Biological and environmental aspects of a mouse outbreak in the semi-arid region of Chile

by

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Pullulation de rongeurs qui s'est produite dans la province de Coquimbo, Chili, en 1972-1973. L'élément principal était *Oryzomys longicaudatus ;* cinq autres espèces ont été également impliquées.

INTRODUCTION

In the summer and autumn of 1972-1973, a high population of mice was reported in the coastal lands and river valleys of the province of Coquimbo, northern Chile ; damage to crops was extensive. We report here some of the species characteristics and environmental factors associated with the outbreak.

Coquimbo is in a warm steppe-biome with xerophytic vegetation, shrubs and thornbushes. Sclerophyll trees grow in some ravines ; cacti are very common. Grasses are mainly annuals, with two seasons of growth (spring and fall). Steppe predominates closer to the coast while inland areas are more savanna-like. Coquimbo is included in the semi-arid mediterranean region of Chile (di Castri, 1968), which exhibits extreme variability in the total amount of precipitation — short wet periods alternating with long droughts, persisting up to 10 years. Normally total annual rainfall ranges from 100 to 150 mm, varying with latitude and altitude. Three main rivers — the Elqui, Limarí, and Choapa — cross the province (Fig. 1). Small farms occupy the valleys, with pastures on drier land away from the rivers.

We visited the area on three occasions : the Limarí and Elqui valleys on May 25 to 27, and the Elqui valley only on June 1 to 3, and September 6 to 9, 1973. The narrow north side of the Elqui valley had high rodent populations only in patches. In contrast, the south side of the valley showed extensive damage. In the country between the Limari and Elqui valleys increase of rodents was noted only in the coastal fog zone. The interior table land between Ovalle and La Serena did not have a dense mouse population (Fig. 1).

RESULTS

We trapped in the Elqui valley zone at Asentamiento Ceres on the upper river terrace, and on the lower terrace in Colonia Alfalfares. Both are agrarian colonies of middle and low income farmers, located about 10 km east of La Serena, and were among the most damaged areas.

