

Original investigation

Distribution and habitat features of southern pudu (*Pudu puda* Molina, 1782) in Argentina

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Abstract

Pudu puda is a very small deer that inhabits humid areas of the temperate forests in Chile and Argentina and is one of the less known South American deer. We provide an updated distribution of *Pudu puda* in Argentina, with georeferenced sighting localities, and some qualitative features of its habitat such as forest type and understory. We also analyse the effects of human settlements, cattle and invasive mammals (*Cervus elaphus* and *Sus scrofa*) on the distribution of the southern pudu. We obtained information on *Pudu puda* occurrence from unpublished sources including protected areas provided by National Parks Administration and interviews of local residents. In the north sector of Nahuel Huapi National Park, where high density of records was found, we obtained information about some qualitative habitat features, proximity of *Pudu puda* sighting localities to human settlements, presence of invasive mammals and cattle. We recorded a total of 54 new localities for *Pudu puda* in Argentina, the northernmost record at S 39°23', W 71°17' and the southernmost at S 42°58', W 72°00'. We recorded low frequency of human settlements, *Sus scrofa* and *Cervus elaphus* in *Pudu puda* sighting localities. We did not detect exclusion of *Pudu puda* from areas with cattle occurrence. Sighting localities of southern pudu were made mostly in monotypic mature *Nothofagus dombeyi* forest, with dense understory dominated by *Chusquea coleu*.

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Introduction

Pudu puda (Molina, 1782) is a very small deer, about 40 cm shoulder height, found in the most humid areas of the temperate forests in Chile and Argentina, in places where understory is thick (Hershkovitz 1982; Eldridge et al. 1987). The geographical distribution of the species ranges from S 36° to S 49° in Chile (Miller et al. 1973) and from south-western Neuquén province to western-central Chubut province in Argentina.

The southern pudu is one of the less known South American deer. In Argentina the only available publications consist of a report of sighting localities (Yepes 1943) and accounts of some biological aspects from individuals reared in captivity, especially in connection with the breeding facility that operated from 1978 to 1990 at Victoria Island, the largest island in Lake Nahuel Huapi. Currently a population of this species,

originally descended from 10 individuals released when the breeding station closed down in 1990, exists on the island (MacNamara 1981; Del Valle and Alvarez 1981; Bruzone 1984; Pellerano 1984; Chehebar and Ramilo 1989; Raimilo 2001, 2005).

The only extant research about habitat use is the work by Eldridge et al. (1987), who analysed the characteristics of southern pudu habitat in the Valdivian forest at Lake Rupanco, Chile (S 40°52'; W 72°24'). No such habitat information exists for Argentina. Recently, Ramilo (2001) has proposed a retraction in the distribution area of southern pudu, due to environmental changes induced by cattle and forest fires in the easternmost areas of the forest; his claim was based on old sightings such as Cox's (1863) for Huemul Peninsula (S 41°02', W 71°25'). MacNamara (1981), Eldridge et al. (1987) and Ramilo (2001) suggest that red deer and wild boar, as well as human settlements, could influence the occurrence of southern pudu. The current conservation status of the species in Argentina is "lower risk, conservation dependent" (Díaz and Ojeda 2000). Our aim was to provide an updated distribution of southern pudu in Argentina and a description of some qualitative features of its habitat. In addition, we analysed the effects of human settlements, invasive animal species (*Cervus elaphus* and *Sus scrofa*) and cattle on the distribution of southern pudu.

Material and methods

The behaviour of the southern pudu (a shy, reclusive species) and the characteristics of its inhabited environment, hinder direct individual counts. Thus, in order to update the distribution data of southern pudu in Argentina, we obtained records of *Pudu puda* occurrence from data of presence in protected areas provided by the National Parks Administration and interviews. The interviews were made between July 2003 and July 2004, following the procedures outlined by Dietrich (1995). All the interviewees were qualified informants, such as rural residents and mountain guides. All the sighting localities were georeferenced and plotted onto IGM 1:250,000 topographic maps.

