

## STOMATOPODS (CRUSTACEA:HOPLOCARIDA) COLLECTED OFF THE COAST OF SINALOA, MEXICO, DURING THE BIOCAPESS CRUISES IV, V AND VI (AUGUST 1991, MARCH AND JUNE 1992)

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### RESUMEN

Se recolectaron estomatópodos en las costas de Sinaloa, México, durante las tres etapas de un estudio (Proyecto BIOCAPESS) de la fauna de macrocrustáceos y peces asociados con la plataforma continental. Las muestras se tomaron entre profundidades de 22 a 150 m. El número de ejemplares capturados fue de 174 (BIOCAPESS IV, agosto de 1991), 264 (BIOCAPESS V, marzo de 1992), y 214 (BIOCAPESS VI, junio de 1992), para un total de 652 ejemplares recolectados. Seis especies de *Squilla* fueron identificadas. Las más abundantes y frecuentes fueron *S. mantoidea* y *S. parva*. *Squilla aculeata aculeata* fue capturada solamente una vez y las otras tres (*S. biformis*, *S. panamensis* y *S. hancocki*) se presentaron en menos de un quinto de las muestras tomadas. Se encontraron estomatópodos en 40 de las 57 muestras revisadas; 14 de las 16 muestras sin estomatópodos se obtuvieron a profundidades comprendidas entre 80 y 135 m. El intervalo de distribución batimétrica ha sido ampliado en el caso de cuatro especies (*S. biformis*, *S. hancocki*, *S. panamensis* y *S. parva*). El análisis de las asociaciones de especies en las muestras revela un patrón fundamentalmente similar al observado anteriormente, con una mayor frecuencia de asociación entre *S. mantoidea* y *S. parva*, *S. hancocki* o *S. panamensis*. *Squilla mantoidea* se destaca como la especie dominante para el área del estudio, reforzando la idea de que esta especie representa uno de los componentes principales de las comunidades de macro-invertebrados bentónicos de la plataforma continental de Sinaloa.

Palabras clave: Crustacea, Stomatopoda, sur de Sinaloa, Golfo de California, distribución.

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### ABSTRACT

Stomatopods were collected off the coast of Sinaloa, Mexico, during a three-leg trawling survey (BIOCAPESS Project) of macroinvertebrates and fishes associated with the continental platform. Samples were obtained from 22 to 150 m depth. Numbers of specimens captured during the survey were 174 (BIOCAPESS IV, August 1991), 264 (BIOCAPESS V, March 1992), and 214 (BIOCAPESS VI, June 1992), with a grand total of 652 specimens. Six species of *Squilla* were recognized among the material. The most abundant and commonly found were *S. mantoidea* and *S. parva*. *Squilla aculeata aculeata* was captured only once, and the three other species (*S. biformis*, *S. panamensis* and *S. hancocki*) occurred in less than one fifth of the samples. Stomatopods were found in 40 out of the 57 samples obtained during the survey; 14 of the 16 samples with no stomatopods were obtained from sampling depths between 80 and 135 m. Depth distribution range is increased for four species (*S. biformis*, *S. hancocki*, *S. panamensis* and *S. parva*). Analysis of co-occurrence of species show a pattern basically similar to the one observed previously for the area, with highest frequency of association found between *S. mantoidea* and either *S. parva*, *S. hancocki* or *S. panamensis*. *Squilla mantoidea* appeared as the dominant species for the survey area, thus reinforcing the idea that it now represents one of the major component of the macroinvertebrates benthic community on the Sinaloa continental shelf.

**Key words:** Crustacea, Stomatopoda, southern Sinaloa, Gulf of California, distribution.

### INTRODUCTION

Stomatopods of the west coast of Mexico have been intensively studied in the last ten years. Their geographic and depth ranges are now clearly defined for the area, at least in what concerns the most common species. Biological and ecological information is available regarding size, color pattern, biometric relationships, habitats, species associations, and sexual dimorphism. A recent monograph on stomatopods from the Pacific coast of Mexico summarized all these data (Hendrickx & Salgado Barragán, 1991). Because this monograph was in editorial process for five years, papers made available between 1987 and 1991 could not be taken into account (cf. Hernández Aguilera *et al.*, 1986; Murillo, 1988; Murillo & Frank, 1989; Villalobos *et al.*, 1989; Hendrickx, 1990; Dittel, 1991; Illescas *et al.*, 1991). Fortunately, these papers did not provide critical new data regarding distribution or taxonomy of species known for the area. Since 1991, only a few papers dealing with the stomatopod fauna of the eastern tropical region or containing data relevant to this fauna, were produced. These were the result of new surveys, synthesis of previously known information or taxonomic review (cf. Manning & Chace, 1990; Hernández Aguilera & Martínez Guzmán, 1992; Manning & Camp, 1993; Hendrickx, 1994b).

Although it now appears clearly that stomatopods of the Gulf of California represent a welldiversified and quantitatively important component of the benthic macrofauna, with a primordial role for the ecology and fisheries in the area, there is still a lack of reliable information regarding the standing stock of these organisms on the fishing grounds (Hendrickx & Salgado Barragán, 1989). Similarly, little is known about their potential as a direct or indirect food source and on how populations have been affected by the intensive trawling activities on *Penaeus* shrimp fishing grounds (Hendrickx 1985, 1994).