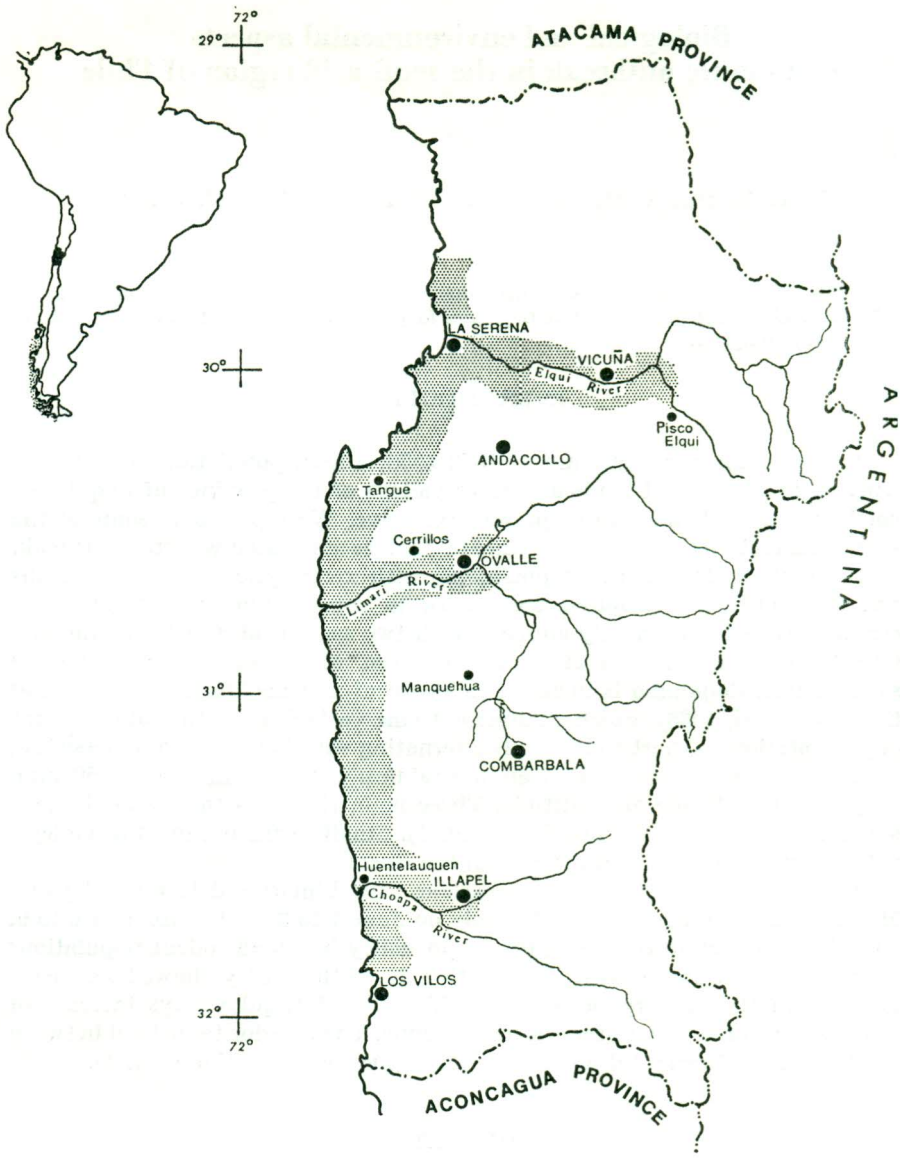

Fig. 1. — Map of Coquimbo province, Chile, showing main localities and the three main hydrological systems. The shaded area indicates the known extent of the rodent outbreak.

On the first night of our visit in May, 20 Sherman live-traps were set in a grid of 30 by 50 m covering a field of broad beans *(Vicia faba)* at Asentamiento Ceres. Fifteen *Oryzomys longicaudatus* and one *Phyllotis darwini* were trapped.

Ten other traps set at Colonia Alfalfares yielded eight *O. longicaudatus*. Chemical bait placed by farmers along stone fences killed several *Rattus rattus*, *Rattus norvegicus* and some *P. darwini*. On the second night, 80 Sherman traps were set at the same plot in Asentamiento Ceres resulting in 24 *O. longicaudatus*, four *P. darwini* and one *Mus musculus*. Average trap success for the two May nights was 45% for 100 trap nights (Table 1).

In June, a sequential capture-recapture procedure was followed at the Asentamiento Ceres plot. A grid covering 1204 square meters of the broad bean field was censused four times using 80 Sherman traps. Traps were set on June 1st at 19:00 hours and inspected at 23:00 hours, 25 *O. longicaudatus* were caught. On the second inspection on June 2nd at 07:00 hours, we caught 20 *O. longicaudatus* and one *M. musculus*. Traps reset on June 2nd at 19:00 hours and inspected at 23:00, obtained 19 *O. longicaudatus*. Finally, on June 3 at 07:00 hours, ten *O. longicaudatus*, eight *M. musculus*, two *Akodon olivaceus* and one *P. darwini* were captured. Trap success in June was 44% for 204 trap nights (Table 1).

All animals captured on June 1st and 2nd at 07:00 hours were toe-clipped and released, while animals trapped in the two latter opportunities were removed from the field. The Lincoln-Petersen (Adams, 1951) and the Schnabel (Smith, 1966) methods for capture-recapture estimation of population size were applied to these figures, resulting in estimates of 217 and 206 individuals respectively. If these figures were carefully extrapolated, the estimated population would be 1802-1710 individuals per hectare, a probably fairly accurate estimation for Asentamiento Ceres, but perhaps not for other places. Asentamiento Ceres, as well as the rest of the moister habitats, acted as a center of attraction by providing a source of food. During late evening hours we actually saw mice invading bean fields from the dry grasslands, and retrating in the early sunrise. In a coeval study done by Fulk in 1972-73, rodent density was estimated at 115 per hectare (Fulk, 1975), considerably lower than our values; however, he had occasional high trap successes (80%). The 45% trap success obtained in Asentamiento Ceres, was much higher than at places we collected in several southern provinces of Chile but lower than the result obtained by Pearson (1975) in a contemporaneous outbreak of *Phyllotis darwini* in Tacna, Peru.

