

**Distribution and use of burrows and tunnels of  
*Chaetophractus villosus* (Mammalia, Xenarthra)  
in the eastern Argentinean pampas**

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Abba A. M., Udrizar Sauthier D. E. and Vizcaíno S. F. 2005. Distribution and use of burrows and tunnels of *Chaetophractus villosus* (Mammalia, Xenarthra) in the eastern Argentinean pampas. Acta Theriologica 50: 115–124.

Burrows and tunnels built by *Chaetophractus villosus* (Desmarest, 1804) (hairy armadillo) were studied in a farming area located in the Argentinean pampas, Buenos Aires Province, Argentina. Fifty-six structures were selected and carefully excavated for this study. Data on diameter, form, and orientation of the entrance, angle, length, and depth of the galleries, and spatial distribution of the structures were recorded. The structures were separated into two types: simple and complex, both located in high terrain. Simple structures are shorter than complex ones and are built when animals are in search of food or as temporary shelters. Complex structures are built as home burrows. The orientation of the entrances of both kinds of burrows is related to the prevalent wind direction.

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*Key words:* *Chaetophractus villosus*, Argentinean pampas, burrows and tunnels

### Introduction

The genus *Chaetophractus* Fitzinger (1871) of the order Xenarthra contains three species: *C. villosus* (Desmarest, 1804), *C. vellerosus* (Gray, 1865), and *C. nationi* (Thomas, 1894). *C. villosus* is commonly known in Argentina as the “peludo” (hairy armadillo). Weighing about 2.5 kg (Wetzel 1985) it is the largest member of the genus and the most widely distributed. *C. villosus* is found in the Chaco region of Paraguay and Argentina and in southern Chile (Redford and Eisenberg 1992).

The hairy armadillo inhabits open areas and is well adapted to semi-desert conditions (Nowak 1991). It is the most common species of dasypodid in the plains and intermountain valleys of Argentina (Cabrera and Yepes 1940), and is frequently found in agricultural lands of Buenos Aires Province (Yepes 1928, Galliari *et al.* 1991, Bolkovic *et al.* 1999). *C. villosus* is considered one of the most adaptable

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armadillos showing resilience to changes in its natural environment. As mentioned by the early naturalists of South America (eg Azara 1802, Hudson 1892) *C. villosus* is a generalist feeder, displaying an omnivorous diet (Redford 1985, Casanave *et al.* in press).

Despite the relative abundance of *C. villosus* on the Argentinean pampas, little is known about its ecology, especially its digging habits. The only available information on burrow structures was published by Crespo (1944) for a site in San Luis Province, central Argentina. The aim of this work is to augment our knowledge of the biology of *Chaetophractus villosus* by describing its burrows and tunnels and analyzing their distribution in an agricultural area in northeastern Buenos Aires Province, Argentina.

### Study area

This work was carried out from 1998 to 2001, in an agricultural area located near La Plata, Buenos Aires Province, Argentina (35°58'S, 57°48'W). The landscape is a plain of low gradient, at an elevation of around 20 meters above sea level, and composed of loessic deposits. A fringe area of mid- to late Holocene beach ridges extends along the northeastern margin of the plain. These coastal deposits form elongated hills up to 6 m above the surrounding plain, composed of marine mollusk shells. Relatively thin (0.5–0.7 m thick) eolian sands cover the ridges and are modified by pedogenesis resulting in an A horizon, ie a IICka profile (Cavallotto 2002).

The weather is moderate-warm and humid with mean annual temperatures ranging from 15 to 16.5°C and 850 to 1000 mm of annual precipitation (Cabrera and Zardini 1978). There is no clear annual prevailing wind direction; however in spring and summer, winds come from the east, and in autumn and winter from the south to northwest. The main landscape units of the study area are: seminatural, agrarian, rural, suburban, and urban-industrial (Ghersa *et al.* 1998). The dominant plant community is grassland, where native species co-occur (*Stipa*, *Paspalum*, *Panicum*, *Piptochaetium*, etc.) with foreign and exotic species (*Medicago*, *Lotus*, *Cardus*, etc.). There are also small forests of native species (*Celtis tala*, *Scutia buxifolia*) and exotic species (*Eucalyptus*).