In 1990, the "Laboratorio de Carcinología" of the Mazatlán Marine Station initiated a survey of the continental platform of southern Sinaloa (BIOCAPESS Project). The main objective was to study populations of penaeid shrimps and portunid crabs occurring in the area. The stomatopods collected during the second part of this survey (1991-92) were provided to the "Laboratorio de Invertebrados Bentónicos" for their study. This material was of special interest as it came from an area which roughly corresponds to the sampling zone of the 1981-82 SIPCO cruises, a short-term survey of the southern coast of Sinaloa which provided information related to abundance and distribution of stomatopod crustaceans (Hendrickx, 1984). Thus, results obtained from the study of the BIOCAPESS material are 10 years away from the results obtained by the SIPCO cruises.

## MATERIAL AND METHODS

The BIOCAPESS material was collected by the R/V "El Puma", of the Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. The sampling area was located on the continental platform of southern Sinaloa, from San Lorenzo to Teacapan. 57 sampling stations were visited during the three legs of the project (Fig. 1, Table 1). Specimens were collected on August 10-13, 1991 (BIOCAPESS IV), March 13-17, 1992 (BIOCAPESS V), and June 25-30, 1992 (BIOCAPESS VI), between 16 and 150 m depth, with 35 or 80 feet commercial otter trawls similar to those commonly used by local shrimpers (mesh size 5.5 cm). Stomatopods were sorted out from the catch and kept frozen or preserved with formaldehyde to be studied at the laboratory. All specimens were identified to species, measured (total length in mm), sexed and kept in the Invertebrates Reference Collection of the Mazatlán Marine Station (cf. text for catalog access number). For each species collected during the survey, the following information is provided: restricted synonymy; list of material examined; distribution and depth ranges, and remarks (optional). Synonymy only includes the original citation and first illustration. Abbreviations used in this paper are: EMU, Estación Mazatlán UNAM reference collection, catalog access code; T.L., total length; St., sampling station; F, female; M, male; Juv., juveniles.

**Table 1.** Occurrence of species of stomatopods at all sampling stations during the BIOCAPESS cruises. All samples collected with 35 or 80 feet shrimp trawling nets. Depth range correspond to initial and final sampling depth

St.	Position	Depth (m)	Species collected
BIOCAPESS IV. 10-12 August, 1991.			
1	24°10.5'N-107°27.8'W	26	<i>S. aculeata aculeata</i> ; <i>S. mantoidea</i> ; <i>S. parva</i>
2	24°08.5'N-107°36.9'W	48	No stomatopods
3	24°00.2'N-107°35.1'W	90	<i>S. mantoidea</i> ; <i>S. parva</i>
4	23°58.7'N-107°41.7'W	124	<i>S. biformis</i>
5	23°49.0'N-106°53.7'W	22	<i>S. parva</i>
6	23°36.6'N-106°54.6'W	44	<i>S. hancocki</i> ; <i>S. panamensis</i>
7	23°32.7'N-107°00.5'W	89	No stomatopods
8	23°29.9'N-107°02.8'W	125	No stomatopods
9	23°06.2'N-106°21.6'W	25	<i>S. biformis</i> ; <i>S. mantoidea</i> ; <i>S. panamensis</i> ; <i>S. parva</i>
9A	23°06.2'N-106°21.6'W	26	<i>S. mantoidea</i>
10	23°01.1'N-106°19.8'W	46	<i>S. hancocki</i> ; <i>S. mantoidea</i> ; <i>S. panamensis</i>
11	22°56.6'N-106°22.9'W	82	No stomatopods
12	22°56.3'N-106°27.9'W	132	<i>S. panamensis</i>
13	22°48.5'N-106°06.0'W	28	<i>S. mantoidea</i> ; <i>S. parva</i>
14	22°43.0'N-106°05.0'W	44	<i>S. hancocki</i> ; <i>S. parva</i>
15	22°36.6'N-106°13.3'W	87	No stomatopods
16	22°35.0'N-106°18.0'W	129	No stomatopods
17	22°35.1'N-106°18.1'W	150	<i>S. parva</i>
18	22°34.3'N-106°17.4'W	138	<i>S. biformis</i> ; <i>S. hancocki</i> ; <i>S. mantoidea</i>
BIOCAPESS V. 13-16 March, 1992.			
1	24°10.6'N-107°29.0'W	28-30	<i>S. mantoidea</i> ; <i>S. parva</i>
2	24°08.7'N-107°37.6'W	47	No stomatopods
3	23°58.0'N-107°39.7'W	119-111	No stomatopods
4	23°59.3'N-107°43.7'W	133-135	No stomatopods
5	23°41.6'N-106°54.7'W	27-30	<i>S. mantoidea</i> ; <i>S. parva</i>
6	23°31.9'N-106°52.6'W	62	<i>S. panamensis</i>
7	23°33.2'N-106°59.9'W	84-92	No stomatopods
8	23°29.9'N-107°03.9'W	136	No stomatopods
9	23°06.6'N-106°22.7'W	26-28	<i>S. mantoidea</i> ; <i>S. parva</i>
10	23°06.2'N-106°25.6'W	47-43	<i>S. panamensis</i>
11	23°00.4'N-106°27.1'W	91-81	No stomatopods
12	22°55.6'N-106°26.9'W	124-120	<i>S. panamensis</i>

