

Predation of marine invertebrates by the kelp gull *Larus dominicanus* in an undisturbed intertidal rocky shore of central Chile

Depredación de invertebrados marinos por la gaviota *Larus dominicanus*
en una zona intermareal no perturbada de Chile central

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ABSTRACT

The kelp gull, *Larus dominicanus* Lichtenstein, is a common marine bird along the central coast of Chile. This study documents prey items used by the kelp gull while foraging in undisturbed rocky intertidal habitats at Los Molles, central Chile. The results are based on direct foraging observations of gulls from blinds with binoculars and on the analysis of prey remains in middens and regurgitated pellets. It was found that *Larus dominicanus* preys upon 30 different species of marine invertebrates. Gastropod and amphineuran molluscs and intertidal crustaceans were among their main prey items. Among their five most important molluscan prey *L. dominicanus* selects from the environment the larger specimens of *Chiton granosus* and the smaller of *Concholepas concholepas*. They do not select prey from above average size in the case of the limpets *Collisella zebrina*, *Scurria scurra* and the key-hole limpet *Fissurella limbata*. Our results suggest that *L. dominicanus* predation on such diverse forms of herbivorous molluscs or high trophic level carnivores, such as *Concholepas concholepas*, could have significant ecological effects in rocky intertidal communities of central Chile. A quantitative and experimental evaluation of the actual ecological role of *L. dominicanus* in rocky intertidal sites of central Chile with and without man interference is called for.

Key words: Seagull, *Larus dominicanus*, diet, middens.

RESUMEN

La gaviota, *Larus dominicanus* Lichtenstein, es un ave marina común a lo largo de la costa de Chile central. Este trabajo documenta las presas utilizadas por la gaviota en hábitats intermareales libres de perturbación humana en la localidad de Los Molles, Chile central. Los resultados están basados en observaciones directas (con anteojos de larga vista desde casetas camufladas) de gaviotas en actividades de depredación y en el análisis de restos de presas en sus "comederos" y regurgitados. Encontramos que *L. dominicanus* depreda sobre 30 especies diferentes de invertebrados marinos. Entre sus principales presas se encuentran moluscos gastrópodos y anfineuros y crustáceos intermareales. De entre las cinco especies de moluscos más importantes en su dieta *L. dominicanus* selecciona los tamaños mayores de *Chiton granosus* y los tamaños menores de *Concholepas concholepas*. No muestra selección de tamaño para las patelas *Collisella zebrina* y *Scurria scurra* ni la lapa *Fissurella limbata*. Nuestros resultados sugieren que *L. dominicanus* al depredar sobre muy diversas formas de moluscos herbívoros o carnívoros de alto nivel trófico, como *C. concholepas*, podría tener efectos ecológicos importantes en las comunidades rocosas intermareales de Chile central. Enfatizamos la necesidad de evaluaciones cuantitativas y experimentales sobre el rol ecológico de *L. dominicanus*, en especial en localidades contrastantes con y sin intervención humana.

Palabras claves: Gaviota, *Larus dominicanus*, dieta, comederos.

INTRODUCTION

The kelp gull, *Larus dominicanus* Lichtenstein, is a common marine bird along the coast of Chile that feeds in rocky intertidal

or sandy habitats. General and qualitative foraging observations on this species have been reported in Chile and geographically related areas by Gay (1847), Reynolds (1935), Murphy (1936), Yáñez (1949),

Goodall *et al.* (1951), Housse (1953), Philippi *et al.* (1954), Shabica (1976), Schlatter (1979), Blankley (1981), and Boshoff & Palmer (1982). These authors have shown that in rocky intertidal habitats the bird's main prey includes molluscs, crustaceans, echinoderms, and fish.

This study documents quantitatively the prey items utilized by the kelp gull while foraging in undisturbed (man-free) rocky intertidal habitats of central Chile. The data gathered enhance our knowledge of the feeding activities of *L. dominicanus* in Chile. Furthermore, they form the basis for future experimental work on the ecological role of the species in intertidal rocky shore ecosystems.

