Rev. Biol. Trop., 44, Suppl. 3: 103-113, 1996

Checklist of copepods from Gulf of Nicoya, Coronado Bay and Golfo Dulce, Pacific coast of Costa Rica, with comments on their distribution

Alvaro Morales-Ramírez
Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica, San José, Costa Rica.

(Rec. 4-IX-1995. Rev. 14-IX-1995. Acep. 22-IV-1996)

Abstract: A list of 54 copepod species (Crustacea) in 23 families is presented for the Pacific coast of Costa Rica. Identifications are from zooplankton samples of the Victor Hensen Expedition during December 1993 and February 1994. Samples were taken with a Bongo net (0.60 m net opening, 2.50 m net length) with 200 µm mesh size. Oblique hauls were done from the surface to the ground at a towing speed of aprox. 1 knot. 37 species (68.5%) were found in the Gulf of Nicoya, 36 in Golfo Dulce (66.6%) and 17 (31.4%) species were common to both gulfs, while only twelve species (22.2%) were found in Coronado Bay. Four species (7.4%) were distributed along the coast and were common to the three regions: *Paracalanus parvus, Euchaeta* sp., *Oithona plumifera* and *O. similis*. Eleven species of calanoids found normally in the Costa Rica Dome show the influence of typical oceanic waters principally at the mouth of Gulf of Nicoya. Differences were observed in the composition and presence of the copepod species when the inner and outer (upper and lower) parts of both gulfs were compared. Gulf of Nicoya was dominated in its upper part by typical neritic estuarine species like *Acartia lilljenborgii, Paracalanus parvus* and, *Hemyciclops thalassius* as well as species of *Pseudodiaptomus*. On the other hand a more oceanic composition of copepods was observed in the lower part of the gulf. Both small species, like *Oncaea venusta,* as well as larger species, such as *Pleuromamma robusta, Eucalanus attenuatus, E. elongatus* and *Rhincalanus nasutus*, were typical of these waters. *Oithona plumifera* and *O. similis* were found in the lower part too; and both species are typical from oceanic water. Coronado Bay was characterized by the presence of typical oceanic species like *Neocalanus gracilis, Euchaeta longicornis, Eucalanus attenuatus* and *Haloptilus ornatus* with more transitional species like *Clausocalanus pergens* and *C. furcatus* near the coast. In the Golfo Dulce differences in copepod composition were also observed, but the separation of the species was not so evident. Outer stations were represented by oceanic species like *Paracalanus aculeatus, Pleuromamma gracilis, Lucicutia ovalis, Candacia catula, Euchaeta wolfendeni* and *Oncaea mediterranea,* while the inner station, located at the upper part of the Gulf, was more characterized by a mixed copepod group, with both neritic species like *Pseudodiaptomus wrigthi, Acartia danae, A. clausi, Canthocalanus pauper* as well as oceanic species like *Scolicithricella marginata, Saphirina nicromaculata* or *Oncaea conifera.* Two species of *Coryceaus, C. flaccus* and *C. speciosus*, were identifed in the outer stations of Golfo Dulce, while *C. brehmi* was found in inner stations of Gulf of Nicoya. The majority of copepods found are typical of the east Pacific. This paper constitutes an additional work about the copepods in the Gulf of Nicoya and the first report of copepod species for Coronado Bay and Golfo Dulce.

Key words: Copepoda, Eastern Pacific, Costa Rica, Gulf of Nicoya, Golfo Dulce, plancton.

Copepods are aquatic crustaceans, the diminutive relatives of crabs and shrimp. In terms of their size, diversity and abundance they can be regarded as the insects of the seas (Huys & Boxshall 1991). They present a high morphological variety (Dudley 1986) and include aproximatly 8500 species. They occur in nearly all marine, brackish, freshwater, inland saline (including alkaline) waters and moist semiterrestrial habitats of the earth (e.g. Raymont 1983). Being extremely abundant in marine and freshwater plankton as well in most meiobenthos communities, they constitute a very important component of the food chain (Vidal 1980 Roman 1991). They are very diverse (Longhurst, 1985) and in the tropics there are many species (Weikert 1984), where calanoids dominate the first 100 m depth, while

small copepods of the order Poecilostomatoidea are very abundant and diverse in the mesopelagical zone in low latitudes (Böttger-Schnak 1990 a;b).

On the Pacific coast of Costa Rica, the Gulf of Nicoya and the Golfo Dulce are sheltered, low energy, depositional estuarine enviroments of similar size, orientation and geographical outline, while Coronado Bay borders the Sierpe-Terraba region, a Forest Reserve influenced by the Terraba and Sierpe rivers (e.g. Wolff & Vargas 1994). Costa Rica's coastal plankton has as yet received little attention. Scattered reports are available on the phytoplankton distribution (Hargraves & Víquez 1985), as well as on local phenomena of red tides (Hargraves & Víquez 1981) and their impact on the distribution of dissolved oxygen (Gocke *et al.* 1990). Zooplankton studies have been concentrated principally on the merozooplanktonic component (Epifanio & Dittel, 1984; Dittel & Epifanio 1990; Dittel *et al.* 1991). Copepod species of Costa Rica's Pacific coast are little known. Morales & Vargas (1995) give a list of twelve calanoid species for the upper part of Gulf of Nicoya with notes about their distribution in the east Pacific. On the other hand, Suárez & Gasca (1989) give a list of 41 copepods species of the Costa Rica Dome region and analyze the high abundances of some herbivores and the presence of certain deep-water copepods, with respect to the upwelling of the Costa Rica Dome.