By our September visit, the bean fields had been cut and burned, and the ground was bare. A similar grid set up in a potato field, 50 meters away from the previous study-site, captured no mice. In other parts of the Elqui valley we trapped only a few *A. olivaceus* and *P. darwini*, and rodent sightings, so frequent in our two former visits, were rare at this time.

Biological observations

Species involved in the outbreak were *Oryzomys longicaudatus*, *Phyllotis darwini*, *Akodon olivaceus*, *Octodon degus*, *Mus musculus*, and *Rattus rattus*. Most of them, if not easily trapped, were frequently sighted crossing the roads or found dead by the roads. Only four out of the six species known to be involved were represented in our collections, though (Table 1).

TABLE 1. — Number of traps/nights, live trapped mice, trap success and species composition of the live-trapped mice collected at Asentamiento Ceres, La Serena, Chile.

	MAY		JUNE		SEPTEMBER	
	25-26	26-27	1-2	2-3	7-8	8-9
trap/nights	20	80	105	99	80	80
catches	16	29	50	40	0	0
trap night succ.	80 %	36%	47%	40%	0%	0%
Average trap success	45%		44%		0%	
O. longicaudatus	39		78		0	
P. darwini	5		1		0	
A. olivaceus	0		2		0	
M. musculus	1		9		0	
Total captures	45		90		0	

Oryzomys longicaudatus.

This species was the most abundant component of the outbreak (Table 1). *O. longicaudatus* has also been recorded in a "plague" state in southern Brazil (Pereira, 1941), and *O. xantheolus* has been reported in great numbers in southern Peru (Gilmore, 1947).

Measurements and weights of trapped *O. longicaudatus* are given on Table 2. The observed differences in total length between sexes in each month were not statistically significant, nor were the differences between sexes with pooled individuals from May and June. However, the size variation between the May and June populations was statistically significant, strongly suggesting that recruitment and replacement was high in this population. Weight, despite size difference, was similar in both May and June male populations : the difference between the female weights was a little larger ; mean weight of an Argentinian population was 26.6 grams (Contreras, 1972). Three age classes juvenile, adult and old individuals, were defined according with the degree, of molar wear (N = 39 skulls). Juveniles comprised 56.4%, adults 30.8%, and old individuals only 12.7% of the combined May and June populations. All these data indicated a population dominated by young animals, as also was evidenced by reproductive state. No captured animals but a female were reproductively active, and most of the males had testes only 3 mm long. In contrast, Fulk (1975) found five out of seven females to be pregnant in March ; and we also trapped a pregnant female in late May. These facts suggest that *O. longicaudatus* is a late (southern hemisphere) summer breeder. Sex ratio combining both months, was 52.6% females to 47.4% males.

Twenty five specimens of *O. longicaudatus* of both sexes were kept in separate boxes provided with cotton, ground corn and water. All of the mice died within three days, with death preceded by violent muscular contractions and tremors. Cannibalism was observed in pairs left together in the same wirebox, as was also reported by Contreras (1972).

TABLE 2. — Mean external measurements and weight of *Oryzomys longicaudatus* from Asentamiento Ceres, La Serena, Chile. (Measurements in mm ; weight in grams).