MATERIALS AND METHODS

Our study was conducted in an undisturbed rocky shore near Los Molles (32°14' S, 71°31' W) in central Chile (Castilla 1976). Observations were made between July 1976 and June 1979. Three rocky sites were monitored.

Site 1: A rocky platform at Caleta El Salto, of *ca.* 12 m facing northwest and located about 20 m above sea level. Gulls used this site for resting, feeding, and regurgitating pellets, thus forming typical gull middens. Collections of gull food remains were made periodically since elevation of this site above the water-washed zone allowed for their accumulation. Three 1-m² quadrats were marked on this platform. Quadrat A was the most protected from wave action, whereas quadrats B and C were exposed to the prevailing southern wind and waves. Food remains were initially collected from all three quadrats: quadrat A starting in July 1976, and B and C starting in January 1977. Subsequent collections were made about every two months for a period of 14 months. Binoculars (10 x 50) were used during a total of 50.5 h of diurnal bird observations at this site.

Site 2: A 250-m stretch of rocky intertidal at Caleta El Salto, with a conspicuous zone of the kelp-like alga *Lessonia nigrescens* Bory (Santelices *et al.* 1980). The site is characterized by a northwest exposure, and subjected to extremely heavy wave action and submergence during high tides. At this site 50 hours of direct feeding observations were made on gulls from a blind.

Careful mapping of the rocks used by the gulls to feed or to drop their prey allowed direct prey identification and measurement in most cases.

Site 3: An elevated rocky platform at Las Escaleras. This site is located about 400 m south of Site 2 and faces south, with an elevation of 3-5 m above sea level. Waves commonly wash completely over it. Gulls used this site mainly for resting and food regurgitation. No gull middens were found at this site. We collected 41 regurgitated pellets between May and June 1979. Their contents were subsequently analyzed in the laboratory. The prey items in the pellets were sorted as follows: 1) gastropods: whole shells; 2) bivalves: one individual counted per pair of valves; 3) amphineurans: one individual counted per eight plates; 4) crustaceans: one individual counted per two chelae; 5) starfish: each arm piece was registered as one individual.

The intertidal invertebrates available as potential prey for *L. dominicanus* were sampled as follows. Three intertidal transects, 10 m apart, were laid perpendicular to the *Lessonia* zone. Each 6-m long and 2-m wide transect was divided into three quadrats, 2x2 m, corresponding approximately to the lower, middle and upper intertidal zones (Castilla 1981a). The lower transect limit was set on the *Lessonia* kelp plants, at the low water mark. The upper limit was characterized by the presence of *Littorina peruviana* (Lamarck) and *L. araucana* Orbigny. All conspicuous invertebrates on rocks (except for barnacles and littorinid snails) and fronds of *Lessonia* were collected from the quadrats. The size of each mollusc specimen was measured using a caliper, 0.1 mm of accuracy.

Student's t-tests were used to compare the mean size of the major species of molluscs found along the intertidal transects and in the gull middens. Chi-square tests (R x C contingency table, Snedecor & Cochran 1980) were used to test for independence between population size structure of the main species of molluscs in the transects and in the gull middens.

RESULTS

1. Caleta El Salto: elevated platform at Site 1 and intertidal transect.

During our study *Larus dominicanus* was the only marine bird observed resting,

eating, and regurgitating marine invertebrates at this site. In all monitored cases at this site gulls carried the prey from nearby rocky intertidal areas and used Site 1 as a safe feeding location. Therefore, we consider that all food remains found on the site are representative of kelp gull middens at this locality.

Table 1 shows the results of the collections of food remains from the quadrats. Fourteen species of gastropods and amphineurans occurred in the middens. Quadrat A, the most protected, had the greatest accumulation of remains at the initial and subsequent collections. The initial mean density of molluscs in the three quadrats was 123 molluscs m⁻². After the initial removal and at the end of the study the mean was 73 molluscs m⁻². The most abundant species in the initial removal were *Collisella zebrina* (Lesson), *Concholepas concholepas* (Bruguiere), *Scurria scurra* (Lesson), *Chiton granosus* Frembly, and *Fissurella limbata*

Sowerby. Of the initial species, only nine were found at the end of the study. Moreover, of the five most abundant species only *C. concholepas*, *C. granosus* and *F. limbata* kept their initial abundance, whereas *S. scurra* became the most abundant, mostly due to its high representation in quadrat A.