In this paper I present a list of copepod species found on the Pacific coast of Costa Rica in the areas of Gulf of Nicoya, Coronado Bay and Golfo Dulce, with comments on their distribution.

MATERIAL AND METHODS

Zooplankton surveys were conducted during leg 1 (December 2-9 1993) and leg 4 (February 2-9 1994) of the Victor Hensen Expedition (Wolff & Vargas 1994). The zooplankton sampling program was done in sample locations of previous studies of Voorhis *et al.* (1983) in the Gulf of Nicoya, while sampling stations for Golfo Dulce followed Richards *et al.* (1971). No previous plankton studies had been done in Coronado Bay. Here a four station transect was set perpendicular to the coast (see Fig. 1 and Table 1). At each station, Bongo (0.60m net opening, 2.5m net length) hauls were performed with a pair of nets; one set was done with 200 µm net for copepods and 300 µm net for chaetognath (Hossfeld 1996) and the rest of the zooplankton groups (von Wangenlin & Wolff 1996). Another set was done with 500 µm and 100 µ nets for ichthyoplankton of different size ranges (Molina 1996). A Hydrobios flowmeter was attached to the mounth of each net to calculate the water volumen filtered.

Oblique hauls were done from the surface to the bottom at a towing speed of aprox. 1.5 knots. Towing time varied between 5 and 10 min, depending on the water depth. The towing depth (and the required length of wire) was determined by a clinometer.

Zooplankton samples were washed with seawater and transferred into a 1-l Kautex bottle. Samples were fixed with formaldehyde to reach a concentration of 4% and then transferred into 70% ethyl alcohol for preservation.

Additional material from other stations in both gulfs and Coronado Bay was analized. Copepod species were identified following Griesbrecht (1892), Rose (1933), Katurinangan (1963), Mori (1964), Fleminger & Frost (1968), Grice (1962), Björnberg (1981), Walter (1989), Campos y Suárez (1994). Voucher specimens were deposited in the Zoology Museum of the University of Costa Rica.

RESULTS AND DISCUSSION

Table 2 gives a list of 54 copepod species in 23 families found during the Victor Hensen Expedition (Wolff & Vargas 1994). Two families presented the highest number with five species each: Paracalanidae and Eucalanidae. In some families, like Centropagidae, Lucicutidae, Augaptillidae, Candacidae, Miraciidae and Clausidiidae only one species was found. Thirty seven species (68.5%) were found in Gulf of Nicoya, thirty six (66.7%) in the Golfo Dulce and only twelve species (22.2%) in Coronado Bay. Four species (7.4%) were distributed along the coast and were common to the three regions: *Paracalanus parvus*, *Euchaeta* sp., *Oithona plumifera* and *O. similis*. *P. parvus* was found near the coast. Seventeen species (31.4%) were common to both gulf systems: *Canthocalanus pauper*, *Acrocalanus gibber*, *A. longicornis*, *Eucalanus elongatus*, *Subeucalanus subcrassus*, *Temora discaudata*,

