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LIVESTOCK AND NATIVE FAUNA: CHANGES AFFECTING PREDATION AND SECONDARY DISPERSAL OF SEEDS OF WOODY PLANT IN THE SEMIARID CHACO WOODLAND, COPO NATIONAL PARK AND SURROUNDINGS, ARGENTINA.

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PRINCIPAL RESEARCHER: Carlos Eduardo Trucco Alemán

E-MAIL: ctrucco@unsa.edu.ar

AFFILIATION:
- National Council of Scientific and Technical Research (CONICET), Argentina
- Biological and Geological Sciences Institute (IBIGEO), Natural Science Museum of Salta National University, Argentina

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I. Introduction.

The Chaco woodland is one of the most diverse and threatened ecosystems in South America (Barchuk *et al.* 1998). Overgrazing, logging, and dry land agriculture are transforming the region into shrub lands with low resource-use potential (Bucher and Huszar 1999).

Cattle raising modifies natural environments directly in different ways:

- livestock selects the plants species it eats (Wallis de Vries and Schippers 1994, Fleischner 1994), creating a series of alterations of the specific structure and composition of the forest modifying the composition of the plants communities (Sala *et al.* 1986, Fleischner 1994, Grulke 1994, Gardner *et al.* 1995),
- livestock affects differentially the establishment of native plants (Oesterheld and Sala 1990) and it promotes the recruitment of exotic species (Fleischner 1994, Milton *et al.* 1994),
- livestock compresses the soil due to trampling (Grulke 1994, Martín *et al.* 1998) which reduces filtration and changes the soil composition (Smith *et al*. 1996, Abril and Bucher 1999),
- livestock modifies the provision and cycle of nutrients of the soil changing the availability of proper sites for recruitment (Abril *et al*. 1993, Milton *et al.* 1994, Abril and Bucher 1999),
- livestock can spread certain species seeds and predate others (Molinillo and Farji Brener 1993, Campos and Ojeda 1997), and
- livestock uses the sceneries selectively, for example, gathering around houses and dams, generating areas with bare soils (Morello and Saravia Toledo 1959, Grulke 1994).

At the same time, cattle raising implies another type of secondary impacts which can affect the structure of the habitat or the availability of shelters and resources for fauna (Fleischner 1994, Gardner *et al.* 1995), such as:

- the construction of dams for the provision of water for livestock, which given the limited natural dams in the area, they usually attract wild fauna (C. Trucco, pers. obs.),
- the shrub lands burning in order to favor the shrubs sprout (Gardner *et al.* 1995),
- the decrease of the storage capacity of natural dams by accelerating its filling up due to the increase of superficial draining and the provision of sediments to the lower areas (Morello and Saravia Toledo 1959),
- the impact caused by dog’s presence and livestock farmers hunting (Bolkovic 1999, Bennett and Robinson 2000).

In this way, whether directly or through changes in the cast of native fauna, cattle raising can modify predation and dispersal of fruits and seeds. Given that the spatial dispersal of seeds results from animal deposition of seeds or other ways of dispersal and that this disposition is modified by post-dispersal predation and secondary dispersal, (Roberts and Heithaus 1986, Verdú and García Fayos 1996) it is to expect that livestock raising effects differ between plants species depending, among other things, on the fruits characteristics and its offer. Even though impacts caused by livestock on native flora and fauna have been studied, its effects on plant-animal interaction have received little attention.

In this way, the study of the relationship between cattle raising and secondary removal of seeds would give information about an unstudied interaction in semiarid Chaco and it would allow to assess the answers of the fauna which is involved in this process to traditional cattle raising activity.

II. Work objectives.

The key objective of this study is to assess the changes in the post-dispersal seed removal of native woody plants and in the removal agents themselves (insects, small and large vertebrates) in eight woodlands with different intensities of cattle grazing in the Copo National Park (CNP) and surroundings.

III. Study area.

Copo National Park (114,000 ha, 160 m.a.s.l.) is located in Santiago del Estero Province, Argentina (25º 55' S, 62º 05' W) (Fig. 1). The area is considered a key preserve for threatened Neotropical birds (Wege and Long 1995). Extensive stands of old-growth forest persist in the northern and eastern portions of the park; the southwestern sector was selectively logged in the 1950s. The climate is seasonal, with 80% of annual rainfall occurring October–March. Summer temperatures in the region are extreme (mean maximum: 47º C; Prohaska 1959).

Fig 1. Map of study site located in Santiago del Estero province, northwestern Argentina

The dominant vegetation is thorny, semi deciduous forest dominated by quebracho Colorado santiagueño (*Schinopsis lorentzii*), quebracho blanco (*Aspidosperma quebracho-blanco*), and mistol (*Ziziphus mistol*), and is interrupted by belts of natural grasslands associated with ancient river beds. The understory is a dense, shrubby layer (4 m mean height), dominated by sacha poroto (*Capparis retusa*, Tálamo and Caziani 2003). Above this layer, mistol forms a sparse layer with both quebracho species, the tops of which attain a mean height of 12 m (López de Casenave *et al.* 1998).

IV. Methodology.

We conducted surveys in eight sites with different cattle use intensities. One site where livestock only sporadically comes in a primary forest area (PF) and seven sites in a secondary forest area with different cattle use intensities (SF 1 to 7, according to a higher or lower cattle use intensity, respectively) (***Fig. 2***).

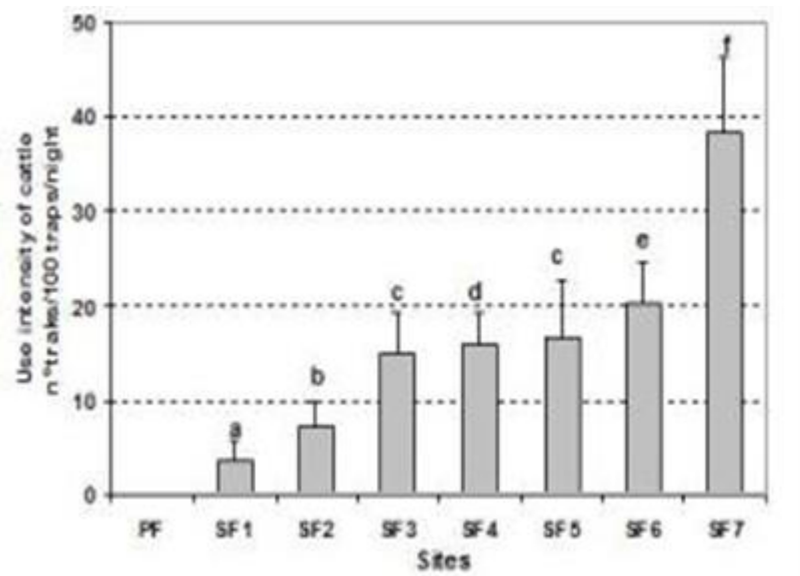


Fig. 2. Cattle use intensities in the eight study sites. Ten simples where done per site, using the same methodology used here for medium and large vertebrates: 2 transects with 20 active track-traps for 7 days per site and per sample. Mediums and its standard mistakes are shown. Different letter prints show significant differences (Kruskal-Wallis test: Hc = 42.27, g.l. = 7, N = 80, P = 0.031) (Trucco 2007).

