

**Control of small mammals  
in a pine plantation (Central Chile)  
by modification of the habitat of predators  
(*Tyto alba*, Strigiforme and *Pseudalopex* sp., Canidae)**

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**ABSTRACT**

An attempt to validate biological control through environmental modifications, was carried out by evaluating the impact of vertebrate predators on rodents and rabbits in a *Pinus radiata* (D. Don) stand. The modification of the habitat consisted of a 4-m belt of cleared vegetation which interrupted as barriers the homogeneity of the pine stand. Perches as lodging places for raptor birds were also established in the stand.

A 12 month (August 1984-July 1985) fortnightly collection of owl-pellets and fox-scats was conducted along a predetermined route, which included roads, trails and strips with cleared vegetation under perches. Fresh pellets ( $n=103$ ) of the common Barn owl (*Tyto alba*) and 44 scats of *Pseudalopex* foxes were collected and their prey content determined. Concurrently, data on small mammal abundances were obtained.

Barn owls mainly consumed rodents, some species being apparently singled out as prey. Foxes consumed a high proportion of rabbits with an increased proportion of rodents during winter.

The rodent responsible for damage in pine stands (*Octodon bridgesi*) was actively preyed on by the two predators throughout the year.

The modification of the habitat produced a double effect: it impaired the population ecology of prey species and increased their vulnerability and it improved habitat conditions for vertebrate predators.

**KEY WORDS:** control, predation, habitat manipulation,  
small mammals, food habits, pine plantation.

**RÉSUMÉ**

En modifiant l'environnement dans une pinède, on a essayé de valider le contrôle biologique des prédateurs en évaluant son impact sur les rongeurs et en particulier sur les lapins. Sur des pistes prédéterminées qui comprenaient des chemins et des bandes sans végétation, on a recensé 103 pelotes de chouettes et 44 défécations de renards. Le régime alimentaire de ces deux prédateurs a été déterminé par l'analyse de leurs pelotes et défécations. Simultanément on a obtenu des renseignements sur un grand nombre d'autres petits mammifères.

La chouette, *Tyto alba*, se nourrit principalement de rongeurs en observant une préférence pour certaines espèces.

Le renard, *Pseudalopex sp.*, consomme une forte proportion de lapins avec une légère augmentation des petits rongeurs en hiver. Le rongeur, *Octodon bridgesi*, responsable des dégâts observés dans les plantations a été fortement consommé par ces deux espèces.

Les modifications de l'habitat produisent un double effet : d'un côté elles affectent l'écologie des proies en augmentant leur vulnérabilité et de l'autre elles favorisent les prédateurs vertébrés.

## INTRODUCTION

The mediterranean zone of Chile (32°SL to 39°SL) has been planted with exotic species, mainly *Pinus radiata* (D. Don) pines, in increasing quantities. Today plantations extend over more than one million ha. This extensive perturbation of the natural landscape could have affected the wild fauna by introducing severe changes in the natural balance. This is reflected in several recent outbreaks of defoliating insects (*Ormiscodes sp.*, *Macromphalia sp.*), fungus (*Diplodia pinea*, *Dothistroma pini*), rodents (*Octodon bridgesi*, Waterhouse) and lagomorphs (*Oryctolagus cuniculus* Linnaeus, HERRERA, 1983; MURÚA & RODRÍGUEZ, 1985; GAJARDO & RODRÍGUEZ, 1985), for central Chile.

Damage produced by rodents and rabbits is considered one of the most important problems by forestry enterprises of the area (Celco, Internal Report, 1983). In the VIIth Administrative Region of Chile, over 1,000 ha were severely damaged by *Octodon bridgesi* (HERRERA, 1983; MURÚA, 1984; MUÑOZ & MURÚA, 1987). Severity of the attack can be as high as 55% of a pine stand (JARA, 1985). Rodents gnaw at the bark of pine trunks producing different types of damage (MURÚA & RODRÍGUEZ, 1985; 1989). Lagomorphs preferentially sever twigs and stems of pine seedlings (GAJARDO & RODRÍGUEZ, 1985).

In attempts to control this problem, routine applications of toxic substances have been employed extensively. One of these, sodium fluoroacetate (1080), is highly toxic to rats, mice as well as other mammals and birds, with the attendant risk of secondary poisoning.