### Material and methods

By observation transects, 150 burrows and tunnels of *C. villosus* were recorded. Fifty-six burrows and tunnels were selected due to the presence of recent signs of activity (trace, soil removed, open galleries, etc), and were carefully excavated and opened for study. Data on width and height, form, and orientation were recorded. The orientation of the entrance of 41 extra burrows was directly recorded without excavation. The angle of the first part of the galleries to the surface was measured using a clinometer. Total length of the structure and depth of the galleries was measured adding all the branches. The shape of the structures were drawn as dorsal and lateral views, establishing the enlargement and branches (Fig. 1). All records are shown in Appendix 1 as burrow number (*n*), mean ( $\bar{x}$ ) and standard deviation (SD). Data on composition of the soil (calcareous-humic) were recorded for the area immediately surrounding each structure.

Topographic maps and aerial photographs of the area were examined to enable analysis of spatial distribution of the structures. Determination of the topographic changes was made using geological prospecting techniques via a theodolite, whereby an open polygonal of nine stations was made for each station located in high terrain. Starting from these stations, points were projected to the surrounding areas to determine the elevation of each of these points. The area studied thus comprised 150 ha with low zones and numerous ephemeral water channels. The most elevated areas were characterized by concentrations of shell ridges.

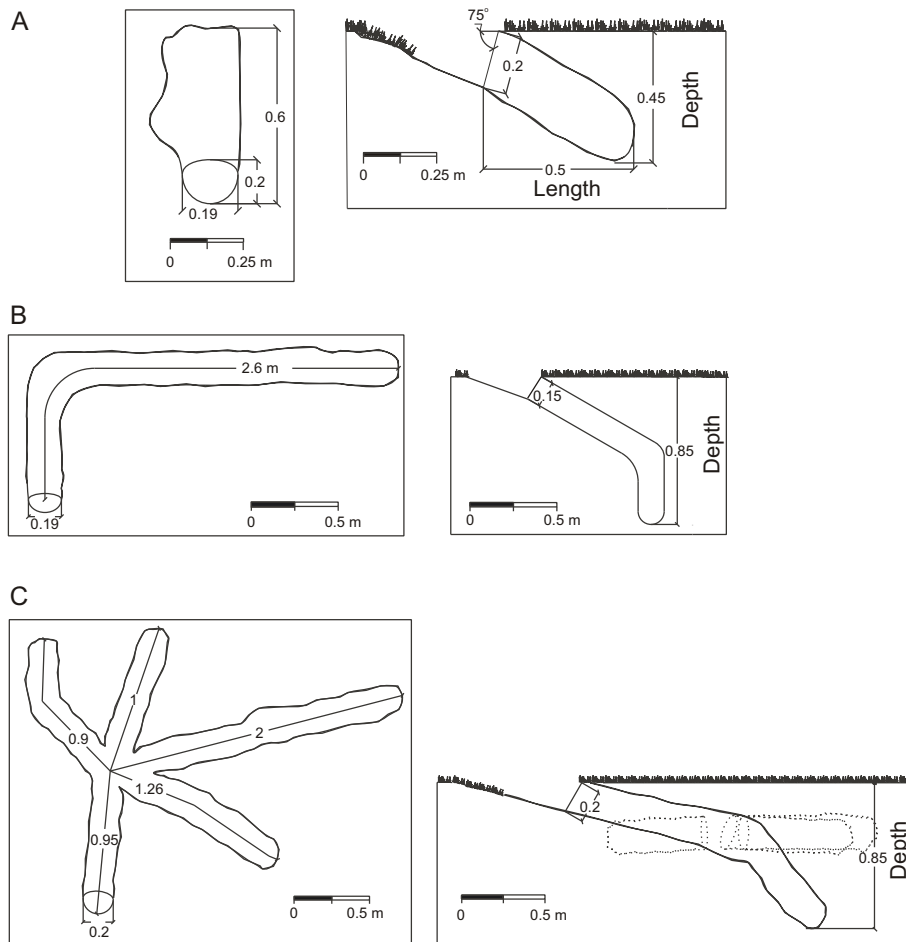


Fig. 1. Diagrams of burrows and tunnels of *C. villosus* in the eastern argentinean pampas, showing the measurements of depth and length. A – top and saggital view of simple structure. B – typical complex structure in dorsal and lateral view. C – schematic representation of a complex structure with numerous branches.