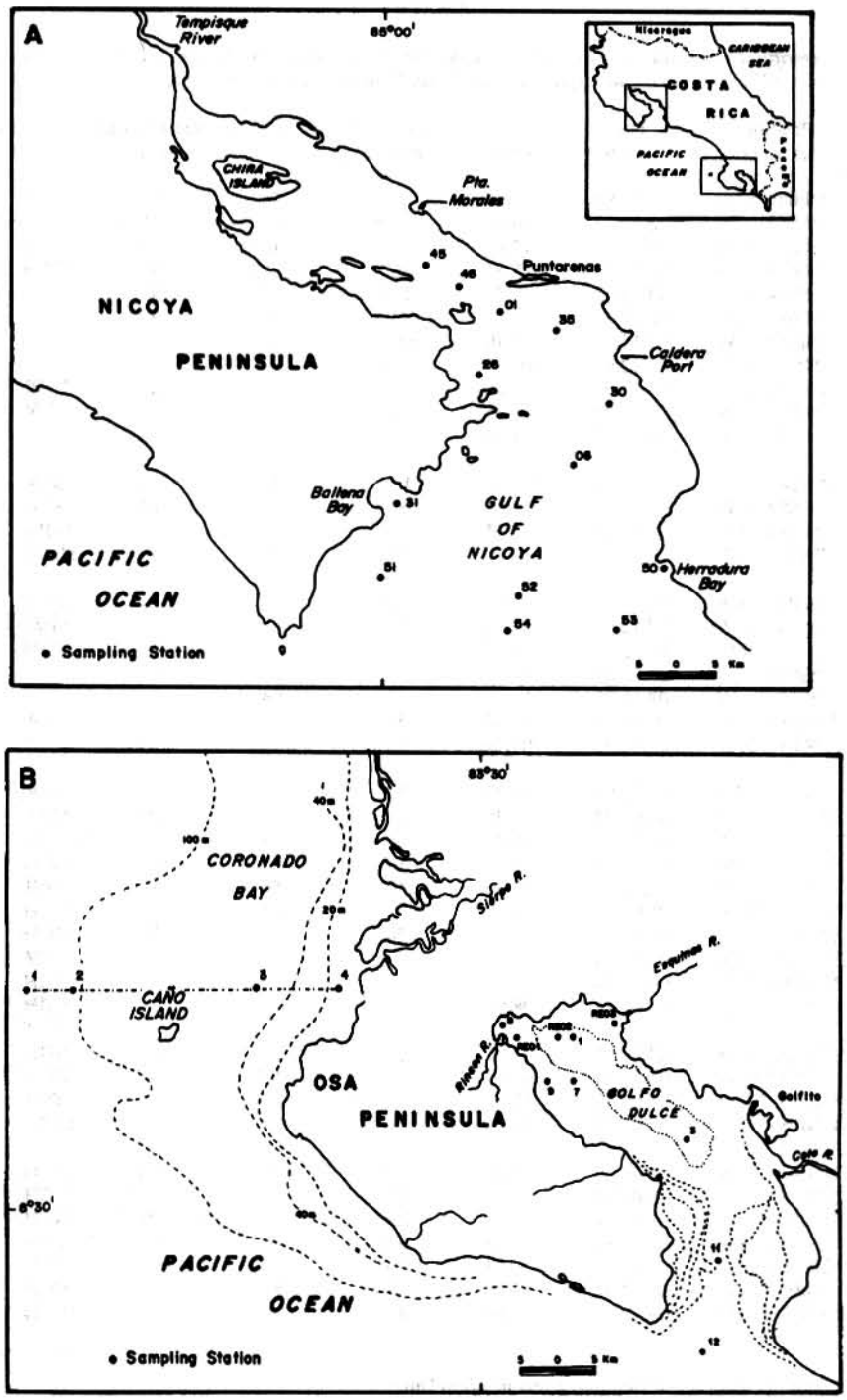

Fig. 1. Location of zooplankton stations during the Victor Hensen Expedition December 1993-February 1994, Pacific coast of Costa Rica (points indicate sampling stations). A: Gulf of Nicoya, and B: Coronado Bay and Golfo Dulce.

TABLE 1

Description of zooplankton stations during the Victor Hensen survey, Pacific coast of Costa Rica
GN: Gulf of Nicoya, BC: Bahía Coronado, GD: Golfo Dulce

Station Code	Position lat./long	Date d/m/y	Time local	Depth of haul(m)	Echo-Depth (m)	Secchi-Depth (m)	Tide	Weather Wind/seg
GN31	09°43N/084°57W	02.12.93	13:33	35	54	8	HIGH	SW 1/2
GN51	09°38N/085°00W	03.12.93	09:31	50-55	62	11	HIGH	E 3
GN52	09°36N/084°50W	03.12.93	13:05	80	100	10	HIGH	SE 3
GN54/8	09°33N/084°50W	03.12.93	15:31	200	250	8	HIGH	SSE 2/STILL
GN54/9	09°33N/084°50W	03.12.93	15:56	150	270	8	HIGH	SSE 2/STILL
GN53	09°34N/084°43W	03.12.93	06:00	60	80	9		N 2
GN06	09°45N/084°46W	03.12.93	17:10	30-35	45	4	HIGH	1./2
GN30	09°51N/084°46W	04.12.93	06:31	25-30	35	5	LOW	SO 1/2
GN35	09°56N/084°48W	04.12.93	09:10	13	17	6	LOW	S 2
GN01	09°57N/084°53W	04.12.93	11:35	30	48	2	LOW	S 2
GN45	10°03N/085°00W	04.12.93	14:21	3.0	6	1	HIGH	1
BC01	08°47N/084°03W	06.12.93	06:05	110	165	20	LOW	SW 2
BC02	08°47N/084°01W	06.12.93	09:34	80	100	17	LOW	SE 2
BC03	08°47N/084°45W	06.12.93	12:35	40	53	9	LOW	W 1
BC04	08°47N/083°42W	06.12.93	14:40	18	20	5	HIGH	W 1/2
GD12	08°21N/083°14W	07.12.93	07:05	145	200	7	HIGH	1
GD11	08°27N/083°13W	07.12.93	14:22	35	65	5	MID	SW 3
GD03	08°35N/083°16W	07.12.93	16:47	145	190	4	HIGH	W 3
GD01	08°42N/083°24W	08.12.93	08:24	150	200	8		STILL
GD07	08°39N/083°24W	08.12.93	11:19	80	94	4,5		STILL
GD09	08°39N/083°26W	08.12.93	13:40	30	48		LOW	2
GD08	08°43N/083°29W	08.12.93	07:39	65	100	7,5		STILL
GN46	10°02N/084°57W	02.02.94	11:33	10	16		LOW	NE 4
GN26	09°52N/084°53W	02.02.94	13:39	10	14	2,5	MID	S 3/4
GN35	09°55N/084°47W	03.02.94	06:27	10	14		HIGH	S 4
GN31*	09°43N/085°00W	03.02.94	06:43	10	15	8	HIGH	W 2
GN31**	09°42N/084°58W	04.02.94	12:36	40	50	9	LOW	E 2
GN51	09°38N/085°00W	05.02.94	06:53	50	65		HIGH	NE 5/6
GN52	09°36N/084°50W	05.02.94	09:28	70	110		HIGH	NE 5
GN54	09°33N/084°50W	05.02.94	10:39	180	300		LOW	1
GN50	09°38N/084°41W	96.02.94	06:43	35	44		HIGH	1
GN53	09°34N/084°43W	06.02.94	08:09	70	84	9,5	HIGH	1
BC01	08°47N/084°04W	07.02.94	07:18	120	280	17,5	HIGH	1
BC02	08°47N/084°01W	07.02.94	08:57	85	100	20	HIGH	STILL
BC03	08°47N/083°46W	07.02.94	11:50	48	55	24	LOW	1
BC04	08°47N/083°42W	07.02.94	12:53	19	27		LOW	1
GD12	08°21N/083°14W	08.02.94	06:26	140	205	5,5	HIGH	NW 1
GD11	08°27N/083°13W	08.02.94	08:28	55	70	10,5	HIGH	N 2
GD03	08°35N/083°16W	08.02.94	10:44	160	190	10	HIGH	1
R-E001*	08°42N/083°28W	08.02.94	13:29	30	40	6	LOW	SE 3
R-E002*	08°42N/083°25W	08.02.94	16:53	160	199		LOW	E 1/2
R-E003*	08°43N/083°21W	09.02.94	10:01	45	57		HIGH	STILL
GD08	08°43N/083°29W	09.02.94	06:16	25	41		HIGH	STILL

