

Neocyclops Gurney from Brazilian sandy beaches (Copepoda: Cyclopoida)

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Abstract

Neocyclops medius Herbst, 1955 and *Neocyclops vicinus* (Herbst, 1955) are redescribed from intertidal interstitial water of sandy beaches along the Brazilian coast. The male of *N. vicinus* is described for the first time.

Neocyclops vicinus can be easily distinguished from *N. medius* by the relatively longer caudal rami, the presence of a mandibular palp, and the sexually dimorphic antenna.

This study revealed the leg 4 endopodite segments 2 and 3 as being fused in both species. The terminal segment of the 2-segmented leg 4 endopodite of the copepodite 5 does not differentiate into 2 distinct segments during the molt to adult. The plane of fusion is marked by a thin and incomplete line on the frontal surface. This scar was erroneously interpreted as a functional articulation by Herbst (1955). Topotypes of *N. salinarum* (Gurney, 1927) examined showed a similar fusion of those segments of leg 4.

Populations from the Black Sea coast ascribed to *N. vicinus* differ from the Brazilian specimens in a number of morphological details, sufficient to propose that they represent a separate taxon, perhaps *N. remanei* (Herbst, 1952).

A diagnosis for *Neocyclops* is provided.

Résumé

Redescription de *Neocyclops medius* Herbst, 1955 et de *N. vicinus* (Herbst, 1955) des eaux interstitielles intercotidales des plages de sable le long des côtes du Brésil. Le mâle de *N. vicinus* est pour la première fois décrit.

Neocyclops vicinus peut être aisément distingué de *N. medius* par ses branches furcales relativement plus longues, la présence d'un palpe mandibulaire et l'antenne à dimorphisme sexuel.

Les articles 2 et 3 de l'endopodite de la patte 4 sont fusionnés dans les deux espèces. L'article terminal de l'endopodite biarticulé de la patte 4 du copépodite 5 ne devient pas biarticulé pen-

dant la mue de ce copépodite; le plan de fusion est marqué par une ligne peu distincte et incomplète sur la surface frontale – ligne par erreur interprétée par Herbst (1955) comme articulation fonctionnelle. Des topotypes de *N. salinarum* (Gurney, 1927) examinés, montrent une fusion similaire de ces articles de la patte 4.

Des populations de la Mer Noire considérées comme appartenant à *N. vicinus* diffèrent des exemplaires du Brésil par plusieurs détails morphologiques, ce qui permet la supposition qu'il s'agirait d'un taxon distinct (peut-être *N. remanei* (Herbst, 1952)).

Une diagnose du genre *Neocyclops* est donnée.

Introduction

Neocyclops has been recorded living in coastal and brackish waters, mostly in interstitial waters.

Petkovski (1986) provided the best critical review of the taxonomic position of the 12 species and subspecies of the genus. He confirmed the opinion that *Neocyclops* should be considered a senior synonym of *Eurycyclops* Sewell, 1949 and *Pareuryte* Herbst, 1952, as was definitively proposed by Pleșa (1981). Pesce (1985), Dussart & Defaye (1985), and Herbst (1986) also accepted Pleșa's proposition. Based on the number of segments comprising the leg 5 exopodite in males, Petkovski (1986) recognized two groups of species, which were considered of subgeneric rank. Species having leg 5 exopodite 2-segmented were included in *Protoneocyclops*, while those species with leg 5 exopodite 1-segmented were grouped in *Neocyclops* s. str. The diagnostic character of *Protoneocyclops* suggested

by Petkovski corresponds to the ancestral state within the cyclopoids (Huys & Boxshall, 1991).

Herbst (1986) listed 5 species of *Neocyclops* from marine interstitial waters. In Brazil, the genus is represented by *Neocyclops (Neocyclops) medius* Herbst, 1955 and *N. (N.) vicinus* (Herbst, 1955), both from sandy beaches in Ilhabela (State of São Paulo) and in Salvador (State of Bahia). During an intensive and extensive survey of the intertidal interstitial fauna along the coast of the State of São Paulo, the two species were commonly found and a reasonable number of specimens could be collected. In addition, a few specimens of *N. vicinus* were identified from a sample from a sandy beach in Salvador (State of Bahia). Based on this material, the species are redescribed here.

Material and methods

The interstitial fauna was collected in the intertidal zone of sandy beaches. The interstitial water, collected in holes dug into the beach during low tide, was filtered through a 125 or 200 μm mesh, and the animals retained were fixed in 4% formalin. Harpacticoids and specimens of *Halicyclops*, *Procyelopina*, *Cyclopina*, and *Cuipora* were collected together with *Neocyclops* (Lotufo & Da Rocha, 1991; Lotufo & Da Rocha, 1993). Granulometric and salinity analyses were carried out only for samples from São Paulo collected by G.R. Lotufo.

Intact specimens were examined in 85% lactic acid. Dissected parts were mounted in glycerine in slides sealed with glyceel for preparing drawings with a camera lucida on a Leitz Laborlux microscope.