Comparisons between different variables were made. Student's *t*-test was used, and in cases of non-normal distribution, a non-parametric test (Mann-Whitney *U*-test) was applied. Differences between expected and observed results for some variables were analyzed using chi-square test after Yates correction when there was one degree of freedom (Sokal and Rohlf 1995).

## Results

The burrows and tunnels consisted of a descending gallery leading to a relatively horizontal area. The entrance was approximately cylindrical, and although it faced various directions, the most frequent was to the northwest (20), northeast (16) and

west (14). The angle of the descending gallery to the surface, length, width and height and depth of the mouth are listed in Appendix I. Fifty-seven percent of the structures had branches. The structures were grouped within 3 m in 90% of the cases, with no connections among them, and differentially distributed in open fields or in gaps in the forest (70 and 30% respectively;  $\chi^2: 16.01, p < 0.01$ ). In soft terrain, tunnels normally reach a mean depth of approximately 30 cm. When an obstacle appears in the way, like consolidated calcareous material or large roots, the depth can reach up to 100 cm.

Because the study site was very level, a mean difference of only 93 cm occurred between the lowest site and the highest zone. However, some differences in the distribution of the structures could be detected. In the lower zones, no burrows were found. In the higher zone 40% of the burrows were sparse and 60% were concentrated on the border with the lower zones always above flood marks ( $\chi^2: 4.01, p < 0.05$ ).

Length and depth of the burrows and tunnels are shown in Fig. 2. A practically continuous relation of depth and length was observed; initially this does not permit a functional identification based exclusively on these measurements. However, the identification of each structure and its correspondent substrate (ie A horizon, IICka, marine deposits) showed two size groups: structures in the A horizon are smaller length (mean difference = 50 cm,  $t$ -test:  $t = -14.74; p < 0.001$ ) than those found in the calcareous material. The comparison between the measurements of length ( $t$ -test:  $t = -6.38; p < 0.01$ ) and depth ( $U$ -test:  $U = 33; Z = -5.72; p < 0.001$ ) and the ratio length/depth ( $t$ -test:  $t = -2.51; p = 0.015$ ) with the types of soil showing significant differences between the structures found in humus and those in calcareous material (Fig. 3).

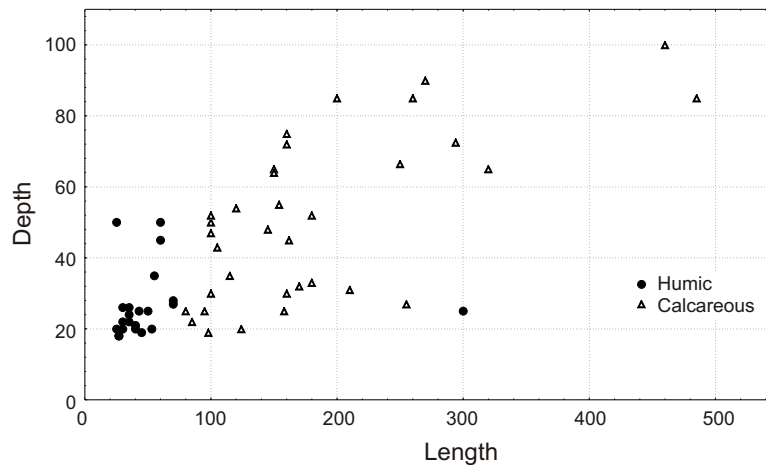


Fig. 2. Comparison of length (cm) versus depth (cm) data of the burrows and tunnels of *C. villosus* showing the different size of the structures in both type of soil in the eastern argentinean pampas. – calcareous soil, • – humic soil.

