Decapod Crustacean Larvae Collected off Northern Chile During an El Niño Event (February–March, 1983)

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ABSTRACT. Decapod crustacean larvae were sorted from plankton samples collected between Arica (18° 30′ S, 70° 20′ W) and Huasco (28° 30′ S, 71° 15′ W), a distance of about 1,050 km along the northern coast of Chile, from February 19 to March 28, 1983, during this century's strongest recorded El Niño event. The samples were taken from 11 east–west transects extending from near the coast (5 km offshore) to approximately 200 km offshore, each with 4 stations approximately 65 km apart. Larvae (nauplius, protozoea, zoea, or megalopa) from 22 species (17 genera, 15 families) were collected; most larvae were zoeae. Of the zoeal larvae, 1.8% were Dendrobranchiata and 98.2% were Pleocyemata. Among the Pleocyemata, the Brachyura were most abundant (88.0%), followed distantly by Anomura (9.9%), Caridea (1.8%), and Thalassinidea (0.2%). Grapsid and pagurid larvae were most numerous within the Brachyura and Anomura (respectively) and were the dominant taxa at coastal stations. The number of species found (22) is far fewer than the normal stock of 139 species (94 genera, 38 families) of decapod crustaceans recorded as adults for this area of northern Chile, although the lack of earlier sampling efforts precludes comparison with decapod larval fauna of non-El Niño years. Protozoeae and zoeae of oceanic species of the genera *Xiphopenaeus* (Penaeidae) and *Sicyonia* (Sicyoniidae), not previously recorded from Chilean waters, were also found. The presence of larvae of these tropical oceanic genera, and the high ratio in which other tropical families and species appeared, may be due to the effects of the strong El Niño event.

INTRODUCTION

Despite the importance of decapod crustaceans to Chile's economy, there are relatively few publications on Chilean marine decapods, especially the larval stages. Most studies dealing with the decapod fauna of the southeastern Pacific have focused on the biology of adults, and often these studies have been restricted to intertidal and shallow water species or are based on few specimens. Most of our knowledge concerning larval development of Chilean decapods is based on descriptions of the same species from other geographic areas. Studies of larval abundance in Chilean waters have been particularly limited geographically (e.g., Palma, 1976, 1980; Palma et al., 1976). Complete larval histories are known for very few species of decapods (see Quintana, 1981), and there have been few examinations of other faunal components of the Chilean plankton (e.g., Antezana, 1970, 1981; Fagetti, 1972) or of Chilean zooplankton community structure (see Fagetti and Fischer, 1964).

Even if the collecting deficit is overlooked, there is indeed a real pattern of lower diversity and lower endemism in the southeastern Pacific as compared to, for example, the western coast of North America (see Wicksten, 1989). Among the hypotheses proposed to explain this low diversity are certain faunistic extinctions in the eastern Pacific (Reaka and Manning, 1987) and the reduced oxygen concentration of waters over the continental slope of Peru and Chile (Rowe and Haedrich, 1979; Wicksten, 1989). Natural disturbances of the ecological conditions of the southern hemisphere have not been seriously considered as causes of the reduced diversity in this area.

The oceanic-atmospheric phenomenon known as El Niño Southern Oscillation (ENSO) is the planet's largest weather system. It introduces often dramatic change to the ecological and faunal conditions of the entire eastern Pacific (e.g., see Canby, 1984; Taft, 1985; Schoener and Fluharty, 1985, and articles in Oceanus 27(2), 1984). Distributions of benthic and pelagic Crustacea are undoubtedly affected by these very rapid and dynamic changes (Arntz and Valdivia, 1985a).

The 1982–1983 El Niño event was unprecedented in strength and impact (Canby, 1984). In Chile, the effects were felt as far south as Concep-