Table 1, continues

St.	Position	Depth (m)	Species collected
13	22°44.5'N-106°02.1'W	28-30	<i>S. hancocki</i> ; <i>S. mantoidea</i> ; <i>S. parva</i>
14	22°47.0'N-106°08.4'W	46	<i>S. hancocki</i> ; <i>S. mantoidea</i>
15	22°37.1'N-106°11.7'W	77-90	<i>S. mantoidea</i>
17	22°26.3'N-105°52.2'W	31	<i>S. parva</i>
18	22°26.0'N-105°55.4'W	42	<i>S. hancocki</i> ; <i>S. mantoidea</i> ; <i>S. parva</i>
29	23°03.1'N-106°18.4'W	28	<i>S. mantoidea</i>
39	23°04.2'N-106°20.4'W	31	<i>S. mantoidea</i>
BIOCAPESS VI. 25-30 June, 1992.			
1	24°08.8'N-107°28.4'W	16	<i>S. mantoidea</i> ; <i>S. parva</i>
2	24°03.2'N-107°44.0'W	33	<i>S. mantoidea</i> ; <i>S. parva</i>
3	23°58.0'N-107°40.4'W	83-85	No stomatopods
4	23°41.7'N-106°53.6'W	128-108	No stomatopods
5	23°35.2'N-106°53.4'W	20	<i>S. mantoidea</i>
6	23°35.2'N-106°53.4'W	49-41	<i>S. hancocki</i> ; <i>S. mantoidea</i>
7	23°33.8'N-107°00.5'W	83-87	<i>S. hancocki</i>
8	23°30.1'N-107°03.6'W	129-137	No stomatopods
9	23°04.9'N-106°20.5'W	28-18	<i>S. mantoidea</i> ; <i>S. parva</i>
9.2	23°04.1'N-106°19.2'W	24	<i>S. mantoidea</i>
10	23°04.9'N-106°23.0'W	42-44	<i>S. mantoidea</i> ; <i>S. panamensis</i>
11	22°52.8'N-106°16.1'W	60-62	<i>S. hancocki</i>
12	22°55.6'N-106°28.0'W	135-130	<i>S. biformis</i>
13	22°48.9'N-106°07.1'W	33	<i>S. mantoidea</i> ; <i>S. panamensis</i> ; <i>S. parva</i>
14	22°48.9'N-106°07.1'W	46-44	<i>S. mantoidea</i>
15	22°39.9'N-106°14.7'W	80-78	No stomatopods
16	22°38.2'N-106°18.5'W	140-136	<i>S. panamensis</i>
17	22°26.7'N-105°52.2'W	32	<i>S. mantoidea</i>
18	22°22.9'N-105°56.1'W	46-42	<i>S. mantoidea</i> ; <i>S. panamensis</i>

## RESULTS AND DISCUSSION

### Composition of samples

Six species of *Squilla* Fabricius, (Squillidae), were collected during the survey, totaling 652 specimens (Table 2).