Per site, we assessed post-dispersal seed removal for three native plant species: quebracho Colorado santiagueño (*Schinopsis lorentzii*), mistol (*Ziziphus mistol*) and tinta negra (*Achatocarpus praecox*). Some characteristics of these species and their fruits are detailed in ***Table 1***. Seeds were exposed experimentally to different removal agents (insects, lizards and/or small mammals, large mammals), with controls, using selective closures. We also estimated the background abundance of arthropods, lizards, mammals and cattle with different capture techniques or indirect methods. Finally, we identified dispersal and predator agents by offering seeds to different animal species.

Table 1. Characteristics of the studied species: habits, type of fruit and seed/fruit and size of fruit (Caziani 1996, pers. obs.), size of the seed (pers. obs., n=50), density and basal area in secondary forests in Copo NP (Tálamo and Caziani 2003), bearing fruit period (in the study area: pers. obs.).

	Schinopsis lorentzii (Quebracho colorado santiagueño)	*Ziziphus mistol* (Mistol)	*Achatocarpus praecox* (Tinta negra)
Habit (height)	tree (to 25 m)	tree (to 10 m)	tree (to3 m)

Type of fruit and seed/fruit	Brown fruit with single elongate wing, single-seeded	Almost spherical dark red drupe single-seeded	Spherical and translucid drupe single-seeded
Size of fruit	23.0 ± 3.28 mm x 8.1 ± 1.1 mm	10.8 ± 0.3 mm	6.8 ± 0.2 mm
Size of seed	5.4 ± 0.8 mm	7.5 ± 0.9 mm	2.9 ± 0.7 mm
Density	250 ± 254 ind/ha	167 ± 125 ind/ha	917 ± 764 ind/ha
Basal area	6.14± 8.58 m^2/ha	5.29 ± 4.36 m^2/ha	0.42 ± 0.52 m^2/ha
Bearing fruit	may-june	november-december	december-february

<u>Seed removal experiments</u>: for each plant species and for each site, we evaluated seed removal rate by placing feeding stations (white plastic dishes on the ground). We propose experiments with the following treatments:

1. Feeding stations exposed only to arthropods removal (ants meanly): protected with interweaved wire (½") fixed to the ground with stakes.
2. Feeding stations exposed only to small mammals removal (probably micro-mammals and lizards): protected with Tangle foot® (sticky resin for insects) and interweaved wire (1½") fixed to the ground with stakes (***Fig. 3***).
3. Feeding stations exposed to all vertebrates removal: seeds surrounded with Tangle food®.
4. Control: feeding stations without any type of closure, exposed to any removal agent.

In this way, we assessed 4 treatments, with 8 replicates (sub-samples) for each one.

Feeding stations were distributed in each habitat along transects of 40 m long inside the forest (300 m apart) along which, every 10 m, 4 feeding stations were placed, to which treatments were assigned at random. The experiment was repeated once with every species during its bearing fruit period: mistol in January, tinta negra in February and quebracho Colorado santiagueño in May. The number of fruits per feeding station varied depending on fruits availability and its handling capacity. We placed 60 mistol fruits per feeding station, 100 tinta negra fruits and 80 quebracho Colorado santiagueño fruits. Feeding stations were active 28 days in each case.

Fig. 3. Feeding station with mistol fruits exposed only to small vertebrates removal.

<u>Seed removal agents</u>: to estimate the abundance of possible removal agents we sampled ants, lizards, small mammals and other vertebrates (***Fig. 4***).

Arthropods were collected using 32 pitfall traps randomly placed at ground level in each site. To avoid the evaporation of the content and the arthropods decomposition we used etilen-glicol at a 70% (Ausden 1999). Pitfall traps were exposed for four days during each seed removal experiment. Then we counted and identified the individuals at an order level, excepting hymenoptera, where ants (Family: Formicidae) were separated from the rest.

Lizards were sampled using interception/pitfall traps. In each forest we placed 8 traps of 28 cm. diameter and 40 cm. depths. Traps were placed in pare, 8 m. apart and joined by a nylon wall (Scrocchi and Kretzschmar 1996). They were active at the same time as the seed removal experiments during the whole month each one of them lasted. We cheeked them once a day, in order to obtain live captures. Once identified, the individuals were set free near the capture place, except for some individuals which were temporarily used before setting them free (see: Identification of dispersal and predation agents).

Fig. 4. Methodologies used to estimate the different animal groups abundance: a) interception/pitfall traps for lizards, b) Sherman traps for small mammals, and c) track- traps for other vertebrates.

Small mammals were trapped on one transect per site using 50 Sherman traps 20 m apart, covering one kilometer long. Traps were active 7 consecutive days. Traps were baited with oats and peanut butter and checked daily. The same as with lizards, once identified, individuals were set free near the capture place, except some individuals which were temporarily used before setting them free (see: Identification of dispersal and predation agents).

Others vertebrates (meanly medium and large mammals) were recorded using track-traps. In each site we placed 2 groups of traps 1 km apart. Each group consisted in a series of 20 track-traps 1 m x 1 m, 50 m apart. Traps were checked once a day and were active 5 consecutive days. With this methodology we did not estimated the relative species abundance, but we obtained a measure of the degree of activity – using the tracks records - in each site.

<u>*Identification of dispersal and predation agents*</u>*:* we identified dispersal and predation agents, whether with studies previously published or by offering seeds to different animal species. We worked in different ways depending on the questioned agents:

a) Arthropods: we did a second experiment on the field offering seeds of the same species to ants, in order to know their destiny (nests, rubbish dumps, etc.). We did this experience only with ants' species whose nests external architecture allows its identification on the field. We placed 20 seeds from each species near 8 ants' nests and we observed the foddering activity of the ants for one hour, since the seeds pile was detected. Nevertheless, this methodology did not allow us to determine if ants act as predators or secondary dispersals of seeds, it gave signs of the "initial" destiny of the seeds.

Fig. 5. Teius teyou (left) and Ameiva ameiva (right) in captivity.

b) Lizards and small mammals: we kept in captivity some individuals of each species to verify if they consumed seeds from the species we are interested (***Fig. 5***). We placed seeds in each cage and we observed the foddering activity for 3 days.

c) *Others vertebrates:* we analyzed faecas of suri (*Rhea americana*), fox (*Pseudalopex griseus*) and southern three-banded armadillo (*Tolypeutes matacus*). For the other species we developed experiments similar to the previously explained. These experiments were done only on tortoises (*Chelonoidis chilensis*); meanwhile for the rest we used animals from the zoo from the Council Ecology Complex from Roque Sáenz Peña (Chaco Province) and from the Native Fauna Station "Finca Las Costas" (Salta Province). These establishments have individuals of most of the recorded species in the study area; however it was not possible to develop the experiments, though we expect to be able to do them this year.

V. Drawbacks.

With support of RSG and a small additional subsidy (CIUNSa) we assessed the 3 species removal and we estimated the potentially removal agents abundances in three opportunities in each site, fulfilling these projects aspects. The total study meant 118 days of field work (4 months aprox.). We have analyzed the role of dispersal and/or predator of seeds of several species of lizards and rodents, but there are still no studies on some species, specially medium and large mammals. The same happens with ants, given that we have only identified the external nest architecture of 3 species, we have not been able to work with more species.

This project is part of my doctoral thesis, and samplings done with the support of RSG allowed the third year of study. I expect to be able to fulfill the inconclusos points this year, and in this way present the thesis on the beginning 2008.