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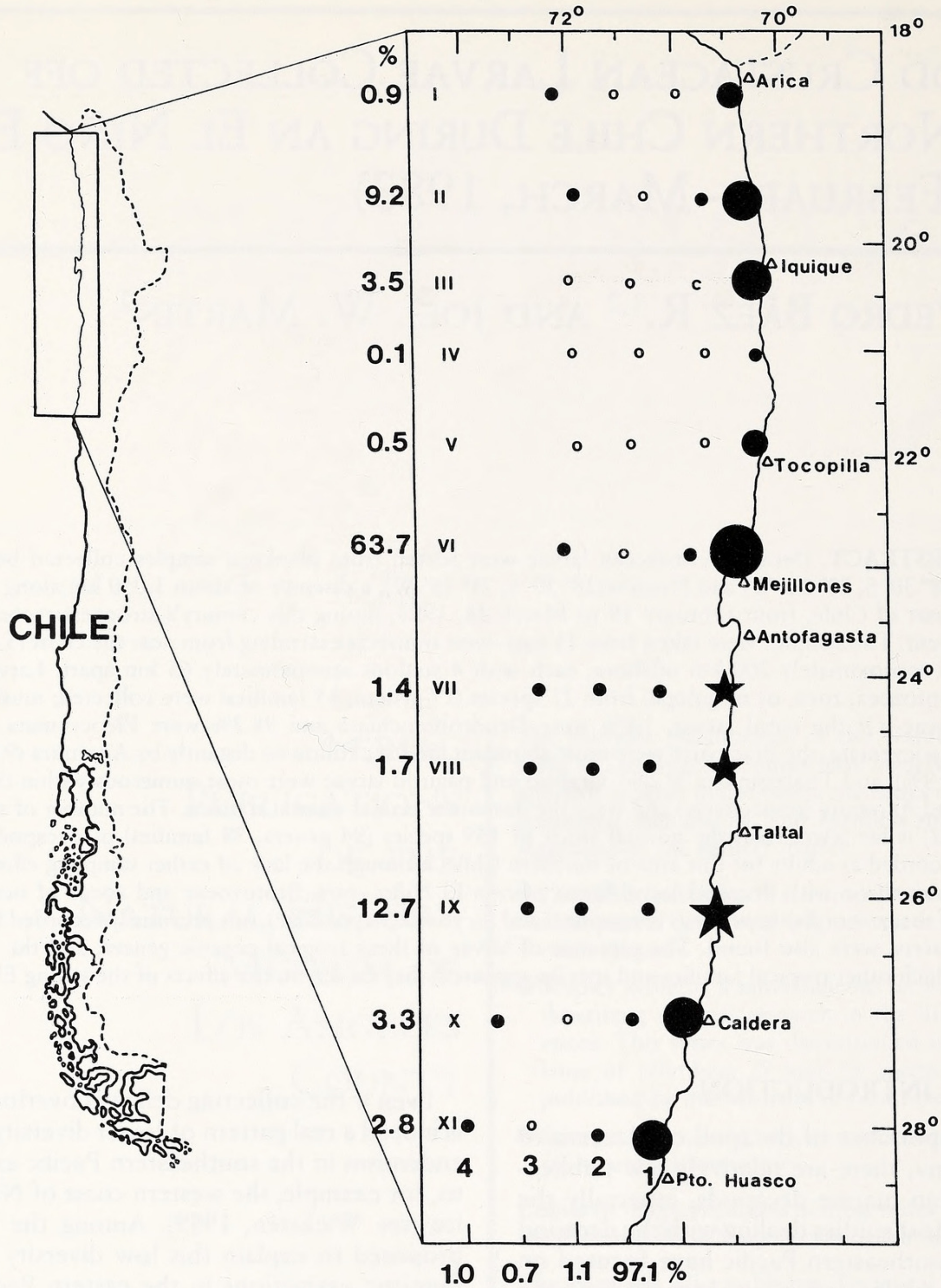

Figure 1. Area of northern Chile covered by cruise Sela I of the Chilean R/V *Itzumi* during the 1982–1983 El Niño event (February–March, 1983). Roman numerals = transect numbers; arabic numerals 1–4 (near bottom of figure) = stations (1 = coastal, 4 = oceanic). Numbers to left of transects are percentages of the total abundance of that transect (stations combined); numbers at bottom of figure are percentage totals by station. Legend for individual station symbols: open circle = 0–0.09% of total abundance; small dot = 0.1–0.4%; medium small dot = 0.5–0.9%; small star = 1.0–1.9%; medium large dot = 2–10%; large star = more than 10%; large dot = more than 50% (transect VI, station 1).

ción (36° 40′ S) (Gallardo, 1985). Among the observations stemming from a 1983 Ecuadorian workshop were positive (Arntz, 1984) and negative (Tsukayama and Santander, 1987) effects on the Peruvian ecosystem, including reduction of biomass of invertebrates from the continental shelf of Peru, species immigrations, increases in the distributions of some benthic invertebrates of the shelf and in their production, and expanded migration in coastal waters of tropical invertebrates. Most crabs diminished along the southern littoral zone of Peru, but in the north there was a strong increase in shrimp production and an invasion of portunid crabs (Arntz and Valdivia, 1985b). Similar distributional anomalies (i.e., increases as well as decreases in abundance) were reported recently by Lavaniegos-Espejo and Lara-Lara (1990) for zooplankton in the Gulf of California.