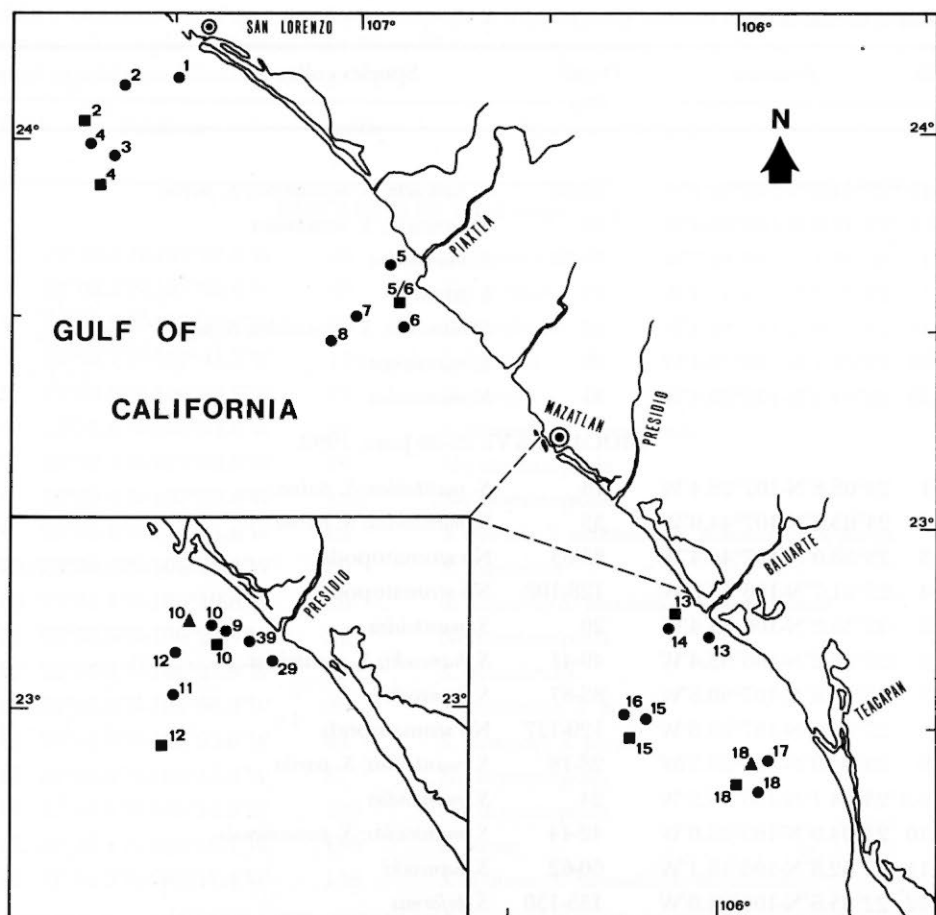


Fig. 1. Location of sampling stations of the BIOCAPESS cruises along the coast of southern Sinaloa, SE Gulf of California, Mexico.

*Squilla aculeata aculeata* Bigelow, 1893

*Squilla aculeata* Bigelow, 1893: 101; 1894: 523, fig. 16. Dittel, 1991: 270.

*Squilla aculeata aculeata*. Murillo, 1988: 98, fig. 2. Hendrickx & Salgado Barragán, 1991: 97, fig. 57, pls. 21 & 31. Hendrickx, 1994b: 382.

**Material examined.** BIOCAPESS IV; St. 1, 10.VIII.91, 1F (136), 26, EMU 2494.

**Known distribution and depth ranges.** From Topolobampo, Sinaloa, to Iquique, Chile. Reported from "shallow littoral water" to 73 m depth; most specimens reported for the Gulf of California have been found between 20 and 35 m (Hendrickx & Salgado Barragán, 1991).

*Squilla biformis* Bigelow, 1891

*Squilla biformis* Bigelow, 1891: 94; 1894: 532, pl. 21, fig. 20. Murillo, 1988: 103, fig. 6. Hendrickx & Salgado Barragán, 1991:100-103, fig. 59, pls. 22 & 32. Illescas *et al.*, 1991: 438. Hendrickx, 1994b: 383.

**Material examined.** BIOCAPESS IV; St. 4, 10.VIII.91, 4F (98-138), 124 m, EMU 2495; St. 9, 11.VIII.91, 3M (133-145), 1F (132), 25 m, EMU 2496; St. 18, 12.VIII.91, 1M (110), 138 m, EMU 2497.

BIOCAPESS VI; St. 12, 28.VI.92, 1F (107), 135 m.

**Known distribution and depth ranges.** From La Paz, east coast of Baja California, and Santa María Bay, Sinaloa, south to Huacho, Perú. Known to occur between 28 and 518 m depth; common depth range in the Gulf of California is from 60 to 130 m (Hendrickx & Salgado Barragán, 1991).

*Squilla hancocki* Schmitt, 1940

*Squilla hancocki* Schmitt, 1940:160, fig. 10. Hendrickx & Salgado Barragán, 1991:107-111, fig. 63, pl. 2. Illescas *et al.*, 1991: 440.

**Material examined.** BIOCAPESS IV; St. 6, 11.VIII.91, 3M (79-90), 44 m, EMU 2498; St. 10, 11.VIII.91, 1M (62), 46 m, EMU 2499A; St. 14, 12.VIII.91, 1M (85), 44 m, EMU 2499B; St. 18, 12.VIII.91, 16M (65-97), 6F (57-81), 138 m, EMU 2500.

BIOCAPESS V; St. 13, 16.III.92, 1M (99), 1F (90), 28-30 m; St. 14, 16.III.92, 1F (105), 46 m, EMU 2516; St. 18, 16.III.92, 3M (78-88), 42 m, EMU 2515.

BIOCAPESS VI; St. 6, 27.VI.92, 1M (89), 1F (92), 41-49 m; St. 7, 27.VI.92, 1F (70), 83-87 m; St. 11, 27.VI.92, 1M (102), 1F (98), 60-62 m.

**Distribution and depth ranges.** From off San Ignacio Bay, Sinaloa, to Paita, Perú. Known to occur between 29 and 220 m depth; it is most commonly found at 35-60 m in the Gulf of California (Hendrickx & Salgado Barragán, 1991).

**Remarks.** The telson of several male specimens did not featured the usual secondary sexual character of the species (Stations 10 and 18 of BIOCAPESS IV), which normally consists in stronger, heavier carinae of marginal teeth.

*Squilla mantoidea* Bigelow, 1893

*Squilla mantoidea* Bigelow, 1893: 101; 1894: 521, figs. 13-14. Murillo, 1988: 99, fig. 3. Hendrickx & Salgado Barragán, 1991:111-115, fig. 65, pls. 25,26 & 33. Dittel, 1991: 270. Hendrickx, 1994: 386.