In order to describe some qualitative features of the habitat occupied by southern pudu in Argentina,

we selected a sector within Nahuel Huapi National Park with high density of sighting localities. The Nahuel Huapi National Park extends over 7140 km² ranging from S 40°08' to S 41°35' and from W 71°02' to W 71°57'. The selected area (2441 km²) was restricted to the north sector of the National Park (S 40°23' to S 41°28' and W 71°28' to W 71°57'), which includes the smaller Arrayanes National Park (Quetrihue Peninsula).

From a phytogeographical viewpoint, this area is included in the Valdivian and Deciduous Forest floristic districts of the Subantarctic Province. The Austral Altoandean district of the Altoandean Province is found above the altitudinal limit of the Subantarctic Province (Cabrera 1971).

Within the study area, yearly precipitation decreases in intensity from west to east (Donoso 1993), from 3913.5 mm at the Rincón arm of Lake Nahuel Huapi (near the Chilean border) (Segurel 1987), to 300–500 mm about 50 km east of the Chilean border (Dimitri 1974). Mean precipitation is 2074.3 mm at Villa La Angostura, a coastal settlement in Lake Nahuel Huapi, in the center of the study area (Segurel 1987). The vegetation reflects this precipitation gradient; accordingly, the following plant formations can be distinguished in the study area (UACH-INTA-APN-FVSA 1999):

1. Monotypic *Nothofagus dombeyi* forests. This formation occurs in the valleys below 1100 m a.s.l., extending to the coastal area around the lakes. It develops in sectors with precipitations above 1800 mm (Veblen et al. 1996). The canopy is 30–40 m high and relatively open. In the vicinity of its upper altitudinal boundary, this formation is interspersed with *Nothofagus pumilio* forest in a narrow ecotone. The bamboo *Chusquea coleu* dominates the understory forming dense thickets that are 3–5 m high and almost impenetrable. Other common understory species are *Aristotelia maqui*, *Schinus patagonicus*, *Berberis darwinii*, *B. linearifolia*, *Azara microphylla*, *Ribes magellanicum* and *Maytenus chubutensis*.
2. Mixed *Nothofagus dombeyi*–*Austrocedrus chilensis* forest. The trees are up to 30 m high, and the shrub stratum comprises *Aristotelia maqui*, *Schinus patagonicus*, *Berberis darwinii*, *Ribes magellanicum* and *Maytenus chubutensis*. *Chusquea coleu* occurs sparsely. These woods develop in areas where mean annual precipitation decreases to less than 1800 mm (Veblen et al. 1996), more eastwards with respect to the above-mentioned plant formation.
3. Monotypic *Nothofagus pumilio* forest. This formation is found over 1100 m a.s.l., above

the level of pure *Nothofagus dombeyi* and mixed *Nothofagus dombeyi*–*Austrocedrus chilensis* forests, forming a narrow shrubland stripe in the boundary of the Altoandean semidesert. The understory is generally open, with predominant sclerophyllous and xeromorphic species (Correa 1998), including *Berberis serratodentata*, *Maytenus disticha*, *Myoschilus oblongum*, *Drimys winteri*, and numerous herbs such as *Alstroemeria aurantiaca*, *Vicia nigricans*, *Adenocaulon chilense*, *Acaena ovalifolia*, *Macrachaenium gracile* and *Viola maculata*. The dense *Chusquea coleu* bamboo thickets occur only in the lower areas.

4. Low *Nothofagus antarctica* forest occurs in very diverse environments. In this study we considered only those that develop in valley plains, where edaphic conditions preclude the establishment of other forest types. This species forms woods that are 7–12 m high (Correa 1998). The understory forms small patches and includes primarily *Berberis* spp. and *Escallonia virgata*. The well-developed herbaceous stratum includes *Fragaria chilensis*, *Acaena ovalifolia*, *Taraxacum officinale*, *Elymus* spp., *Agrostis* spp. and *Poa* spp.