The Instituto de Fomento Pesquero (IFOP) organized a national workshop on El Niño that was held in Santiago, Chile, in November, 1984 (Investigación Pesquera, Chile, 1985). The plankton composition during El Niño 1982–1983 was reported in two papers, IFOP (1984) and Rojas and Orellana

(1984). Both papers focused on the biomass and abundance of zooplankton and on qualitative composition of the zooplankton exploited for economic purposes. The present paper draws from data collected by both studies. Additionally, Mendez (1987) presented an overview of the effects on Chile's fisheries, noting that ENSO 1982–1983 was detected in Chile about August–September, 1982, reaching its greatest intensity during February, 1983. The effects on Chilean decapod resources were reviewed by Mendez (1987), who noted that crab production increased during 1982–1983 by a remarkable 463% over previous years, constituting 9,142 tons (about 11%) of the yearly total of some 40,000 tons of commercially harvested crustaceans (two species of galatheids, *Pleuroncodes monodon* and *Cervimunida johni,* together constituted about 43%, while the "camaron nylon," *Heterocarpus reedi,* accounted for another 16%). Mendez (1987) noted the scarcity of information on the distribution of planktonic organisms during non-ENSO years that would allow comparisons of ENSO and non-ENSO zooplankton composition.

In this paper we document the distribution of the Chilean larval decapod fauna during the strong ENSO event of 1982–1983. These data will provide a backdrop for future comparisons with zooplankton composition and distribution patterns during ENSO's of varying magnitudes and will serve as a reference point for comparing the composition of the southeastern Pacific plankton in non-ENSO years.

MATERIALS

Forty-four plankton samples were collected by the Chilean R/V *Itzumi* (Cruise Sela I), along 11 parallel east–west transects (4 stations each) between 18° 38′ 00″ S and 28° 04′ 00″ S from near the coast (5 km offshore) to about 200 km west, from 19 February to 28 March, 1983 (Fig. 1). The 11 parallel transects were approximately 105 km apart (on average), spanning a distance of approximately 1,050 km along the northern coast of Chile, with the 4 stations per transect approximately 65 km apart (Fig. 1). The total study area was therefore approximately 210,000 km^2. Samples, taken while the ship was stationary, were collected with a cylindric-conic net type WP-2 (UNESCO, 1968) with an internal mouth diameter of 57 cm, a total length of 261 cm, and a mesh size of 300 μm. At each station the net was deployed with 100 m of line, but the actual depth reached by the net (estimated by depth recorder) varied from close to 100 m (98.8 m, Station 10.1) to almost 74 m (Station 6.1). The amount of water filtered was estimated using a flow-meter placed at the net mouth, following the methods of Smith and Richardson (1979). The average amount of water filtered was 0.36 ± 0.09 m^3 per vertical meter of water (IFOP, 1984). Additional details on collecting techniques and cruise data are available in the technical reports of the IFOP (1984), in Rojas and Orellana (1984), and from the senior author. Specimens were preserved in 5% formalin prepared with seawater. After removal of fish larvae (Rojas and Orellana, 1984) each sample was split and quartered using a Folsom apparatus. Decapod larvae were removed from two of the 25% aliquots, and quantitative estimates were calculated

Table 1. Summary of decapod crustacean families, and numbers of genera and species, reported as adults from the area of study.

Families[1]		No. of genera[2]	No. of species[2]
Suborder Dendrobranchiata			
*Penaeidae		3 (2)†	3 (2)†
*Sicyonidae		0 (1)†	0 (1)†
*Sergestidae		1 (1)	1 (1)
Suborder Pleocyemata			
Infraorder Caridea			
*Oplophoridae		4 (1)	7 (1)
Pasiphaeidae		1	1
Rhynchocinetidae		1	1
Palaemonidae		1	1
*Alpheidae		3 (1)	4 (1)
Hippolytidae		3	3
Pandalidae		1	1
*Crangonidae		2 (1)	2 (1)
Glyphocrangonidae		1	2
Infraorder Astacidea			
Nephropidae		1	1
Infraorder Thalassinidea			
*Callianassidae		1 (1)	1 (1)
Infraorder Palinura			
Polychelidae		1	2
Infraorder Anomura			
Coenobitidae		1	1
Diogenidae		1	2
Lithodidae		5	9
*Paguridae		1 (1)	4 (2)
Parapaguridae		1	3
Chirostylidae		1	1
*Galatheidae		2 (1)	9 (1)
*Porcellanidae		5 (1)	14 (1)
Albuneidae		2	2
*Hippidae		1 (1)	2 (1)
Infraorder Brachyura			
Homolodromiidae		1	1
Calappidae		2	2
Leucosiidae		1	1
Majidae		10	11
Hymenosomatidae		1	1
*Atelecyclidae		3 (1)	5 (1)
*Cancridae		1 (1)	4 (2)
Corystidae		3	3
Portunidae		4	4
Platyxanthidae		1	2
*Xanthidae		10 (1)	10 (1)
*Grapsidae		9 (2)	10 (5)
Pinnotheridae		4	5
Ocypodidae		2	5
Total	39 (15)	96 (17)	141 (22)

[1] * = Collected as larvae during 1983 El Niño event.