**Material examined.** BIOCAPESS IV; St. 1, 10.VIII.91, 1M (140), 26 m, EMU 2501; St. 3, 10.VIII.91, 8M (131-158), 3F (125-151), 90 m, EMU 2502; St. 9, 11/VIII/91, 9M (125-158), 5F, 25 m, EMU 2503; St. 9A, 13.VIII.91, 1M (140), 120 m, EMU 2504; St. 10, 11.VIII.91, 7M (129-166), 3F (112-143), 46 m, EMU 2505; St. 13, 12.VIII.91, 1F

(138), 28 m, EMU 2506; St. 18, 12.VIII.91, 6M (92-162), 10F (97-157), 138 m, EMU 2507.

BIOCAPESS V; St. 1, 13.III.92, 28M (70-173), 13F (68.5-148), 28-30 m, EMU 2517; St. 5, 14.III.92, 1M (93), 27-30 m; St. 9, 15.III.92, 4M (not measured), 26-28 m; St. 13, 16.III.92, 31M (49-166), 21F (55-168), 3 juveniles, 28-30 m; St. 14, 16.III.92, 1M (147), 46 m, EMU 2518; St. 15, 16.III.92, 1M (182), 77-90 m, EMU 2519; St. 18, 16.III.92, 17M (41-171), 20H (58-153), 42 m; St. 29, 17.III.92, 7M (72-157), 16F (79-138), 28 m; St. 39, 17.III.92, 8M (66-195), 9F (91-171), 31 m.

BIOCAPESS VI; St. 1, 25.VI.92, 5M (98-165), 1F (118), 16 m, EMU 2535; St. 2, 26.VI.92, 23M (68-1150), 14F (90-145), 32-33 m, EMU 2536; St. 5, 26.VI.92, 9M (108-174), 3F (111-127), 20 m, EMU 2525; St. 6, 27.VI.92, 4M (61-131), 4F (89-143), 41-49 m, EMU 2537; St. 9, 27.VI.92, 7M (11-167), 4F (107-178), 18-28 m, EMU 2538; St. 9.2, 29.VI.92, 3M (126-129), 1F (163), 24 m, EMU 2548; St. 10, 27.VI.92, 8M (83-171), 8F (92-180), 42-44 m, EMU 2526; St. 13, 28.VI.92, 2F (136 and 176), 33 m, EMU 2539; St. 14, 28.VI.92, 2M (107 and 166), 44-46 m, EMU 2540; St. 17, 29.VI.92, 1M (122), 1F (111), 32 m, EMU 2541; St. 18, 29.VI.92, 7M (70-132), 11F (not measured), 42-46 m, EMU 2542.

**Known distribution and depth range.** From Guaymas, Sonora, to Tumbes, Perú. Known to occur between 9 and 60 m depth; common depth range in the Gulf of California is from 20 to 40 m (Hendrickx & Salgado Barragán, 1991).

**Remarks.** The only male specimen collected presented an asymmetrical telson. As observed by Hendrickx & Salgado Barragán (1991) in about 3% of the specimens collected in 1984 from off the coast of northern Sinaloa, presented a spined, submedian carina on the 5th abdominal segment, in addition to the similar spined carina always carried by this species on the 6th segment. Considering the time that has elapsed between these two surveys (1984 and 1991-92), this feature appears to be consistently transmitted.

### *Squilla panamensis* Bigelow, 1891

*Squilla panamensis* Bigelow, 1891: 94; 1894: 526, figs. 17-18 (part). Murillo, 1988: 101, fig. 5. Hendrickx & Salgado Barragán, 1991: 116-119, fig. 67, pls. 27 & 32. Dittel, 1991: 270. Hendrickx, 1994b: 387.

**Material examined.** BIOCAPESS IV; St. 6, 11.VIII.91, 1M (55), 44 m, EMU 2508A; St. 9, 11.VIII.91, 6M (74-104), 2F (76; one damaged), 25 m, EMU 2509; St. 10, 11.VIII.91, 2M (74 and 87), 12F (59-103), 46 m, EMU 2510; St. 12, 12.VIII.91, 1M (89), 132 m, EMU 2508B.

BIOCAPESS V; St. 6, 14.III.92, 2M (74 and 89), 62 m; St. 10, 15.III.92, 2M, 2F (not measured), 43-47 m; St. 12, 15.III.92, 8 juveniles, 120-124 m.

BIOCAPESS VI; St. 10, 27.VI.92, 15M (75-105), 5F (51-96), 42-44 m, EMU 2527; St. 11, 27.VI.92, 5M (97-118), 8F (87-110), 60-62 m, EMU 2528; St. 13, 28.VI.92, 1F



(84), 33 m, EMU 2530; St. 16, 28.VI.92, 18M (46-82), 20F (44-82), 136-140 m, EMU 2531; St. 18, 29.VI.92, 2F (79 and 87), 42-46 m, EMU 2532.

**Known distribution and depth ranges.** From the Bay of Guaymas, Sonora, to Tumbes and Callao (extralimital), Perú. Known from 18 to 102 m, but most commonly found between 30 and 45 m in the Gulf of California (Hendrickx & Salgado Barragán, 1991).