The most common vertebrate predators in central Chile are the Barn owl, *Tyto alba* (Scopoli), and the fox *Pseudalopex sp.* (BERTA, 1987); they have been severely affected by toxic substances, used in rodent control and have decreased in abundance. It is known that these predators consume rodents and rabbits in the central Chilean scrub areas (JAKSIC *et al.*, 1977; JAKSIC & YAÑEZ, 1979; JAKSIC *et al.*, 1980).

To avoid the disappearance of these vertebrates, and also to control the rodent populations, an integrated rodent control system has been proposed, as an alternative to chemical control. It includes habitat modification such as a belt cleared of vegetation between the plots and the setting up of artificial perches for avian predators (MURÚA & RODRÍGUEZ, 1989).

This paper presents the results of a study to validate these habitat modifications in an attempt to control rodents in a pine plantation. It also describes the food habits and a contingent dietary selectivity of vertebrate predators inhabiting the area.

## STUDY AREA

The work was carried out in Burca ( $36^{\circ}32'S$ ;  $79^{\circ}55'W$ ) an area 15 km north of Dichato (VIII Region Chile) (fig. 1). The study area is located on the Coastal Ranges and is characterized by low hills (200 m elevation) separated by ravines, 3.5 km from the Pacific Ocean.

The climate is mediterranean with variable humidity; 900-1,300 mm of rain per year fall mainly in the winter, and during the dry months the temperature averages  $14^{\circ}C$  (HAJEK & DI CASTRI, 1976).

The vegetation consists of 10-year old *Pinus radiata* (D. Don) trees, interspersed with abundant shrubs and regrowth of native species. The latter are found along road sides, stand clearings, gorges and streams. The native species present are *Ugni molinae* (Turczaninov), *Escallonia pulverulenta* (R. et Pavon), *Lithraea caustica* (Molina), *Aristotelia chilensis* (Molina), *Gevuina avellana* (Molina),