Some of the specimens examined were deposited in the Museu de Zoologia, Universidade de São Paulo (MZUSP), São Paulo. The remaining material is in C.E.F. da Rocha's collection at the Departamento de Zoologia, Universidade de São Paulo.

The terminology applied to body and appendage segmentation follows that of Huys & Boxshall (1991).

Taxonomy

Family CYCLOPIDAE Burmeister, 1834

Subfamily HALICYCLOPINAE Kiefer, 1927

Neocyclops medius Herbst, 1955

(Figs. 1–17)

Holotype not examined.

Material examined. – Brazil, State of São Paulo. Carlos E.F. da Rocha leg.: Ubatuba: Codó beach (23°30'S 45°7'20"W), 4 Nov. 1983, 36 ♀♀ and 2 ♂♂.

Liliana Forneris leg.: Ubatuba, Codó beach, 22 Feb. 1972, 4 ♀♀; Lamberto beach (23°29'55"S 45°7'15"W), 25 Feb. 1972, 2 ♀♀; Ilhabela: Siriúba beach (23°45'5"S 45°21'15"W), 29 May 1975, 7 ♀♀ and 1 ♂.

Guilherme R. Lotufo leg.: Ubatuba: Codó beach, 6 July 1991, 20 ♀♀ and 10 ♂♂; São Sebastião: Cigarras beach (23°45'15"S 45°24'45"W), 17 Sep. 1990, 1 ♀; São Francisco beach (23°45'30"S 45°24'40"W), 17 Sep. 1990, 2 ♀♀ and 2 ♂♂; 14 June 1991, 2 ♀♀ and 2 ♂♂; Olaria beach (23°46'S 45°24'20"W), 15 June 1991, 20 ♀♀ and 13 ♂♂; Arrastão beach (23°46'20"S 45°24'15"W), 17 Sep. 1990, 1 ♀; 11 March 1991, 2 ♀♀; Pontal da Cruz beach (23°46'40"S 45°24'W), 17 Sep. 1990, 8 ♀♀; 11 March 1991, 2 ♀♀; Deserta beach (23°47'5"S 45°24'20"W), 17 Sep. 1990, 3 ♀♀; 11 March 1991, 1 ♂; Calhetas beach (23°49'15"S 45°28'10"W), 16 Sep. 1990, 1 ♀; Ilhabela: Pinto beach (23°44'30"S 45°20'52"W), 10 March 1991, 1 ♀ and 1 ♂; Garapocia beach (23°44'50"S 45°20'50"W), 10 March 1991, 1 ♀; Viana beach (23°45'50"S 45°21'50"W), 6 Nov. 1990, 2 ♀♀; 10 March 1991, 3 ♀♀ and 2 ♂♂; Engenho d'Água beach (23°47'25"S 45°21'50"W), 6 Nov. 1990, 2 ♀♀.

Lot of 36 ♀♀ and 1 ♂ from Codó beach and lot of 21 ♀♀ and 6 ♂♂ from Olaria beach, São Sebastião in MZUSP (coll. nrs. 11383 and 11384, respectively)

Description of female. – Body length 605–700 μm ($n = 10$). Prosome: urosome ratio = 1.3–1.4 : 1. Posterior margin of all prosomites and urosomites (except anal somite) smooth (Fig. 1). Genital double somite (Fig. 2) about as long as wide and with lateral expansions bearing spiniform projections at first third. Seminal receptacle as shown in Fig. 2. Anal somite with row of spinules on posterior edge. Pseudopericulum as in *N. vicinus* (Fig. 19). Caudal rami (Fig. 3) 1.5–1.7 times longer than wide. Dorsal seta 1.7 times longer than outer apical seta. Inner apical seta 1.3 times longer than outer apical seta. All caudal setae plumose.