[2] Numbers in parentheses are totals collected during El Niño. † = Not previously recorded.

Table 2. Families, genera, and species of decapod larvae collected, larval stage collected, and distribution by transect and station, 1983 El Niño event. Larvae listed under genus only possibly do not belong to same species.

Taxon	Larval stage	Transect and station
Suborder Dendrobranchiata		
Family Penaeidae		
Xiphopenaeus	Protozoea	9.4
Penaeus	Protozoea I	6.2, 6.4, 8.2
	Protozoea II	11.1
	Mysis I	1.4, 9.1
Family Sicyoniidae		
Sicyonia	Zoea, final stages	3.1, 3.4
Family Sergestidae		
Sergestes + *Sergia* (indistinguish.)	Protozoea I	11.1
	Protozoea II	10.4
	Protozoea III	6.2, 6.4, 8.3, 8.4
	Zoea I	1.4, 2.6, 3.2, 6.2, 7.1
	Zoea II	7.4
	Post larva	2.4, 5.1, 5.3, 6.4, 7.2, 7.4, 8.1, 9.2, 9.3, 9.4, 10.3, 10.4, 11.2
Suborder Pleocyemata		
Infraorder Caridae		
Family Oplophoridae		
Acanthephyra	Zoea, final stages	3.1, 6.1
Family Alpheidae		
genus indet.	Zoea, final stage	6.1
Family Crangonidae		
genus indet.	Zoea, int. stages	3.1, 5.1, 6.1, 8.1, 8.4, 9.1, 10.1, 10.2, 10.4, 11.1, 11.2, 11.4
Infraorder Thalassinidae		
Family Callianassidae		
Callianassa	Zoea, final stages	5.1, 6.1, 9.1, 11.1
Infraorder Anomura		
Family Paguridae		
genus indet.		
sp. "A"	Zoea I	6.1, 9.1
	Zoea II	2.1, 6.1, 8.1, 8.3
sp. "B"	Zoea II	3.1, 4.1, 5.1, 6.1, 7.1, 8.1, 9.1, 10.1, 11.1
	Zoea III	11.1
	Megalopa	1.1, 2.1, 4.1, 7.1, 10.1
Family Galatheidae		
Pleuroncodes	Zoea I	6.1, 11.1
	Zoea II	3.1, 11.1
Family Porcellanidae		
genus indet.	Zoea I	11.1
	Zoea III	9.1, 11.1
Family Hippidae		
genus indet.	Zoea I	1.1, 2.1, 3.1, 6.1, 7.3
	Zoea II	11.1
	Zoea III	7.3, 8.1, 9.1
	Zoea IV	4.1

Table 2. Continued.

Taxon	Larval stage	Transect and station
Infraorder Brachyura		
Family Atelecyclidae		
genus indet.	Zoea I	2.1, 3.1
	Zoea II	2.1, 3.1, 6.1
	Zoea III	11.2
Family Cancridae		
Cancer sp. "A"	Zoea I	1.1, 1.2, 2.1, 5.1, 11.1
	Zoea II	1.1, 8.1, 11.1
	Zoea III	3.1, 11.1
C. edwardsii	Zoea I	3.1, 6.1, 9.1, 11.1
	Zoea II	2.1, 6.1, 10.2
	Zoea III	2.3, 7.1, 7.3, 10.1, 10.2, 11.1
	Zoea IV	7.3, 8.2, 9.4
	Zoea V	2.1, 2.2
Family Xanthidae		
Homalaspis plana	Zoea I	3.1, 8.1
	Zoea III	3.1, 8.1
	Zoea IV	3.1, 8.1
Family Grapsidae		
Cyclograpsus punctatus	Zoea I	2.1, 6.1, 9.1
	Zoea II	2.1, 6.1, 8.1, 9.1
	Zoea III	2.1, 6.1, 6.2, 9.1, 9.2, 10.1, 10.2
	Zoea IV	2.1, 7.2
	Zoea V	2.2
genus indet.		
sp. "A"	Zoea I	3.1
	Zoea II	3.1
	Zoea III	3.1, 5.1
sp. "B"	Zoea I	1.1
	Zoea II	3.1
sp. "C"	Zoea II	3.1, 4.1, 6.1, 11.1
sp. "D"	Zoea I	6.1
	Zoea II	6.1

Table 3. Abundance of decapod crustacean larvae per 1,000 m^3 by transect and station, 1983 El Niño event.