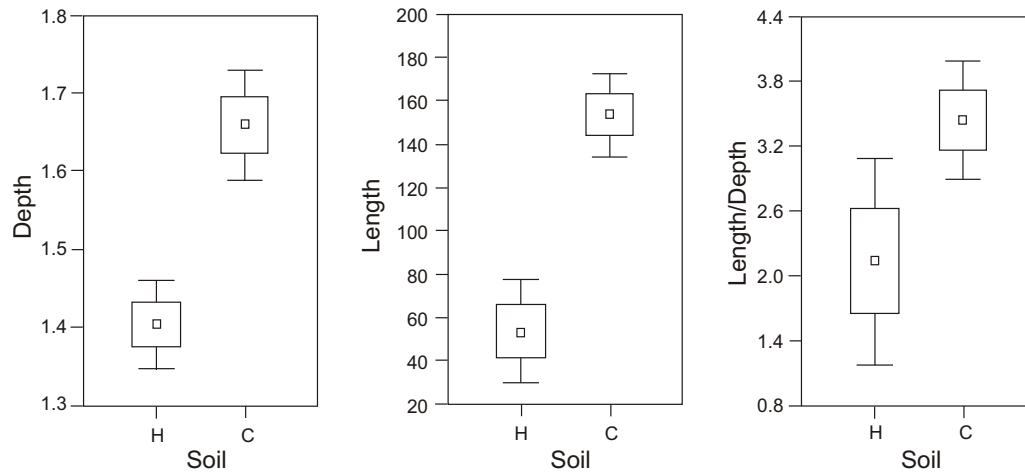


Fig. 3. Box plot showing the comparison between the measurements of length (m) and depth (cm) and the ratio length/depth of the burrows and tunnels of *C. villosus* with the types of soils in the eastern argentinean pampas.

On this basis, the burrows and tunnels were separated in two types, simple and complex. A greater number of simple structures was observed. The simple structures had a mean length of 70 cm and mean depth of 50 cm (Fig. 1A). They were found exclusively in soils with primarily organic material, where arthropods, grubs, and annelids were frequent (Sanchez *et al.* 1976). In 60% of the cases these structures end in passageways built by beetle larvae (Insecta: Coleoptera: Scarabaeidae). Only one structure in this type of soil reached a length of 300 cm, due to a particular morphology; it had five branches whose measurements were from 45 to 75 cm in length.

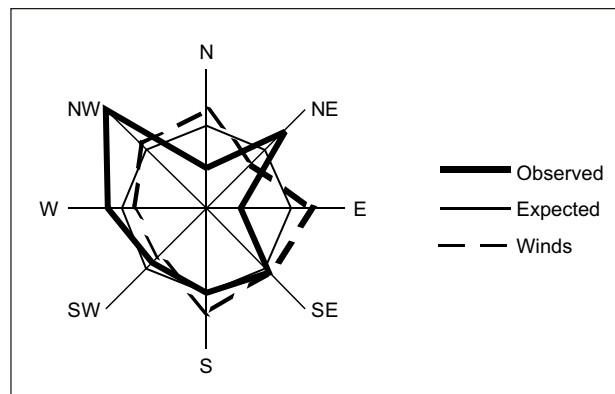


Fig. 4. Frequency polygon of the cardinal orientation of 97 entrances of the burrows and tunnels of *C. villosus* and the prevalent winds in the eastern argentinean pampas.

Complex structures were found in areas with a high proportion of calcareous material, little organic material, and low moisture, resulting in a hard soil. Tunnels were longer than simple structure reaching up to 485 cm in length and 100 cm in depth (Fig. 1B and C). Seven of the 34 complex structures had enlargements (chambers) near the mouth and at the end of the galleries. Mean measurements of the chambers were: 20 × 30 × 50 cm.

A comparison of orientation of 97 entrances (Fig. 4) showed significant differences between the 8 main orientations measured ( $\chi^2$ : 15.333,  $p < 0.05$ ), with a strong negative selection for the east ( $\chi^2$ : 4.083,  $p < 0.05$ ) and north ( $\chi^2$ : 4.083,  $p < 0.05$ ).