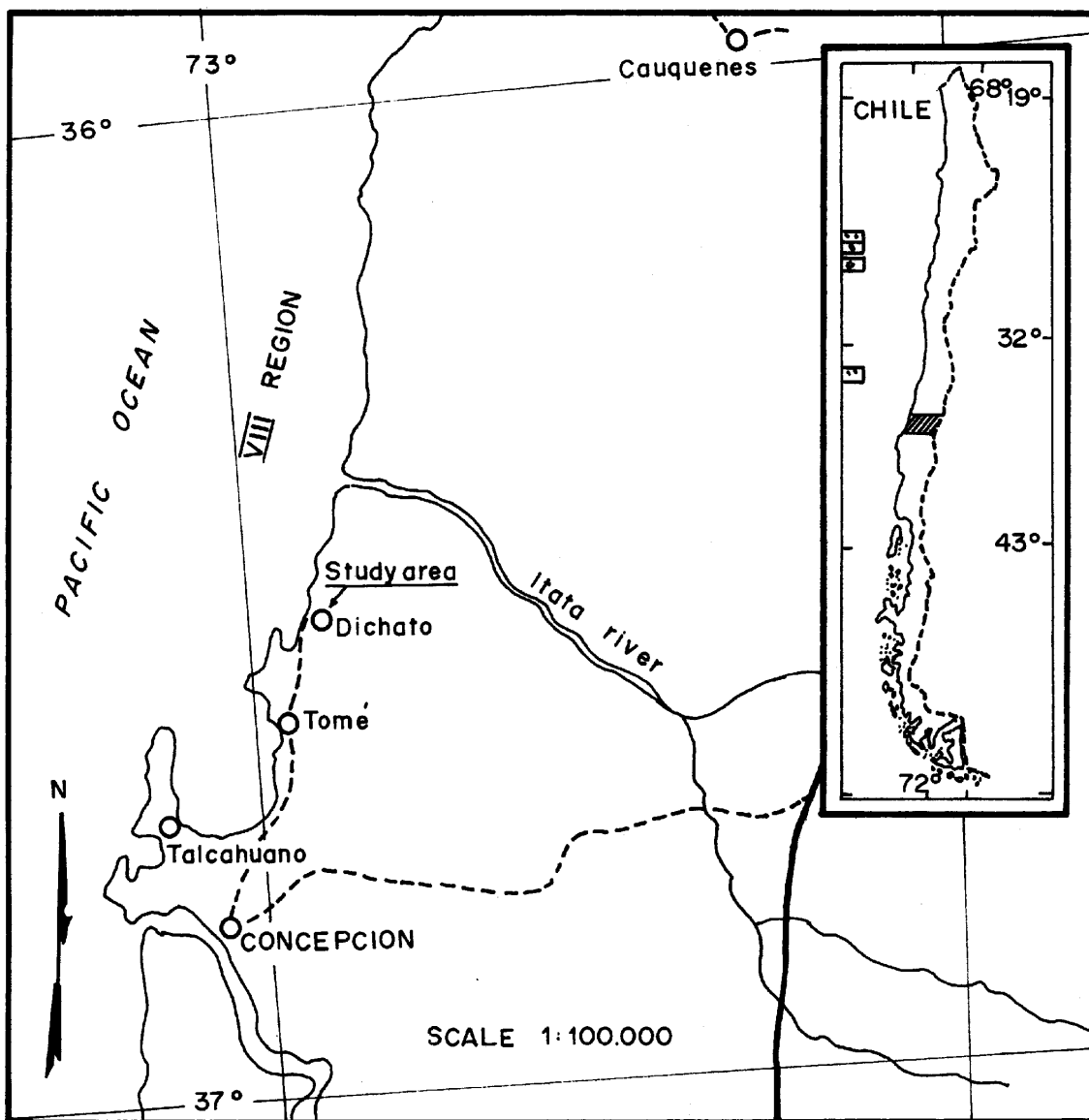


FIG. 1. — Location of the study area in Burca, VIII Administrative Region of Chile.

*Luma apiculata* (Molina), *Peumus boldus* (Molina), *Ribes punctatum* (Philippi), and *Teline monspessulanus* (Linnaeus).

## MATERIAL AND METHODS

### (a) HABITAT MODIFICATION

The pine plantation was a dense and homogeneous habitat with 1,800 trees per ha. Strips (4 m wide), cleared of all vegetation formed plots of 25 × 25 m. A mosaic landscape design with 25 × 25 m plots was established. A perch was set in each corner to attract predatory birds. The perches (8) consisted of 2,5 m high poles joined by a third 3 m wide pole on the top (MURÚA & RODRÍGUEZ, 1989).

The area of scat/pellet collection was approximately 40 ha of open habitat represented by trails and roads left during the management of the plantation. A 12 month (August 1984-July 1985) collection was conducted at fortnightly intervals along a predetermined route of roads and trails. Furthermore, strips with cleared vegetation where perches had been previously set up were observed at regular intervals.

### (b) FOOD HABITS AND DIET SELECTIVITY OF PREDATORS

A total of 103 owl-pellets and 44 fresh fox-scats were collected. The diets of *Tyto alba* and *Pseudalopex sp.* were determined by analysis of these pellets and scats. They were dried at 60°C for 24 hours before being weighed and measured. The pellets were hydrated for one hour before being dissected and examined. The presence of bones, teeth, hair, feathers, and parts of insects were noted. Crania, mandibles and teeth of small mammals were separated and identified with the help of keys by REISE (1973) and PEARSON (unpublished report), and by reference to a collection of skulls residing at the Instituto de Ecología y Evolución, Universidad Austral de Chile.

Concurrently, data on the abundance of small mammals were obtained in the area and have been published elsewhere (MUÑOZ & MURÚA, 1987; MUÑOZ, 1987). In order to assess the selectivity of predation by *T. alba* on small mammals, the proportion of each species in the diet was compared with their respective abundance in the study site by application of a Chi square goodness of fit test proposed by JAKSIC (1979).

## RESULTS

*Tyto alba* was the only raptor encountered in the study area. After the habitat modification a marked increase of these raptors occurred on the site as indicated by the increased numbers of faeces and pellets collected, which were assumed to belong to this species. The weight (+S.D.) of the pellets was 5.97 (1.89) g, the length was 4.53 (0.96) cm, and the width 2.88 (0.55) cm. Eighty-five percent of the pellets were under the perches, 12% on the main access road to the area and 3% on secondary trails.