Tran-	Stations[1]				Average	Total per	
sects	1	2	3	4	per station	transect	%
1	2,467 (0.8)	129 (0)	—	232 (0.1)	707.0	2,828	0.9
2	27,627 (9.0)	266 (0.1)	149 (0)	240 (0.1)	7,070.5	28,282	9.2
3	10,471 (3.4)	122 (0)	—	129 (0)	2,680.5	10,722	3.5
4	391 (0.1)	—	—	—	97.8	391	0.1
5	1,517 (0.5)	—	128 (0)	—	411.2	1,645	0.5
6	193,823 (63.4)	448 (0.1)	—	344 (0.1)	48,653.8	194,615	63.7
7	3,322 (1.1)	246 (0.1)	442 (0.1)	251 (0.1)	1,065.3	4,261	1.4
8	3,474 (1.1)	268 (0.1)	1,032 (0.3)	381 (0.1)	1,288.8	5,155	1.7
9	37,628 (12.3)	264 (0.1)	286 (0.1)	543 (0.2)	9,678.3	38,721	12.7
10	8,028 (2.6)	1,255 (0.4)	141 (0)	835 (0.3)	2,564.8	10,259	3.3
11	8,099 (2.6)	387 (0.1)	—	230 (0.1)	2,179.0	8,716	2.8
Total	296,847	3,385	2,178	3,185	6,945.3	305,595	100.0
%	97.1	1.1	0.7	1.0		100.0	

[1] Number (%).

Table 4. Abundance of decapod larvae (per 1,000 m^3) by family, 1982–1983 El Niño event.

Categories	Stations[1]								
	1.1	1.2	1.4	2.1	2.2	2.3	2.4	3.1	3.2
Suborder Dendrobranchiata									
Family Penaeidae	—	—	116 (9.0)	—	—	—	—	—	—
Family Sicyoniidae	—	—	—	—	—	—	—	209 (61.8)	—
Family Sergestidae	—	—	116 (2.9)	—	—	—	240 (6.1)	—	122 (3.1)
Suborder Pleocyemata									
Family Oplophoridae	—	—	—	—	—	—	—	314 (68.1)	—
Family Alpheidae	—	—	—	—	—	—	—	—	—
Family Crangonidae	—	—	—	—	—	—	—	105 (2.2)	—
Family Callianassidae	—	—	—	—	—	—	—	—	—
Family Paguridae	176 (0.7)	—	—	533 (2.0)	—	—	—	314 (1.2)	—
Family Galatheidae	—	—	—	—	—	—	—	105 (5.9)	—
Family Porcellanidae	—	—	—	—	—	—	—	—	—
Family Hippidae	176 (12.8)	—	—	107 (7.8)	—	—	—	105 (7.6)	—
Family Atelecyclidae	—	—	—	107 (9.1)	—	—	—	209 (17.7)	—
Family Cancridae	1,586 (12.2)	129 (0.1)	—	533 (4.1)	133 (1.0)	149 (1.1)	—	314 (2.4)	—
Family Xanthidae	—	—	—	—	—	—	—	419 (28.0)	—
Family Grapsidae	529 (0.2)	—	—	26,347 (10.6)	133 (<0.1)	—	—	8,377 (3.4)	—
Total	2,467	129	232	27,627	266	149	240	10,471	122
%	0.8	<0.1	0.1	9.0	0.1	<0.1	0.1	3.4	<0.1

Categories	Stations								
	3.4	4.1	5.1	5.3	6.1	6.2	6.4	7.1	7.2
Suborder Dendrobranchiata									
Family Penaeidae	—	—	—	—	—	112 (8.6)	115 (8.9)	—	—
Family Sicyoniidae	129 (38.2)	—	—	—	—	—	—	—	—
Family Sergestidae	—	—	89 (2.2)	128 (3.2)	—	224 (5.7)	229 (5.8)	138 (3.5)	123 (3.1)
Suborder Pleocyemata									
Family Oplophoridae	—	—	—	—	147 (31.9)	—	—	—	—
Family Alpheidae	—	—	—	—	147 (100.0)	—	—	—	—
Family Crangonidae	—	—	89 (1.9)	—	294 (6.2)	—	—	—	—
Family Callianassidae	—	—	89 (11.3)	—	441 (56.1)	—	—	—	—
Family Paguridae	—	195 (0.7)	357 (1.4)	—	17,206 (67.3)	—	—	969 (3.8)	—
Family Galatheidae	—	—	—	—	—	—	—	—	—
Family Porcellanidae	—	—	—	—	—	—	—	—	—
Family Hippidae	—	98 (7.1)	—	—	294 (21.3)	—	—	—	—
Family Atelecyclidae	—	—	—	—	735 (62.3)	—	—	—	—
Family Cancridae	—	—	89 (0.7)	—	5,294 (40.6)	—	—	277 (2.1)	—
Family Xanthidae	—	—	—	—	—	—	—	—	—
Family Grapsidae	98 (<0.1)	—	804 (0.3)	—	169,265 (68.1)	112 (<0.1)	—	1,938 (0.8)	123 (<0.1)
Total	129	391	1,517	128	193,823	448	344	3,322	246
%	<0.1	0.1	0.5	<0.1	63.4	0.1	0.1	1.1	0.1

