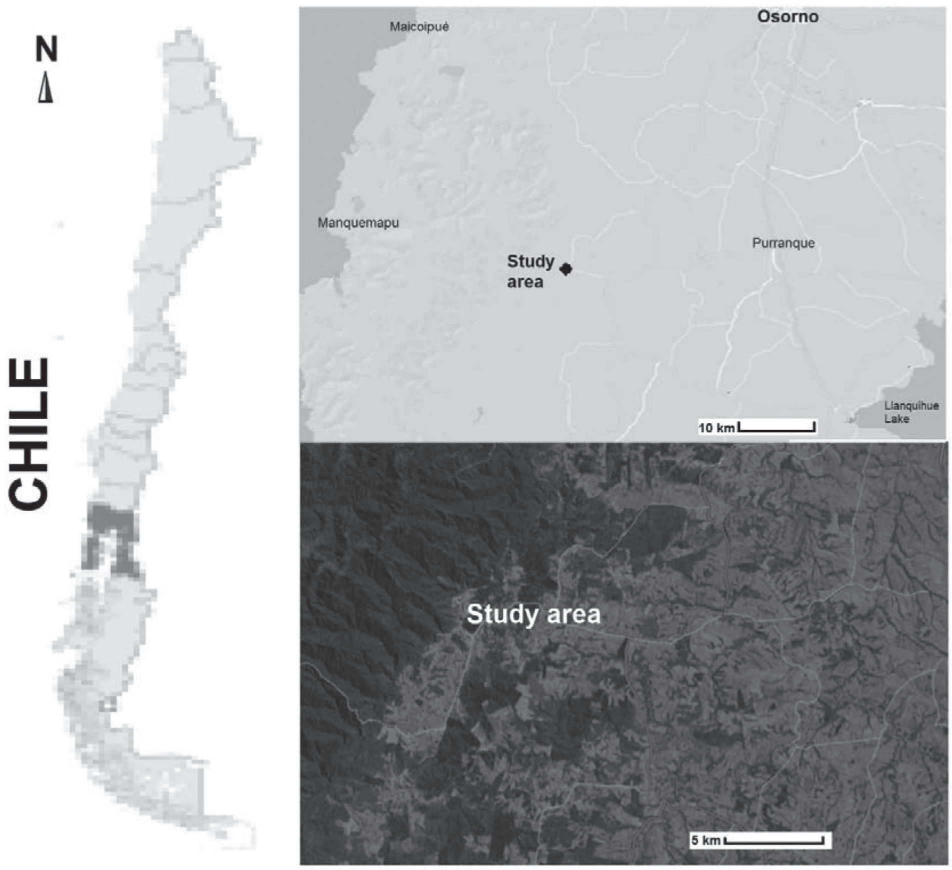

Fig. 1. Study area.

Materials and methods

Hueyusca is a rural location in the precordilleran zone in southern Chile (40°55'44''S-73°31'51''W; Fig. 1). It has an elevation of 127 m asl, with a temperate rainy climate, characterized by moderate temperatures, which varies from 7.5 °C in winter and 22 °C in summer (Koeppen et al., 2011). This sampled area comprises approximately around 30,000 ha, and is adjacent to the rural community of Purranque to the east, as well as the coastal mountain range to the west. The forest formation corresponds to the deciduous forest type (Gajardo, 1994), where the oak species (*Nothofagus obliqua*) stands out in association with laurel (*Laurelia sempervirens*), mañío (*Podocarpus saligna*) and ulmo (*Eucryphia cordifolia*). The landscape is currently made up of mosaics of forest plantations of *Pinus* sp. and *Eucalyptus* sp., as well as anthropogenic-type shrublands, which are used for livestock grazing.

As part of a previous study conducted in the study area (García-Solís et al., 2022), camera traps were used. This equipment is part of a non-invasive monitoring technique, that allows detecting photographically the presence of individuals approaching the devices by activating a sensor (Kays and Slauson, 2008). The species considered here can be recognized at the species level without ambiguity, as well as the date and time of recording. During two years (2016 and 2017), nine cameras were installed in the study area at an average distance of 3 km from each other (García-Solís et al., 2022), using secondary paths with random points (Brassine and Parker, 2015). Battery status and memory cards were checked on a monthly basis. For analytical purposes, a time horizon of one hour between successive photographs was considered for temporal independence (Lucherini et al., 2009). To estimate the detection rate of species, the number of independent records was calculated as a proxy of abundance (Zúñiga and Jiménez, 2018), and the statistical significance was obtained through Mann-Whitney paired tests (Sokal and Rohlf, 1995), with the abundance of records obtained each 15 days (García-Solís et al., 2024).