* R-E Transect between Rincon and Esquinas rivers in Golfo Dulce.

TABLE 2

Sistematic classification of the copepods found during the Victor Hensen Expedition in the Pacific coast of Costa Rica. December 1993 - February 1994 GN: Gulf of Nicoya, BC: Bahía Coronado, GD: Golfo Dulce, No CAT: Catalogue number

Orden Calanoidea Sars 1903	GN	BC	GD	N° CAT.
Family Calanidae				
Canthocalanus pauper Giesbrecht 1888	X		X	UCR-2090-01
Calanus minor Claus 1863	X			UCR-2088-01
Undinula vulgaris Dana 1852		X	X	UCR-2097-01
				UCR-2098-02
				UCR-2100-01
Neocalanus gracilis Dana 1849	X	X		UCR-2088-02
				UCR-2095-01
Family Paracalanidae				
Acrocalanus gibber Giesbrecht 1888	X		X	UCR-2090-01
				UCR-2102-01
A. longicornis Giesbrecht 1888	X			UCR-2094-02
				UCR-2103-01
Paracalanus aculeatus Giesbrecht 1888			X	UCR-2102-02
P. parvus Claus 1863	X	X	X	UCR-2090-02
				UCR-2101-01
				UCR-2098-01
P. crassirostris Dahl 1894	X			UCR-2090-03
Family Calocalanidae				
Calocalanus stylerimis Giesbrecht 1888	X			UCR-2094-03
Family Clausocalanidae				
Clausocalanus furcatus Brady 1883	X			UCR-2101-02
C. pergens Farran 1926	X			UCR-2095-02
Family Eucalanidae				
Eucalanus monachus Griesbrecht 1888	X			UCR-2090-04
E. elongatus Dana 1849	X		X	UCR-2102-03
				UCR-2094-04
E. attenuatus Dana 1849	X	X		UCR-2092-01
				UCR-2096-01
Rhincalanus nasutus Giesbrecht 1888	X			UCR-2094-05
Subeucalanus subcrassus Griesbrecht 1888	X		X	UCR-2092-02
				UCR-2102-04
Family Euchaetidae				
Euchaeta wolfendeni Scott A. 1909		X	X	UCR-2097-02
				UCR-2101-03
longicornis Giesbrecht 1888		X		UCR-2097-03
uchaeta sp. Philippi 1843	X	X	X	UCR-2094-06
				UCR-2097-04
				UCR-2102-05
Family Scolecithridae				
Scolecithricella bradyi Griesbrecht 1888	X			UCR-2094-06
S. marginata Griesbrecht 1888		X		UCR-2099-02
Family Temoridae				
Temora discaudata Giesbrecht 1889	X		X	UCR-2088-03
				UCR-2103-02
Temoropia mayumbaensis Scott 1894			X	UCR-2103-03
Family Metridinidae				
Pleuromamma gracilis Claus 1863			X	UCR-2102-06
P. robusta Dahl 1893	X			UCR-2094-08
Family Centropagidae				
Centropages furcatus Dana 1849	X		X	UCR-2090-05
				UCR-2101-04

Table 2 (continued)