VI. Participants.

PARTICIPANTS	PROJECT INVOLVEMENT	INSTITUTION
Lic. Carlos E. Trucco	Leader	Doctoral Fellow, CONICET. Biological and Geological Sciences Institute (BIGEO), Natural Science Museum, Salta National University (UNSa), Argentina.
Dr. Marcelo Cabido	Researcher	Researcher, CONICET. Professor in charge of Biogeography, Córdoba National University, Argentina. Director of the Multidisciplinary Institute of Vegetation Biology (IMBIV, Córdoba National University and CONICET).
Lic. César Bracamonte	Researcher	Teacher Assistant in Vertebrates Course, Faculty of Natural Sciences, Salta National University.
José Mercedes Pérez	Field Assistant	Local People - Copo National Park inhabitant.
Ricardo Pérez	Field Assistant	Local People - Copo National Park inhabitant.
José Vicente Pérez	Field Assistant	Local People - Copo National Park inhabitant.
Miguel Maldonado	Field Assistant	Local People - Copo National Park inhabitant.
Andrea Suarez	Field Assistant	Student, Eng. in Natural Resources and Environment, UNSa.
Eugenia Giamminola	Field Assistant	Student, Eng. in Natural Resources and Environment, UNSa.

VII. Results & Discussion.

Seed removal experiments: Removal of quebracho colorado santiagueño was very low compared to the other two species. We did not find significant differences in the removal of each species between sites with different livestock uses. (***Fig. 6***).

The agents which removed more fruits were the arthropods, represented exclusively by ants, given that they were the only ones we observed removing seeds. However, removal of the quebracho colorado santiagueño fruit was similar among treatments, meanwhile for the other two species; removal by small vertebrates (micro-mammals and lizards) was also important (***Fig. 7***). Medium and large vertebrates – whose removal is inferred from the differences between the observed removals of the “vertebrates” and of the “small vertebrates” – would not be important removal agents (***Fig. 7***).

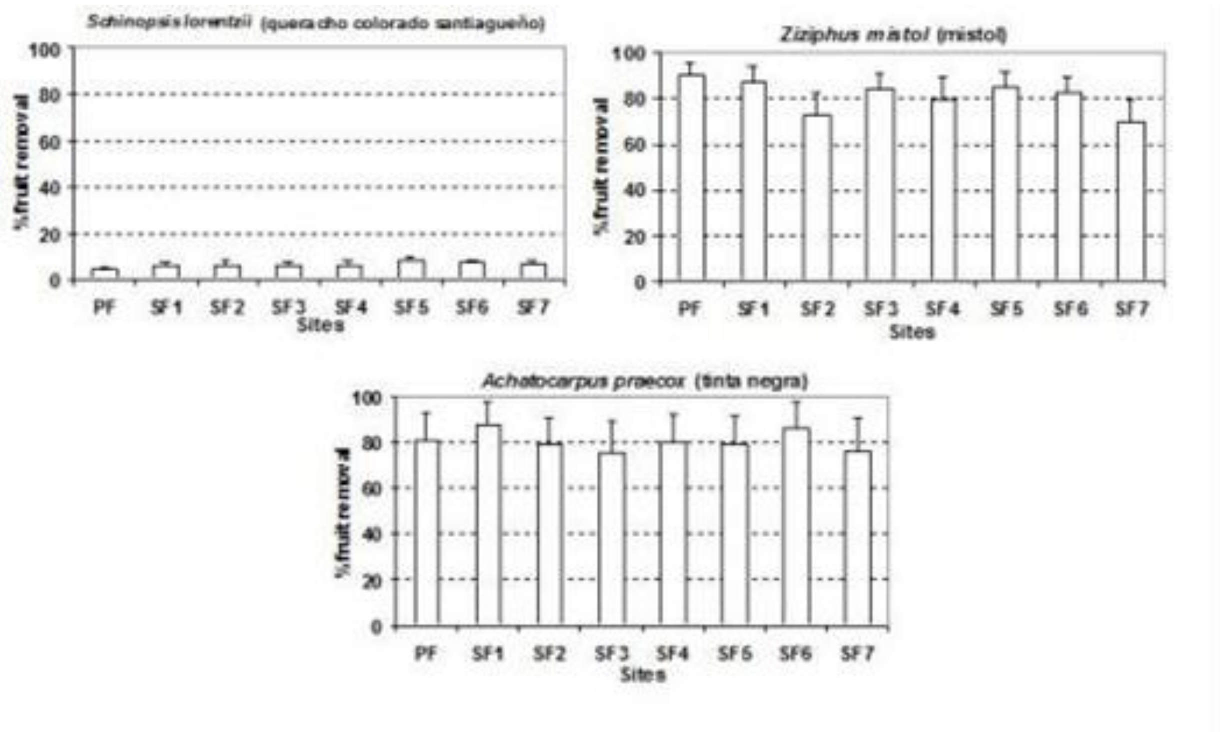


Fig. 6. Percentage of seeds removed in the field experiments with feeding stations. Mediums and its standard mistakes are shown. Sites - BP and Bs1 to Bs7 – are ordered in an increasing way according to livestock use intensity

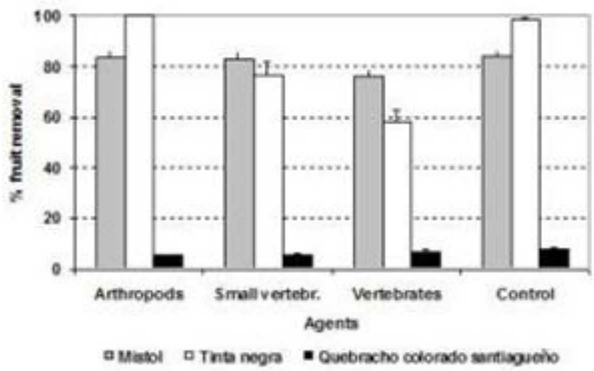


Fig. 7. Removal discriminated in groups, according to the treatments used in the experiment.

<u>Seed removal agents</u>:

a) Arthropods:

We have completed the proposed samplings; therefore we have samples from January, February and may of the 8 sites. In some cases we have suffered the loss of 3 pitfall traps, nevertheless, this was foreseen when we selected the number of traps to place. Losses were due to flooding over rains, cattle and/or horses trampling, or to breaking caused by grey foxes (*Pseudalopex griseus*).

Samples are being checked counting the number of individual per order and discriminating ants (Formicidae: Hymenoptera) for being the only arthropods identified as seed removal agents. For this reason, from now on, when we mention Hymenoptera we refer to wasps, therefore we will refer to ants as Formicidae. We have not finished the analysis, however, a preliminary analysis done in function to May's sampling makes evident the big proportion of ants in respect to the other orders (***Fig. 8***).