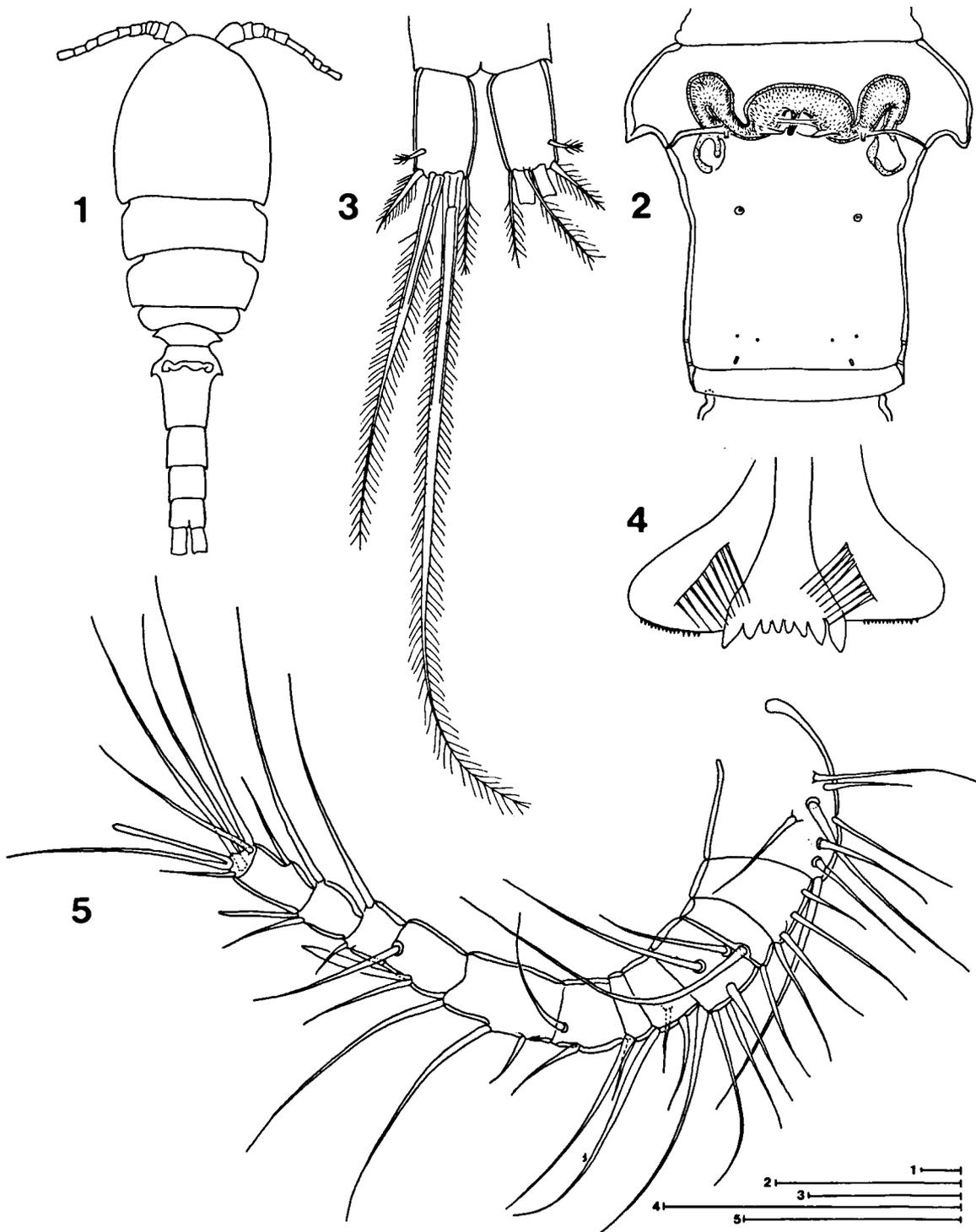
Labrum (Fig. 4) with 6–10 teeth on free margin.

Antennule (Fig. 5) 12-segmented. Armature as follows (Roman numeral = segment; Arabic numeral = seta; ae = aesthetasc): I - 8; II - 4; III - 2; IV - 6; V - 3; VI - 2; VII - 2; VIII - 3; IX - 2 + ae; X - 2; XI - 2 + ae; XII - 7 + ae.

