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NATURAL DIET OF THE SOUTHERN KING CRAB *LITHODES SANTOLLA* (LITHODIDAE) IN THE BEAGLE CHANNEL, TIERRA DEL FUEGO, ARGENTINA

DIETA NATURAL DE LA CENTOLLA PATAGONICA *LITHODES SANTOLLA* (LITHODIDAE) EN EL CANAL BEAGLE, TIERRA DEL FUEGO, ARGENTINA

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ABSTRACT

Stomach contents of 320 southern king crabs (*Lithodes santolla*) ranging from 40 mm to 100 mm in carapace length (CL) from Beagle Channel, near Ushuaia city, Argentina, were examined by the frequency of occurrence method of analysis and by the relative weight of stomach content. Of the total number of the crabs contained food (77.19%) 24 were damaged, so that they were excluded of the analysis. Molluscs (mainly gastropods) dominated in terms of frequency of occurrence; crustaceans and bryozoa were the second-and third- most important groups, respectively. The relative frequency of different prey groups varied in relation to the size class and season. No significant differences in the quantity of relative weight of food was observed between sexes, but significant differences were detected in the quantity of food consumed from different seasons and size groups. Consumption was greatest during winter in crabs <70 mm (CL). Generally small crabs (<60 mm CL contained more food than did large crabs (>70 mm CL).

Key words: Feeding habits - centolla - stomach contents - crab.

RESUMEN

Se analizaron 320 contenidos estomacales de centolla (*Lithodes santolla*) comprendidos entre 40 mm y 100 mm de largo de caparazón (LC) provenientes del Canal Beagle, principalmente de la zona cercana a la ciudad de Ushuaia, Argentina. El análisis se basó en la frecuencia de ocurrencia de los grupos que conforman la dieta y el peso relativo del contenido estomacal. Del total de organismos con alimento en su estómago (77,19%) 24 estaban dañados por lo cual fueron excluidos del análisis. Los moluscos (principalmente gasterópodos) dominaron en términos de frecuencia de ocurrencia, siendo los crustáceos y briozoos los que siguieron en importancia. La frecuencia relativa de los diferentes grupos varió en relación a la talla y el período de muestreo. No se determinó diferencias significativas en la cantidad relativa de alimento consumido entre sexos, pero sí según épocas de muestreo y talla. El consumo fue mayor durante el invierno en los organismos <70 mm LC. Generalmente los cangrejos de talla menor (<60 mm LC) consumieron mayor cantidad de alimento que los de talla mayor (>70 mm LC).

Palabras clave: Hábito alimentario - centolla - contenido etomacal - cangrejo.

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INTRODUCTION

The southern king crab *Lithodes santolla* (Molina) commonly named "centolla", is an important shellfish in Tierra del Fuego, Southern South America. This species has been harvested commercially in the Beagle Channel since 1965, the largest catches of 316.6 mT being recorded during 1974, in Argentina.

This species is distributed from Chiloé to Tierra del Fuego, and along the South Atlantic coast, from the Magellan Strait to Uruguay (Macpherson, 1988). Boschi *et al.* (1984) reported that *L. santolla* usually inhabits the intertidal

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zone up to more than 700 m, with maximum concentrations located between 10 and 50 m. Information concerning its natural diet is scarce. Buttini & Hernández (unpublished data) and Campodónico *et al.* (1982) addressed only the diversity of prey species from a small sample of predators in a single habitat. Comoglio *et al.* (1990) made a preliminary analysis of the natural diet of two species commercially harvested in the Beagle Channel, *L. santolla* and *Paralomis granulosa*, and compared them to determine a possible niche overlapping.

Crustacean feeding habits are difficult to quantify from gut content analysis of individuals freshly collected from the field, due to excessive maceration and fragmentation. Methods typically employed for the description of gut contents in crustaceans are based on the frequency of occurrence or estimation of gut content volume proportionately contributed by each prey taxon. Both of these methods will rank the more important prey species but are biased for or against certain types of foods (Williams, 1981). The aim of this study is to describe the natural diet of *Lithodes santolla* and improve the information available.