The fox was not observed directly in the area but several ( $N=7$ ) spoors were measured with a length of 48 (2) mm hind leg; 43 (2) mm foreleg, which is consistent with the size and shape of track marks left by *P. culpaeus* (51+5 mm; 46+3 mm;  $N=5$ ; MARTÍNEZ, pers. comm.). The scats collected had an average weight of 19.5 (12.6) g.

*Tyto alba* consumed mainly rodents, with seasonal occurrences being 89% during spring-summer and 75% during fall-winter (fig. 2). Six rodent species were present in the diet: *Akodon olivaceus*, *Phyllotis darwini*, *Octodon bridgesi*, *Akodon*

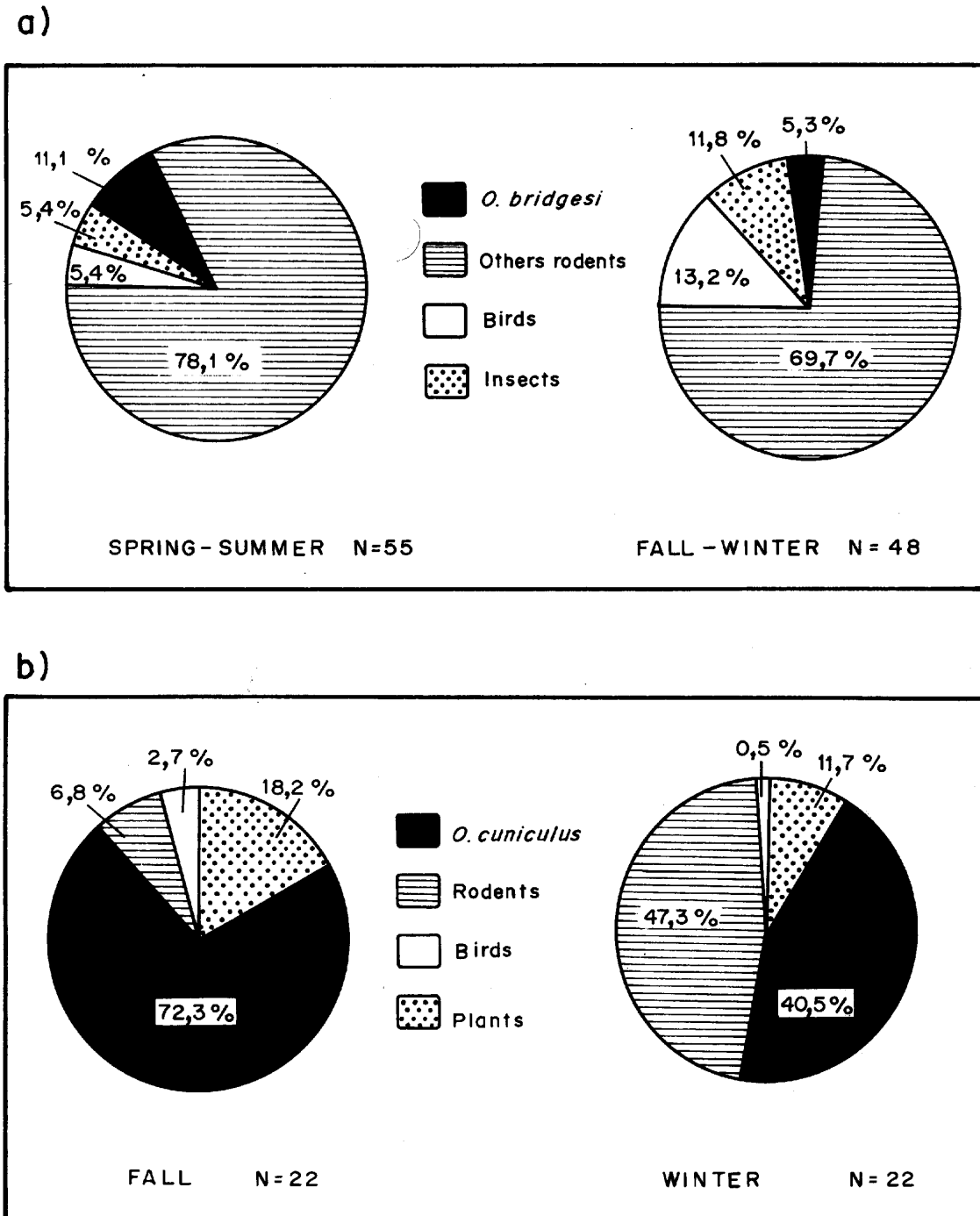


FIG. 2. - Seasonal contents of: (a) 103 *Tyto alba* pellets, (b) 44 *Pseudalopex* species collected in Burca (VIII Region, Chile). 1984-1985. N=N° of pellets or scats.