Additional observations on areas adjacent to the sampled quadrats revealed the presence of crustacean remains mainly associated with rock crevices. They comprised six specimens of *Acanthocyclus* spp.; one *Petrolisthes punctatus*; one *P. tuberculatus*, and one *Pachycheles grossimanus*. We believe that while the mollusc shell remains are fairly represented in the quadrat middens analyzed, light crustaceans remains are rain-washed or blown away (personal observations), with the result that they are under-represented in the quadrats sampled.

Five molluscs were the most conspicuous and abundant invertebrates species in the

TABLE 1

Larus dominicanus. Middens at elevated platform (Site 1), Los Molles. FIRST: First removal, quadrat A July 1976; quadrats B and C January 1977. CUM: cumulative removals (N = 6) after the first one, August 1976 – February 1978

Larus dominicanus. "Comederos" en la plataforma elevada (Sitio 1) Los Molles. FIRST: primera remoción, cuadrante A, julio 1976; cuadrantes B y C, enero 1977. CUM: remociones acumulativas (N = 6) después de la primera, agosto 1976 – febrero 1978

PREY ITEM	NUMBER OF SHELLS						TOTAL (%)	
	QUADRATS						FIRST	CUM
	A		B		C			
FIRST	CUM	FIRST	CUM	FIRST	CUM	FIRST	CUM	
<i>Collisella zebrina</i>	37	34	12	–	48	7	26.29	18.64
<i>Concholepas concholepas</i>	44	31	34	20	6	7	22.77	26.36
<i>Scurria scurra</i>	33	52	6	8	25	–	17.34	27.27
<i>Chiton granosus</i>	27	37	30	–	2	–	15.99	16.82
<i>Fissurella limbata</i>	3	15	13	–	3	2	5.15	7.73
<i>Scurria parasitica</i>	11	–	–	–	–	–	2.98	–
<i>Fissurella rudis</i>	2	–	5	–	3	2	2.71	0.91
<i>Fissurella maxima</i>	2	2	4	–	1	–	1.90	0.91
<i>Siphonaria lessoni</i>	7	–	–	–	–	–	1.90	–
<i>Fissurella crassa</i>	2	1	1	–	–	–	0.81	0.45
<i>Tegula atra</i>	1	1	1	–	1	1	0.81	0.91
<i>Collisella araucana</i>	2	–	–	–	–	–	0.54	–
<i>Collisella variabilis</i>	2	–	–	–	–	–	0.54	–
<i>Tonicia</i> sp.	–	–	1	–	–	–	0.27	–
n	173	173	107	28	89	19	100.0	100.0

intertidal transect: *Concholepas concholepas*, *Collisella zebrina*, *Chiton granosus*, *Scurria scurra*, and *Fissurella limbata*. The limpet *C. zebrina* was the only species present in all the transect quadrats. The highest density was found in the upper intertidal zone: 10.7 individuals m^{-2} . The muricid *C. concholepas* was rare in the upper and middle quadrats. *S. scurra* occurs exclusively on *Lessonia nigrescens* fronds (Santelices *et al.* 1980). The amphineuran *C. granosus* was found in the middle and low quadrats. The key-hole limpet *F. limbata* was found only in the low quadrats. At Caleta El Salto the normally common intertidal mussel *Perumytilus purpuratus* Lamarck was rare (Castilla 1981a, Castilla and Durán 1985). Other species present in low densities were: *Fissurella crassa* Lamarck, *F. maxima* Sowerby, *Tegula atra* (Lesson), *Prisogaster niger* (Wood), *Tonicia* spp., *Heliaster helianthus* (Lamarck), and *Stichaster striatus* (Muller & Troschel). The molluscs *Littorina araucana*, *L. peruviana*, and *Siphonaria lessoni* Blainville, were represented by between four and twelve individuals in all upper intertidal quadrats.