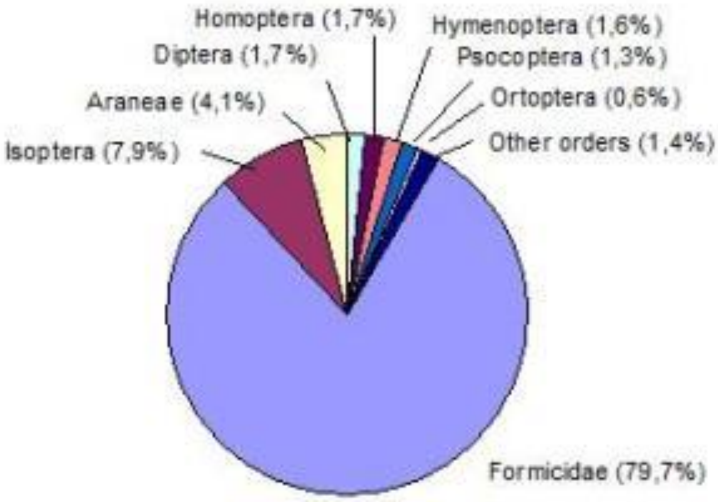
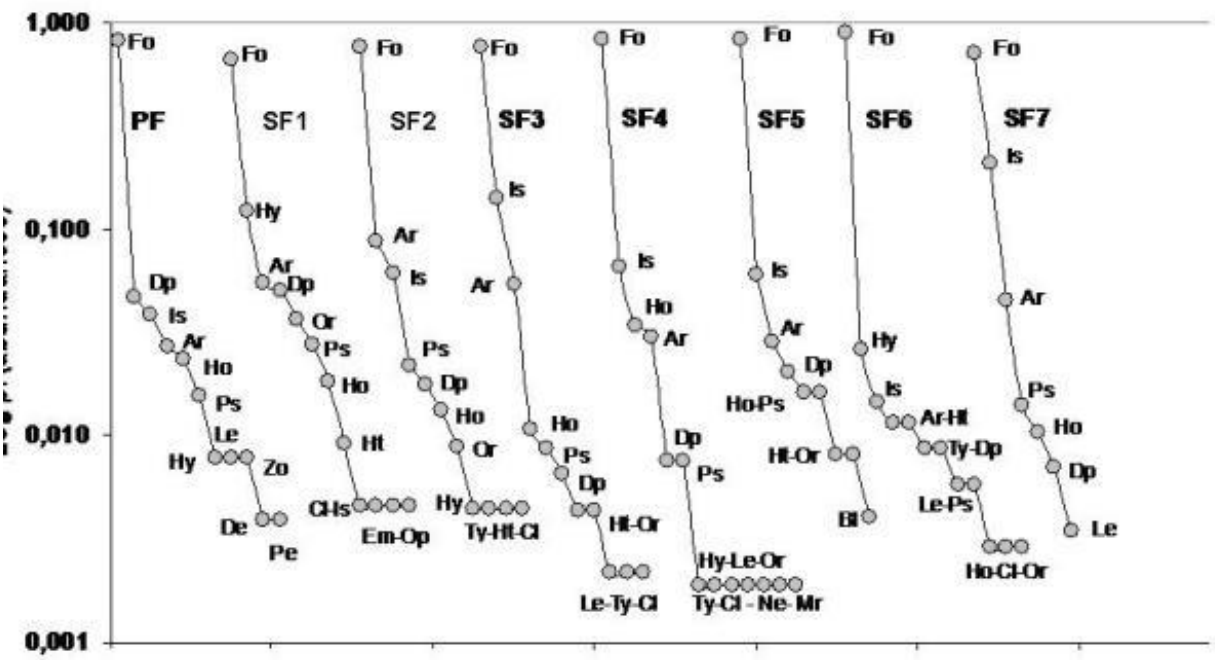


Fig. 8. Relative proportions of arthropods most representative captured during the sampling in June. Total proportions are shown without differentiating among sites. Other orders include the orders represented by less than 10 individuals: Heteroptera, Tysanoptera, Lepidoptera, Coleoptera, Zoraptera, Blatodea, Neuroptera, Miriapoda, Embioptera, Opilionida, Dermaptera and Pseudoscorpiones.

The big ants abundance in respect to the other groups, was consistent in all sites (***Fig. 9***). Some orders were exclusive from certain sites, like Zoraptera, Dermaptera and Pseudoscorpiones in the primary forest. As for richness we observed that it is higher in SF4, with 13 orders, and lower in SF7 and SF5 with 7 and 9 orders respectively. However, in general the assembly structure is similar, given that richer sites have different orders than the other sites but always in very low proportions. Data do not show a clear pattern for order richness and their abundances in relation to the sites, which could give us a hint about the possible influence of cattle raising on them.



Rank Fig. 9. Rank-abundance curves for the arthropods captured in one primary forest and seven secondary forests with livestock. PF, primary forest; SF, secondary forests (from 1 to 7). n = 32 for all cases. Ar: Araneae, Bl: Blatodea, Cl: Coleoptera, De: Dermaptera, Dp: Diptera, Em: Embioptera, Fo: Formicidae, Ho: Homoptera, Ht: Heteoptera, Hy: Hymenoptera, Is: Isoptera, Le: Lepidoptera, Mr: Miriapoda, Ne: Neuroptera, Op: Opilionida, Or: Ortoptera, Pe: Pseudoscorpiones, Ps: Psocoptera, Ty: Tysanoptera, Zo: Zoraptera.

In tropical and subtropical semiarid environments, disturbances caused by land use can affect negatively different arthropods richness in short term (Abbott *et al.* 2002, Strehlow *et al.* 2002). In our study, sites with higher livestock use seem to lose the less abundant orders than in the other sites, meanwhile the better represented orders in abundance terms would not be affected. It should be done an analysis at a minor taxonomic level (gender, species) or of functional groups, in order to analyze the answers in detail.

We still have to analyze a big number of traps, but until now we checked a total of 555 pitfall traps. This represents a total of 60588 arthropods of 22 orders, of which the most abundant one still is Hymenoptera for the great ant's representativeness (Formicidae) with 54566 individuals. This great ants domain is similar to what was found in other woody forests, tropical and subtropical (Stork 1991).

In this way, given the leading role of ants – for their number as well as for being the only arthropods identified as seed removal agents – we are identifying the different species to do an analysis at this level among sites. We have identified 57 species of 21 genders (***Table 2***), at least 10 of which are seed removals and other 4 or 5 remove the pulp of fleshy fruits, such as mistol.

Table 2. Ants species captured in pitfall traps during January and may samplings in one of the secondary forests (SF6, n = 32).

#	Species	#	Species	#	Species
1	*Acromyrmex aspersus*	20	*Cyphomyrmex sp 1*	39	*Pheidole radoskowsky*
2	*Acromyrmex hispidus*	21	*Cyphomyrmex sp2*	40	*Pheidole spininodis*
3	*Acromyrmex lundi*	22	*Dorymyrmex breviscapus*	41	*Pheidole sp 1*
4	*Acromyrmex striatus*	23	*Dorymyrmex cf exanguis*	42	*Pheidole sp 2*
5	*Atta vollenweideri*	24	*Dorymyrmex exanguis*	43	*Pheidole sp 3*
6	Attini	25	*Dorymyrmex thoracicus*	44	*Pheidole sp 4*
7	*Brachymyrmex gaucho*	26	*Ectatomma brunnea*	45	*Pheidole sp 5*
8	*Brachymyrmex sp 1*	27	*Ectatomma edentatum*	46	*Pheidole sp 6*
9	*Brachymyrmex sp 2*	28	*Ectatomma tuberculatum*	47	*Pheidole sp 7*
10	*Camponotus atriceps*	29	*Forelius albiventris*	48	*Pheidole sp 8*
11	*Camponotus punctulatus*	30	*Forelius nigriventris*	49	*Pogonomyrmex cunicularius*
12	*Camponotus rufipes*	31	*Forelius rubriceps*	50	*Pseudomyrmex sp*
13	*Camponotus sp1*	32	*Forelius sp*	51	*Solenopsis "gr globularia"*
14	*Camponotus substitutus*	33	*Gracillidris pombero*	52	*Solenopsis sp 1*
15	*Cephalotes sp.*	34	*Linepithema micans*	53	*Solenopsis sp 2*
16	*Cephalotes incertus*	35	*Myrmelachista sp*	54	*Solenopsis sp 3*
17	*Cephalotes pusillus*	36	*Neivamyrmex sp*	55	*Solenopsis sp 4*
18	*Crematogaster cf crinosa*	37	*Odontomachus chelifer*	56	*Trachymyrmex pruinosus*
19	*Crematogaster sp 1*	38	*Pheidole cavifrons*	57	*Wasmannia auropunctata*

b) Lizards:

We sampled only during summer months, which is at the same time as seed removal experiments of mistol and tinta negra, not during the experiments with quebracho colorado santiagueño, given that lizards were not active.