For each southern pudu sighting locality within this area we obtained the following information:

1. Forest and understory type. Forest typification was based upon dominant upper stratum species (monotypic *Nothofagus dombeyi* forest; mixed *Nothofagus dombeyi*–*Austrocedrus chilensis* forest; monotypic *Nothofagus pumilio* forest; and monotypic *Nothofagus antarctica* forest). The understory was characterised using four categories: dense *Chusquea coleu*, where this species creates an impenetrable and continuous thick stand; open *Chusquea coleu*, dominated by this bamboo species, but with discontinuous canopy; dense without *Chusquea coleu*, where the canopy is continuous, but not dominated by *Chusquea coleu*; open without *Chusquea coleu*, where the canopy is open and this bamboo species is not dominant.
2. Proximity to human settlements.
3. Presence/absence of any signs of invasive mammals (*Cervus elaphus* and *Sus scrofa*) and cattle at the site.

To assess the existence of significant differences in southern pudu occurrence frequency between the sighting localities in the north sector of Nahuel Huapi National Park, we used a *G*-test (Sokal and Rohlf 1995) considering the four types of forests identified in the study area; we used the same method to analyse the understory.

To test for relationships between forest type and understory we used a *G*-test of independence, using Williams's correction (Sokal and Rohlf 1995) on the basis of a two-by-two table, where the highest frequency types were compared to the rest. This table was used because the four-by-four forest and understory table presents several null values.

To assess the disturbing effects of human settlements, cattle, *Cervus elaphus* and *Sus scrofa* on the distribution of southern pudu we used a binomial test in which the probability of occurrence of each variable was estimated for 50% of the southern pudu records.

Results

To provide an updated distribution of southern pudu in Argentina, we obtained in total 54 new georeferenced sighting localities, 52 of which were situated within National Parks Lanín, Nahuel Huapi, Lago Puelo and Los Alerces (Fig. 1). Twenty-one of the new sighting localities (39%) were recorded in the north sector of Nahuel Huapi National Park selected study area (Fig. 2). Most of these consisted of indirect evidences (tracks, 81.6%), whereas the remaining corresponded to direct observations (18.4%).

The northernmost and easternmost record corresponds to Lake Quillén (Lanín National Park, S 39°23', W 71°17'), whereas the southernmost record was Pirámides creek (Los Alerces National Park, S 42°58', W 72°00'). Records of southern pudu in the north sector of Nahuel Huapi National Park were significantly associated with monotypic *Nothofagus dombeyi* forests (*G*: 27.64 *P*<0.05, df: 3). Also, presence was significantly associated with dense *Chusquea coleu* understory (*G*: 38.62, *P*<0.05, df: 3) (Tab. 1). Southern pudu presence was found to be significantly associated with monotypic *Nothofagus dombeyi* forests with dense *Chusquea coleu* understory (*G*: 3.9056, *P*<0.05, df: 3).

We found low occurrence of southern pudu presence with human settlements (binomial test, *P*: 0.07). No exclusion of the species from areas with cattle was detected (binomial test, *P*: 0.66), but the presence of *Sus scrofa* and *Cervus elaphus* was low (binomial test, *P*: 0.09 and *P*: 0.03, respectively) at the localities where southern pudu presence was recorded.