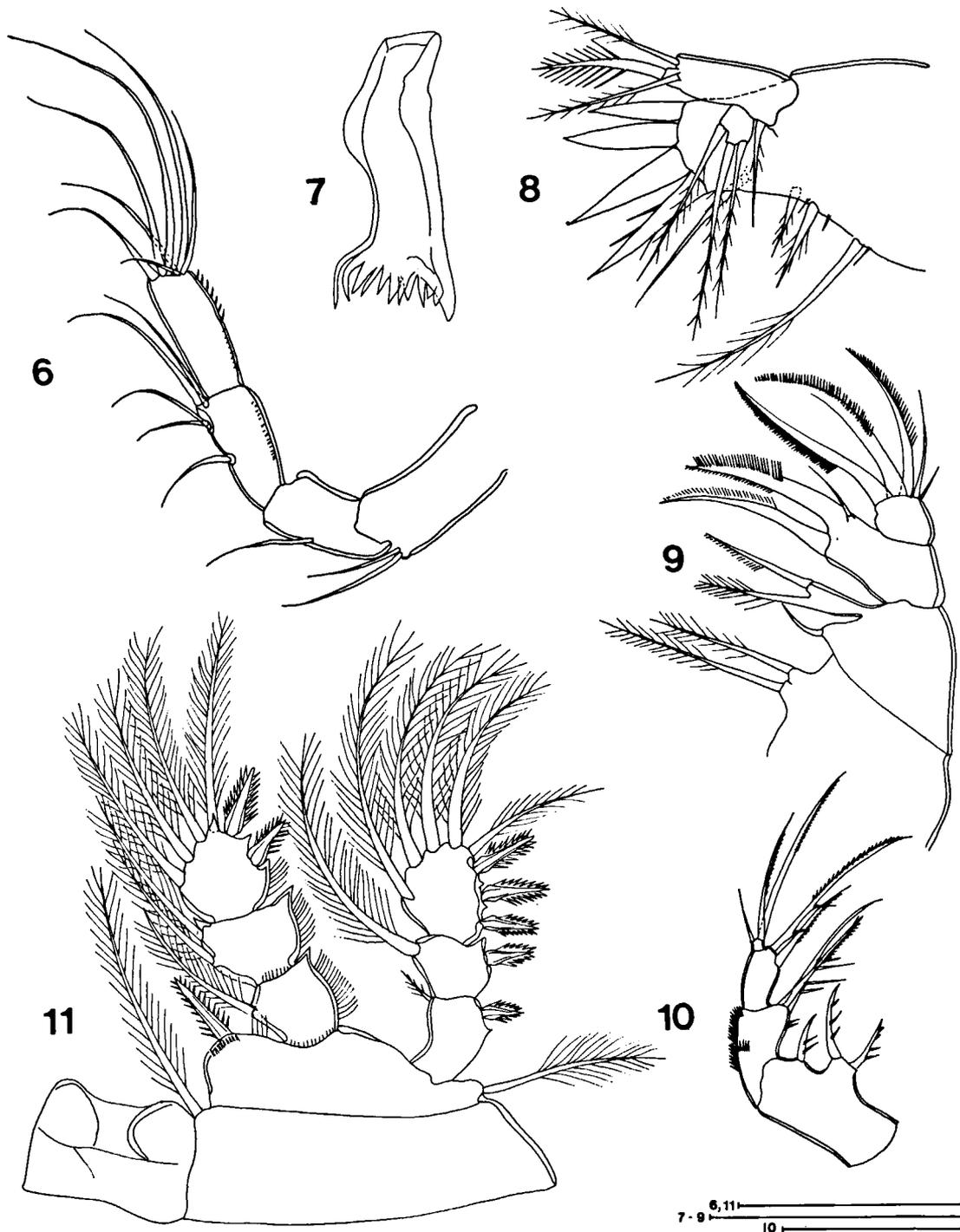
Antenna (Fig. 6) 4-segmented. Basis with 2 inner apical setae. Endopodite segments 1–3 with 1, 5, and 7 setae, respectively. Seta representing exopodite lacking.

Mandible (Fig. 7) reduced to coxa with gnathobase. Palp lacking.

Maxillule (Fig. 8) with enlarged praecoxa bearing



Figs. 1–5. *Neocyclops medius* Herbst, 1955, ♀ from Codó beach, Ubatuba: 1, habitus, dorsal; 2, genital double somite, ventral, showing seminal receptacle; 3, caudal rami, dorsal; 4, labrum; 5, antennule. Scale bars 50 μ m.