We captured a total of 97 individuals from 5 families and 12 species (***Table 3***), among which *Cnemidophorus ocellifer*, *C. serranus* and *Homonota fasciata* were the most abundant (***Fig. 10***). Ten of these species are not in threaten, meanwhile *Stenocercus doellojuradoi* is characterized as insufficiently known and *C. serranus* as vulnerable (Lavilla *et al.* 2000). We did not find a tendency for total abundance and species richness in relation to livestock use, even in the site without livestock the number of captured individuals was intermediate and its richness was similar to two sites with a higher livestock activity (***Fig. 11***).

Table 3. Lizards species captured during january and february samplings (N = 32).

#	Species	#	Species	#	Species
	Fam. Teiidae		**Fam. Gymnophthalmidae**		**Fam. Gekkonidae**
1	*Ameiva ameiva*	6	*Vanzosaura rubricauda*	9	*Homonota fasciata*
2	*Cnemidophorus ocellifer*		**Fam. Scincidae**		**Fam: Tropiduridae**
3	*Cnemidophorus serranus*	7	*Mabuya frenata*	10	*Stenocercus doellojuradoi*
4	*Teius teyou*	8	*Mabuya dorsivittata*	11	*Tropidurus spinulosus*
5	*Tupinambis rufescens*			12	*Tropidurus etheridgei*

Fig. 10. *Homonota fasciata*, one of the most abundant lizards in the study sites.

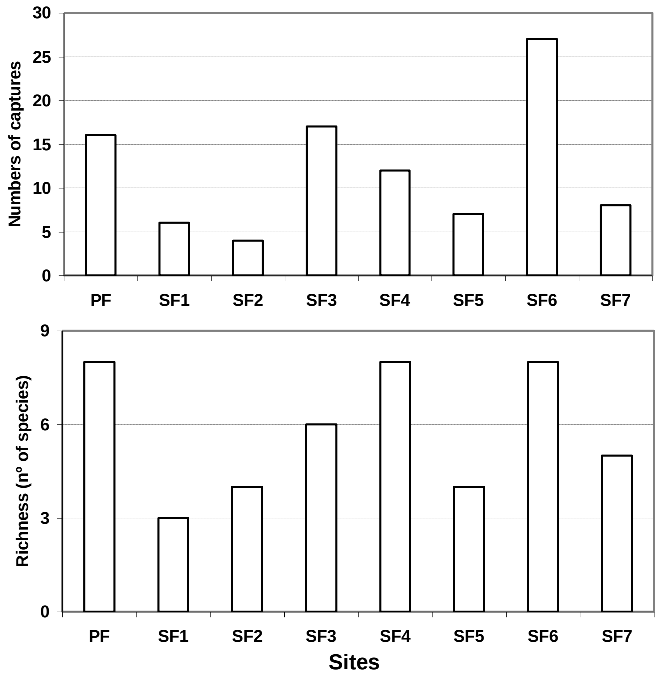


Fig. 11. Nº of captured lizards and richness in each site.

Even when the number of recorded species does not reflect diversity similar to other Chaco areas (Cruz *et al*. 1992, Alvarez *et al.* 2002), the richness found was quite high, especially if we consider that the sampling effort was high and in only one summer. Besides, we must consider that no active captures were done. According to the known lizards in Copo National Park, we have captured 12 of the 15 species recorded until now (Caziani *et al.* 2003).

All species are frequent in Chaco environments, except *Cnemidophorus serranus*, whose biology is not well known, and adding to the fact that it is categorized as vulnerable, it makes that its records in the area be of great interest.

It is also appealing the presence of *Stenocercus doellojuradoi* in SF4, SF6 and SF7, given that this species is usually found on dead leaves in the forests, and in this case the mentioned sites have low soil cover (C. Trucco, pers. obs.).

c) Small mammals:

We recorded a total of 157 individuals (excluding recaptures) belonging to 9 species. The medium success of captures at ground level was of 2.0 ± 3.5 % (media ± DS). From the captured species one is marsupial belonging to the family Didelphidae, while the rest are rodents from the families Muridae (7 species) and Caviidae (1 species) (***Table 4***).

Table 4. Species of captured micro-mammals during January, February and June samplings.

#	Species	Vulgar name (spanish / english)
	Orden. Didelphimorphia	
	Fam. Didelphidae	
1	*Thylamys pusilla*	Comadreja Enana /Common Mouse Opossum
	Orden. Rodentia	
	Fam. Muridae (Cricetidae)	
2	*Akodon simulator*	Ratón de Vientre Gris / Gray-bellied Gass Mouse
3	*Akodon sp.*	-
4	*Calomys callosus*	Laucha Grande / Large Vesper Mouse
5	*Calomys laucha*	Laucha Chica / Vesper Mouse
6	*Calomys musculinus*	Laucha Bimaculada / Drylands Vesper Mouse
7	*Graomys griseoflavus*	Pericote Común / Gray Leaf-eared Mouse
8	*Oligoryzomys chacöensis*	Colilargo Chaqueño / Chacoan Rice Rat
9	*Oligoryzomys longicaudatus*	Colilargo Común / Common Rice Rat
	Fam. Caviidae	
10	*Galea musteloides*	Cuis Común / Common Yellow-toothed Cavy

Micro-mammals richness per site varied from zero (SF3) to a maximum of 5 species in both sites with the higher livestock use (SF6 and SF7) (***Fig. 12***).

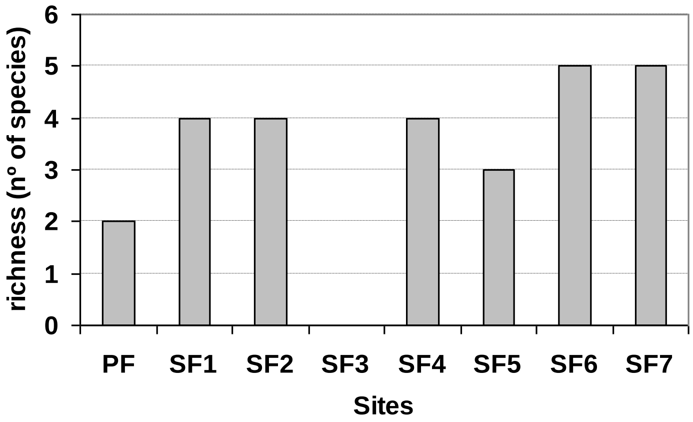


Fig. 12. Total richness of captured species in the different sites, considering the 3 samplings.