The study of the activity pattern of the detected species was carried out by accumulating independent records of each species, thus establishing a frequency distribution based on the 24-hour cycle (Zúñiga et al., 2017). The diversity of the use of temporal activity was calculated using the Levins index (β; Levins, 1968), which has been used to estimate the activity pattern of mammals in different types of environments (Zúñiga and Jiménez, 2018; Zúñiga and Sandoval, 2020). This index ranges between 1 and 24, the number of hours in a day, which makes it an indicator of the extent of species activity throughout this period. The standard deviation of this index was calculated using the Jackknife procedure (Jaksic and Medel, 1987). In parallel, probability density functions were performed for each year (2016 and 2017). We calculated an overlap coefficient (Δ) among species and years as the area under the curve formed by determining the minimum value between each pair of density functions. This process was carried out using the overlapEst function from the 'overlap' package in R (Ridout and Linkie, 2009; Meredith and Ridout, 2021). The Δ1 estimator was used because it is suitable for smaller data sets (Ridout and Linkie, 2009). We generated 95% confidence intervals from the distributions of data for each year. To evaluate the significance of the difference between curves, Watson's U^2 statistic was used, through the watson.two function of the 'CircStats' R package (Agostinelli and Lund, 2018). This test analyzes the probability that two circular data sets come from the same population (Jammalamadaka et al., 2021). The similarity in activity patterns among species was analyzed using the Bray-Curtis index (Brower and Zar, 1984), and projected using a dendrogram. We divided the day into four periods based on 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). For this purpose, goodness-of-fit tests were used (Sokal and Rohlf, 1995), where the expected frequency was weighted according to the duration of each period.

Results

Activity patterns

A sampling effort of 5,823 camera-days/nights (2,637 in 2016 and 3,186 in 2017), yielded a total of 442 records in the first year (cougar: 9, chilla fox: 56, domestic dog, 248 and humans: 129), and 357 the second year (cougar: 24, chilla fox: 76, domestic dog: 136 and humans: 121). Rates of photographic recording (records/100 trap-nights) varied among species, both in the first year (cougar: 4.28; chilla fox: 26.66; domestic dog: 115.23; humans: 61.42, respectively), as in the second year (cougar: 8.45; chilla fox: 26.76; domestic dog: 47.88; humans: 42.60, respectively). However, cougar was the only species that differed among these periods (Mann-Whitney test, U = 74, p = 0.045).

In terms of activity, a variation in patterns was obtained between species (Fig. 2). The first year, the dog showed the highest index of temporal activity (β = 21.56 + 0.69), followed by the chilla fox (β = 11.44 + 0.78), cougar (β = 7.36 + 0.87), and humans (β =11.62 + 0.87). In the second year, dog had a decrease in this value (β =16.75 + 0.88), while the puma presented an increase (β = 15.15 + 0.91), and chilla foxes and humans were similar in relation to previous years (β = 11.23 + 0.97 and 12.80 + 0.87, respectively). Domestic dog was the only species where changes in activity were significant (U^2 = 0.304; p = 0.006). In relation to the similarity among species, it was found that in the first year the puma obtained the lowest value (14%; Fig. 3), while the chilla fox obtained an intermediate one (37%) and dogs and humans obtained the highest values between them (63%). In the second year, although the puma did not show major differences (14%), there was a decrease in the case of the chilla fox (31%), as well as an increase for dogs and humans (71%).