### *Squilla parva* Bigelow, 1891

*Squilla parva* Bigelow, 1891:94; 1894: 518, figs. 11-12. Murillo, 1988: 100, fig. 4. Hendrickx & Salgado Barragán, 1991:119-121, figs. 69 and 70, pl. 28. Dittel, 1991: 270. Hendrickx, 1994b: 388.

**Material examined.** BIOCAPESS IV; St. 1, 10.VIII.91, 1M (52), 46 m, EMU 2511A; St. 3, 10.VIII.91, 35M (56-77), 11F (54-76), 90 m, EMU 2512; St. 5, 11.VIII.91, 2F (60-64), 22 m, EMU 2511B; St. 9, 11.VIII.91, 3F (48-67), 25 m, EMU 2513; St. 13, 12.VIII.91, 2M (72 and 73), 28 m, EMU 2514; St. 14, 12.VIII.91, 1M (69), 2F (68-71), 44 m, EMU 2547; St. 17, 12.VIII.91, 1F (57), 150 m, EMU 2511C.

BIOCAPESS V; St. 1, 13.III.92, 7M (47-53.4), 10F (38.4-54), 28-30 m, EMU 2520; St. 5, 14.III.92, 9M (43-89), 14F (44-56), 27-30 m, EMU 2521; St. 9, 15.III.92, 8 specimens (not sexed, not measured), 26-28 m; St. 13, 16.III.92, 4 specimens (not sexed, not measured), 28-30 m; St. 17, 16.III.92, 1M (51.3), 2F (35.9, 42.3), 31 m, EMU 2523; St. 18, 16.III.92, 2M (45 and 46), 7F (30-51), 42 m, EMU 2524.

BIOCAPESS VI; St. 1, 25.VI.92, 3M (89-167), 10F (72-172), 16 m, EMU 2533; St. 2, 26.VI.92, 1M (45) 32-33 m, EMU 2546; St. 9, 27.VI.92, 1M (71), 18-28 m; St. 13, 28.VI.92, 2M (62 and 68), 33 m, EMU 2534.

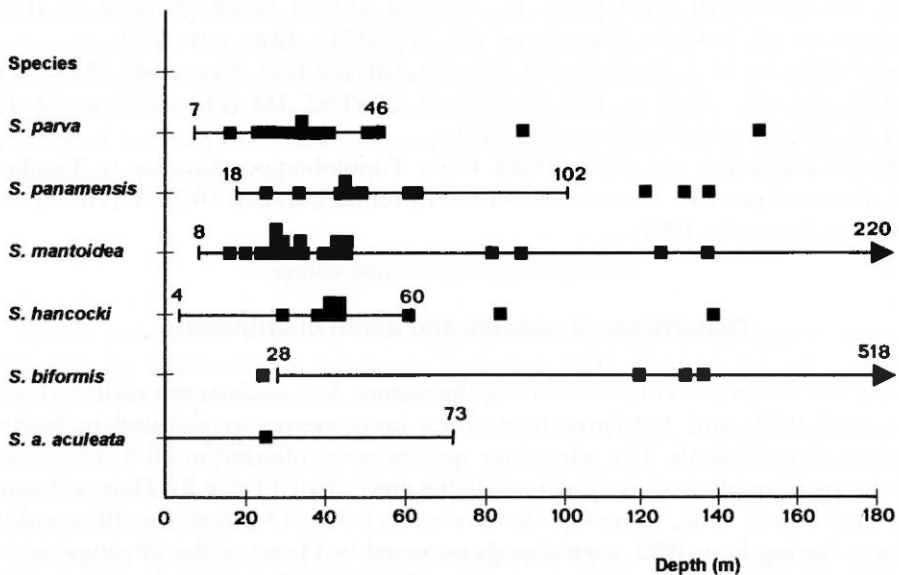
**Known distribution and depth ranges.** From Topolobampo, Sinaloa, to Tumbes, Perú. Known from 7 to 46 m; most commonly found between 10-25 m (Hendrickx & Salgado Barragán, 1991).

### Occurrence of species and depth distribution

Among the six species collected during the survey, *S. a. aculeata* was collected only once (VIII.1991) and *S. biformis* four times; both species were found in limited numbers of individuals. The other four species were collected in all three cruises, and the total number of specimens available are similar (Table 2). During August 1991 and March 1992, stomatopods were collected in 13 out of the 19 sampling stations. During June 1992, stomatopods occurred in 14 out of the 19 sampling stations (Table 1). Stations with no stomatopods (16 of 57) included outer shelf localities, where sampling gears were operated at 108-135 m (7 of 16 stations). Also significant is the fact that 14 of the 16 samples without stomatopods came from stations with depths between 80 and 135 m. In the southeastern Gulf of California,

**Table 2.** Specimens of stomatopods of the genus *Squilla* collected during the legs IV, V and VI of the BIOCAPESS Project (Total: 652; M=male; F=female; juv.=juveniles; \*=unsexed specimens) and occurrence of species in samples (Total = 57)