Even when the sampling effort was important, the capture number was low therefore it is necessary to intensify it. For this reason we consider irresponsible any attempt to make comparisons between sites, given that – for example- the lack of any of the species in any of the sites does not necessary reflect its absence but maybe just a matter of luck (P. Feinsinger, pers.com.).

d) Others vertebrates:

We recorded a total of 22 wild species and 6 domestic animals, including mules which are the result of the cross breed of donkey and mare. Among wild ones, one is a bird, two are reptiles and the rest are mammals (***Table 5***). One species could not be identified by its tracks, but may be it is another Xenarthro.

Total abundance of wild animals was not different among sites (ANOVA: $F_{7,80}$ = 2.321, P = 0.056), however there was a tendency to be higher in the PF (***Fig. 13***).The most frequent species were *Mazama gouazoubira*, *Sylvilagus brasiliensis*, *Pseudalopex griseus*, *Conepatus chinga*, and *Tolypeutes matacus* (***Fig. 14***). None of these species showed significant statistic differences among sites (Kruskal-Wallis tests, P>0.1), however *M. gouazoubira* seems to be less frequent in sites with higher livestock activity.

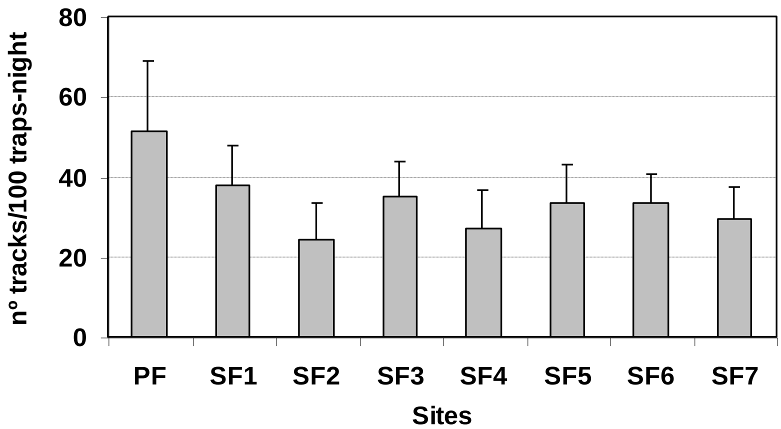


Fig.13. "Abundance" (nº of records of tracks in the track-traps) of medium and large vertebrates in the sampled sites. Medias and its standard variances.

The richer site was SF3 followed by SF7, whether considering or not domestic species, nevertheless several species were recorded in very low numbers (see the length of the tail in SF3, ***Fig. 15***). It is appealing that SF3 is in the limit between the southern area of the NP and a private field, so it includes an unprotected area (and even with a lot of hunting, pers. obs.).

Table 5. Medium and large species of vertebrates recorded in the track-traps in the 8 sampling sites. A total of 21 wild species were recorded (1 bird, 2 reptiles and 18 mammals) and 7 domestic (including the mule).

#	Wild species	Vulgar name (spanish / english)
	AVES	
	Orden. Rheiformes	
	Fam. Rheidae	
1	*Rhea americana*	Suri / Greater Rhea
	REPTILIA	
	Orden. Sauria	
	Fam. Teiidae	
2	*Tupinambis rufescencs*	Iguana / Red Tegu
	Orden. Chelonii	
	Fam. Testudinidae	
3	*Chelonoidis chilensis*	Tortuga Terrestre / Chacoan Tortoise
	MAMMALIA	
	Orden. Didelphimorphia	
	Fam. Didelphidae	
4	*Didelphis albiventris*	Comadreja / White-eared Opossum
	Orden. Xenarthra	
	Fam. Dasypodidae	
5	*Chaetophractus villosus*	Peludo / Seven-banded Armadillo
6	*Dasypus novemcinctus*	Mulita grande / Nine-banded Armadillo
7	*Priodontes maximus*	Tatú carreta / Giant Armadillo
8	*Tolypeutes matacus*	Mataco bola / Three-banded Armadillo
	Fam. Myrmecophagidae	
9	*Myrmecophaga tridactyla*	Oso hormiguero / Giant Anteater
10	*Tamandua tetradactyla*	Oso melero / Collared Anteater
	Orden. Carnívora	
	Fam. Canidae	
11	*Pseudalopex griseus*	Zorro gris / Argentine Gray Fox
	Fam. Felidae	
12	*Herpailurus yaguaroundi*	Gato moro / Jaguarundi
13	*Puma concolor*	Puma o león / Cougar
14	*Panthera onca*	Tigre / Jaguar
	Fam. Mustelidae	
15	*Conepatus chinga*	Zorrino / Common Hog-nosed Skunk
16	*Galictis cuja*	Hurón menor / Lesser Grison
	Orden. Artiodactyla	
	Fam. Tayassuidae	
17	*Pecari tajacu*	Morito / Collared Peccary
18	*Tayassu pecari*	Majano / White-lipped Peccary
	Fam. Cervidae	
19	*Mazama gouazoubira*	Corzuela / Brown Brocket Deer
	Orden. Rodentia	
	Fam. Caviidae	
20	*Pediolagus salinicola*	Conejo de los palos / Chacoan Cavy
	Orden. Lagomorpha	
	Fam. Leporidae	
21	*Sylvilagus brasiliensis*	Tapetí / Forest Rabbit

#	Domestic species	Vulgar name (spanish / english)
	Orden. Carnivora	
	Fam. Canidae	
1	*Canis familiaris*	Perro /Dog
	Orden. Artiodactyla	
	Fam. Suidae	
2	*Sus sus*	Chancho doméstico /Domestic pig
	Fam. Bovidae	
3	*Bos taurus*	Vaca / Cow
	Fam. Caprinidae	
4	*Capra hircus*	Cabra / Goat
	Orden Perisodactyla	
	Fam. Equidae	
5	*Equus caballus*	Caballo / Horse
6	*Equus asinus*	Burro / Donkey
7	*Equus (horse x donkey)*	Mula / Mule

Fig. 14. a) Suris (*Rhea americana*) in a shrubland, b) a Tatú carreta (*Priodontes maximus*) confiscated by the wild life keeper, c) Skunk tracks (*Conepatus chinga*) in a track-trap, d) Mataco bola (*Tolypeutes matacus*) captured during field work to collect its faecas.

The PF showed 17 wild species, while the SF 20 species. Three of the recorded species are of high conservational value, such as *Priodontes maximus*, *Panthera onca* and *Myrmecophaga tridactyla*. This last species was present in the 8 sites.

Therefore, according to our data, the mammals' assembly varied in its composition, being some species more frequent in some sites than in others. Nevertheless we did not find a clear pattern in respect to the cattle raising.