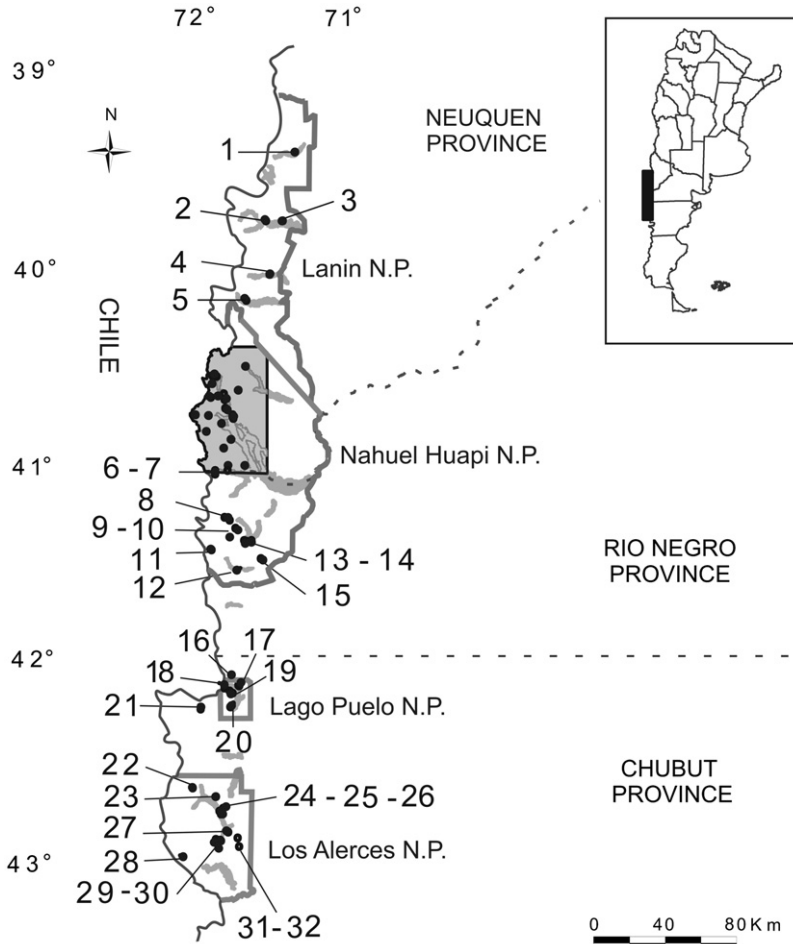


Fig. 1. Recorded localities of *Pudu puda* in Argentina. Localities at Neuquén province: 1. Pudú camping, Lake Quillén (S 39°23' W 71°17'); 2. Lake Huechulafquen, El Manzano camping (S 39°45' W 71°28'); 3. Estancia Los Helechos (S 39°44' W 71°21'); 4. Route N° 48, River Quiñilhue (S 40°01' W 71°26'); 5. Potrero de los Ciervos (S 40°09' W 71°35'). See Fig. 2 for localities within north sector of Nahuel Huapi National Park. Localities at Río Negro province: 6. Puerto Frías (S 41°00' W 71°47'); 7. south coast of Blest arm (S 41°02' W 71°45'); 8. Hotel Tronador (S 41°15' W 71°41'); 9. Los Césares lake (S 41°18' W 71°39'); 10. South side of Los Moscos hill (S 41°20' W 71°38'); 11. Los Alerces waterfall (S 41°24' W 71°49'); 12. NW coast of Martin lake (S 41°31' W 71°38'); 13. Road to Tronador, Mirador del Mascardi (S 41°21' W 71°36'); 14. Granito hill (S 41°22' W 71°35'); 15. Seccional Veranada (S 41°22' W 71°29'). Localities at Chubut province: 16. Path to Motoco river (S 42°01' W 71°40'); 17. Lago Puelo camping, Puelo lake (S 42°05' W 71°38'); 18. Los Hitos, NW coast of Puelo lake (S 42°06' W 71°43'); 19. Melo river (S 41°07' W 71°41'); 20. Puerto Bayo (S 42°12' W 71°41'); 21. El Turbio river (S 42°13' W 71°53'); 22. Torrecillas lake (S 42°37' W 71°56'); 23. Gaviota river (S 42°40' W 71°47'); 24. Arrayanes river (S 42°43' W 71°44'); 25. Puerto Chucao (S 42°44' W 71°45'); 26. Route N° 7 (Verde lake) (S 42°45' W 71°45'); 27. Playas Blancas (S 42°50' W 71°41'); 28. Pirámides river (S 42°58' W 72°00'); 29. Kruguer lake (S 42°52' W 71°47'); 30. Krugger lake, near to the source of Frey river (S 42°53' W 71°45'); 31. Limonao port (S 42°51' W 71°39'); 32. Futalaufquen village (S 42°52' W 71°38'). Light gray: north sector of Nahuel Huapi National Park; Dark gray: lakes