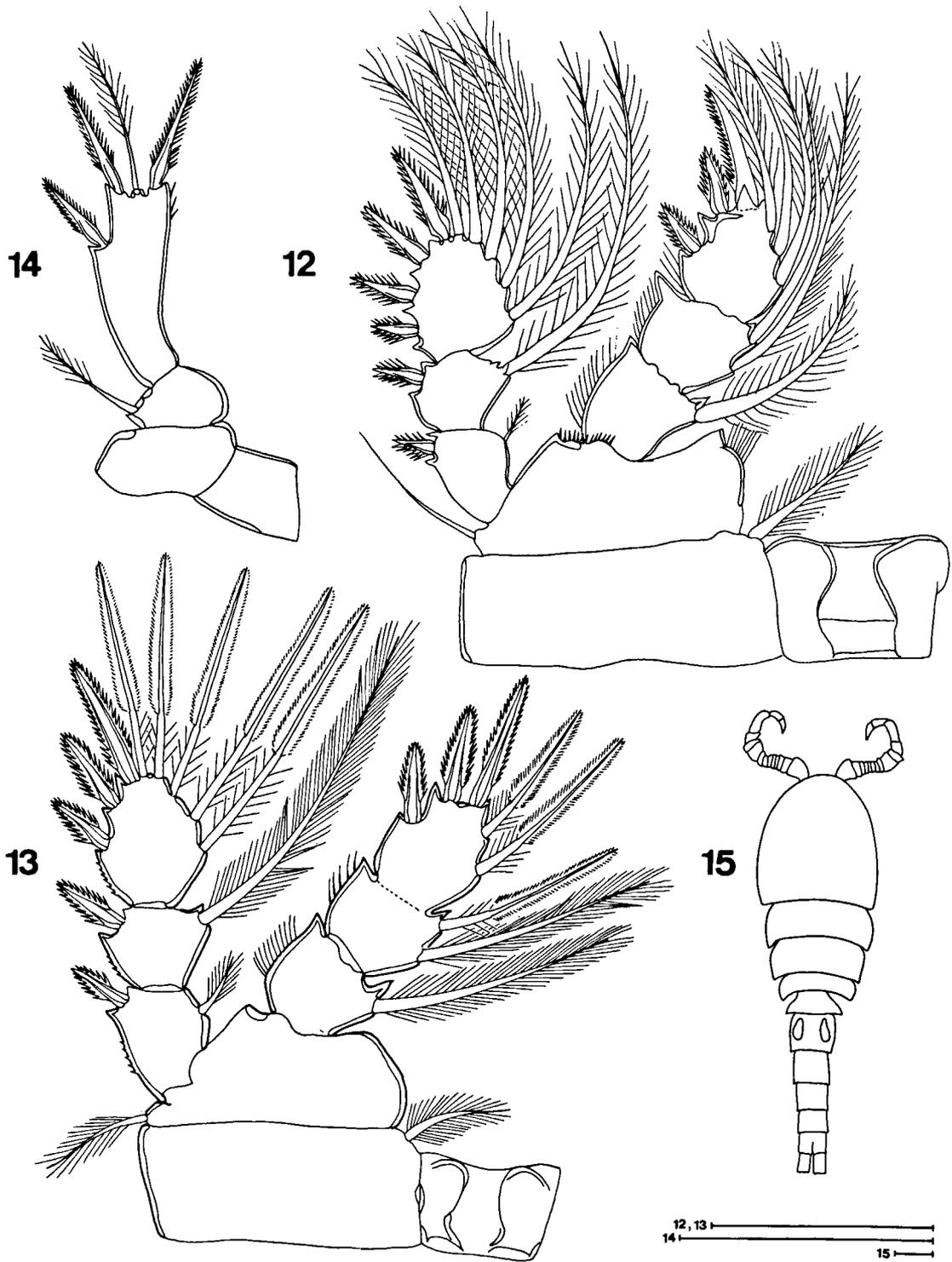


Figs. 6–11. *Neocyclops medius* Herbst, 1955, ♀ from Codó beach, Ubatuba: 6, antenna; 7, mandible; 8, maxillule; 9, maxilla; 10, maxilliped; 11, leg 1. Scale bars 50 μ m.

arthrite with 7 setae on inner face and 4 spines on distal margin. Palp consisting of long basis bearing 3 setae on inner margin, 1 proximal seta represent-

ing exopodite, and endopodite 1-segmented with 3 setae.

Maxilla (Fig. 9) 4-segmented. Praecoxa bearing



Figs. 12–15. *Neocyclops medius* Herbst, 1955, from Codó beach, Ubatuba: 12, ♀ leg 3; 13, ♀ leg 4, caudal face; 14, ♂ leg 5; 15, ♂ habitus, dorsal. Scale bars 50 μ m.

endite with 2 setae. Coxa bearing 2 endites, proximalmost with 1 seta and distalmost, enlarged, with 2 setae. Basis drawn out into claw fused to endite, with 1 stout seta longer than claw and 1 reduced seta set basally on claw. Free endopodite 1-segmented with 5 setae.

Maxilliped (Fig. 10) 4-segmented. Syncoxa with 3 setae. Basis with 2 setae. Endopodite 2-segmented, with 2 setae on proximal segment and 3 setae on distal segment.

Legs 1–4 armature as follows (Roman numerals representing spines; Arabic numerals indicating setae):

	Coxa	Basis	Endopodite	Exopodite
Leg 1	0-1	I-1	0-1, 0-2, II-4	I-1, I-1, III-5
Leg 2	0-1	I-0	0-1, 0-2, III-3	I-1, I-1, IV-5
Leg 3	0-1	I-0	0-1, 0-2, III-3	I-1, I-1, IV-5
Leg 4	0-1	I-0	0-1, 0-2, III-2	I-1, I-1, III-5

Leg 1 exopodite segment 1 (Fig. 11) with very reduced inner seta. Leg 2 differing from leg 3 (Fig. 12) in size and in having more slender spines on exopodite. Leg 4 endopodite segments 2 and 3 (Fig. 13) fused, scar visible as thin and incomplete suture only on frontal surface. Leg 4 endopodite segment 2 with 3 inner distal setae, and all setae on exopodite segment 3 modified, being plumose proximally and with hyaline membrane finely serrate distally.

Leg 5 (Fig. 14) 3-segmented, joined by intercoxal sclerite. Coxa unarmed. Basis with 1 plumose outer seta. Terminal segment (exopodite) 3 times longer than wide, with 3 spines shorter than segment and 1 seta; inner apical spine about 1.1 times longer than outer apical spine, and 1.4 times longer than lateral spine.

Description of male (Fig. 15). – Body length 465–520 μm ($n = 10$). Prosome : urosome ratio = 1.3 : 1. Urosome with 6 somites.

Antennule 16-segmented, armed as in *N. vicinus* (cf. Fig. 22).

Leg 5 (Fig. 16) with 1 inner seta in addition to elements present in female.

Leg 6 (Fig. 17) consisting of serrate inner spine and 2 setae.

The male is identical to the female in all other respects.