Figure 1 shows the size-frequency distribution of the most common prey items collected from the gull midden quadrats and from the intertidal transects. Student's t-tests show that two species in the middens, *Chiton granosus* ($t = 9.77$, $P \leq 0.001$) and *Concholepas concholepas* ($t = 4.96$, $P \leq 0.001$) have mean sizes significantly different from those in the intertidal transects. Further, the χ^2 tests reject the null hypothesis of independence between size structure of *C. granosus* ($\chi^2 = 70.06$, $P = 0.0001$) and *C. concholepas* ($\chi^2 = 27.84$, $P = 0.0001$) in the transects and in the middens. The null hypothesis is not rejected in the case of the other three species, *Collisella zebrina*, *Scurria scurra*, and *Fissurella limbata*. The above facts suggest that *L. dominicanus* forages selectively on larger *C. granosus* and smaller *C. concholepas*, but not on any specific size of the other three species of intertidal molluscs.

2. Direct observations of feeding of *L. dominicanus* at Sites 2 and 3.

A total of 50 hours of direct gull foraging observations at Site 2 were completed along eight days of neap tides between No-

vember 1978 and March 1979. The density of gulls at this site at neap tide during the selected days ranged between 4.8 and 11.6 per kilometer of coast line. Two types of additional observations were made. First, Table 2 shows 49 direct observations on the feeding of *L. dominicanus* at Site 2. Seventeen prey species were identified. About half were molluscs and the rest crustaceans, except for one species of starfish. In spite of the limited number of observations, the results show that *C. concholepas*, *C. granosus*, *S. scurra*, *C. zebrina*, and *Fissurella* spp. were the main molluscs eaten by the kelp gull at this site. These figures are in agreement with the collections obtained from gull middens. Furthermore, the mean prey sizes accord with those found at the middens. Moreover, Table 2 shows that crustaceans (particularly *Petrolisthes* spp.) were important prey items. This confirms our former claim that crustaceans may be under-represented in gull middens such as those studied at Site 1.

Gulls observed at Site 3 foraged 2 to 4 hours before and after low tides, mainly in and around the *Lessonia* belt. We observed three successful attacks on the starfish *S. striatus*, that ended with the destruction of the starfish, although we did not observe ingestion. Only once did we observe gulls to drop a specimen of *C. concholepas* on to the rocks in order to break the shell.

3. Analysis of pellets collected at Site 3

Pellets regurgitated by *L. dominicanus* were collected only at Site 3. The shape and color of pellets differed depending on the prey contents and period of exposure to air; color ranged from white when the main prey were fishes or the sandy beach bivalve *Mesodesma donacium*, to reddish-black when the main prey were crabs (*Petrolisthes* spp.). The pellets' mean length was 43.4 mm, mean width 29.6 mm, and mean height 15.9 mm. Mean weight was 4.21 g and mean volume 3.64 cm^3 . Table 3 shows the prey items found in the pellets. Out of a total of twenty species identified, eleven were molluscs, one a starfish, and the rest crustaceans.

The percentage of occurrence of mollusc species in the gull pellets was rather low, ranging between about 2.5-5% for any one of them. Nevertheless, two species: *Semi-*