	GN	BC	GD	N° CAT.
Family Lucicutiidae				
Lucicutia ovalis Wolfenden 1911			X	UCR-2101-05
Family Augaptilidae				
Haloptilus ornatus Griesbrecht 1892		X		UCR-2098-03
				UCR-2102-07
Family Pseudodiaptomidae G.O. Sars 1903				
Pseudodiaptomus cristobalensis Marsh 1919	X			UCR-2091-01
P. wrigthi Johnson 1964		X	X	UCR-2090-06
				UCR-2103-04
P. panamensis Walter 1989	X			UCR-2090-07
Family Candaciidae				
Candacia catula Giesbrecht 1889			X	UCR-2090-07
Family Pontellidae				
Labidocera acuta Dana 1849	X		X	UCR-2089-01
				UCR-2093-01
				UCR-2100-02
				UCR-2102-08
L. lubbocki Griesbrecht 1892	X		X	UCR-2101-08
Family Acartiidae				
Acartia clausi Giesbrecht 1889	X		X	UCR-2103-05
A. danae Giesbrecht 1889			X	UCR-2091-02
				UCR-2091-06
A. lilljeborgii Griesbrecht 1889	X		X	UCR-2091-03
				UCR-2103-07
A. tonsa Dana 1848			X	UCR-2103-08
Orden Cyclopoidea Burmeister 1834				
Family Oithonidae				
Oithona plumifera Baird 1843	X	X	X	UCR-2094-09
				UCR-2095-03
				UCR-2102-09
O. similis Claus 1863	X	X	X	UCR-2094-10
				UCR-2095-04
				UCR-2102-10
Orden Harparticoida G.O. Sars 1903				
Family Tachidiidae Sars 1909				
Euterpina acutifrons Dana 1852	X		X	UCR-2090-09
				UCR-2101-09
Family Clytemnestridae S. Scott 1909				
Clytemnestra rostrata Brady 1883	X		X	UCR-2090-10
				UCR-2102-11
Family Miraciidae				
Macrosetella gracilis Dana 1852	X		X	UCR-2088-04
				UCR-2099-03
Orden Poecilostomatoida Thorell 1859				
Family Oncaeidae				
Oncaea conifera Griesbrecht 1891	X		X	UCR-2092-04
				UCR-2101-10
O. mediterranea Claus 1863			X	UCR-2101-11
O. venusta Philippi 1843	X	X		UCR-2092-05
				UCR-2095-05
Family Corycaeidae				

Table 2 (continued)

	GN	BC	GD	N° CAT.
Corycaeus bremhi Dana 1849	X			UCR-2090-11
C. flacus Griesbrecht 1891			X	UCR-2102-12
C. speciosus Dana 1849			X	UCR-2102-13
Copilia sp. Dana 1849			X	UCR-2094-11
Familia Clausidiidae Emblenton 1901				
Hemicyclops thalassius Verv.& Ram.1966	X			UCR-2088-05
Family Sapphirinidae				
Sapphirina nigromaculata Claus 1863			X	UCR-2103-09
S. scarlata Griesbrecht 1891	X			UCR-2094-12

Candacia catula, Pseudodiaptomus wrigthi, Centropages furcatus (= velificatus), Labidocera acuta, L. lubbocki, Acartia clausi, A. lilljeborgii, Euterpina acutifrons, Clytemnestra rostrata, Macrosetella gracilis and Oncaea conifera. Other eleven species of calanoids recorded in the Costa Rica Dome (Suárez & Gasca 1989), were common, which show the influence of typical oceanic waters principally at the mouth of Gulf of Nicoya.

Differences were observed in the composition and presence of copepods when the inner (shore station) and outer (offshore station) stations of both gulfs were compared. The Gulf of Nicoya was dominated in its upper (shore stations) part by typical neritic estuarine species like *Acartia lilljenborgii* and *Hemyciclops thalassius* as well as species of *Pseudodiaptomus*. The former species is the most abundant in the Gulf of California (Briton *et al.* 1986) displacing *A. tonsa* during summer. *H.thalassius* is a typical species from estuarine waters (Björnberg, 1981). The genus *Pseudodiaptomus* is circumglobal in tropical and temperate, shallow coastal waters (Walter 1989). The majority of the species found in this part of the Gulf of Nicoya are common in estuarine regions (Björnberg, 1981) and associated with the continental shelf. Some of them have been observed in equatorial waters from the east Pacific (Grice 1961) and from other regions such as the Indian Ocean (Kasturisangan 1963) and tropical Atlantic (Björnberg, 1963). Circumglobal distributions are widely accepted as commonplace among the epiplanktonic copepods occurring in warm oceanic waters (Fleminger & Hulsemann 1973).

Acartia lilljenborgii was the most numerous species. *Acartia* species generally dominate different estuarine systems (Kimmerer & McKinnon 1987) probably because they are very well adapted to maintain high clearance rates (Paffenhöfer & Stearns 1988). Also, estuarine zooplankton, like other estuarine fauna, is usually more abundant and less diverse than oceanic zooplankton (Riley 1967), which was observed in both gulfs for mesozooplankton, especially copepods (Morales & Molina in prep.) and for chaetognats (Hossfeld 1996). Molina (1996) found differences in the ichthyoplankton neritic-and oceanic assemblages between inner and outer stations. Families like Engraulidae, Scianidae and Gobiidae were typical of inner and central stations, while Myctophidae, Bregmacerotidae and Trichiuridae dominated the outer stations.

This is a clear example of the differences in the biological response to the environment of the organisms in the Gulf of Nicoya. However much more effort is required to understand the proper biology of the species.

Both small species like *Oncaea venusta*, as well as larger species like *Pleuromamma robusta*, *Eucalanus attenuatus*, *E. elongatus* and *Rhincalanus nasutus* were typical of offshore stations of the Gulf of Nicoya. *Oithona plumifera* and *O. similis* were found in the lower part too and both species are typical of oceanic waters. Small copepods like *Oncaea* and *Oithona* are considered, on a physiological basis, as stabilizers of the marine enviromment (Paffenhöfer 1993), because of their limited specialization. Compared with calanoids, they could be seen having an advantage in survival over an extended range of environmental conditions (Paffenhöfer 1993), although they were not found in the upper part of the gulf. However *Oithona* spp. were common along the Pacific coast.