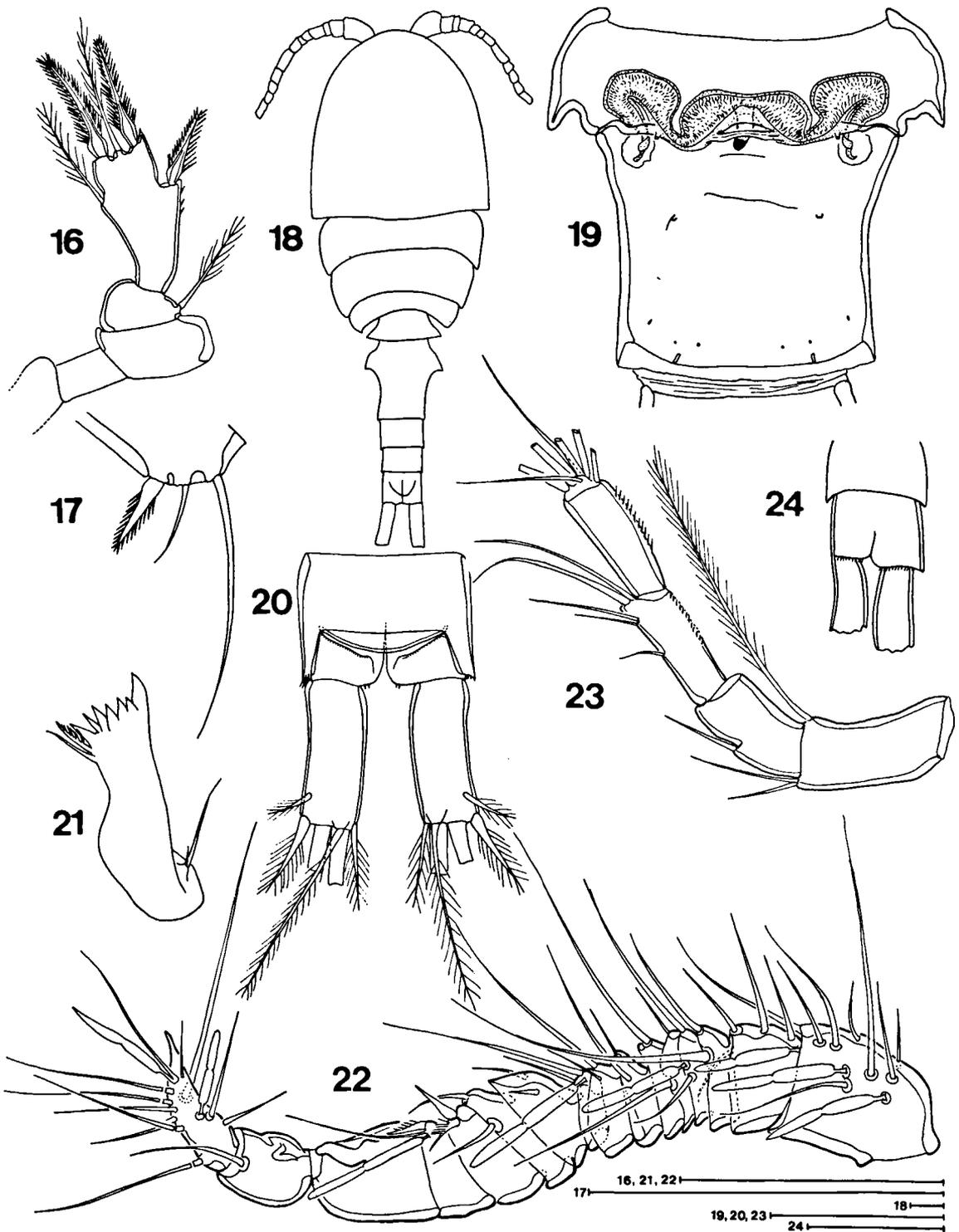
Habitat. – Medium and coarse sand (median grain size 300–1150 μm). Salinity ranged from 1 to 32‰. Temperature ranged from 20 to 32°C.

Distribution. – Brazil, State of Bahia: Salvador (type-locality); State of São Paulo: Ubatuba, São Sebastião, and Ilhabela. West Indies: Tortuga, Blanquilla, Los Roques, Margarita, and Bonaire (Pesce & Galassi, 1993).

Discussion. – The specimens were identified as *Neocyclops medius* because they agreed with the original description in respect to body shape and length, shape of genital double somite, proportions and armature of caudal rami, absence of mandibular palp, and armature of leg 5 in both male and female.

There are differences between Herbst's (1955) description and the specimens examined here. Herbst represented the leg 4 endopodite as 3-segmented and apparently had no difficulty in observing an articulation between the second and third segments. He did not point it out in the text. In the specimens from our samples, this articulation is seen as a thin and incomplete suture on the frontal surface and is interpreted as the fusion scar between those two segments. No line could be seen on the caudal surface. Examination of the copepodid stages revealed that what actually happens is a failure of division of the terminal segment of the leg 4 exopodite of the copepodite into 2 segments during the molt to adult. If these scars also occurred in Herbst's specimens, one may suppose that he considered them a functional articulation. The transformation of plumose setae into modified ones occurs in the change from copepodid 5 to 6. Herbst did not represent the distal seta of leg 4 endopodite segment 2, making it impossible to know whether it was modified. He did not represent the short seta on the leg 1 exopodite 1 in his drawings either.