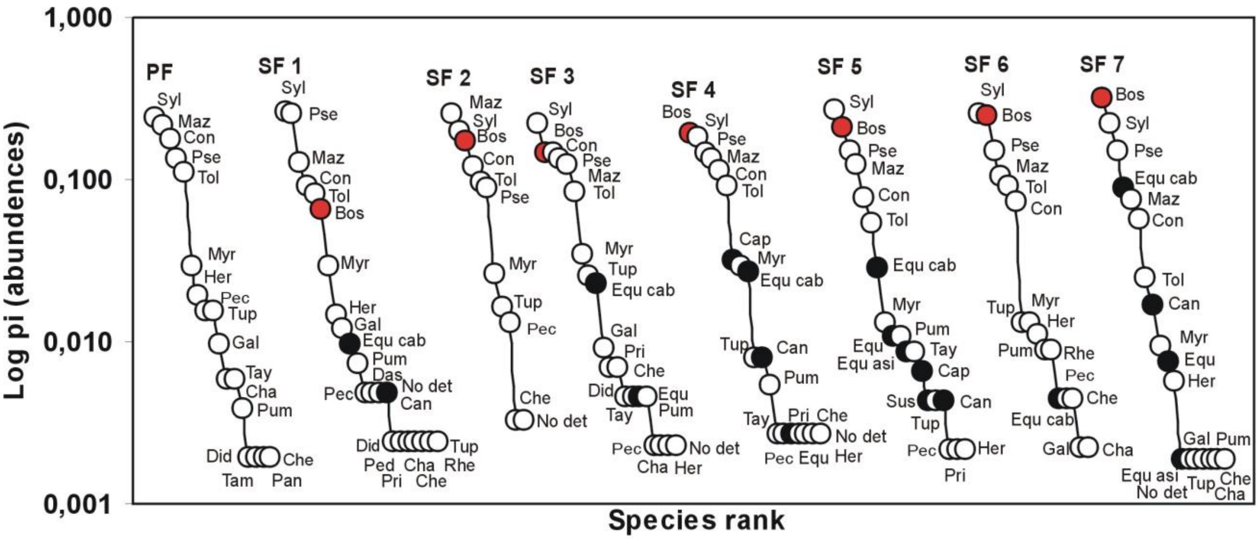


Fig. 15. Rank-abundance curves for the medium and large vertebrates recorded in the primary forest and seven in the secondary forest with livestock. PF, primary forest; SF, secondary forest (from 1 to 7). n = 6 for all cases. In red = Bos: Bos taurus. In black, the other domestic species = Can: Canis familiaris, Cap: Capra hircus, Equ asi: Equus asinus, Equ cab: Equus caballus, Equ: mule, Sus: Sus sus. In white, the wild species: Con: Conepatus chinga, Cha: Chaetophractus villosus, Che: Chelonoidis chilensis, Das: Dasypus novemcinctus, Did: Didelphis albiventris, Gal: Galictis cuja, Her: Herpailurus yaguaroundi, Maz: Mazama gouazoubira, Myr: Myrmecophaga tridactyla, Pan: Panthera onca, Pec: Pecari tajacu, Ped: Pediolagus salinicola, Pri: Priodontes maximus, Pse: Pseudalopex griseus, Pum: Puma concolor, Rhe: Rhea americana, Syl: Sylvilagus brasiliensis, Tam: Tamandua tetradactyla, Tay: Tayassu pecari, Tol: Tolypeutes matacus, Tup: Tupinambis rufescens, and No det.: Not determined.

Identification of dispersal and predation agents:

We did an intense bibliographic research in order to get published information about the grazing or feeding habits of the different species recorded during the study. With this information we identified the species that eat fruits and/or seeds being dispersers and/or predators of them.

For those species that had not been studied previously we developed the experiments and we obtained the following results.

a) Arthropods: we developed the experiments with 3 ants' species from the same gender, for being the only ones we were able to identify on the field for their external architecture of their nests: Acromyrmex striatus, A. hispidus and A. lundi.

The results of the developed observations with the fruits of each species are the following:

- <u>With fruits of Quebracho colorado santiagueño</u>:
  - *A. striatus:* removed very few fruits taking only 4 and 10 fruits in two occasions.
  - *A. hispidus* and *A. lundi*: were not active during the period when quebracho Colorado fruits mature and fall to the ground, which is when the experiments were developed. However, non systematic observations allow us to afirmar that the ants species *A. hispidus* are active removers of immature fruits of this species (***Fig. 16***), which reach the ground in big quantities before their maturity due to the great predation by ponk parakeet (*Myiopsitta monacha*).

Fig. 16. Leave cutter ants, *Acromyrmex hispidus*, removing immature fruits (in color red) of Quebracho colorado santiagueño.

- <u>With fruits of Mistol</u>:
  - *A. striatus:* they did not carry any fruit, but removed the pulp of a few.
  - *A. hispidus:* in all cases they removed very few fruits, taking to the nest a maximum of 4 fruits during the hour of observation. Besides, they removed the pulp of between 4 to 6 fruits more in each case.
  - *A. lundi:* they removed the fruits in all cases, in periods of between 10 to 30 minutes, taking them into the nests.

- <u>With fruits of Tinta negra</u>:
  - *A. striatus:* in 7 occasions (7 replicates) they removed the totality of the fruits offered in periods of between 8 to 45 minutes. In the eighth case, in one hour of observation they had removed the 75% of all fruits. In all cases they took the fruits inside their nests.
  - *A. hispidus:* in 6 occasions they removed the totality of the fruits in periods of between 11 to 44 minutes. In the other two cases, in one hour of observation they had removed 55 and 65% of the fruits. In all cases they took the fruits inside their nests.
  - *A. lundi*: they removed the totality of the fruits in all cases, in periods of between 5 and 27 minutes. Again, they took the fruits inside the nests.

The three species, as well as the ants from the *Attini* tribe, grow fungus for their feeding and have a symbiotic relation with them. Therefore, the taxa of the gender *Acromyrmex*, commonly known as leave cutter ants, the harvest live vegetable material as a substrate for the fungus they grow and not as a food resource for themselves (Bucher and Montenegro 1974, Bestelmeyer and Wiens 1996, Fowler 1988). Cuezzo (1998) comments that lots of ants species that remove seeds, remove more seeds than the ones they eat, leaving a good percentage of them stored inside their nests, many of which are viable to germinate.

b) Small vertebrates:

- <u>Lizards</u>: however having found information on several species diet, we developed experiences with all of them in order to provide new evidence about it. The number of individuals to which we offered fruits varied from 4 to 9 depending on the species. We only offered them fruits of mistol and tinta negra, and not of quebracho colorado for considering that if they were inactive during the bearing fruit period of it, then they would not consume them.

Only *Teius teyou* and *Tupinambis rufescens* consumed fruits of mistol however the first species did it in two opportunities. Both species defecated live seeds, acting then as dispersers of this species.

On the other hand, for both species of *Tropidurus* there is evidence of sporadic consuming of fruits of mistol (Cruz 1998, Cruz *et al.* 1998), contrary to what we found.

- <u>Micro-mammals</u>: we offered fruits of quebracho colorado, mistol and tinta negra to the 3 species of rodent recorded (*Calomys callosus, C. musculinus* and *C. laucha*). We offered the fruits to 4 individuals of each species and only one individual of C. musculinus consumed part of the fruits of quebracho colorado breaking the seeds. Previous studies quote this species as omnivore with tendency to grainivory (Ojeda 1989, Campos *et al.* 2001), but the seeds it consumes would be smaller than the studied ones here.

We also offered fruits of the three species to 4 individuals of *Graomys griseoflavus*. They consumed fruits of quebracho colorado and mistol. In the first case acting as seed predators like the rodents, and in the second case consuming only the pulp of the fruits and leaving the seeds in piles inside their shelters (small cardboard boxes we placed in the cages).

We did not find information on the diet of the species of the gender *Oligoryzomys*, but we could not develop the experiments with these species due to the low capture. In order to develop these experiments, we only kept in captivity the individuals captured the last day of micro-mammals sampling, in order not to influence the abundance estimations.