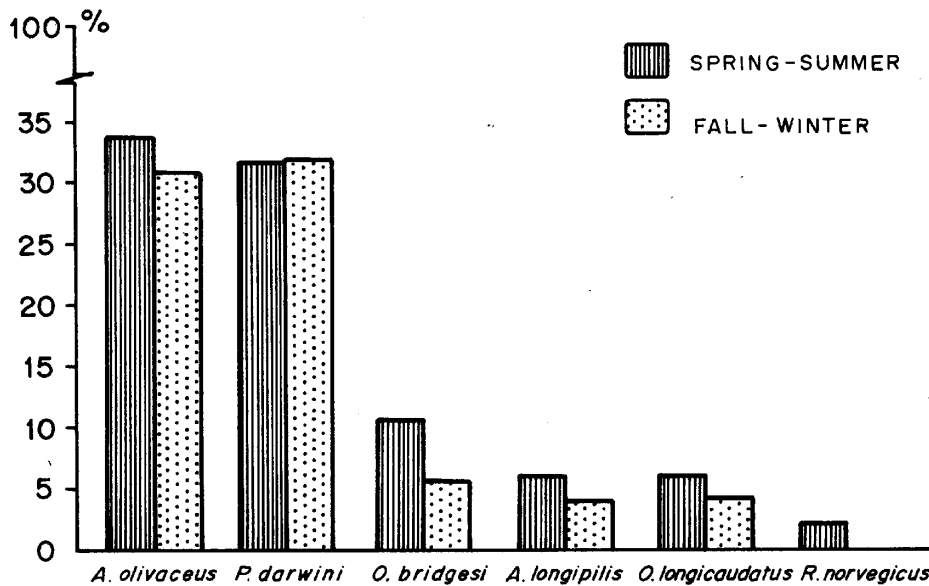


FIG. 3. — Seasonal frequencies of rodents in 103 pellets of *Tyto alba*, Burca, 1984-1985.

TABLE I. — Comparison of the observed frequency (FO) of prey in single pellets and expected frequency (FE) according to trapping in Burca, VIII Region, Chile, 1984-1985.

SPECIES	FO	FE	(FO-FE) <sup>2</sup> /FE
<i>Akodon longipilis</i>	8	79	63,80
<i>Akodon olivaceus</i>	44	38	0,95
<i>Oryzomys longicaudatus</i>	8	8	—
<i>Octodon bridgesi</i>	18	6	24,00
<i>Phyllotis darwini</i> *	59	4	} 351,10
<i>Rattus norvegicus</i> *	2	1	
<i>Marmosa elegans</i> *	0	3	
N	139	139	

Species that present FO values < 5,0.

*(Abrothrix) longipilis*, *Oryzomys longicaudatus* and *Rattus norvegicus*. The first three species dominated the spring-summer diet whereas *P. darwini*, *A. olivaceus* and *O. bridgesi* occurred more frequently in fall-winter diet (fig. 3). It is evident that *T. alba* did not consume these rodent prey in the same proportion as they were available in their natural environment ( $\chi^2 = 363.3 < p < 0.001$  d. f. = 5).

Table I shows that *P. darwini* and *O. bridgesi* appeared to be selected, *A. longipilis* was avoided and *A. olivaceus* and *O. longicaudatus* were consumed in about the proportion of their abundance in the study site. The higher consumption of *O. bridgesi*, nearly double in spring-summer than in fall, coincides with the period of the annual recruitment of the species (MUÑOZ & MURÚA, 1987). Remains of insects in the pellets were found to be more abundant in fall-winter than in spring-summer (fig. 2).

*Pseudalopex sp.* consumed a high proportion of *Oryctolagus cuniculus* during fall and winter. Rodent items were also important, especially in winter (fig. 4).