Within *Neocyclops*, only *N. salinarum* (Gurney, 1927), the type-species, and *N. medius* have the mandible lacking a palp. *Neocyclops salinarum* differs from *N. medius* in possessing an antennule of 8 segments and, according to Por's (1973) re-description, in possessing a seta representing the exopodite of the antenna. Examination of speci-



Figs. 16–17. *Neocyclops medius* Herbst, 1955, ♂ from Codó beach, Ubatuba: 16, leg 5; 17, leg 6.

Figs. 18–24. *Neocyclops vicinus* (Herbst, 1955), from Codó beach, Ubatuba: 18, ♀ habitus, dorsal; 19, ♀ genital double somite, ventral, showing seminal receptacle; 20, ♀ anal somite and caudal rami; 21, ♀ mandible; 22, ♂ antennule; 23, ♂ antenna; 24, ♂ abnormal caudal rami. Scale bars 50 μm.

mens of *N. salinarum* from the Sirbonian Lagoon (Sabkhat and Bardawil), Mediterranean coast of Sinai, kindly provided to us by Dr. F.D. Por, confirmed both the presence of the outer seta on the basis of the antenna in both sexes and a fusion between leg 4 endopodite segments 2 and 3 as observed in our specimens of *N. medius*. Both Gurney (1927) and Por (1973) lapsed in observation by representing the leg 4 endopodite as having 3 segments. The fusion is clearly seen when the articulation between the endopodite segments 2 and 3 of the leg 4 is compared to the actually functional articulations on leg 4, as well as to those on other swimming legs.

Neocyclops vicinus (Herbst, 1955)
(Figs. 18–24)

Syn. – *Pareuryte vicina* Herbst, 1955.

Non *Eurycyclops remanei vicinus*; Pleša, 1963; Monchenko, 1974; 1975; 1979.

Holotype not examined.

Material examined. – Brazil, Carlos E.F. da Rocha leg.: State of Bahia, Salvador: Bregari beach (12°55'S 38°31'W), 4 Nov. 1985, 2 ♀♀ and 2 ♂♂. State of São Paulo, Ubatuba: Codó beach (23°30'S 45°7'20"W), 4 Nov. 1983, 49 ♀♀ and 2 ♂♂; São Sebastião: Segredo beach (23°49'38"S 45°25'30"W), 6 July 1983, 4 ♀♀ and 5 ♂♂; 7 July 1983, 6 ♀♀ and 4 ♂♂; Peruibe: Rio Verde beach (24°34'S 47°13'W), 30 Oct. 1984, 1 ♀ and 1 ♂.

Liliana Medeiros leg.: State of São Paulo, Ubatuba: Anchieta Island, Grande beach (23°32'10"S 45°4'20"W), 30 July 1984, 15 ♀♀ and 10 ♂♂.

Guilherme R. Lotufo leg.: State of São Paulo, Ubatuba: Brava do Sul beach (23°30'10"S 45°10'30"W), 7 Oct. 1990, 1 ♀; Vermelha do Sul beach (23°30'30"S 45°10'30"W), 7 Oct. 1990, 1 ♀; Caraguatatuba: Martim de Sá beach (23°38'S 44°23'30"W), 5 Nov. 1990, 1 ♀; São Sebastião: Cigarras beach (23°45'15"S 45°24'45"W), 17 Sep. 1990, 1 ♀; 15 June 1991, 1 ♀ and 1 ♂; São Francisco beach (23°45'30"S 45°24'40"W), 11 March 1991, 9 ♀♀ and 5 ♂♂; 14 June 1991, 9 ♀♀ and 3 ♂♂; Olaria Beach (23°46'S 45°24'20"W), 15 June 1991, 18 ♀♀ and 4 ♂♂; Pontal da Cruz beach (23°46'40"S 45°24'W), 11 March 1991, 1 ♀; Deserta beach (23°47'5"S 45°24'20"W), 11 Sep. 1990, 1 ♀; Porto Grande beach (23°47'30"S 45°24'W), 11 March 1991, 1 ♀; Zimbros beach (23°49'25"S 45°25'10"W), 11 March 1991, 3 ♀♀ and 5 ♂♂; Segredo beach (23°49'38"S 45°25'30"W), 15 June 1991, 10 ♀♀ and 10 ♂♂; 27 July 1991, 12 ♀♀ and 5 ♂♂; Ilhabela: Pinto beach (23°44'30"S 45°20'52"W), 10 March 1991, 2 ♀♀ and 4 ♂♂; Garapocaiá beach (23°44'50"S 45°20'50"W), 6 Nov. 1990, 1

♀; Barreiros beach (23°45'40"S 45°21'5"W), 6 Nov. 1990, 3 ♀♀; Pequeá beach (23°47'10"S 45°21'50"W), 10 March 1991, 1 ♀ and 1 ♂; 27 July 1991, 10 ♀♀ and 5 ♂♂; Feiticeiras beach (23°49'10"S 45°22'30"W), 10 March 1991, 1 ♀; Guarujá: Guaiúba beach (24°1'5"S 46°17'45"W), 2 Feb. 1991, 1 ♂.