The larger species like *P. robusta, Calanus minor*, *Eucalanus* spp. and *R. snasutus* were

found during February and contributed significantly to biomass (Morales & Molina in prep.). The influence of water masses originating mainly in the Equatorial Countercurrent appear to be reflected here. *Eucalanus* species are typical of equatorial waters (Grice 1961). Some of these species were more abundant in the Costa Rica Dome Region (Suárez & Gasca 1989).

Coronado Bay was characterized by the presence of typical oceanic species like *Neocalanus gracilis, Euchaeta longicornis, Eucalanus attenuatus* and *Haloptilus ornatus* with more transitional species like *Clausocalanus pergens* and *C. furcatus* reflecting closeness to the coast. *Paracalanus parvus* was found in the closer stations. It is a conspicuous member of the continental association and a species with a broader distribution (Raymont 1983). A strong gradient of species richness (Morales, in prep.) can be seen: typical oceanic species were more common at station 1 and 2 where a high species number, while more neritic species were common at stations 3 and 4, where there was an apparent decrease in the number of species. Larval fish of the open waters of this area are typical oceanic forms (Hossfeld *et al.* 1994).

In the Golfo Dulce differences in the copepod groups were also observed, but the separation of species was less evident. Outer stations were represented by oceanic species like *Paracalanus aculeatus, Pleuromamma gracilis, Lucicutia ovalis, Candacia catula, Euchaeta wolfendeni* and *Oncaea mediterranea*. Two species of *Coryceaus, C. flaccus* and *C. speciosus* were identifed in the outer stations of Golfo Dulce, which reflect the typical oceanic character of these waters. On the other hand, the inner station, located at the upper part of the Gulf, was characterized by a mixed copepod group, with both neritic species like *Pseudodiaptomus wrigthi, Acartia danae, A. clausi and Canthocalanus pauper,* as well as oceanic species like *Scolicithricella marginata, Saphirina nicromaculata* or *Oncaea conifera.* Saphirinid copepods are distribuited widely in the tropical and subtropical waters of the world's oceans, but rarely predominate in epipelagic copepod communities (Chae & Nishida 1995). Oncaedids are more typical oceanic organisms (Böttger-Schnack 1990a;b), although *O. conifera,* a species distributed widely from 60° S to 60°N in both oceans (Malt 1983), was apparently introduced, like *S. nicromaculata* and *S. marginata* in the Golfo Dulce. *S. marginata* dominated the abundance of copepods assemblages at St. 01 in the inner part of the gulf (Morales & Molina in prep.). If deep water renewal occurs at least once or twice per year (Richards *et al.* 1971), the entrainment of denser water likely occurs during the dry season. Observations made in the dry season failed to show deep water replacement (Brenes & Leon 1988) within a 19-day period. In 1990 major entrainment events occurred twice during the dry season, within a 14-16 week interval (Yokihara 1992). So it seems that many typical oceanic copepods are introduced into the Golfo Dulce and are mixed with more typical estuarine copepod assemblages. The inner stations of Golfo Dulce show a more estuarine behavior due to runoff waters from Rincon and Esquinas rivers. Molina (1996) found that ichthyoplankton was more uniformely distributed across the basin in Golfo Dulce, contrary to those in Gulf of Nicoya. The high abundance of *Sagitta popovici*, a neritic species of chaetognath, points to the neritic-estuarine character of inner stations of Golfo Dulce (Hossfeld 1996).

The Gulf of Nicoya and Golfo Dulce represent two different ecosystems. The composition and dominance of copepod species show that the dynamics and mechanisms which dominate the biology of both gulfs are different. Others differences such as relatively continuous biomass spectra (von Wangelin & Wolff 1996, Morales & Molina, in prep.) suggest different conditions for the development of zooplankton communities in the two gulfs.

ACKNOWLEDGEMENTS

I would like to thank the captain and crew of the Victor Hensen for their help during the cruise legs of this study. My sincere thanks go to Priscilla Cubero for separating copepods and Paul Hanson for help with English. This is CIMAR Contribution No. 240.

RESUMEN

Se presenta una lista de 54 especies de copépodos (Crustacea) representados en 23