On the other hand, we have offered fruits of mistol and tinta negra to 3 individuals of *Ctenomys* sp., which were captured in traps for lizards. In all cases they consumed fruits of mistol, but not of tinta negra. We could not identify if they predated or not the seeds, for not having found faecas nor rests of them in the cages (we had to put 5-6 cm of sand in the cages, given the cave habits of these animals).

c) Others vertebrates:

We analyzed a total of 129 faecas of fox, 91% of them had seeds. Five of them had live seeds of tinta negra and 22 seeds of mistol. We did not find seeds of quebracho colorado.

In the faecas of suri (n = 12) we found only seeds of mistol in 3 cases, meanwhile in the faecas of the southern three-banded armadillo we did not find seeds (n = 16). Nevertheless Bolkovic *et al.* (1995) found seeds of mistol in 22% of the analyzed stomachs of this armadillos.

The tortoises (n = 4) consumed seed of the 3 species, nevertheless they seem to disperse only the seeds of tinta negra. Previous studies show that this species have an important disperser role of several plant species (Richard 1994, Varela and Bucher 2002, Varela 2004).

We still have to develop experiments with seven-banded armadillos, chacoan cavy, broker deer, white-lipped peccary and jaguarundi. There is published information on their diet we expect to develop the experiments this year, given that they show information on the fruits consuming but not on their role as dispersers and/or predators. The chacoan cavy, in low frequencies, consumes fruits of mistol (Rosati and Bucher 1992). The broker deer as well as the white-lipped peccary and the jaguarondi consume a wide variety of fruits, among them, mistol (Cuéllar and Noss 2003, Varela 2004), being the jaguarondi dispersers of a great number of them (Varela 2004).

VIII. Conclusions.

In general terms and up to the analyzed level of detail, it was not possible to find clear patterns of secondary seed removal associated to the gradient of livestock use intensity. This could be because the analyzed livestock gradient does not consider the areas of over grazing or extremely high use intensity. Therefore, it is likely to be differences among sites which are not noticed at present and that livestock load does not reflect it. Then, it is probable that the present livestock use intensities are not the same as the ones a few years ago (our records in the area are from the period 2000-2007).

This study agrees with previous reports in that the main seed removal agents in semiarid environments in the southern hemisphere are ants (Morton 1985, Kerley 1991, López de Casenave *et al.* 1998). It is necessary to continue identifying the ants species that spread the seeds of interest, given that the observed removals in this study, tell us that it would be several species, and not only *Acromyrmex hispidus, A. striatus* and *A. lundi*, that would be removing seeds.

In respect to the rest of the cast of potentially disperser fauna, some species, considered of great interest for conservation for their intervention in key ecological processes, have not shown important changes in their activity intensity in livestock presence. The three-banded armadillo, a frigivorous species that consumes big quantities of fruits of mistol (Bolkovic et al. 1995) was the most abundant species among Xenarthra, and did not show differences between sites. The same happened with the grey fox, another important frugivorous and seed disperser, which we would have expected to be more abundant in sites with livestock given its ruderal personality however we did not find differences among sites.

It is appealing that we did not find marked tendencies, nevertheless this shows the great heterogeneity of semiarid Chaco, being able to distribute in a differential way according to parameters not measured here. Being this accurate, it would also explain the results found about the secondary seed removal.

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X. Publications in progress related with the research project.

Trucco, C.E. and M. Cabido. Agentes de remoción y su papel como dispersores o depredadores de semillas en el Chaco semiárido argentino. (Chapter 3, Doctoral Thesis)

Trucco, C.E. and M. Cabido. Variabilidad en la remoción post-dispersión de semillas en relación a la ganadería en el Parque Nacional Copo, chaco semiárido argentino. (Chapter 4 and 5, Doctoral Thesis)

Trucco, C.E., M. Cabido and J.C. Bracamonte. ¿Varía la composición y abundancia del ensamble de artrópodos y vertebrados terrestres en sitios con diferentes intensidades de uso ganadero en el bosque chaqueño semiárido de Argentina? Potencial journal: Journal of Arid Environment.

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XIII. Budget & expenditure. **All expenditures are in pounds.**

a) Travels & field/lab work:

Description	Planed budget	Expenditure
Travels		
Vehicle maintenance	200,00	301,80

Vehicle insurance policy (x month)	98,88	0,00
Gasoline (local travel)	544,00	298,56
Field and lab work		
Local field assistant	750,00	489,13
Academic assistant	1400,00	1667,98
Food & lodging (3 persons)	804,60	554,31
SUBTOTAL	**3797,48**	**3311,78**

b) Field equipment:

Description	**Planed budget**	**Expenditure**
Insect sampling		
Plastic cups (300 cc. X 100 u.)	8,82	5,19
Plastic plates (x 100 u.)	6,90	5,93
Ethylene glycol & alcohol	46,76	35,08
Lizard sampling		
Galvanized wire (1 kg = 60 m)	2,85	7,51
PVC fence150 ų x 50 m	157,50	50,98
Seed removal experiments		
Plastic bags (x100 u.)	1,95	8,92
Green plastic plates (x 100 u.)	11,04	11,86
Fiber plastic mesh (high density)	96,20	50,99
Tangle-trap 15 oz (sticky resin)	10,38	20,75
Galvanized ½" and 1½" wire mesh	55,80	63,64
Miscellaneous		
Batteries, markers, notebooks	50,00	68,79
SUBTOTAL	**448,20**	**329,63**

c) Office equipment:

Description	**Planed budget**	**Expenditure**
Computer supplies (CDs, floppy disks, toner)	80,00	84,95
Manuscript/report translation	100,00	158,00
Tel – Fax – Postal Service	80,00	55,10
SUBTOTAL	**260,00**	**298,05**

TOTAL = SUBTOTAL 1 + 2 + 3 = **£sterling 3939, 46.-**

As it can be seen in the table, we have expended less than the predicted in several items especially in gasoline, local field assistance and food. On the one hand, the minor expenditure in gasoline was because we could not have the vehicle along each trip, but we used it to get to the study site and then somebody took it to the city and we stayed with a motorbike as mobility. Expenditures related to local field assistant were also minor because the person who worked with us was hired by National Park Administration. This also reduced food expenses. Expenditures on PVC fences were also reduced given that we used the ones from the previous year. This allowed us to do unexpected but necessary expenses. We had to work with Salta National University students who were paid as academic assistances (as it can be seen in afore table). On the other hand, we expended on replacing or fixing camping or sampling equipment that had been damaged. This expenses which had not been mentioned in the project proposal were:

Description	Expenditure
Aluminum rod	34,28
Articles for rodents' cage & lizard's terrariums	3,72
Bank charge	74,51
Calipers	3,91
Camping equipment (tent, containers, & equipment repair)	219,05
Courses and congress assistance	83,00
Forage (alfalfa)	3,95
Gas for carafe and supply of portable stove	14,94
Insect repellent	5,08
Latex gloves	5,38
Medicine	25,28
Mist respirators & steel forceps	2,37
Photocopies	23,15
Photographical costs	29,64
Sticky and duck tape	11,41
Tanned leather (for repair saddle of a cart or "zorra")	18,97
Wooden survey stakes	8,89
TOTAL	**567,54**

Therefore: **3939, 46 + 567, 54 = £sterling 4507, 00.-**

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