Lot of 30 ♀♀ and 2 ♂♂ from Codó beach, Ubatuba, and lot of 15 ♀♀ and 10 ♂♂ from Grande Beach, Anchieta Island in MZUSP (coll. nrs. 11385 and 11386, respectively).

Description of female (Fig. 18). – Body length 590–970 μm ($n = 10$). Prosome : urosome ratio = 1.3–1.4 : 1. Genital double somite (Fig. 19) as in *N. medius*. Anal pseudopericulum (Fig. 20) with smooth margin. Caudal rami (Fig. 20) 2.5–3.0 times longer than wide. Dorsal seta 2.2–2.5 times longer than apical seta. Inner and outer apical setae equal in length. All caudal setae plumose.

Labrum similar in general outline to that of *N. medius*, but with 8 to 10 teeth on free margin.

Mandible (Fig. 21) with gnathobase, and palp comprised of 2 setae inserted on reduced lobe.

Antennule, antenna, maxillule, maxilla, maxilliped, and legs 1–5 as in *N. medius*.

Description of male. – Body length 480–600 μm ($n = 10$). Prosome : urosome ratio = 1.3 : 1. Urosome with 6 somites. Some males with abnormal caudal rami (Fig. 24).

Antennule (Fig. 22) 16-segmented, armed as follows (Roman numeral = segment; Arabic numeral = seta; sp = spine; ae = aesthetasc): I – 8 + 3 ae; II – 4; III – 2; IV – 2 + ae; V – 2; VI – 1; VII – 2; VIII – 2; IX – 2 + ae; X – 2; XI – 2; XII – 2 sp; XIII – 1 + sp + ae; XIV – 0; XV – 1; XVI – 11 + 2 ae.

Antenna (Fig. 23) differing from that of female by presence of seta representing exopodite at outer corner of basis, almost reaching tip of antenna.

Leg 6 as in male of *N. medius*.

The male is identical to the female in all other respects.

Habitat. – Medium and coarse sand (median grain size 300–1150 μm). Salinity ranged from 15 to 32‰. Temperature ranged from 21 to 32°C.

Distribution. – Brazil, State of São Paulo: Ilhabela (type-locality), Ubatuba, Caraguatatuba, São

Sebastião, Guarujá, and Peruíbe; State of Bahia: Salvador. West Indies: Los Roques, Jamaica (Pesce & Galassi, 1993).

Discussion. – The specimens were identified as *N. vicinus* (Herbst, 1955) because they agreed with the original description in respect to body shape and length, genital double somite shape, caudal rami armature and proportions, armature of leg 5, and presence of 2 setae on the mandibular palp. Just like for *N. medius*, Herbst represented the leg 4 endopodite as 3-segmented, interpreting the scars we observed as a functional articulation. In his drawing, Herbst did not represent the distal seta of leg 4 endopodite segment 2, present in our material as a modified seta.

Neocyclops vicinus was described as *Pareuryte vicina* by Herbst (1955). Pleşa (1963) transferred it to the genus *Eurycyclops* as a subspecies of *E. remanei* (Herbst, 1952). Pleşa's new combination was adopted by Monchenko (1974; 1975; 1979). Fortunately, both Pleşa and Monchenko provided descriptive data about females and males they identified from the Black Sea. Females from the Black Sea are larger (body length ranging from 720 to 1100 µm) and possess longer caudal rami (length : width ratio = 2.72–3.48 : 1) in relation to the Brazilian females. They also differ from our specimens in having two plumose setae on the inner margin of the leg 4 endopodite segment 2. Monchenko (1975) illustrated the female antenna with short seta representing the exopodite, which was not mentioned by Pleşa (1963).

No author mentioned the existence of sexual dimorphism in the antenna of the Black Sea specimens, a character certainly helpful in making a decision about the identity of these specimens. The differences pointed out here indicate that the Black Sea specimens should be ascribed to another species. They seem to be more closely related to *N. remanei* from the North Sea than to *N. vicinus*.

N. vicinus is easily separated from *N. medius* by possessing longer caudal rami, mandibular palp with 2 setae, and sexually dimorphic antenna. It also differs in the shape of the seminal receptacle. On the other hand, *N. vicinus* differs from *N. remanei* in having shorter caudal rami and in lack-

ing the seta representing the exopodite of the antenna in the female.

Emendation of diagnosis of *Neocyclops*

Neocyclops is defined as follows: antennule of 8 to 12 segments, mandibular palp absent or reduced to a small lobe with 1 or 2 setae, maxilliped with 2-segmented endopodite, leg 4 exopodite segment 3 with all setae modified (plumose at the base and finely serrate on the more distal part of the seta), and the genital double somite expanded at the proximal third. If confirmed for the other species, the fusion of leg 4 endopodite segments 2 and 3 observed in both Brazilian species and in *N. salinarum* can be considered another diagnostic character of the genus.

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