familias de la costa Pacífica de Costa Rica. La identificación de las especies fue hecha de muestras de zooplancton de la Expedición Víctor Hensen durante diciembre de 1993 y febrero de 1994 en colaboración con el Centro de Ecología Marina Tropical de la Universidad de Bremen, República Federal de Alemania. El zooplancton fue muestreado con una red tipo Bongo (0.60 m de boca, 2.50 m de longitud) con 200 µm de poro. Se hizo arrastres oblicuos de algunos metros arriba del fondo hasta la superficie a una velocidad de arrastre de aproximadamente un nudo.37 especies (68.5%) fueron identificadas para el Golfo de Nicoya, 36 (66.6%) para el Golfo Dulce y 17 (31.4%) comunes a ambos golfos; 12 especies (22.2%) fueron identificadas para la Bahía de Coronado. Cuatro especies (7.4%) estuvieron distribuídas a largo de la costa y fueron comunes en las tres regiones: *Paracalanus parvus, Euchaeta* sp., *Oithona plumifera* y *O. similis*. Once especies de calanoideos, registrados en el Domo de Costa Rica, muestran la influencia de aguas típicamente oceánicas principalmente en la boca del golfo de Nicoya. Hubo diferencias en la composición y presencia de especies de copépodos cuando fueron comparadas las partes internas y externas de ambos golfos (parte superior y parte inferior). El golfo de Nicoya estuvo dominado en su parte superior por especies de copépodos típicamente neríticas-estuarinas como *Acartia lilljenborgii, Paracalanus parvus, Hemyciclops thalassius* así como también por especies del género *Pseudodiaptomus*. Por otro lado especies más oceánicas fueron observadas en la parte más baja del golfo. Tanto especies pequeñas como *Oncaea venusta,* como también especies más grandes como *Pleuromamma robusta, Eucalanus attenuatus, E. elongatus* y *Rhincalanus nasutus* fueron típicas de éstas aguas. *Oithona plumifera* y *O. similis* fueron encontradas en la parte inferior del golfo y son típicas de aguas oceánicas. La región de la Bahía Coronado estuvo caracterizada por la presencia de especies oceánicas como *Neocalanus gracilis, Euchaeta longicornis, Eucalanus attenuatus* y *Haloptilus ornatus* con una copepofauna más transicional dominada por especies como *Clausocalanus pergens* y *C. furcatus* conforme se acercó a la costa. En el Golfo Dulce también hubo diferencias, pero la separación de las especies no fue tan evidente. Las estaciones externas estuvieron representadas por especies oceánicas como *Paracalanus aculeatus, Pleuromamma gracilis, Lucicutia ovalis, Candacia catula, Euchaeta wolfendeni* y *Oncaea mediterranea*, mientras que las estaciones internas estuvieron más caracterizadas por una mezcla de especies tanto neríticas (*Pseudodiaptomus wrigthi, Acartia danae, A. clausi, Canthocalanus pauper*) como oceánicas (*Scolicithricella marginata, Saphirina nicromaculata* y *Oncaea conifera*). Dos especies de *Coryceaus, C. flaccus* y *C. speciosus* fueron identificadas de las estaciones externas del Golfo de Nicoya mientras que *C. brehmi* fue encontrada en estaciones internas del Golfo de Nicoya. Este artículo constituye un trabajo adicional acerca de los copépodos del Golfo de Nicoya y el primer reporte de especies de copépodos para la región de Bahía Coronado y Golfo Dulce.

REFERENCES

Björnberg, T.K.S. 1963. On the marine free living copepods off Brazil. Bull. Inst. Oceanog. Univ. Sao Paulo 13: 3-142.

Björnberg, T.K.S. 1981. Copepoda, p. 587-679. *In* D. Boltovskoy (ed.). Atlas del Zooplancton del Atlántico Sudoccidental y métodos de trabajo con el zooplancton marino. INEDEP, Mar del Plata, Argentina.

Böttger-Schnack, R. 1990a. Community structure and vertical distribution of cyclopoid copepods in the Red Sea. I. Central Red Sea, autumm 1980. Mar. Biol. 106: 473-485.

Böttger-Schnack, R. 1990b. Community structure and vertical distribution of cyclopoid copepods in the Red Sea. II. Aspects of seasonal and regional differences. Mar. Biol. 106: 487-501.

Brenes, C.L. & S. León. 1988. Algunos aspectos físico-químicos del Golfo Dulce. Ing. Cienc. Quím. 12: 12-16.

Briton, E., A. Fleminger & D. Siegel-Causey. 1986. The temperate and tropical planktonic biotas of the Gulf of California. Cal. COFI Report. XXVII: 228-266.

Campos, A. & E. Suárez-Morales. 1994. Copépodos pelágicos del Golfo de México y mar Caribe.I. Biología y Sistemática. Centro de Investigaciones de Quintana Roo, México. 353p.

Chae, J. & S. Nishida. 1995. Vertical distribution and diel migration in the irridescent copepods of the familiy Sapphirinidae: a unique example of reverse migration?. Mar. Ecol. Progr. Ser. 119: 111-124.

Dittel, A.I. & C.E. Epifanio. 1990. Seasonal and tidal abundance of crab larvae in a tropical mangrove system, Gulf of Nicoya, Costa Rica. Mar. Ecol. prog. Ser. 65: 25-34.

Dittel, A.I.,C.E. Epifanio & O. Lizano. 1991. Flux of crab larvae in a mangrove creek in the Gulf of Nicoya, Costa Rica. Est. Coast. Shelf Sci. 32: 129-140.

Dudley, P.C. 1986. Aspects of general body shape and development in Copepoda. Syllogues 59: 7-25.

Epifanio, C.E. & A.I. Dittel. 1984. Seasonal abundance of brachyuran crab larvae in a tropical estuary: Gulf of Nicoya, Costa Rica, Central America. Estuaries 7: 501-505.

Fleminger, A. & K. Hulsemann. 1973. Relationship of indian epiplanktonic calanoids to the world ocean. p.:339-347. *In* B. Zeitzchel (ed.) The Biology of the Indian Ocean. Springer-Verlag, Berlin.

Frost, B. & A. Fleminger. 1968. A revision on the genus *Clausocalanus* (Copepoda:Calanoida) with remarks on distributional patterns in diagnostic characters. University of California, Los Angeles, California. 235p.

Gocke, K., J. Cortés & C. Villalobos. 1990. Effects of red tides on oxygen concentration and distribution in the Gulf of Nicoya, Costa Rica. Rev. Biol. Trop. 38: 425-429.