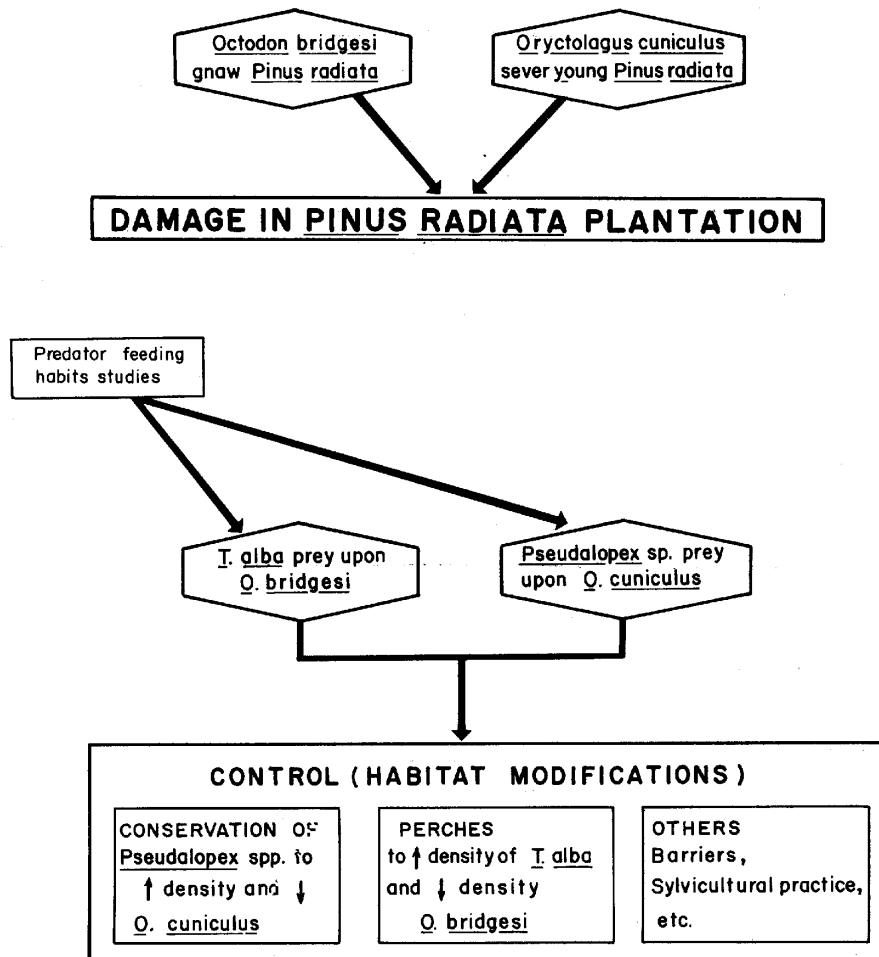


FIG. 4. — Practical control measures to reduce rodent damage in pine plantations based on habitat modifications.

Unfortunately, no concurrent studies on the population abundance of *O. cuniculus* were undertaken, so it was not possible to make a selectivity analysis. However, some information could be obtained for the rodent species. Comparing the items present in fox scats with the respective abundances of rodents in winter, it is possible to determine that *P. darwini*, *O. longicaudatus* and *O. bridgesi* were consumed out of proportion (table II).

TABLE II. — Results of the analysis of scats/pellets of both predators and of trapping of small mammals (number/72 traps/nights) (in parenthesis, percentage of total capture, 1984-1985).

SPECIES	PELLETS <i>Tyto alba</i>	SCATS <i>Pseudalopex</i> sp.	TRAPPING RESULTS
<i>Akodon longipilis</i>	8	0	11,5 (57,0)
<i>Akodon olivaceus</i>	44	0	5,5 (27,4)
<i>Oryzomys longicaudatus</i>	8	4	0,6 ( 3,0)
<i>Octodon bridgesi</i>	18	4	0,9 ( 4,6)
<i>Phyllotis darwini</i>	59	8	1,1 ( 5,4)
<i>Rattus norvegicus</i>	2	0	0,1 ( 0,4)
<i>Marmosa elegans</i>	0	0	0,5 ( 2,2)
	139	16	20,2