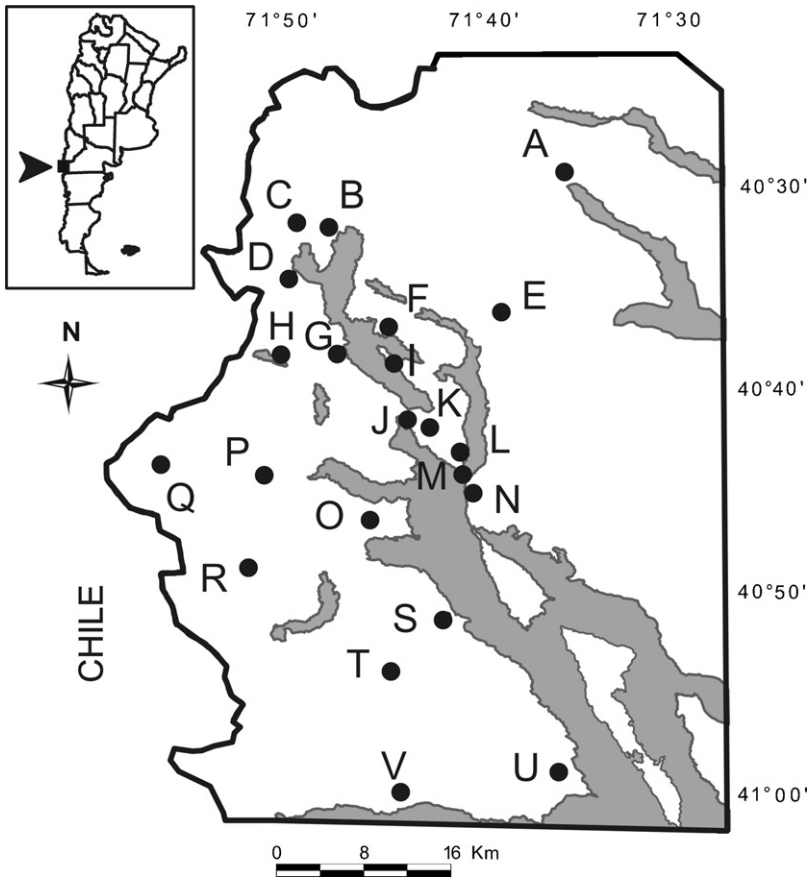


Fig. 2. Recorded localities of *Pudu puda* in the north sector of Nahuel Huapi National Park (Neuquen province): A. Route N° 234, Pichi Traful (S 40°29' W 71°35'); B. Cuerno river (S 40°32' W 71°47'); C. Cacho Sur river (S 40°32' W 71°49'); D. Lake Espejo (Campana arm) (S 40°34' W 71°49'); E. Route N° 65, Portezuelo Traful (S 40°36' W 71°38'); F. Lake Espejo (Guardaparque arm) (S 40°38' W 71°44'); G. Lake Espejo (western shore) (S 40°38' W 71°46'); H. Lake Arunco-Hue (S 40°38' W 71°50'); I. Lake Espejo (Hotel arm) (S 40°39' W 71°44'); J. Lake Nahuel Huapi (Ultima Esperanza arm) (S 40°42' W 71°43'); K. Route N° 231 (Inalco) (S 40°42' W 71°43'); L. Lake Correntoso (western shore) (S 40°43' W 71°40'); M. Correntoso river (S 40°44' W 71°40'); N. Villa la Angostura (S 40°45' W 71°40'); O. west side of Dormilón hill (S 40°47' W 71°45'); P. Pireco river (S 40°44' W 71°50'); Q. Pantojo river (S 40°44' W 71°55'); R. Millaqueo river (S 40°49' W 71°51'); S. Colorado river (low sector) (S 40°51' W 71°41'); T. Río Colorado (middle sector) (S 40°54' W 71°44'); U. Vinagre river (S 40°59' W 71°35); V. Blanco river (S 40°01' W 71°42') Gray lakes