The observed activity pattern had a clear differentiation between light periods, where the first year the chilla fox was the most clearly nocturnal (Chi square test, χ^2 =

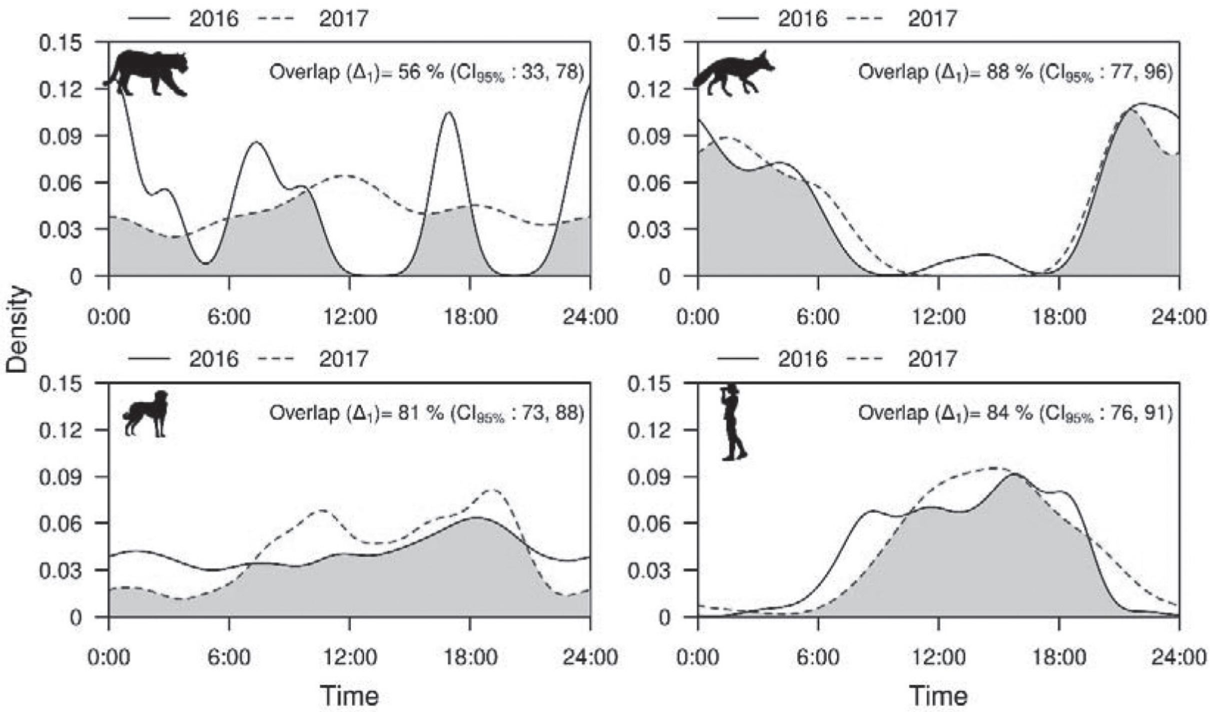

Fig. 2. Activity patterns in the studied species in Hueyusca, Southern Chile, in the two years of sampling.

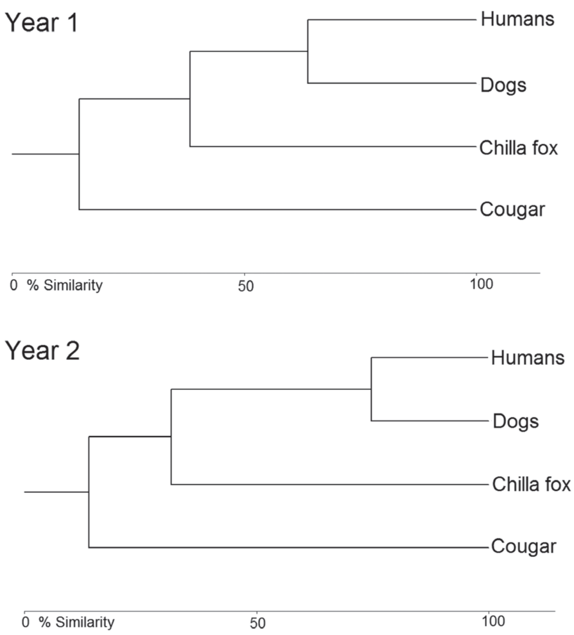

Fig. 3. Similarity in the activity pattern among species in the study area, for the two years of monitoring.