MATERIALS AND METHODS

Specimens of *Lithodes santolla* were collected during 1988-1990 (N=320) from 6 to 36 m in the Beagle Channel, by SCUBA diving. In the laboratory, crabs were measured (carapace length, CL hereafter, in mm) weighed (wet weight, in g) and sexed. Crabs with CL>70 mm were considered sexually mature based on size of morphometric maturity (Vinuesa, 1984).

Foreguts were isolated immediately and contents, when present, were removed and weighed to the nearest 0.01 g, then fixed in 10% buffered seawater formalin. Prey organisms were identified to the lowest possible taxonomic level. Sampling with dredges at each stations made it possible to obtain information on potential prey, and facilitated identification of stomach contents. Gastropoda, Bryozoa and Foraminifera groups were identified by specialists.

The percentage frequency of occurrence for each prey taxon identified in the foregut was calculated.

The Wilcoxon signed-rank test and the Kruskal-Wallis test, were used in analysing the relative food weight of crabs (stomach content weight / body weight) by a classification factor. A P-value was calculated and, if found to be less than 0.05, a third procedure was employed to make multiple comparisons using the rank sums (Daniels, 1978).

RESULTS

General considerations

The crabs examined ranged from 40 mm to 100 mm in CL. The percentage of empty stomachs was 22.81%, mainly during spring (37.5%). Twenty four crabs with food in their stomachs were damaged, and were discarded in further analyses.

The percentage of females in the samples was 51.57%. The were no significant differences in the relative food weight between sexes (Table 1) and in the frequency of occurrence of the prey groups, without considered the subgroups for statistical analysis (Chi-square=13.13, d.f.=1 p=0.285, Table 2); thus, food data for both sexes were combined.

Table 1. **Statistical results. Wilcoxon signed-rank test for *Lithodes santolla* relative food wt by sexes.**

Prueba de Wilcoxon para el peso relativo del alimento según sexos.

Sex	Stomachs with food (N)	Rank sum of contents[a]	Average rank Sum of contents
Female	101	9898	98.0
Male	99	10202	103.05

[a]Calculated test statistic= 0.381. Calculated P-value=0.537.

Natural diet

Prey items belonged to 7 food groups (Table 3): Molluscs were the predominant food group (frequency of occurrence=70.4%) and the dominant subgroup were gastropods (63.2%); crustaceans (54.3%) and bryozoa (50.2%) were the second and third-most important food groups, respectively; followed by Echinoderms (43.9%), algae (41.3%), Foraminifera (39.5%) and Hydrozoa (27.8%).

Table 2. **Natural diet of *Lithodes santolla* from Beagle Channel. Frequency of occurrence (%) of food groups in the stomachs of crabs by sexes.**

Frecuencia de ocurrencia (%) de los grupos de alimento en los estómagos de los cangrejos según sexos.

Food Groups	Frequency of occurrence (in %) Females	Males
Foraminifera	41.1	37.5
Hydrozoa	29.9	25.2
Bryozoa	51.4	48.7
Mollusca	68.2	73.0
Crustacea	51.4	56.5
Echinodermata	41.1	46.1
Algae	42.1	40.9
N° of stomach w/food	107	115

Mollusca identified were *Mytilus edulis chilensis, Aulacomya ater ater, Hyatella solida, Margarella violacea, Calliostoma nudum and Fisurella picta.* Among crustaceans, decapods were the most frequently found, especially *Munida sp.* (21.08%). Bryozoa was only represented by *Membranipora isabelleana* and Echinodermata by *Pseudechinus magellanicus.* Foraminiferans were represented by 26 species, some of which were *Bucella peruviana, Cibicides sp., Elphidium* sp., *Discorbis peruvianus, Cribrostomoides* sp., and *Trochammina sp.*, which are commonly found in this area (Lenna, 1966; Boltovskoy *et al.*, 1983).

Crab size and diet

Stomach contents of 223 southern king crabs from 6 size classes were examined (Table 3).

There were differences in the frequency of occurrence of food items among size classes, but there was not any exclusive food group. Mollusca showed higher frequencies in size classes between 50-89.9 mm CL. Crustaceans were present in all size classes with similar frequency of occurrence but there were more unidentified crustaceans in the <50 mm CL crabs and in crabs >90 mm CL.