[1] Numbers in parentheses are percentage contributions of a station (totaled vertically) and family (horizontal) to the total catch of 305,595 larvae.

by taking the average of these two subsamples and multiplying that figure by 4. Specimens of species well represented in each sample were dissected to confirm identification. Larval nomenclature follows that of Williamson (1982). A checklist (not included in this paper) of 139 species of decapod crustaceans reported from the area of study (northern Chile) was prepared using both the published literature and unpublished data of P. Báez R. Space limitations do not allow us to list all 139 species reported to occur in northern Chile or consulted references, many of which report single species descriptions or range extensions. A summary of the families and the number of genera and species per family is presented in Table 1. Many of the more important references consulted for compiling the faunal list are in Retamal (1981) and Wicksten (1989); special mention should be made of the extensive compilations of Chilean decapods by Holthuis (1952, macrurans), Haig (1955, anomurans), and Garth (1957, brachyurans). Identification of the 22 species represented by larvae (Table 2) was accomplished using published literature on the larval development of northern Chilean decapod species where possible. Those species for which larval stages have not been described, or that were new for the area, were identified from literature describing related taxa from other geographic areas. Important references used as starting points to identify larvae to a particular developmental stage or to higher taxonomic levels (e.g., superfamily or family) include the works of Williamson (1957a, b, 1960, 1982), Bourdillon-Casanova (1960), Gurney (1939, 1942), Hart (1971), Rice (1980), and Boschi (1981). For the classification of the decapod families we have followed Bowman and Abele (1982).

RESULTS

Few nauplii, megalopae, or protozoeae were found. Most larvae were zoeae (Table 1). Twenty-two species of decapods were identifiable in the collections,

Table 4. **Continued.**

Categories	7.3	7.4	8.1	8.2	8.3	8.4	9.1	9.2	9.3
	Stations								
Suborder Dendrobranchiata									
Family Penaeidae	—	—	—	134 (10.3)	—	127 (9.8)	316 (24.4)	—	—
Family Sicyoniidae	—	—	—	—	—	—	—	—	—
Family Sergestidae	—	251 (6.3)	120 (3.0)	—	387 (9.8)	127 (3.2)	—	132 (3.3)	286 (7.2)
Suborder Pleocyemata									
Family Oplophoridae	—	—	—	—	—	—	—	—	—
Family Alpheidae	—	—	—	—	—	—	—	—	—
Family Crangonidae	—	—	599 (12.6)	—	—	127 (2.7)	791 (16.6)	—	—
Family Callianassidae	—	—	—	—	—	—	158 (20.1)	—	—
Family Paguridae	—	—	838 (3.3)	—	—	—	4,427 (17.3)	—	—
Family Galatheidae	—	—	120 (6.7)	—	—	—	—	—	—
Family Porcellanidae	—	—	—	—	—	—	316 (31.6)	—	—
Family Hippidae	221 (16.0)	—	120 (8.7)	—	—	—	158 (11.5)	—	—
Family Atelecyclidae	—	—	—	—	—	—	—	—	—
Family Cancridae	221 (1.7)	—	120 (0.9)	134 (1.0)	—	—	1,107 (8.5)	—	—
Family Xanthidae	—	—	1,078 (72.0)	—	—	—	—	—	—
Family Grapsidae	—	—	479 (0.2)	—	645 (0.2)	—	30,355 (12.2)	132 (<0.1)	—
Total	442	251	3,474	268	1,032	381	37,628	264	286
%	0.1	0.1	1.1	0.1	0.3	0.1	12.3	0.1	0.1