49.31, $p < 0.0001$, d.f. = 3; Fig. 4), while the cougar and the dog were similarly active day and night ($\chi^2 = 1.40$, $p = 0.705$; $\chi^2 = 5.66$, $p = 0.129$, respectively). Humans, by other hand, were mainly diurnal ($\chi^2 = 99.94$, $p < 0.0001$). In the second year, a similar pattern was obtained in the case of the chilla fox, cougar and humans ($\chi^2 = 73.52$, $p < 0.0001$; $\chi^2 = 3.01$, $p = 0.390$; $\chi^2 = 79.09$, $p < 0.0001$ respectively), while in the case of the domestic dog, this pattern changed towards a more diurnal activity profile ($\chi^2 = 14.17$, $p = 0.002$). Regarding overlap among species, it's highlighted low (and significant) values for humans and dogs vs. chilla foxes (Fig. 4), while this trend among puma and chilla fox was only in the second year (intermediate values). Humans and dogs had high (and significant) values of overlap in both years of study.

Discussion

The observed temporal pattern shows partial agreement with what has been reported for these species elsewhere, which shows that anthropic influence would have had a clear impact. In the case of cougar, the extension of the activity period differs from what was observed in protected areas of central-southern Chile (Zúñiga et al., 2017). This would be explained by the greater human presence in Hueyusca, thus increasing the nocturnal activity of pumas, as an avoidance mechanism (Paviolo et al., 2009). The people who pass through the study area are agricultural workers who carry out their daily routine from early morning until dusk, which generates pressure on native carnivores to avoid them. On the other hand, large home range of cougar could allow them to compensate for such pressure, with animals towards other patches in the landscape (Grigione et al., 2002; Rau, 2024), which agrees with previous reports from the study area (García-Solís et al., 2022). It is important to highlight that this pattern would be largely modulated to couple with the activity of pudu deer (*Pudu puda*), its main prey, which is present and whose activity is predominantly nocturnal (Zúñiga and Jiménez, 2018; Colihueque et al., 2020). In this sense, it