Amphipoda, Copepoda and Isopoda were more frequently found in crabs <59.9 mm CL and Decapoda in crabs >60 mm CL. The

Table 3. **Natural diet of *Lithodes santolla* from Beagle Channel. Frequency of occurrence (%) of food groups in the stomach of crabs.**

Frecuencia de ocurrencia (%) de los grupos de alimento en los estómagos de los cangrejos.

Food Groups	Total	Frequency of occurrence (in %) Size Classes (CL in mm) 40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-99.9
Mollusca	70.4	51.5	75.0	81.4	76.3	75.0	45.0
Polyplacophora	17.5	6.1	22.7	16.3	25.4	16.7	5.0
Gastropoda	63.2	51.5	65.9	72.1	67.8	62.5	45.0
Pelecypoda	14.3	12.1	9.1	20.9	5.3	16.7	10.0
Crustacea	54.3	57.6	50	51.2	59.3	50	55.0
Cirripedia	0.5	0.0	0.0	2.3	0.0	0.0	0.0
Amphipoda	1.8	6.1	0.0	0.0	1.7	4.2	0.0
Copepoda	2.7	3.0	2.3	2.3	3.4	4.2	0.0
Isopoda	12.1	12.1	27.3	14.0	6.8	4.2	0.0
Decapoda	27.4	18.2	9.1	32.6	39.0	33.3	30.0
Munida sp.	21.1	15.2	2.3	23.3	32.2	25.0	30.0
Pagurus sp.	6.3	3.0	6.8	4.7	6.8	8.3	10.0
Halicarcinus sp.	3.6	0.0	0.0	4.7	5.1	8.3	5.0
Unidentified Crustacea	17.0	24.2	22.7	14.0	13.6	4.2	25.0
Bryozoa	50.2	51.5	40.9	37.2	67.8	54.2	40.0
Echinodermata	43.9	57.6	31.8	34.9	37.3	70.8	55.0
Algae	41.3	51.5	29.5	34.9	44.1	54.2	40.0
Foraminifera	39.5	69.7	40.9	41.9	27.1	33.3	25.0
Hydrozoa	27.8	36.4	20.5	30.2	25.4	33.3	25.0
Polychaeta	11.7	12.1	15.9	11.6	13.6	0.0	10.0
Unidentified	20.6	18.2	25.0	18.6	20.3	16.7	25.0
Sediment	5.8	12.1	6.8	4.7	3.4	8.3	0.0
N° of stomach w/food	223	33	44	43	59	24	20

presence of echinoderms was higher in crabs between 40-49.9 mm CL and 80-89.9 mm CL and the presence of algae was similar among size classes with frequencies between 29.5% and 54.2%. Foraminifera were more frequent among <50 mm CL crabs (69.7%).

A significant difference in the relative food weight of various size groups was detected (Table 4). Crabs <50 mm CL contained significantly more food than crabs >60 mm CL and crabs <60 mm CL contained significantly more food than crabs >90 mm CL.

Seasons

The natural diet of *L. santolla* was different between seasons (Table 5). During autumn, the presence of *Pseudechinus magellanicus* (66.7%) was the most frequent and the least was that of Foraminifera. In winter, a high frequency of Bryozoa (*Membranipora isabelleana*), which is associated with *Macrocystis pirifera* was observed, but algae were more important during summer. In spring, Crustacea had a higher frequency than in other seasons, principally Isopoda and *Munida sp.*

A significant difference was found in the relative amount of food in stomachs between seasons (Table 6). Crabs sampled in winter contained significantly more food than crabs sampled in other seasons. During winter, immature crabs consumed more food, and no significant differences were found in mature crabs, Table 7).

Table 4. **Statistical results. Kruskal-Wallis one-way ANOVA for *Lithodes santolla* food wt relative to crab size groups.**

Prueba de Kruskal-Wallis para el peso relativo del alimento y los grupos de tamaño.

Carapace length (mm)	Stomachs with food (N)	Rank sum of contents [a]	Average rank sum of contents
40-49.9	29	4093	141.17
50-59.9	40	4543	113.58
60-69.9	41	3529	86.07
70.79.9	49	4353	88.84
80-89.9	23	1833	79.69
90-99.9	14	954	68.14

Pairs significantly different (P<0.20): [b]
40-49.9 > 60-69.9; 70-79.9; 80-89.9; 90-99.9
50-59.9 > 90-99.9

[a] Calculated test statistic = 29.1637. Calculated P-value = 2.1534E-5 assuming a X^2 distribution with 5 DF.