Categories	9.4	10.1	10.2	10.3	10.4	11.1	11.2	11.4	Total	%
	Stations									
Suborder Dendrobranchiata										
Family Penaeidae	136 (10.5)	141 (10.9)	—	—	—	98 (7.6)	—	—	1,295	0.4
Family Sicyoniidae	—	—	—	—	—	—	—	—	338	0.1
Family Sergestidae	136 (3.4)	—	—	141 (3.6)	716 (18.1)	—	129 (3.3)	115 (2.9)	3,949	1.3
Suborder Pleocyemata										
Family Oplophoridae	—	—	—	—	—	—	—	—	461	0.1
Family Alpheidae	—	—	—	—	—	—	—	—	147	0
Family Crangonidae	—	704 (14.8)	314 (6.6)	—	119 (2.5)	1,366 (28.7)	129 (2.7)	115 (2.4)	4,752	1.6
Family Callianassidae	—	—	—	—	—	98 (12.5)	—	—	786	0.3
Family Paguridae	—	563 (2.2)	—	—	—	—	—	—	25,578	8.4
Family Galatheidae	—	—	—	—	—	1,561 (87.4)	—	—	1,786	0.6
Family Porcellanidae	—	—	—	—	—	683 (68.4)	—	—	999	0.3
Family Hippidae	—	—	—	—	—	98 (7.1)	—	—	1,377	0.4
Family Atelecyclidae	—	—	—	—	—	—	129 (10.4)	—	1,180	0.4
Family Cancridae	271 (2.1)	282 (2.2)	627 (4.8)	—	—	1,756 (13.5)	—	—	13,022	4.3
Family Xanthidae	—	—	—	—	—	—	—	—	1,497	0.5
Family Grapsidae	—	6,338 (2.5)	314 (0.1)	—	—	2,439 (1.0)	—	—	248,428	81.3
Total	543	8,028	1,255	141	835	8,099	387	230	305,595	100.0
%	0.2	2.6	0.4	<0.1	0.3	2.6	0.1	0.1		99.5

although several could be assigned only to family or genus with any certainty (Table 1). The few nauplii were not recorded numerically because of difficulties in identification. The greatest abundance of zoeae and megalopae occurred in transect 6, north of Mejillones, where the number of larvae constituted 63.7% of the total study collection (Table 3, Fig. 1). Transect 9, between Taltal and Caldera, and transect 2, to the north of Iquique, followed in abundance with 12.7% and 9.2%, respectively. In all other transects the abundance was relatively low, ranging from 3.5% (transect 3) to near 0.1% (transect 4) of the total catch. There was a steady decrease in the number of larvae from transect 9 southward, but there were no other obvious latitudinal patterns of abundance. Coastal stations had by far the greatest density, accounting for 97.1% of the total number of larvae collected. At the most offshore stations (Station 4 of each transect) the combined abundance reached only about 1%. Nine offshore stations (Stations 1.3, 3.3, 4.2, 4.3, 4.4, 5.2, 5.4, 6.3, and 11.3) did not yield any larvae, and on transect 4, near Punta Patache, only the coastal station yielded any specimens. The average abundance per station was 6,945 larvae per 1,000 m^3, but the range was great, from 193,823 (transect 6, Station 1) to zero larvae (9 stations). The lowest station average for any transect was 98 larvae (per 1,000 m^3) per station along transect 4. By transect, the average abundance was 27,781 larvae per 1,000 m^3, ranging from 194,615 (transect 6) to 391 (transect 4) larvae per 1,000 m^3.

Taxonomic diversity also decreased markedly from coastal to more oceanic stations (Table 4); all families were represented in at least 1 coastal station whereas only 5 families (penaeids, sicyoniids, sergestids, crangonids, and cancrids) were found in Station 4 samples combined for all 11 transects.

Little insight on the significance of larval distributions is possible without information on adults. A total of 139 species belonging to 38 families is known from this area of northern Chile. Of those 38 families, 2 (Penaeidae and Sergestidae) are in the Dendrobranchiata and the remaining 36 are in the Pleocyemata, distributed taxonomically as follows: Caridea (9 families, 22 species), Astacidea (1 family, 1 species), Thalassinidea (1 family, 1 species), Palinura (1 family, 2 species), Anomura (10 families, 47 species), Brachyura (14 families, 64 species) (summarized in Table 1).

In rather sharp contrast, only 22 species (17 genera, 15 families) were found as larvae. Thus larvae were found for only 15.8% of the total species pool and 39.5% of the available families. Among collected larvae, dendrobranchiates constituted only 1.8% of the total number of larvae and were represented by 3 families and 4 species; the additional (third) family, not previously recorded from off Chile, was the Sicyoniidae (larvae of *Sicyonia* sp.). Among the Pleocyemata larvae, which accounted for 98.2% of the total larvae collected, there were 12 families and 18 species, distributed as follows: Caridea (3 families, 3 species), Thalassinidea (1 family, 1 species), Anomura (4 families, 5 species), Brachyura (4 families, 9 species). The number of Pleocyemata species is about 14% of the number of adult species (16% of the genera and 37% of the families) reported for the study area. The finding of larvae of two previously unreported dendrobranchiate genera, *Xiphopenaeus* and *Sicyonia*, raises the number of species reported from northern Chile to 141 (96 genera, 39 families).