Grice, G.D. 1961. Calanoid copepods from equatorial waters of the Pacific Ocean. Fish. Bull. 61: 171-246.

Griesbrecht, W. 1892. Systematik und Fauna der pelagischen Copepoden des Golfes von Neapel. Fauna Flora Golf Neapel. Monogr. 19: 1-831.

Hargraves, P.E. & R. Víquez. 1981. The dinoflagellate red tide in Golfo de Nicoya, Costa Rica. Rev. Biol. Trop. 29: 31-38.

Hargraves, P.E. & R. Víquez. 1985. Spatial and temporal distribution of phytoplankton in the Gulf of Nicoya, Costa Rica. Bull. Mar. Sci. 37: 577-585.

Hossfeld, B. 1996. Distribution and biomass of species of chaetognats in Golfo de Nicoya and Golfo Dulce, Costa Rica. Rev. Biol. Trop. 44. Suppl. 3: 157-172.

Hossfeld, B., H. Molina-Ureña & A. Morales-Ramírez.1994. Zooplankton. p.:42-53. *In* M. Wolff and J.A. Vargas (eds.) RV Victor Hensen Costa Rica Expedition 1993/1994. Cruise Report. Center for Tropical Marine Ecology, Bremen.

Huys, R. & G.A. Boxshall. 1991. Copepod Evolution. The Ray Society, London. 468p.

Kasturirangan, L.R. 1963. A key for the identification of the more common planktonic copepods of Indian coastal waters. Council Sci. & Industrial Research, New Dehli. 87p.

Kimmerer, W.J. & A.D. McKinnon. 1987. Zooplankton in a marine bay. I. Horizontal distribution used to estimate net population growth rates. Mar. Ecol. Prog. Ser. 41: 43-52.

Longhurst, A.R. 1985. Relationship between diversity and the vertical structure of the upper ocean. Deep Sea Res. 32: 1535-1570.

Malt, S.J. 1983. Copepoda, Oncaea. Fisch Ident. Zooplankton 169/179/171. 11pp. Conseil Intern. Pour L'Expl. Mer.

Molina-Ureña, H. 1996. Ichthyoplankton assemblages in the Gulf of Nicoya and Golfo Dulce embayments, Pacific coast of Costa Rica. Rev. Biol. Trop. 44. Suppl. 3: 173-182.

Morales-R., A. & J. A. Vargas. Especies comunes de copépodos pelágicos (Crustacea:Copepoda) del Golfo de Nicoya. Rev. Biol. Trop. 43: 207-218.

Mori, T. 1964. The pelagic copepods from the neighbouring waters of Japan. Soyo, Tokio. 150p.

Paffenhöfer, G.-A. 1993. On the ecology of marine cyclopoid copepods (Crustacea, Copepoda). J. Plankton Res. 15:37-55.

Paffenhöffer, G.A. & D.E. Stearns. 1988. Why is *Acartia tonsa* (Copepoda:Calanoidea) restricted to nearshore environments?. Mar. Ecol. Progr. Ser. 42: 33-38.

Raymont, J.E.G. 1983. Plankton and productivity in the oceans. Vol. II. Zooplankton. Pergamon, Oxford. 824 p.

Richards, F.A., J.J. Anderson & J.D. Cline. 1971. Chemical and physical observations in Golfo Dulce, an anoxic basin in the Pacific coast of Costa Rica. Limnol. & Oceanogr. 16: 43-50.

Riley, G.A. 1967. The plankton of estuaries. p.: 316-326. *In* G.H. Lauff. (ed.). Estuaries. American Association for the advancement of Science. Washington, D.C.

Roman, M.R. 1991. Pathways of carbon incorporation in marine copepods: effects of development stage and food quality. Limnol. & Oceanogr. 36: 796-807.

Rose, M. 1933. Faune du France. 26. Copépodes Pélagiques. Paris. 373p.

Suárez, E. & R. Gasca. 1989. Copépodos calanoides epipelágicos del Domo de Costa Rica (Junio-Agosto, 1982). Ciencias Marinas 15: 89-102.

Vidal, J. 1980. Physioecology of zooplankton. I. Effects of phytoplankton, temperature and body size on the growth rate of *Calanus pacificus* and *Pseudocalanus* sp. Mar. Biol. 56: 111-134.

Von Wangelin, M. & M. Wolff. 1996. Comparative biomass spectra and species composition of the zooplankton communities of Golfo Dulce and Golfo Nicoyas ecosystems. Rev. Biol.Trop.44. Suppl. 3:135-155.

Walter, T. Ch. 1989. Review of the new world species of *Pseudodiaptumus* (Copepoda:Calanoida) with a key to the species. Bull. Mar. Sci. 45: 590-628.

Weikert, H. 1984. Zooplankton distribution and hydrography in the Mauritanian upwelling region off northwestern Africa, with special reference to the calanoid Copepods. Meeresforsch. 30: 155-171.

Wolff, M. & J.A. Vargas. 1994. RV Victor Hensen Costa Rica Expedition 1993/1994. Cruise Report. Center for Tropical Marine Ecology, Bremen. 109p.

Yokihara, H. 1992. Algunos parámetros del ambiente acuático de la Bahía Golfito y el Golfo Dulce relacionados con su potencial para el cultivo de moluscos. Unpublished manuscript. Escuela de Ciencias Biológicas, Universidad Nacional, Heredia, Costa Rica. 23p.