Date of capture	N	Sex	Total length	tail length	Hind foot length	Ear length	Testes length	Weight
May 26-27	21	♀	215.2	121.6	26.5	15.1	----	21.7
	15	♂	222.5	127.3	27.0	15.5	2.72	23.5
June 2-3	9	♀	197.8	111.1	24.1	15.1	----	21.1
	10	♂	199.5	114.1	24.2	14.9	2.50	22.5

Mus musculus.

In May and June, 10 specimens of both sexes were collected. The largest specimen, a male, measuring 157 mm total length, weighed 18.0 grams. They were more abundant close to human shelter and in barn and silos than in the open field.

Phyllotis darwini.

Six specimens were trapped in May and June, and a non-pregnant female was taken in September among stones closer to the collection site. May-June females were nulliparous and males had testes measuring 3 and 4 mm. One of these males was held under the same conditions as *Oryzomys* (see above), and survived 97 days, measuring 252 mm in total length, and weight 40.6 grams, with scrotal testes 11 mm at death. In September, a small male (23.3 grams ; scrotal testes 10 mm) was taken at Andacollo, on Highway 43.

Akodon olivaceus.

Only two specimens, both females, were trapped in Asentamiento Ceres in June. Later, in September, a male and a female were collected in a stone fence close to the trapping plot. All three females were nulliparous (average weight 18.5 grams) ; the male weighed 28.1 grams with testes measuring 8 mm.

Other species.

Although *Rattus rattus* and *Octodon degus* were not trapped, they were noticeably abundant. Road kills were often found. *R. rattus* destroyed potatoes crops by digging up the bulbs. *Octodon degus*, however, preferred xeric conditions, and had a patchy distribution. Whereas populations increased *in situ*, they did not invade from far distant habitats. Tunas *(Opuntia sp.)*, corn ears and grapes were their favored cultivated food. In the mountainous Pisco Elqui locality, most of the vineyards were attacked by this large diurnal rodent.

Predators

Owls, hawks, chotacabras *(Caprimulgus longirostris)* and tiuques *(Milvago chimango)* were observed in the study area. The owl *Tyto alba* was seen nightly

TABLE 3. — Rodent remains in owl pellets from the area affected by a rodent outbreak in Coquimbo, Chile.

	Speotyto cunicularia* 28 pellets	7 pellets	Tyto alba** 16 pellets
P. darwini			
Juvenile	11	2	3
Adult	4	1	2
Old	8	-	4
A. olivaceus			
Juvenile	2	-	-
Adult	5	1	-
Old	4	1	-
M. musculus			
Juvenile	-	-	3
Adult	-	-	3
Old	-	-	-
O. longicaudatus			
Juvenile	-	2	3
Adult	-	-	1
Old	-	-	1

* Samples collected on May 26 ; details in Péfaur *et al.*, 1976. — ** Sample collected on September 8 : see text for details.

at several places in the Elqui valley. Chotacabras were also observed nightly at Asentamiento Ceres ; two carcasses were found by the collection site. Hawks and tiuques, both diurnal, were usually at perches around the area.

In order to assess the relative importance of avian predators on the "outbreak" species, owl pellet samples were collected from three different places in dry habitats of the study areas (Péfaur *et al.*, 1976). On May 26, a sample of 28 burrowing owl *(Speotyto cunicularia)* pellets was obtained near Andacollo, on Highway 43 ; seven other pellets were collected at 20 km north of the previous site. On September 8, a sample of 16 barn owl *(Tyto alba)* pellets was collected in Las Rojas, Elqui valley, from under a molle tree *(Schinus molle)*. Pellet analysis showed some differences in the prey composition (Table 3). Both owls included *P. darwini* and *O. longicaudatus* in their diets, but while the barn owl ate additionally *M. musculus*, the burrowing owl ate *A. olivaceus*. The absence of the latter species in the barn owl's pellets might indicate that this rodent was no longer present in the wetter valley by September, but its presence in the burrowing owl's pellets indicated its existance earlier in the drier bushy land, its natural habitat. *P. darwini*, the third most frequently trapped rodent at Asentamiento Ceres, was the most important food item for both owls. *Oryzomys longicaudatus*, on the other hand, made a rather small contribution ot the owl's diet.