Species	BIOCAPESS IV		BIOCAPESS V		BIOCAPESS VI		Number of samples (%)
	M	F	M	F	M	F	
<i>S. a. aculeata</i>	-	1	-	-	-	-	1 (1.7)
<i>S. biformis</i>	4	5	-	-	-	1	4 (7.0)
<i>S. hancocki</i>	21	6	3	4	2	3	10 (17.5)
<i>S. mantoidea</i>	32	23	98	78	63	38	27 (47.4)
			(3 juv.)				
<i>S. panamensis</i>	10	14	4	2	49	43	11 (19.3)
			(8 juv.)				
<i>S. parva</i>	45	13	19	33	5	10	17 (29.8)
			12*				
Total:	112	62	124	117	119	95	57 (100)
	174		264		214		



**Fig. 2.** Depth distribution patterns of specimens of *Squilla* collected during the BIOCAPESS cruises (squares). Continuous line indicate the extension of the previously known depth range for each species (numbers are extreme depths in m).

benthic biodiversity is drastically reduced due to rapid oxygen depletion starting at 50-70 m; values below 1 ml/l O<sub>2</sub> are commonly measured in the 60-90 range and below, depending upon the period of the year (Hendrickx *et al.*, 1984; Hendrickx, 1994a). As it can be seen, stomatopods were consistently absent from station 8 and *S. biformis* was the only species collected at station 4. Off Teacapan (Sts. 15 to 18), stomatopods appeared inconsistently, with deeper stations occasionally richer than shallow stations.

Depth distribution of stomatopods occurring in western Mexico were summarized by Hendrickx & Salgado Barragán (1991). Comparatively, three species (*S. parva*, *S. panamensis* and *S. mantoidea*) collected during the BIOCAPESS survey present a significant increase of the lower limit of their depth range. They were collected at depths greater than 138 m, in samples from off Teacapan. The greatest increase of depth range was observed for *S. parva*, a species previously known from depths of 7 to 46 m, and captured at 80 and 150 m during the BIOCAPESS cruises (Fig. 2). Dittel (1991) states that *S. parva* is found predominantly in the more oceanic, deeper part of the Gulf of Nicoya, Costa Rica. The capture of adult specimens of *S. biformis* at a depth of 25 m is also surprising, considering the depth range known from off the coast of Sinaloa (61-117 m; Hendrickx & Salgado Barragán, 1991), although it is close to the previously known lowest depth record for this species (28 m), (Fig. 2, Table 1).

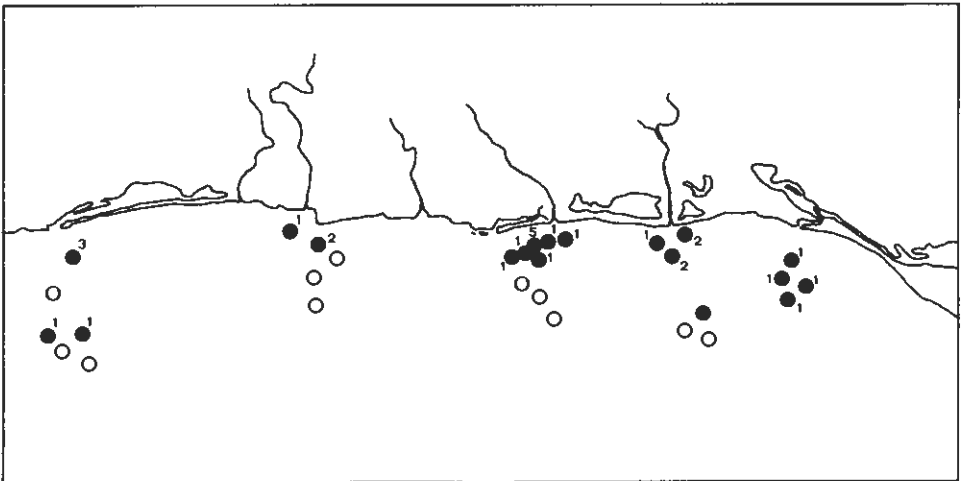
Considering all sampling stations, 40 (71.4%) of the 56 samples obtained during the survey contained stomatopods. This is a notably high frequency of occurrence for the area, as shown by comparative data available from the SIPCO survey (southern Sinaloa, 1981-82, from Punta Piaxtla to Teacapan) during which six species of stomatopods were collected in only eight of the 24 samples, including two species rarely found in trawls [*Euryquilla veleronis* (Schmitt) and *Meiosquilla swetti* (Schmitt)] (Hendrickx, 1984). The other four species (*Squilla biformis*, *S. hancocki*, *S. panamensis* and *S. parva*) also appeared in the present survey, together with *S. aculeata aculeata* and *S. mantoidea*, two species not collected during the SIPCO cruises (Table 3). Three other series of stomatopods samples obtained from 1979 to 1986, from off the coast of Sinaloa (22°10'N to 25°37'N), provide additional comparative data which indicate that *Squilla hancocki*, *S. panamensis* and *S. parva* are the only three species that have been consistently captured in this area over a 13 year period (1979-1992). *Squilla mantoidea* was found in all these cruises, except the SIPCO, while *S. biformis* was captured in two series of cruises, in addition to the present survey (Table 3).