[b] Multiple comparisons test (Daniels, 1978).

Table 5. **Natural diet of *Lithodes santolla* from Beagle Channel. Frequency of occurrence (%) of food groups in the stomachs of crabs in different seasons).**

Frecuencia de ocurrencia (%) de los grupos de alimento en los estómagos de los cangrejos en las diferentes épocas del año.

Food Groups	Frequency of occurrence (in %) Sampling Period			
	Summer	Autumn	Winter	Spring
Mollusca	80.8	61.1	64.9	76.9
Polyplacophora	7.7	5.6	21.9	23.1
Gastropoda	78.8	61.1	56.1	64.1
Pelecypoda	15.4	5.6	13.2	20.5
Crustacea	50.0	44.4	50.9	74.4
Cirripedia	0.0	0.0	0.0	2.6
Amphipoda	5.8	0.0	0.9	0.0
Copepoda	7.7	0.0	1.8	0.0
Isopoda	1.9	0.0	10.5	35.9
Decapoda	28.8	22.2	23.7	38.5
Munida sp.	17.3	16.7	20.2	30.8
Pagurus sp.	11.5	5.6	4.4	5.1
Halicarcinus sp.	3.9	5.6	3.5	2.6
U. Crustacea	11.5	22.2	17.5	2.6
Bryozoa	32.7	33.3	74.6	10.3
Echinodermata	36.5	66.7	47.4	33.3
Algae	76.9	50.0	26.3	33.3
Foraminifera	48.1	11.1	39.5	41.0
Hydrozoa	23.1	27.8	23.7	46.2
Polychaeta	19.2	5.6	11.4	5.1
Unidentified	11.5	33.3	17.5	35.9
Sediment	15.4	0.0	3.5	2.6
N° of stomach w/food	52	18	114	39

Table 6. **Statistical results. Kruskal-Wallis one-way ANOVA for *Lithodes santolla* food wt relative to seasons.**

Prueba de Kruskal-Wallis para el peso relativo del alimento y las épocas del año.

Season	Stomachs with food (N)	Rank sum of contents [a]	Average rank sum of contents
Summer	51	3876	76.0
Autumn	18	1608	89.33
Winter	97	11548	119.04
Spring	35	3270	93.43

Pairs significantly different (P<0.20): [b]
Winter > Summer; Autumn; Spring

[a] Calculated test statistic = 20.069. Calculated P-value = 1.6424E-4 assuming a χ^2 distribution with 3 DF.

[b] Multiple comparisons test (Daniels, 1978)

Table 7. **Statistical results. Kruskal-Wallis one-way ANOVA for *Lithodes santolla* food wt relative to seasons. i) Immature crabs ii) mature crabs.**

Prueba de Kruskal-Wallis para el peso relativo del alimento y las épocas del año. i) Cangrejos inmaduros, ii) Cangrejos maduros.

i) Immature crabs (range = 40-70 mm CL)

Season	Stomachs with food (N)	Rank sum of contents [a]	Average rank sum of contents
Summer	26	960	36.92
Autumn	2	29	14.50
Winter	52	3700	71.15
Spring	30	1416	47.20

Pairs significantly different (P<0.20):[b]
Winter > Summer; Autumn; Spring

[a] Calculated test statistic = 26.67. Calculated P-value = 6.88138 E-6 assuming a χ^2 distribution with 3 DF.

[b] Multiple comparison test (Daniels, 1978)

ii) Mature crabs (range = 70 to - 100 mm CL)

Season	Stomachs with food (N)	Rank sum of contents [a]	Average rank sum of contents
Summer	25	932	37.28
Autumn	12	594	49.50
Winter	44	2031	46.16
Spring	5	194	36.80

[a] Calculated test statistic = 3.10. P = 0.376 assuming a χ^2 distribution with 3 DF.

DISCUSSION

The percentage of occurrence is a measure of the regularity of inclusion of a food in the diet of a sample or population. This method is recommended when a broad description of the types of food eaten by a population or sample of crabs is required (Williams, 1981). Errors due to accumulation of material slowly digested or cleared by crabs are introduced by this method and that of estimated volume of foregut contents (Haefner, 1990). Most food ingested by crabs is finely fragmented although the extent of mastication varies with type of food and the way in which it is manipulated (Williams, 1981).