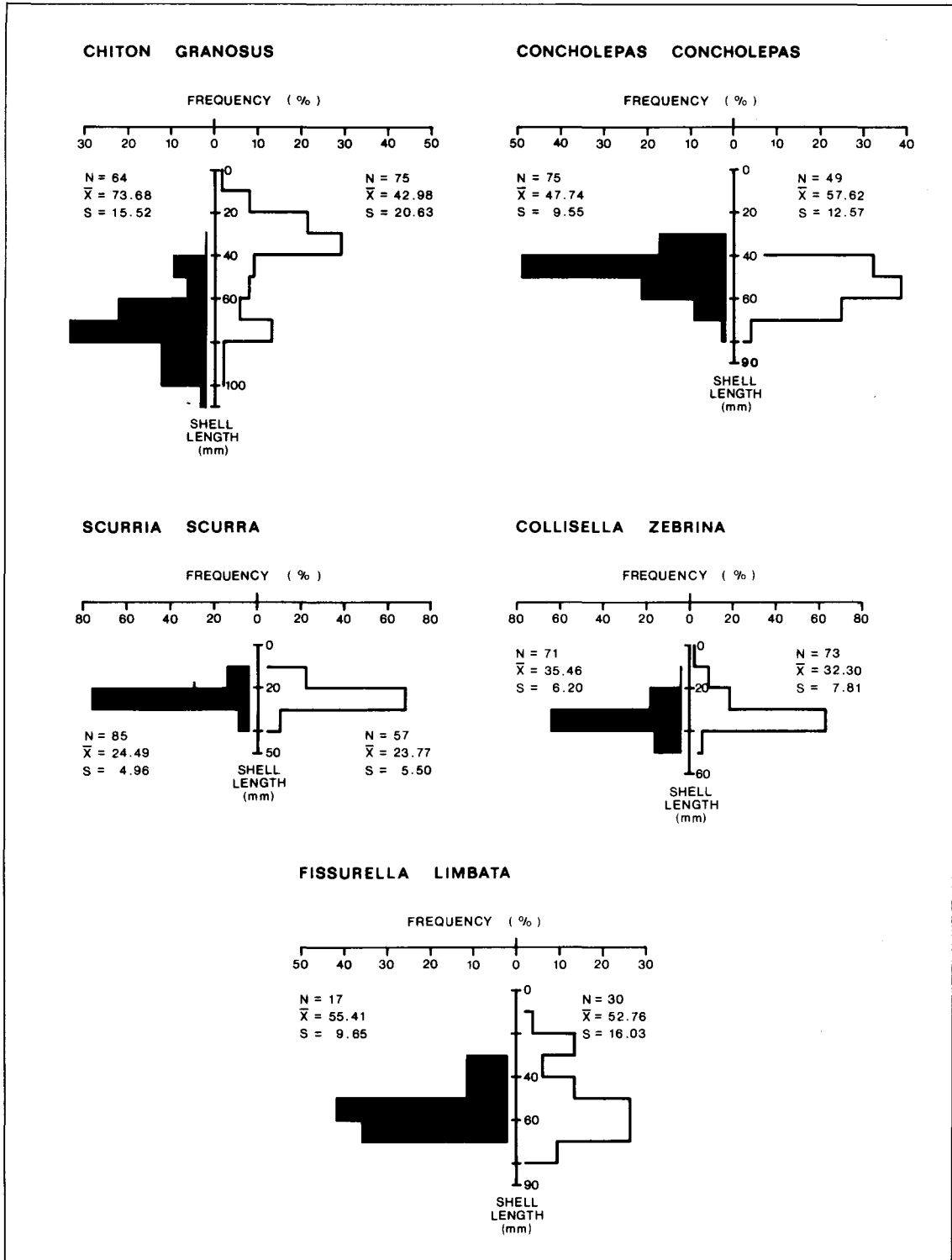


Fig. 1. Size frequency distribution of the five most abundant species of invertebrates found in *Larus dominicanus* middens (black histograms), and in intertidal transects (white histograms) at Caleta El Salto Los Molles.

Distribución de las frecuencias de tamaño para las cinco especies más abundantes de invertebrados encontrados en "comederos" (histogramas negros) de *Larus dominicanus* y en los transectos intermareales (histogramas blancos) en Caleta El Salto, Los Molles.

mytilus algosus and *Littorina araucana* accounted for approximately 55% of the total number of prey found. On the other hand, crustacean occurrences were high. *Acanthocyclus* spp. showed over 65% of occurrence in the pellets and accounted for about 30% of the total number of prey.

TABLE 2

Larus dominicanus. Direct observations on feeding at Site 2, Los Molles, 1978-1979. Molluscs' shell length and starfish's arm length (mm)

Larus dominicanus. Observaciones directas sobre alimentación en el Sitio 2, Los Molles, 1978 - 1979. Largo de la concha para los moluscos y largo de brazos para las estrellas de mar (mm).