DISCUSSION

Knowledge of rodent plagues in Chile goes back to Philippi (1879), who

gave an account of the association between high increase of rodents and seed production of the bamboo Colihue *(Chusquea quila)*. As these tall, solid-caned grasses fructify every 15 to 25 years, seeds are available in large quantities, providing abundant resources to support an increase of rodents. These cyclic outbreaks of rodents related to bamboo seed production are known to occur worldwide (Derby, 1879 ; Philippi, 1879 ; Pereira, 1941 ; Janzen, 1976). The outbreak reported here, however, was not in response to bamboo fructification.

In semidesert or desert condition rain(s) of at least 25 mm occurring in the autumn provokes mass germination of winter annuals. Availability of this type of food during the breeding season determines, in turn, the success or failure of rodent reproduction (Beatley, 1969). In addition, under semidesert conditions, the amount and time of precipitation also determine the production of perennial grasses (Cable, 1975). Above-normal rainfalls, then, could act as indirect releasers for rodent increases (Beatley, 1969 and 1976 ; Gilmore, 1947 ;

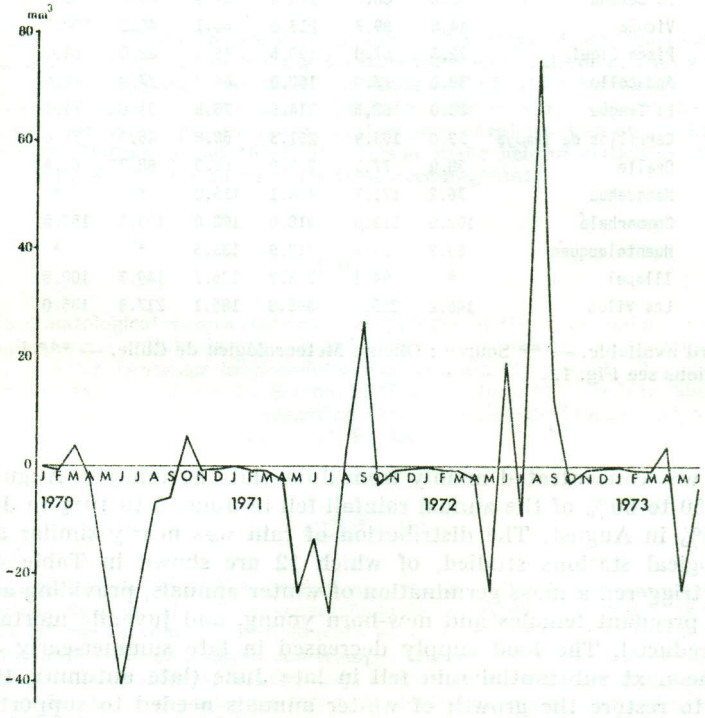

Fig. 2. — Departures from the mean monthly rainfall for 42 months at La Serena, Coquimbo province, Chile.

Pearson, 1975 ; Poulet, 1974 ; Prakash and Rana, 1972 ; Reichman and van de Graaff, 1975). In Coquimbo province, rainfall departures from the mean,

as illustrated with the example of La Serena (Fig. 2), were favourable for rodent reproduction on two consecutive occasions : September 1971, and especially June-September 1972. Moreover, heavy rainfall in the late autumn of 1972 in the whole north-central and central part of Chile resulted in much growth of winter annual vegetation.

Records for selected climatological stations (Table 4) show the striking difference between rainfall in 1972 and in preceeding and subsequent years ; 1972 was one of the wettest on record, something that may be in relation with the "El Niño" warm countercurrent along the west coast of South America.

TABLE 4. — Annual rainfall for 12 climatological stations of Coquimbo province, Chile.