Discussion

According to the new sighting localities, the geographical distribution of *Pudu puda* in Argentina ranges from S 39° to S 43°. In Chile, the distribution of this species ranges

from S 35° to S 49° (Miller et al. 1973); south of S 43° its distribution range extends southwards receding from the Argentine border (Eldridge et al. 1987). The Argentine and Chilean populations could probably be connected by numerous forest-covered valleys

Table 1. Forest and understory types for *Pudu puda* sighting localities in the north sector of Nahuel Huapi National Park (Neuquén, Argentina).

		Forest type				Total
		<i>Nothofagus pumilio</i>	<i>Nothofagus dombeyi</i>	<i>Nothofagus antartica</i>	<i>Austrocedrus chilensis</i>	
Understory	Dense <i>Chusquea coleu</i>	4	13	1	0	18
	Open <i>Chusquea coleu</i>	0	1	1	0	2
	Dense without <i>Chusquea coleu</i>	0	0	0	0	0
	Open without <i>Chusquea coleu</i>	0	0	0	1	1
	Total	4	14	2	1	21

that extend across the border below 1200 m a.s.l., i. e., at the maximum altitudinal limit recorded for the species.

Eldridge et al. (1987) suggested that in Chile, southern pudu prefer zones with dense understory, especially with *Chusquea quila*. This plant species does not occur in Argentina, but *Chusquea coleu*, a similar species, occurs from S 38°50' to S 45° (Triplett and Clark 2003). According to our results, in the north sector of Nahuel Huapi National Park the presence of southern pudu is closely linked with the distribution of this bamboo species. Thus, the presence of *Chusquea coleu*, especially within *Nothofagus dombeyi* forests, could be an important factor for southern pudu occurrence.

Cabrera and Yepes (1940) provided the first approximate distribution of southern pudu in Argentina, considering it to extend from S 37° to S 50°. Later, Hershkovitz (1982) provided a map based on localities from National Parks, mentioning Perito Moreno National Park (S 48°) as a probable area occupied by the species. However, considering that no records have confirmed this presence to date, and also that the dominant plant formation in this National Park consists of monotypic *Nothofagus obliqua* forest with no *Chusquea coleu* understory, the presence of southern pudu in this protected area is unlikely. In the same publication, Los Glaciares National Park (S 50°) is also cited as part of the distribution area of this species

on the basis of a reference in Dennler de la Tour (1957). As in the case of Perito Moreno National Park, the type of plant formation in this area is probably not adequate for *Pudu puda*.

Heinonen Fortabat and Chebez (1997) mentioned the presence of southern pudu in Arrayanes National Park. Although *Pudu puda* was not detected during fieldwork performed in this study, its presence is possible because the dominant vegetation in the area (monotypic *Nothofagus dombeyi* forest with *Chusquea coleu* understory) is suitable for the species.

Ramilo (2001) proposed Pico river (S 44°13', W 71°21') and Lake Fontana (S 44°56', W 71°30') as possibly the southernmost areas of occurrence of this species. However, the forest type found at these two localities seems not to be appropriate for southern pudu. The southernmost ingression of monotypic *Nothofagus dombeyi* forests with *Chusquea coleu* understory extends to the headwaters of Corcovado River (S 43°29', W 71°30'); therefore, the presence of southern pudu in the aforementioned localities, which are situated in Chubut province, is uncertain. Aside from this, and according to the map of Eldridge et al. (1987), at such latitude the distribution of southern pudu is restricted to Chile and distant from the Argentine border.