## Discussion

The relationship of simple and complex structures with the two types of soil can be interpreted in different ways. On one hand, horizon A may impose physical limitations to the construction of deep and long galleries that do not exist in calcareous soils. On the other hand, two reasons attributable to armadillo behaviour can be considered. First, due to their length, depth and complexity, there is little chance that simple structures represent actual home burrows for the hairy armadillo. It is well known that armadillos escape by digging (Cabrera and Yepes 1940, Carter and Encarnaçao 1983), therefore simple structures may have been built as temporary shelters to escape predators, such as dogs and humans in this region. These structures are found in high density, in areas where the soil is wet, with a high content of organic material and an abundance of grubs and annelids (frequent items of the armadillo's diet, Redford 1985, Casanave *et al.* in press). Therefore, there could be a relationship with associated food gathering. Many species of armadillos dig in search of food (Talmage and Buchanan 1954, Nowak 1991, Redford 1985). Many armadillos are known to make large numbers of "food probes". Greeger (1980) found that a single *C. vellerosus* made 222 "food probes" (holes < 30 cm) in five days. The structures resulting from this activity are commonly known as rooting places ("hozaduras", Crespo 1944, Bolkovic *et al.* 1999). As mentioned above, at the end of these structures empty beetle passageways were found. But these passageways were found in recently dug tunnels, suggesting that these armadillos dug in search of invertebrate food items.

We believe that due to their complexity, and size, living chambers found in the galleries, represent home burrows. Moreover, the type of soil (calcareous) where this structure was found was not appropriate for searching for food, since there was a low density of grubs and annelids (Sanchez *et al.* 1976).

Xenarthrans are imperfect homeotherms; therefore their body temperatures do change with the environment (Grassé 1955, McNab 1980, 1985, Boily 2002). Construction of home structures could be a consequence of the limited thermoregulatory capability of these animals (MacNab 1980, 1985). González *et al.* (2001)

proposed that the southern long-nosed armadillo or “mulita”, *Dasypus hybridus*, may meet minimal metabolic requirements in any kind of burrow in summer, but in winter, the use of longer and deeper burrows may be needed to aid in thermoregulation. As a result, temperatures inside the burrows of *D. hybridus* were higher than outside.

We found that *C. villosus* builds its burrows and tunnels in the highest areas that do not flood. This also was observed by Bolkovic *et al.* (1999) in western Buenos Aires Province (about 400 km from our study area) that has similar annual precipitation. During dry periods, when the topsoil of lower terrains is not saturated, the water table is located a few centimeters below the surface. In San Luis Province, about 700 km to the west, annual precipitation is much lower (500 mm), and the distribution of burrows seems to be related mainly to soil hardness (Crespo 1944).

In our study area, the orientation of burrows and tunnels was related to wind direction. Winds from the east prevail during warm months, and the winds from the north, although not so marked, prevail during temperate months. This could be due to the imperfect thermoregulation of *C. villosus* mentioned above as a generalized feature of xenarthrans and suggests that the construction of home structures would be also important in summer. Burrow orientation is different for *D. hybridus* in Uruguay – the prevailing orientation of burrows was to the north sector (González *et al.* 2001).

Another study on *C. villosus* (Crespo 1944) found burrow entrances oriented to the WSW. Burrows of other species, the six-banded armadillo *Euphractus sexcintus*, the giant armadillo *Priodontes maximus*, and the naked-tailed armadillo *Cabassous unicinctus* and *C. tatouay*, were also oriented in the same direction (Carter and Encarnaçao 1983). As in our interpretation, they related entrance orientation with the prevailing wind direction in the area, which is from the ENE, and proposed that the armadillos tended to enter burrows from downwind.