PREY ITEM	Number of observations	\bar{x} length (mm)
Mollusca		
Polyplacophora		
<i>Chiton granosus</i>	3	68.4
Gastropoda		
<i>Concholepas concholepas</i>	7	45.5
<i>Fissurella maxima</i>	6	36.9
<i>Fissurella crassa</i>	—	—
<i>Fissurella rudis</i>	1	38.8
<i>Collisella zebrina</i>	1	32.8
<i>Scurria scurra</i>	3	23.5
Bivalvia		
<i>Protothaca thaca</i>	1	40.0
<i>Mesodesma donacium</i>	1	48.0
Asteroidea		
<i>Stichaster striatus</i>	3	70.0
Arthropoda		
Crustacea		
<i>Gaudichaudia gaudichaudii</i>	2	?
<i>Petrolisthes punctatus</i>	1	?
<i>Petrolisthes violaceus</i>	6	?
<i>Petrolisthes tuberculatus</i>	7	?
<i>Pachycheles grossimanus</i>	1	?
<i>Acanthocyclus</i> spp.	4	?
<i>Pilumnoides perlatus</i>	2	?
n	49	

TABLE 3

Larus dominicanus. Analysis of 41 regurgitated pellets collected at Site 3, Los Molles, May-June 1979. Four pellets contained fish remains and are not included in the table.

Larus dominicanus. Análisis de 41 regurgitados recolectados en el Sitio 3, Los Molles, mayo - junio 1979. Cuatro regurgitados contenían restos de peces y no son incluidos en la Tabla.

PREY ITEM	% of occurrence in regurgitates	% of total number of prey
Mollusca		
<i>Chiton granosus</i>	2.44	0.42
<i>Fissurella crassa</i>	4.88	1.66
<i>Fissurella maxima</i>	4.88	0.83
<i>Fissurella limbata</i>	4.88	0.83
<i>Scurria scurra</i>	2.44	0.42
<i>Concholepas concholepas</i>	2.44	0.42
<i>Tegula atra</i>	2.44	0.42
<i>Prisogaster niger</i>	2.44	0.42
<i>Semimytilus algosus</i>	4.88	28.75
<i>Perumytilus purpuratus</i>	4.88	1.25
<i>Littorina araucana</i>	2.44	26.25
Arthropoda Crustacea		
<i>Acanthocyclus</i> spp.	65.85	29.16
<i>Petrolisthes punctatus</i>	4.88	2.91
<i>Petrolisthes violaceus</i>	12.20	2.50
<i>Petrolisthes tuberculatus</i>	4.88	0.83
<i>Pachycheles grossimanus</i>	7.32	1.25
<i>Gaudichaudia gaudichaudii</i>	2.44	0.42
<i>Pilumnoides perlatus</i>	2.44	0.42
<i>Homalaspis plana</i>	2.44	0.42
Echinodermata		
<i>Stichaster striatus</i>	2.44	0.42
n	41	240

DISCUSSION

Undisturbed rocky shores are difficult to find in central Chile. Our study sites at Los Molles are unusual in being inaccessible to visitors, making it possible to study biological processes without or with minimal human disturbance (Castilla & Bahamondes 1979, Castilla 1981a, 1981b, Castilla & Durán 1985). Marine birds are common at Los Molles. Some of them forage in the rocky intertidal areas, i.e., the black

oystercatcher *Haematopus ater* Vieillot et Oudart (Castilla 1981a), dippers, *Cinclodes* spp., and the kelp gull *Larus dominicanus*. We have found that the latter is a frequent and efficient predator of marine intertidal invertebrates at this locality.