With regard to the effects of anthropogenic activities on the presence of southern pudu, hunting has been mentioned as a serious

threat to conservation (Miller et al. 1973). However, Ramilo (2001) considered the incidence of this factor in Argentina to be low. No evidence of hunting activities was detected during the survey. On the other hand, the availability of more appreciated prey such as *Cervus elaphus* and *Sus scrofa* in nearby localities could attract hunters and thus reduce hunting pressure on this species. Ramilo (2001) proposed cattle as the main agent in the modification of understory vegetation, a phenomenon that would affect the presence of southern pudu in these modified areas. Nevertheless, the information gathered in the north sector of Nahuel Huapi National Park does not support this statement, because no exclusion of southern pudu was detected in areas with cattle activity. It is important to take into account that cattle farming is typically very extensive in this area, with low animal load.

The presence of *Cervus elaphus* has been suggested to affect the distribution of southern pudu (MacNamara 1981; Eldridge et al. 1987). Although low *Cervus elaphus* occurrence was recorded at the sites where southern pudu were present, this could be attributed to the different habitat preference of these two species. *Cervus elaphus* is found in more "open" environments such as *Nothofagus obliqua* and *Austrocedrus chilensis* forests or the patagonian steppe.

Wild boar (*Sus scrofa*) is widely distributed in the areas inhabited by southern pudu,

and more specific research is necessary to assess the impact of this invasive species on southern pudu habitat. Our information indicates low frequency of association between these two species; however, the potential capacity of wild boar to occupy and modify diverse habitats (Choquenot et al. 1996) might affect the distribution of southern pudu.

In summary, the distribution of southern pudu in Argentina comprises a narrow area adjacent to the Andean mountain range, occupied mainly by *Nothofagus dombeyi* forests with dense *Chusquea coleu* understory; this territory, situated below 1200 m a.s.l., includes four National Parks. Therefore, any management policies implemented at the various National Parks of the area could affect the quality of the natural environment of southern pudu.

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Zusammenfassung

Verteilung und Aspekte des Habitats des südlichen Pudú (*Pudu puda* Molina, 1782) in Argentinien

Pudu puda ist ein kleiner Cervide, der in den feuchtesten Sektoren der in zum milden Klima gehörenden Wäldern Chiles und Argentinien lebt. Es ist einer der unbekanntesten Hirsche Südamerikas. Wir beschreiben eine aktuelle Verbreitung des *Pudu puda* in Argentinien und charakterisieren einige Aspekte seines Habitats. Wir analysieren auch die Effekte menschlicher Siedlungen, wie Vieh und nicht einheimische Tierarten (*Cervus elaphus* und *Sus scrofa*) auf die Verteilung des südlichen Pudú. Unsere Information stammt von Orten, an denen die Anwesenheit des *Pudu puda* nachgewiesen ist, von Ansichtsangaben in beschützten Gebieten, die von der Verwaltung des Nationalparks mitgeteilt wurden und persönlichen Interviews mit örtlichen Einwohnern. In den nördlichen Sektor des Nationalparks Nahuel Huapi, wo eine hohe Konzentration des *Pudu puda* lokalisiert wurde, erhielten wir Information über Aspekte seines Habitats, von der Nähe der Sichtungen an von Menschen bewohnten Orten, und über die Anwesenheit fremdartiger

Säugetiere und Rinderherden. Insgesamt wurden 54 neue Orte als mögliches Vorkommen in Argentinien ermittelt, der nördlichste S 39°23', W 71°17' und der südlichste S 42°58', W 72°00'. Es fand sich eine geringe Abhängigkeit des *Pudu pudu* bei menschlicher Anwesenheit, auch von *Cervus elaphus* und *Sus scrofa*, und kein Ausschluss des *Pudu pudu* in Gegenden, wo Rinderherden zu finden sind. Das Habitat des südlichen Pudu in den analysierten Orten ist ein reifer monotypischer Buchenwald in Südamerika (*Nothofagus dombeyi*), der teilweise einen dichten Niederwald bambusartiger Pflanzen (*Chusquea coleu*) enthält.

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