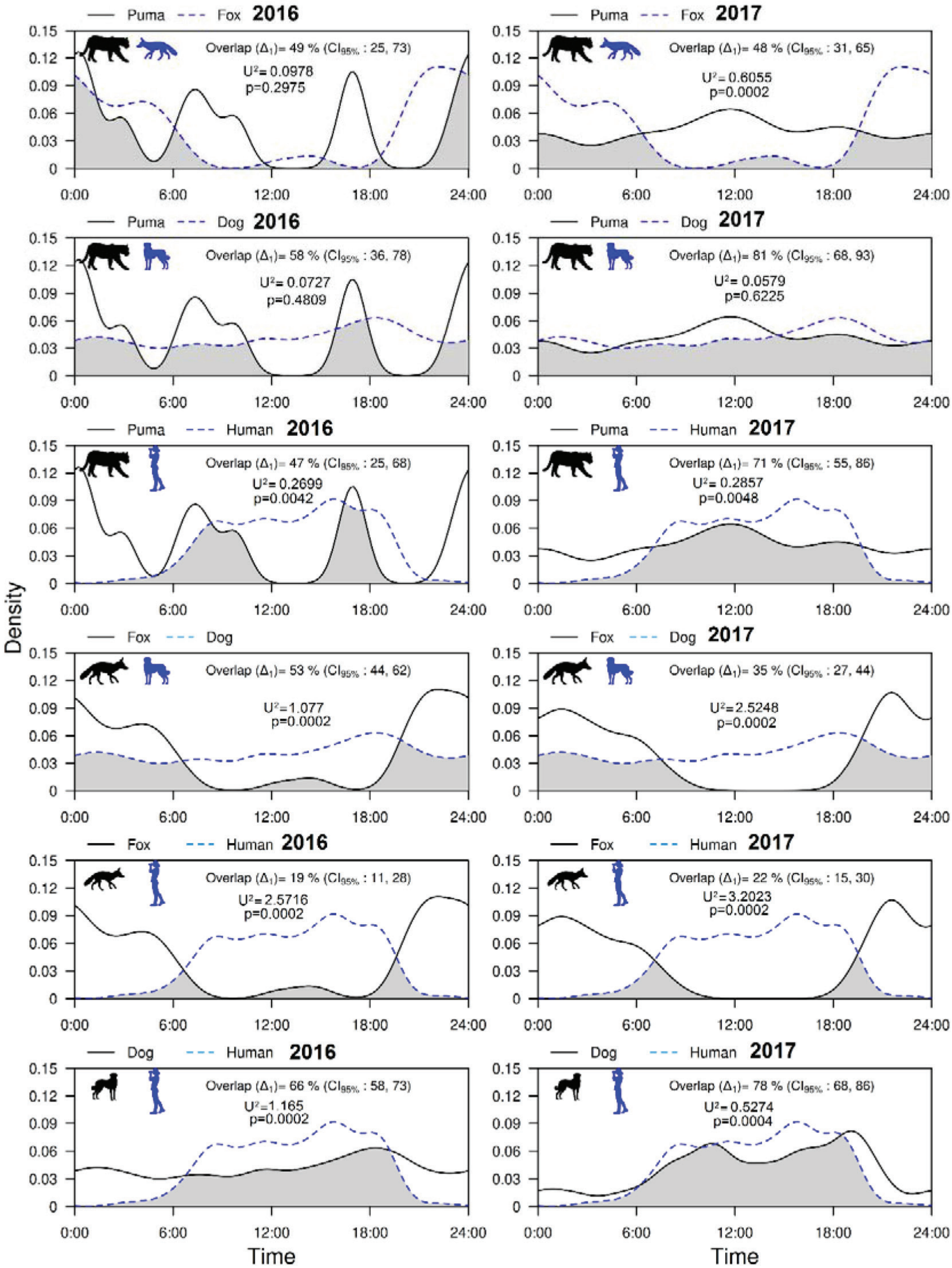

Fig. 4. Overlap of active patterns among species of Hueyusca, southern Chile.

is important to quantify the abundance of this cervid at local scale, in order to test the hypothesis about the variation in its rate of recordings between years.

In the case of the chilla fox, the activity pattern is consistent with reports in this type of environments (Gálvez et al., 2021), which suggests an active avoidance strategy with other carnivores. This would be the case of its interaction with domestic dogs (Silva-Rodríguez et al., 2010), and to a lesser extent with cougars, as has been reported for the fox *Lycalopex culpaeus* (Zúñiga et al., 2017), with constraints in habitat use. In a similar way, temporal avoidance to humans agrees with reports in other canids, which has been the case for the red fox *Vulpes vulpes* in Europe (Díaz-Ruiz et al., 2016), which evidences a disturbing effect on their occupation. On the other hand, chilla foxes must develop a temporary coupling with their main prey, rodents and hares, which are notably nocturnal (Zúñiga and Sandoval, 2020; Salgado et al., 2022). Regarding domestic dogs, the broad spectrum of activity documented here is similar to what has been reported in urban parks (Mella-Méndez et al., 2019), while it contrasts with dogs controlled by their owners (Griss et al., 2021). This fact is consistent with the high frequency of records obtained, with an asymmetric potential for interaction with the rest of the species in the community, with eventual imbalances around their distribution (Farris et al., 2017).

In general terms, the similarities obtained for native species reflect their flexibility in capturing prey and their avoidance humans and dogs. In this way, the interannual differences in the activity patterns of the studied species would be explained by the high presence of dogs in the first year, which would generate an important interference effect, restricting the occupancy of carnivores in the study area. Nevertheless, the relaxation of this interaction in the second year would be associated with a lower abundance of dogs, following a control effort done by the municipality of Purranque (approximately 10 km from Hueyusca), which is mainly associated with sterilizations of the individuals and good care practices on the part of the owners (C. Oyarzún, pers. comm.).

In conclusion, native carnivores appear to coexist through the partition of their niche axes, but this may be constrained by the emergence of the exotic domestic dog. The wide extension of the temporal niche that this canid exhibits generates a great potential for interaction with the rest of the native species in the assemblage, affecting its persistence. It is necessary to develop control actions over free roaming dogs to minimize their impact on the native fauna.

Acknowledgements

The authors thank to Carlos Oyarzún, from Purranque Natural History Museum, for its logistical support during the study, and to Fabián Jaksic for his donation of camera traps to the Laboratorio de Ecología from University de Los Lagos. We also thank to two reviewers who helped to improve this manuscript, and we are grateful for the review of a final version of the manuscript, kindly performed by Dr. Douglas Kelt from the University of California at Davis. CG was supported by Scholarship ANID-Subdirección de Capital Humano/Doctorado Nacional/2023 – 21230972.

References

Agostinelli, C., Lund, U., 2018. *Package "CircStats"*. [online]. [cit. 2024-04-02]. https://cran.r-project.org/web/packages/CircStats/CircStats.pdf

Boitani, L., Francisci, F., Ciucci, P., Andreoli, G., 2017. The ecology and behavior of feralbdogs: a case study of Central Italy. In Serpell, J. (ed.). *The domestic dog: its evolution, behavior, and interactions with people.* Cambridge: Cambridge University Press, p. 342–348.