The presence of *S. mantoidea* in the BIOCAPESS samples is noteworthy, because it is the most commonly captured species (27 occurrences in 40 positive samples) (Table 2). As mentioned above, the SIPCO cruises failed to capture this species in the area, and at that time it was considered absent or little abundant from the southeastern Gulf of California (Brusca, 1980; Hendrickx, 1984). The series of samples obtained during the CICLO cruises, in 1984 (northern Sinaloa), showed a completely different pattern of distribution and abundance. These data, pre-

**Table 3.** Comparative analysis of capture of stomatopods reported from off the coast of Sinaloa (1979-1992)\*

Cruise name, period and area sampled (latitudinal extension)	List of species captured	
SHRIMPERS 1979-80 22°10'N to 25°37'N	<i>Hemisquilla ensigera californiensis</i> <i>Squilla aculeata aculeata</i> <i>Squilla biformis</i> <i>Squilla hancocki</i>	<i>Squilla mantoidea</i> <i>Squilla panamensis</i> <i>Squilla parva</i>
SIPCO cruises 1981-82 22°24'N to 23°38'N	<i>Eurysquilla veleronis</i> <i>Meiosquilla swetti</i> <i>Squilla biformis</i>	<i>Squilla hancocki</i> <i>Squilla panamensis</i> <i>Squilla parva</i>
CICLO cruises 1984 22°33'N to 25°55'N	<i>Lysiosquilla descaussurei</i> <i>Squilla aculeata aculeata</i> <i>Squilla hancocki</i> <i>Squilla mantoidea</i>	<i>Squilla panamensis</i> <i>Squilla parva</i> <i>Squilla tiburonensis</i>
BIOCAICT cruises 1986 22°23'N to 24°10.5'N	<i>Squilla hancocki</i> <i>Squilla mantoidea</i> <i>Squilla panamensis</i>	<i>Squilla parva</i> <i>Squilla tiburonensis</i>

\*Data from Hendrickx, 1984 and Hendrickx & Salgado-Barragán, 1992.  
Species in bold face are species not found during the BIOCAPESS survey.



**Fig. 3.** Distribution pattern of *Squilla mantoidea* according to its presence (solid circles) in the BIOCAPESS samples. Numbers refer to numbers of captures per station.

		6	5	4	3	2	1
1	<i>S. a. aculeata</i>	1	0	1	0	0	
2	<i>S. bifornis</i>	1	1	2	1		
3	<i>S. hancocki</i>	3	2	6			
4	<i>S. mantoidea</i>	9	5				
5	<i>S. panamensis</i>	2					
6	<i>S. parva</i>						

Fig. 4. Co-occurrence of species of *Squilla* in samples obtained during the BIOCAPESS cruises.

sented by Hendrickx & Salgado Barragán (1991) indicated that an important population of *S. mantoidea* had been either undersampled until then or had recently invaded the area. Present data emphasize the presence of *S. mantoidea* as an important member of the benthic community also in southern Sinaloa (Fig. 3). As stated by Hendrickx & Salgado Barragán (1991), *S. mantoidea* is a tough species, able to survive on ship deck for relatively long periods of time and to resist physical stress and injuries caused by gear. This would represent a major advantage over more fragile or sensitive species caught by trawling that perish before shrimp bycatch is returned to sea. The abundance and distribution pattern of *S. mantoidea* observed herein could be a direct consequence of the shrimp fishery impact in the area and might indicate an increase of the population of this large, voracious species known to be an active predator of shrimps (Hatzioles, 1985).

### Species associations

Co-occurrence of species of stomatopods in samples collected in the Gulf of California has been documented only once (Hendrickx & Salgado Barragán, 1991). Because many species live in burrows or are too small to be retained by fishing gears, occurrence in commercial trawls is generally limited to species of *Squilla*, *Hemisquilla* and occasionally *Parasquilla* and *Lysiosquilla*. In the BIOCAPESS survey, 20 catches were monospecific (2 with either *S. bifornis* or *S. hancocki*; 3 with *S. parva*; 5 with *S. panamensis*; 8 with *S. mantoidea*). The others included 2, 3 or 4 species (Table 1). Analysis of co-occurrence of species (Fig. 4) shows highest values for *S. mantoidea* - *S. parva* (9), *S. mantoidea* - *S. hancocki* (6) and *S. mantoidea* - *S. panamensis* (5); this coincides well with results of Hendrickx & Salgado Barragán (1991), except for the co-occurrence of *S. mantoidea* - *S. a. aculeata*, which appears to be much lower during the BIOCAPESS cruises than in previous surveys made in the Gulf of California, and of *S. parva* - *S. a. aculeata* which was not observed during the BIOCAPESS cruises.

In her survey of the Gulf of Nicoya, Dittel (1991) reported *S. parva* and *S. aculeata* as the two dominant species in shallow water, the latter with a 100% rate of occurrence at the 12 sampling stations; co-occurrence of these two species was observed in 50% of the sampling stations. Two other species were found during this Gulf of Nicoya survey: *S. panamensis* and *S. mantoidea*. With only 13 specimens caught in 80 trawls, *S. mantoidea* did not appear to be a common species, although it is said to occur more abundantly at depths of 35-45 m.

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