Kelp gull middens have been previously reported from the southern hemisphere, (e.g., Murphy 1963, Shabica 1976). Our results, based on kelp gull direct feeding observations, analysis of middens, and regurgitated pellets show that this gull feeds on at least thirty different marine invertebrate species at Los Molles. Among these, twenty are molluscs, nine are crustaceans and one is a starfish. Of the crustaceans commonly found in the pellets, the carnivorous crabs *Acanthocyclus* spp. deserve special mention. Castilla (1981a) discussed the position of these crabs in the intertidal trophic webs of central Chile. They feed mainly on two kind of sessile invertebrates, the mussel *Perumytilus purpuratus* and the barnacles *Chthamalus scabrosus* and *Jehlius cirratus*, which are important holders of primary space. According to our results and those of Castilla (1981a), *L. dominicanus* is a major predator of *Acanthocyclus* spp.

Marine molluscs are also important prey items of *L. dominicanus*. Among these are 15 species of herbivorous gastropods, primarily key-hole limpets and acmaeid limpets. Predation by *L. dominicanus* on the limpet *Scurria scurra*, which lives almost exclusively on the fronds of *Lessonia nigrescens* deserves another special mention. Santelices *et al.* (1980) have discussed the *L. nigrescens* – *S. scurra* interaction at the same localities we studied. Their results indicated that *S. scurra* had a pruning effect on the largest and heaviest stipes of the kelp and probably prevented *L. nigrescens* from becoming so heavy as to become susceptible to detachment by wave action. A predator such as *L. dominicanus*, depleting *S. scurra* populations, could have an ecologically significant effect on the final population structure and abundance of *L. nigrescens* if predation were high enough.

The density of *Larus dominicanus* at Caleta El Salto reported in this paper is similar to that reported by Branch (1985) at Marion Island (subantarctic, South Africa), where the kelp gull has been shown to feed selectively on the largest limpets *Nacella delesserti*, and to account for about

50% of their known mortality. The carnivorous muricid gastropod *Concholepas concholepas*, which feeds mainly on barnacles and mussels (Castilla *et al.* 1979, Castilla & Durán 1985) is also consumed by *L. dominicanus*. *Concholepas concholepas*, or “loco”, is a commercially important shellfish in Chile (Castilla & Becerra 1975, Castilla 1982, 1983) and its nursery grounds are found in the rocky intertidal (Castilla *et al.* 1979, Guisado & Castilla 1983) whereas the main adult populations exploited by humans are subtidal. Castilla (1981a) noted that at Los Molles (particularly at Caleta El Salto) the intertidal density of *C. concholepas* was comparatively high, and the sizes of animals found between tide marks were unusually large. In this paper we show that the “loco” is one of the most important gull prey items in Caleta El Salto which is undisturbed by humans. Because the “loco” is a high trophic level carnivore, playing an ecological role similar to a key-stone species (Paine 1966, Castilla & Durán 1985) the predatory action of *L. dominicanus* on their intertidal populations could be extremely important from an ecological point of view. Manipulative experiments will be needed to resolve this point.

Our results show that the most common molluscs along the rocky intertidal shore of Los Molles are present in the middens of *L. dominicanus*. The comparison between the size distribution of the main molluscs present in the middens and in the nearby intertidal areas suggests that *L. dominicanus* is selecting the larger specimens of *Chiton granosus* and the smaller specimens of *Concholepas concholepas*. The latter is probably related to the patelloid-like shape of *C. concholepas* and to its large and strong foot which attaches the gastropod firmly to the rocks, rendering the larger specimens more difficult to detach by the gulls.

Hartwick (1976, 1978) has experimentally shown that the black oystercatcher *Haematopus bachmani*, another marine bird feeding on intertidal invertebrates, selects limpets of above average size.

At Caleta El Salto, *L. dominicanus* preys mainly upon motile marine invertebrates. It should be mentioned that the common mussel *Perumytilus purpuratus* is nearly absent from the sites we monitored (Castilla 1981a). Most likely other sites of the rocky intertidal zone of central Chile, where dense populations of *P. purpuratus* and a

rich community of associated invertebrates are available to *L. dominicanus*, could yield different results. We think that the ecological importance of *L. dominicanus* on intertidal ecosystems of central Chile needs to be evaluated on a site-by-site basis. The density of gulls and their food resources can drastically change along the central coast of Chile, and human interference seems to affect both variables (see Castilla & Durán 1985).

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