The data obtained for *C. villosus* were compared with the available information of *C. vellerosus*, a smaller species distributed mainly in central and northern Argentina (Wetzel 1985, Carlini and Vizcaíno 1987). Different authors (Crespo 1944, Greegor 1980, 1985) observed similar patterns in the distribution of burrows in higher terrain, and with respect to each other and the lack of grass in the interior of the burrow (nesting material). The most evident differences are that burrows of *C. vellerosus* may have numerous entrances (Greegor 1980, 1985). Burrows of *C. villosus* also differ from those of *Dasypus*. Although some morphological variation of the burrows of *Dasypus* has been reported, most structures contain grass and have multiple entrances (Taber 1945, Talmage and Buchanan 1954, Grassé 1955, Zimmerman 1990, Vizcaíno 1990, González *et al.* 2001).

Carter and Encarnaçao (1983) provided general characterizations of the burrows of the four species mentioned above. Similar to *C. villosus* burrows of *E. sexcintus*, *P. maximus*, *C. unicinctus*, and *C. tatouay*, had only one entrance and lacked nesting material.

In summary, *C. villosus* build different types of burrows and tunnels, as do other armadillos, which can be related to different activities and recognized by morphological differences. We found that simple structures were built in search for food and larger and more complex structures were built as home burrows.

Acknowledgements: We thank F. Archuby and A. Kehr for helping us with statistical analysis; S. Bargo, C. Deschamps and R. Fariña for the critical revision; M. Zárate, A. Blasi, M. Manceñido for their comments; I. Friedman de Casse for helping with the first translation to English; R. Armas, L. Ferretti, L. Lagomarsino, A. D'Agostino and W. Udrizar Sauthier for their invaluable assistance during fieldwork; M. Galvan and L. Perez for preparation of the figures; Office of Levantamiento Geológico and Climatología (UNLP) for providing with technical element; the Abba family for their constant support and patience; the Comisión de Investigaciones Científicas de la provincia de Buenos Aires for financial support to the first author. This paper is contribution to the projects UNLP N-336 and PICT 07-06348.

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*Received 23 April 2003, accepted 17 March 2004.*

*Associate Editor was Joseph F. Merritt.*

Appendix I. Angle, length, depth (cm) of the burrow and tunnel of *Chaetophractus villosus* in the eastern argentinean pampas.  $\bar{x}$  – arithmetic mean and SD – standard deviation.

No.	Angle	Opening		Length	Depth	No.	Angle	Opening		Length	Depth
		Width	High					Width	High		
1.	50	15	14	25	20	29.	45	20	14	150	65
2.	42	19	19	158	25	30.	50	22	20	120	54
3.	47	15.5	17	27	18	31.	90	20	18	55	–
4.	35	20	21	180	33	32.	75	26	21	180	52
5.	24	16	17	98	19	33.	60	21	22	100	50
6.	40	25	19	124	20	34.	60	21	17	105	43
7.	47	17	15	30	22	35.	60	21	18	162	45
8.	50	23	20	95	25	36.	85	23	18	100	52
9.	30	19	12	30	20	37.	70	26	23	154	55
10.	35	17	22	170	32	38.	90	22	23	145	48
11.	42	19	19	70	27	39.	70	21	16	25	50
12.	40	19	22	43	25	40.	60	23	22	160	75
13.	40	19	22	27	18	41.	60	19	22	294	72
14.	45	20	18	255	27	42.	60	19	22	485	85
15.	45	20	18	50	25	43.	70	19	20	60	50
16.	60	26	20	80	25	44.	60	21	19	460	100
17.	40	22	20	300	25	45.	75	20	19	60	45
18.	40	22	20	45	19	46.	60	15	19	260	85
19.	45	19	18	40	20	47.	60	20	20	200	85
20.	35	22	24	85	22	48.	45	20	21	100	30
21.	40	22	26	53	20	49.	70	20	22	160	30
22.	65	19	18	30	26	50.	90	20	22	210	31
23.	58	21	25	35	26	51.	60	22	20	70	28
24.	55	25	20	35	24	52.	40	16	15.5	150	64
25.	35	21	24	40	21	53.	54	22	20	270	90
26.	45	27	20	115	35	54.	45	30	18	250	66
27.	45	20	18	35	22	55.	50	18	22	160	72
28.	48	18	15	100	47	56.	45	25	20	320	65
						$\bar{x}$	53.3	20.7	19.5	131	41.38
						SD	15	3	2.8	104	28