Brassine, E., Parker, D., 2015. Trapping elusive cats: using intensive camera trapping to estimate the density of a rare African felid. *PLoS ONE*, 10: e0142508. https://doi.org/10.1371/journal.pone.0142508

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

Butler, J.R.A., Du Toit, J.T., 2002. Diet of free-ranging domestic dogs (Canis familiaris) in rural Zimbabwe: implications for wild scavengers on the periphery of wildlife reserves. *Animal Conservation*, 5 (1): 29–37. https://doi.org/10.1017/s136794300200104x

Carbone, C., Gittleman, J., 2002. A common rule for the scaling of carnivore density. *Science*, 295 (5663): 2273–2276. https://doi.org/10.1126/science.1067994

Carroll, C., Noss, R.E., Paquet, P.C., 2001. Carnivores as focal species for conservation planning in the Rocky Mountain Region. *Ecological Applications*, 11 (4): 961–980.https://doi.org/10.1890/1051-0761(2001)011[0961:CAFSFC]2.0.CO;2

Colihueque, N., Arriagada, A., Fuentes, A., 2020. Distribution modelling of the pudu deer (Pudu puda) in southern Chile. *Nature Conservation*, 41: 47–69. https://doi.org/10.3897/natureconservation.41.53748

Crooks, K.R., 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. *Conservation Biology*, 16 (2): 488–502. https://doi.org/10.1046/j.1523-1739.2002.00386.x

Díaz-Ruiz, F., Caro, J., Delibes-Mateos, M., Arroyo, B., Ferreras, P., 2016. Drivers of red fox (Vulpes vulpes) daily activity: prey availability, human disturbance or habitat structure? *Journal of Zoology*, 298 (2): 128–138. https://doi.org/10.1111/jzo.12294

Echeverría, C., Coomes, 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 (3-4): 439–449. https://doi.org/10.1016/j.ecolmodel.2007.10.045

Farris, Z.J., Gerber, B.D., Valenta, K., Rafaliarison, R., Razafimahaimodison, J.C., Larney, E., Rajaonarivelo, T., Randriana, Z., Wright, P. C., Chapman, C.A., 2017. Threats to a rainforest carnivore community: a multi-year assessment of occupancy and co-occurrence in Madagascar. *Biological Conservation*, 210: 116. https://doi.org/124. 10.1016/j.biocon.2017.04.010

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* [Interspecific relationships between the Iberian lynx, Lynx pardinus, the fox, Vulpes vulpes, and the badger, Meles meles, in the Doñana National Park]. PhD thesis. University of Sevilla, Spain. [In Spanish).

Fedriani, J. M., Palomares, F., Delibes, M., 1999. Niche relations among three sympatric carnivores. *Oecologia*, 121: 138–148. https://doi.org/10.1007/s004420050915

Fernández-Sepúlveda, J., Martin, C.A., 2022. Conservation status of the world's carnivorous mammals (order Carnivora). *Mammalian Biology*, 102 (7401): 1911–1925. https://doi.org/10.1007/s42991-022-00305-8

Gajardo, R., 1994. *La vegetación natural, clasificación y distribución geográfica* [Natural vegetation, classification and geographical distribution]. Santiago de Chile: Editorial Universitaria. 165 p.

Gálvez, N., Meniconi, P., Infante, J., Bonacic, C., 2021. Response to mesocarnivores to anthropogenic landscape intensification: activity patterns and guild tem poral interactions. *Journal of Mammalogy*, 102: 1149–1164. https://doi.org/10.1093/jmammal/gyab074

García-Solís, F., Oyarzún, C., Rau, J.R., Crespo, J.E., 2021. Registro de perrosvdomésticos con trampas cámaras en la provincia de Osorno, sur de Chile [Records of free-roaming dogs with camera traps in the Osorno Province, southern Chile]. *Boletín del Museo Nacional de Historia Natural*, 70 (1): 9–14. https://doi.org/10.54830/bmnhn.v70.n2.2021.204

García-Solís, F., Oyarzún, C., Napolitano, C., Rau, J.R., 2023. Carnivores public appreciation in rural areas of the coastal range of southern Chile. *Etnobiología*, 21 (2): 178–193.