## DISCUSSION

It has already been established that among rodent species, *Octodon bridgesi* has an economical relevance because of its damage to pine plantations (HERRERA, 1983; MURÚA, 1984; MURÚA & RODRÍGUEZ, 1985). The congeneric species *Octodon degus* is the main prey item in the diet of *T. alba* (JAKSIC *et al.*, 1980) and also occurs in the diet of *P. culpaeus* in central and northern Chile (JAKSIC & YAÑEZ, 1980; MESERVE *et al.*, 1987). There was no previous information about the presence of *O. bridgesi* in the diet of either vertebrate predator. The low predation rate on this rodent may be explained by its habits: *O. bridgesi* is nocturnal, with a preference for habitats with high shrub cover, low tree densities and a soil cover with plant debris (MUÑOZ & MURÚA, 1987). In contrast *O. degus* is a diurnal species with preference for habitats with low shrub cover in dense shrub cover areas, whereas they prefer high cover in areas with low density shrub cover (MESERVE *et al.*, 1984).

A very interesting situation occurred in the pine stand, where habitat modifications were introduced. Areas where vegetation was cleared and artificial perches were erected all attracted *T. alba* because they afforded lodging and improved visibility and potential for aerial manœuvring. In fact, 85% of the owl pellets were collected under the artificial perches. Furthermore, these areas cleared of vegetation increased the visibility and ease of movements for foxes while simultaneously increasing the vulnerability of rodents and rabbits to predation.

*Tyto alba* showed a strong selectivity for some rodent species (*P. darwini*, *O. bridgesi*), a finding similar to other areas of Chile (PEFAUR *et al.*, 1977; JAKSIC *et al.*, 1977; JAKSIC & YAÑEZ, 1979). It has been suggested that *T. alba* selects its prey according to size (CERPA & YAÑEZ, 1981). The optimum size reported includes 3 rodents such as *A. olivaceus*, *O. longicaudatus* and *P. darwini* whose size do not exceed 260 mm. The selective consumption of *O. bridgesi* reported here, whose maximum size reached 348 mm, is therefore not in agreement with their conclusions. Furthermore, nearly a third of the owl diet in Nipas/Ranquil area



was made up of *Rattus sp.* (REISE, pers. comm.) which also exceeds the optimum size proposed for the owl.

*Pseudalopex sp.* preferentially consumed three rodents, *P. darwini*, *O. bridgesi* and *O. longicaudatus*. Interestingly, rabbits (*O. cuniculus*) appeared as the most frequent prey. This finding is in contradiction with the suggestions of some authors (JAKSIC & YAÑEZ, 1980; FUENTES & JAKSIC, 1980) who in light of the low predation figures reported for rabbits, have proposed that foxes are not good candidates for the control of rabbit populations in central Chile. However, a higher percentage of rabbits in diet of foxes has been recently reported in central Chile. IRIARTE (1986) documented that *O. cuniculus* was the mammal most frequently preyed on, accounting for 37% of the total prey items identified. SIMONETTI (1986) also found a significant percentage of rabbits in fox diet, but he attributed this to the opportunistic consumption by foxes of rabbits which had been captured by snares.

The level of predation upon rabbits in Burca (65%) is even higher than those reported in England before the introduction of the myxomatosis virus (55% of all prey) (SOUTHERN & WATSON, 1941). The environmental modification introduced in the study site in order to reduce rodent populations and prevent damage to pines apparently increased prey vulnerability and also improved habitat conditions for foxes. Better visibility and ease of movement could account for a higher predation on rodents and rabbits. The success of providing perches for *Tyto alba*, a selective predator on *O. bridgesi*, is clear. Also it is showed that foxes are important for controlling rabbits. This should justify adequate measures to avoid poaching of foxes in the area. Potential control of these two vertebrate pests in central Chile should include direct actions such as provision of perches and conservation policies in order to prevent decreasing predator populations and indirect like barriers, silvicultural practices, etc. (fig. 4).

The habitat modifications produced a double effect: on one hand, they interfered with the population ecology of prey species, and, on the other, they improved the habitat conditions for vertebrate predators. Future studies should consider other habitat improvements such as introduction of nesting boxes, in order to increase the numbers of predators as a potential method to control outbreaks of rodents and insects in pine plantations.

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