Among the Pleocyemata, brachyuran larvae were most abundant (88.0% of the total yield), followed distantly by anomurans (9.9%), carideans (1.8%), and thalassinideans (0.2%). Brachyuran and anomuran larvae were the most abundant taxa at coastal stations, with most belonging to species common in the study area as adults. Crabs of the family Grapsidae were by far the most abundant, accounting for 81.3% of all larvae collected. The most numerous anomurans were pagurids (8.4% of the total), while the most numerous of the shrimp families was the Crangonidae (1.6%); the lowest abundance was in the snapping shrimp family Alpheidae (less than 0.1%). For some taxa a wide sequence of larval stages was found (*Sergestes* + *Sergia* [inseparable], Crangonidae, Hippidae; Table 2), and for some of the brachyuran species almost the entire sequence of larval stages was collected. For some genera and families, the same stages were found over a wide range of stations (genera *Sergestes* + *Sergia*, *Cancer*, and *Cyclograpsus* and families Crangonidae, Paguridae, and Hippidae). For a few species, most notably the brachyurans *Cyclograpsus punctatus* and "Grapsidae species A," different stages of the larval sequence (zoea I, II, and III) were found at a single station.

DISCUSSION

The large difference between the number of decapod species collected as larvae (22) and the number in the species list for this region of northern Chile (139) could be the result of several factors. It is probable that a significant factor was the strong ENSO event of 1983, displacing normally occurring plankton to the south and introducing the typically tropical genera *Xiphopenaeus* and *Sicyonia*. However, the results of the ENSO event cannot be clearly separated from a variety of other factors. Because the samples were taken during a relatively short (2 month) period, it is probable that larvae of some species were not in the plankton during that time of the year. For example, in a study of similar duration, larval stages of only 43 species of crabs (many not identifiable to species) were found in extensive plankton tows taken during July, 1976, in the northern Gulf of Mexico (Truesdale and Andryszak, 1983). The species pool for crabs of this area is about 100 (Felder, 1973; Powers, 1977), so that only about 43% of the species were represented (or captured) as larvae during that time of year. Even under non-ENSO conditions, it is unlikely that more thorough plankton sampling would yield larvae of all species in a given geographic area, as evidenced by the 2-year study of Sandifer (1973) in Chesapeake Bay. Sandifer's study, with plankton tows made at variable depths and salinities in all seasons, yielded only 37 species of decapods in an area of rather high adult decapod diversity (over 300 species; Williams, 1984). Patchiness of plankton and the fact that some of the decapods in the species list are restricted to deep waters also must be considered.

With the above caveats taken into consideration, it is not possible to say to what extent the 1982–1983 ENSO event affected abundance and distribution of decapod larvae off the coast of northern Chile. However, McGowan (1984) noted that one salient feature associated with all ENSO events in California was a "vast reduction in macrozooplankton abundance and, nearshore, the widespread occurrence of some nekton, normally found to the south, off central Mexico"; McGowan's observations were based on one of the few long-term data bases, the time series of zooplankton, temperature, salinity, and oxygen readings from 1949 through 1969 in southern California (McGowan, 1984). Miller et al. (1985) estimated that in 1983 the zooplankton off the coast of Oregon, an area even more distant from the equatorial Pacific than is our study area, was "about 30% of that in non-El Niño years," and Soto (1985) noted that the general faunal diversity, including decapods, in waters off northern Chile decreased significantly during the event. That only 22 species, 2 of which belonged to tropical genera normally not found in Chilean waters, were found as larvae off the coast of northern Chile, with over 80% of the total catch accounted for by a single family (Grapsidae), is consistent with the above observed patterns of response to ENSO in the zooplankton community. The actual effect on the decapod plankton may have been more severe than our figures indicate. It is probable that some families and genera recorded by us as present off Chile are in fact represented by tropical or subtropical species, and not the species normally found here as adults.

The overall picture of faunal response to the 1982–1983 ENSO is complex and unclear. In most areas, the local commercial fauna was greatly altered, with entire fisheries collapsing and with virtually all important decapods disappearing. In other areas, there were increases in faunal diversity, albeit mostly because of the arrival of tropical or subtropical species. Off the coast of Peru, there were enormous increases in swimming crabs of the genus *Euphyplax,* octopi, scallops, polychaete and nemertean worms, rays, and bottom feeding fish, at least partly as a result of changes in oxygen content (Arntz, 1984). Concerning the zooplankton, there were mixed results during 1983–1984 (i.e., increases and decreases in zooplankton biomass) even within relatively small geographic areas, such as the Gulf of California. There, Lavaniegos-Espejo and Lara-Lara (1990) reported a drop in the zooplankton biomass in the spring of 1984 in the southern Gulf (compared with earlier years) but increases in the biomass in more northern stations in the Gulf.

Because some other faunal components of the planktonic and midwater environments depend heavily upon crustaceans as food (e.g., see Smith, 1985), it is possible that furthering our understanding of planktonic Crustacea during an ENSO event will enhance our understanding of the more general effects on coastal faunas. At the very least, it is necessary that sampling be conducted off Peru and Chile in non-ENSO years for comparisons with data of the present study and to establish "normal" patterns of decapod larval abundance and distribution.

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