García-Solís, F., Rau, J.R., Niklitschek, E., 2022. Occurrence and abundance of an apex predator and a sympatric mesopredator in rural areas of the Coastal range of Southern Chile. *Land*, 11: 40. https://doi.org/10.3390/land11010040

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 (1): 17–21.

Gittleman, J.L., 1985. Carnivore body size: Ecological and taxonomic correlates. *Oecologia*, 67: 540–554. https://doi.org/10.1007/BF00790026

Gittleman, J.L., 1989. *Carnivore behavior, ecology, and evolution*. New York: Springer. 620 p.

Grigione, M.M., Beier, P., Hopkins, R.A., Padley, W., Schonewald, C.W., Johnson, M. L., 2002. Ecological and allometric determinants of home-range size for mountain lions (Puma concolor). *Animal Conservation*, 5 (4): 317–324. https://doi.org/10.1017/S1367943002004079

Griss, S., Riemer, S., Warembourg, C., Sousa, F.M., Wera, E., Berger-González, M., Álvarez, D., Bulu, P.M., López, A., Roquel, P., Dürr, S., 2021. If they could choose: How would dogs spent their days? Activity patterns in four populations of domestic dogs. *Applied Animal Behaviour Science*, 243: 105449. https://doi.org/10.1016/j.applanim.2021.105449

Hairston, N., Smith, F.E., Slobodkin, L.B., 1960. Community structure, population control, and predation. *American Naturalist*, 94 (912): 421–425. https://doi.org/10.1086/282415

Hunter, J., Caro, T., 2008. Interspecific competition and predation in American carnivore families. *Ethology Ecology and Evolution*, 20 (4): 295–324. https://doi.org/10.1080/08927014.2008.9522514

Iriarte, J.A., Franklin, W.L., Johnson, W.E., Redford, K.H., 1990. Biogeographic variation of food habits and body size of the American puma. *Oecologia*, 85: 185–190. https://org/10.1007/BF00319400

Iriarte, A., Jaksic, F., 2012. *Los carnívoros de Chile* [Carnivores of Chile]. Santiago: Flora & Fauna CASEB Ediciones. 257 p. (In Spanish).

Jaksic, F., Medel, R., 1987. El acuchillamiento de datos como método de obtención de intervalos de confianza y de prueba de hipótesis para índices ecológicos [The jackknifing data as a method of obtaining confidence intervals and hypothesis testings for ecological indices]. *Medio Ambiente*, 8: 95–103. (In Spanish).

Jammakamadaka, S.R, Guerrier, S., Mangalam, V., 2021. A two-sample nonparametric test for circular data-its exact distribution and performance. *Sankhya B*, 83 (Suppl. I): 140–166. https://doi.org/10.1007/s13571-020-00244-9

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

Koeppen, W., Volken, E., Brönnimann, S., 2011. The internal zones of the Earth according to the duration of hot, moderate and cold periods and the impact of heat on the organic world. *Meteorologische Zeitschrift*, 20 (1): 351–360. DOI: 10.1127/0941-2948/2011/105

Krauze-Gryz, D., Gryz, J., 2014. Free-ranging domestic dogs (Canis familiaris) in Central Poland: density, penetration range and diet composition. *Polish Journal of Ecology*, 62 (1): 183–193. https://doi.org/0.3161/104.062.0101

Kronfeld-Schor, N., Dayan, T., 2003. Partitioning of time as an ecological resource. *Annual Review of Ecology and Systematics*, 34 (1): 153–181. https://doi.org/10.1146/annurev.ecolsys.34.011802.132435

Levins, R., 1968. *Evolution in changing environments* New York: Princeton University Press.120 p.

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 in the High Andes. *Journal of Mammalogy*, 90 (6): 1404–1409. https://doi.org/10.1644/09-MAMM-A-002R.1

Mella, J.E., Simonetti, J.A., Spotorno, A.E., Contreras, L.C., 2002. Mamíferos de Chile [Mammals of Chile]. In Ceballos, G., Simonetti, J. (eds). *Diversidad y conservación de los mamíferos neotropicales*. México: CONABIO; Instituto de Ecología, Universidad Nacional Autónoma de México, p. 151–183. (In Spanish).