The frequency of occurrence is appropriate for most kind of foods (Haefner, 1990), but overestimates the importance of unidentifiable material, sand and small animals occurring frequently, but in small amounts. This method is a technique used to assess feeding trends but often fails to give an accurate interpretation of the importance of a given food item. Those items with a high (or low) percent frequency o occurrence do not necessarily equate with a high (or low) percent food weight. For example in the present study, Foraminifera occurred in 39.5% of crabs and especially in crabs between 40-49.9 mm CL in 69.7%, but from 1 to 4 individuals per stomach and its importance in relation to the food intake is unknown and are presumably ingested incidentally while taking other prey items Although there were no significant differences in the relative quantity of food consumed between seasons among mature crabs, during spring months the percentage of empty stomachs was higher. This period agreed with the established by Vinuesa (1984) as the spawning-molting-mating period of *L. santolla.*

For other crab species feeding generally takes place throughout the year, except during a few weeks of the molting-mating period, when feeding ceases or is at a minimum (Feniuk, 1945; Kun & Mikulich, 1954; Kulichkova, 1955; Cunningham, 1969; Jewett & Feder, 1982).

Cannibalism is a common phenomenon observed in other crab species *Chionoecetes* sp. (Paul *et al.*, 1979; Feder & Jewett, 1981), *Ovalipes catharus* (Wear & Haddon, 1987), *Lithodes murrayi* (Arnaud & Miquel, 1985), and *Cancer magister* (Stevens *et al.*, 1982), but was not recorded in the present study.

When *L. santolla* was examined according to size groups it was apparent that small crabs (40-60 mm CL) generally fed relative more than did larger crabs and especially during winter, may be that they feed more frequently and the chances of sampling a small crab with a full gut are greater. Taking into account that the principal period of molting for juveniles of *L. santolla* is during summer (Vinuesa *et al.*, 1990), these results indicate that crabs fed relative more during the intermolt.

Similarly, small crabs of *Chionoecetes bairdi, Chionoecetes opilio, Paralithodes camstchatica* (Cunningham, 1969; Tarverdieva, 1979; Jewett & Feder, 1982) fed more intensively than large ones did. This might be due to the fact that among small crabs molting frequency and the percentage increment per molt are greater, due to a greater energy demand.

Lithodes santolla has a diverse diet but Gastropods predominate. The composition of the diet changes in relation to size of the predator and season. This points to broad opportunistic foraging by crabs during their seasonal migrations. In the present study, similarities in food habits between sexes have been observed. In the same way, Kun & Mikulich (1954), Kulichkova (1955), McLaughlin & Hebard (1961) and Jewett & Feder (1982) have reported about these similarities in king crabs.

Buttini & Hernández (unpublished data) described the anatomy of the digestive system and mentioned the stomach contents of a few *Lithodes santolla*. Campodónico *et al.* (1982) analysed crabs of these species that ranged 15 to 43 mm CL, so that we could not compare with our results. These authors determined that the groups present in the stomach contents were algae, molluscs and crustaceans. This latter group was represented by Ostracoda, Amphipoda, Copepoda and Isopoda, a smaller number of crustacean types than in the present study. This result agrees with Stevens *et al.* (1982), who concluded that prey size was directly proportional to crab size and the optimum prey size increased with crab width.

To assign a food to a definite species category was not always possible, but it could usually be included in a general taxonomic group. Many stomachs contained food remains that were too fragmented or digested for identification. These were classified as unidentified remains as occurred in the present study with "unidentified crustaceans" in crabs <50 mm CL and >90 mm CL. Most authors concluded that crabs eat a representative selection of the benthos around them, that most feeding is opportunistic, and that little selection is evident (Stevens *et al.*, 1982). However, additional data are needed to clarify the feeding biology of this commercial crab in the Beagle Channel.

Furthermore, it is important to quantify the availability and productivity of the food resources utilized by southern king crabs in regions that traditionally have large commercial catches of crabs. The preceding information may contribute to a better understanding of the feeding of southern king crabs in Beagle Channel waters.

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