Locality ***	Precipitation in mm **					
	1970	1971	1972	1973	1974	1975
La Serena	62.0	80.1	173.6	57.3	49.7	68.3
Vicuña	14.8	89.7	213.0	60.1	45.5	108.7
Pisco Elqui	22.5	67.0	190.5	45.0	82.0	54.0
Andacollo	39.0	77.0	160.0	66.2	77.0	80.0
El Tangue	35.0	68.5	214.5	73.5	91.0	71.5
Cerrillos de Tamaya	29.0	103.9	251.3	50.8	48.0	71.0
Ovalle	38.9	77.1	210.0	62.9	68.3	63.4
Manquehua	76.2	171.7	456.1	115.0	*	*
Combarbalá	102.6	113.0	418.0	108.0	103.5	152.0
Huentelauquén	59.3	164.7	312.9	133.5	*	*
Illapel	*	94.1	353.2	126.7	149.3	100.9
Los Vilos	146.2	205.7	345.8	186.1	217.9	135.0

* No record available. — ** Source : Oficina Meteorológica de Chile. — *** For location of stations see Fig. 1.

Rainfall was concentrated mainly from June (late autumn) to August (early winter): 50 to 60% of the annual rainfall fell in June, 5 to 10% in July, and 20 to 30% in August. The distribution of rain was nearly similar at all 25 climatological stations studied, of which 12 are shown in Table 4. These rainfalls triggered a mass germination of winter annuals, providing abundant food for pregnant females and new-born young, and juvenile mortality was greatly reduced. The food supply decreased in late summer-early autumn, 1973. The next substantial rain fell in late June (late autumn), 1973, too delayed to restore the growth of winter annuals needed to support a large rodent population. The dense populations that were far from alternative food sources probably perished, but those living close to the river valleys migrated to the farms. It has been claimed that rodents from xeric habitats are opportunistic in their food intake behavior (Reichman, 1975); the Coquimbo rodents switched from wild seeds and green leaves to cultivated products. This switching strategy temporarily reduced mortality.

CONCLUSIONS

In general, the semidesert environment in Coquimbo province is an unstable habitat for mice due to the unpredictability in both the appearance and duration of wet and/or dry years. Environments of this kind impose high density-independent mortality such as food scarcity following surplus, den flooding, loss of soil structure, etc., upon rodent populations. Above-normal rainfall, resulting in increased food supply, are principal factors behind the increase, but other factors may also have played an important role. Pearson (1975) also suggested that precipitation and food may be the cause of outbreaks in semidesert habitat of *Phyllotis darwini* in southern Peru. Soon after the effect of the abundant rains was over at the end of 1973, the populations of Coquimbo's rodents decreased steadily as density-independent mortality once again began to influence the majority of the rodent species.

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SUMMARY

Due to climatological reasons there was a surplus production of annual herbs and grasses in Coquimbo province, Chile, during 1972 and 1973. This availability of food caused a rodent outbreak, of which *Oryzomys longicaudatus* was its main component. The outbreak was studied at Asentamiento Ceres, La Serena, in May and June 1973, mainly. Sherman live-trap success was about 45 %. It is suggested that these biological factors are responses to the oceanic-metereological phenomenon of "El Niño".

RESÚMEN

Durante los años 1972 y 1973 se produjo una cantidad extra de hierbas y pastos anuales en la provincia de Coquimbo, Chile, acompañada de una explosión demográfica de ratones. Esta "ratada" fue estudiada principalmente en el Asentamiento Ceeres, La Serena, en Mayo y Junio de 1973. El trampeo con trampas Sherman tuvo un exito de alrededor del 45 % en ambas oportunidades, con *Oryzomys longicaudatus* conformando más del 85 % de las capturas. Se sugiere que éstas son respuestas biológicas al fenómeno oceanico-meteorológico de "El Niño". Los perjuicios agrícolas provocados por esta ratada fueron inmensos.

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