Mella-Méndez, I., Flores-Peredo, R., Pérez-Torres, J., Hernández-González, S., González-Uribe, D.U., Bolívar-Cimé, B., 2019. Activity patterns and temporal partitioning of dogs and medium-sized mammals in urban parks of Xalapa, Mexico. *Urban Ecosystems*, 22: 1061–1070. https://doi.org/10.1007/s11252-

019-00878-2

Meredith, M., Ridout, M., 2014. *Overlap: estimates of coefficient of overlapping for animal activity patterns. R package version 0.3.4.* [cit. 2024-04-16]. URL: https://cran.r-project.org/web/packages/overlap/overlap.pdf

Morin, P., 2011. *Community ecology*. Sussex: Wiley-Blackwell. 373 p.

Murúa, R., 1996. Comunidades de mamíferos en el bosque nativo de Chile [Communities of mammals in the native forest of Chile]. In Armesto, J.J., Villagrán, C., Arroyo, M.T.K. (eds). *Ecología de los bosques nativos de Chile*. Santiago: Editorial Universitaria, Santiago, p. 113–133. (In Spanish).

Paviolo, A., Di Blanco, Y.E., De Angelo, C.D., Di Bitetti, M.S., 2009. Protection affects the abundance and activity patterns of pumas in the Atlantic forest. *Journal of Mammalogy*, 90: 926–934. https://doi.org/10.1644/08-MAMM-A-128.1

Rau, J.R., 2024. Relación entre el peso y la superficie de su territorio en carnívoros de Chile [Relationship between weight and surface of the home range in carnivores of Chile] *Acta Zoológica Lilloana*, 68 (2): 267–271.

Ridout, M.S., Linkie, M., 2009. Estimating overlap of daily activity patterns from camera trap data. *Journal of Agricultural, Biological and Environmental Statistics*, 24: 322–337. https://doi.org/10.1198/jabes.2009.08038

Ripple, W.J., Estes, J.A., Beschta, R.L., Wilmers, C.C., Ritchie, E.G., Hebblewhite, M., Berger, J., Elmhagen, B., Letnic, M., Nelson, M.P., Schmitz, O.J., Smith, D.W., Wallach, A.D., Wirsing, A.J., 2014. Status and ecological effects of the world's largest carnivores. *Science*, 343 (6167): 151–162. https://doi.org/10.1126/science.1241484

Rodríguez, M., Donadio, E., Middleton, A.D., Pauli, J.N., 2022. Carnivore niche partitioning in a human landscape. *American Naturalist*, 199 (4): 496–509. https://doi.org/10.1086/718472

Salgado, R., Barja, I., Hernández, M., Lucero, B., Castro-Arellano, I., Bonacic, C., Rubio, A., 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. https://doi.org/10.1186/s40850-022-00152-7

Silva-Rodríguez, E., Ortega-Solís, G., Jiménez, J.E., 2010. Conservation and ecological implications of the use of space by chilla foxes and free-ranging dogs in a human-dominated landscape in southern Chile. *Austral Ecology*, 35 (7): 765–777. https://doi.org/10.1111/j.1442-9993.2009.02083.x

Sokal, R.R., Rohlf, F.J., 1995. *Biometry*. New York: W.H. Freeman and Company. 887 p.

Vanak, A.T., Gompper, M.E., 2002. Dogs Canis familiaris as carnivores: their role and function in intraguild competition. *Mammal Review*, 39 (4): 265–283. https://doi.org/10.1111/j.1365-2907.2009.00148.x

Zapata-Ríos, G., Branch, L.C., 2016. Altered activity patterns and reduced abundance of native mammals in sites with feral dogs in the high Andes. *Biological Conservation*, 193: 9–16. https://doi.org/10.1016/j.biocon.2015.10.016

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 (31-32): 2047–2054. https://doi.org/10.1080/00222933.2018.1510995

Zúñiga, A.H., Sandoval, R., 2020. Patrón de actividad y uso del espacio de la liebre europea (Lepus europaeus, Pallas 1782) en un área protegida del centro-sur de Chile afectada por un incendio [Activity pattern and space use of the European hare (Lepus europaeus, Pallas 1782) in a protected area in central-southern Chile affected by a fire]. *Mastozoología Neotropical*, 27 (2): 253–257. https://doi.org/10.31687/saremMN.20.27.2.0.12

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. https://doi.org/10.1515/mammalia-2015-0090

Received April 28, 2024
Accepted August 23, 2024