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Distribution and hosts of *Stellicola* (Copepoda, Cyclopoida) associated with *Linckia* (Asteroidea) in the Indo-West Pacific

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ABSTRACT

Five lichomolgid copepods belonging to the genus *Stellicola* are reported from three species of the sea star genus *Linckia* in the Moluccas: *Stellicola flexilis* n. sp. from *Linckia guildingi*, *L. laevigata*, and *L. multiflora*, *S. caeruleus* (Stebbing, 1900) from *L. laevigata*, *L. guildingi*, and *L. multiflora*, *S. illgi* Humes & Stock, 1973, from *L. laevigata*, *S. novaecaledoniae* Humes, 1976, from *L. laevigata*, *L. multiflora*, and *L. guildingi*, and *S. pollex* from *L. laevigata*, *L. guildingi*, and *L. multiflora*. The distribution and hosts of *Stellicola* on *Linckia* in the Indo-West Pacific are summarized.

INTRODUCTION

Members of the genus *Linckia* are shallow-water sea stars common throughout the tropical Indo-West Pacific. According to Clark and Rowe (1971) three species occur in this region. *Linckia laevigata* (Linnaeus) is often abundant subtidally among corals and easily recognized by its bright blue color. Copepods belonging to the genus *Stellicola* may be visible crawling over the blue body surface (Humes & Stock, 1973: 296). *Linckia guildingi* Gray, light olive green in color, and *Linckia multiflora* (Lamarck), speckled brown, are less commonly seen.

Until now four species of *Stellicola* have been known to be associated with these three sea stars, four with *L. laevigata*, two with *L. guildingi*, and one with *L. multiflora* (Humes, 1976: 12). The names of these *Stellicola*, their hosts, and their geographical distribution are given below.

In this paper a new species of *Stellicola* is described, certain features of *S. caeruleus* are redescribed, and the geographical distribution and hosts of the various species of *Stellicola* on *Linckia* are summarized.

The observations and measurements of the new species and *S. caeruleus*

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have been made on specimens cleared in lactic acid. All figures have been drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are: R = rostrum, L = labrum, A₁ = first antenna, A₂ = second antenna, MD = mandible, MX₁ = first maxilla, MX₂ = second maxilla, MXP₁ = maxilliped, and P₁ = leg 1.

ACKNOWLEDGMENTS

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I am indebted to Miss Maureen E. Downey of the National Museum of Natural History, Smithsonian Institution, Washington, D.C., for the identification of the sea stars.

Lichomolgidae Kossmann, 1877

Stellicola Kossmann, 1877

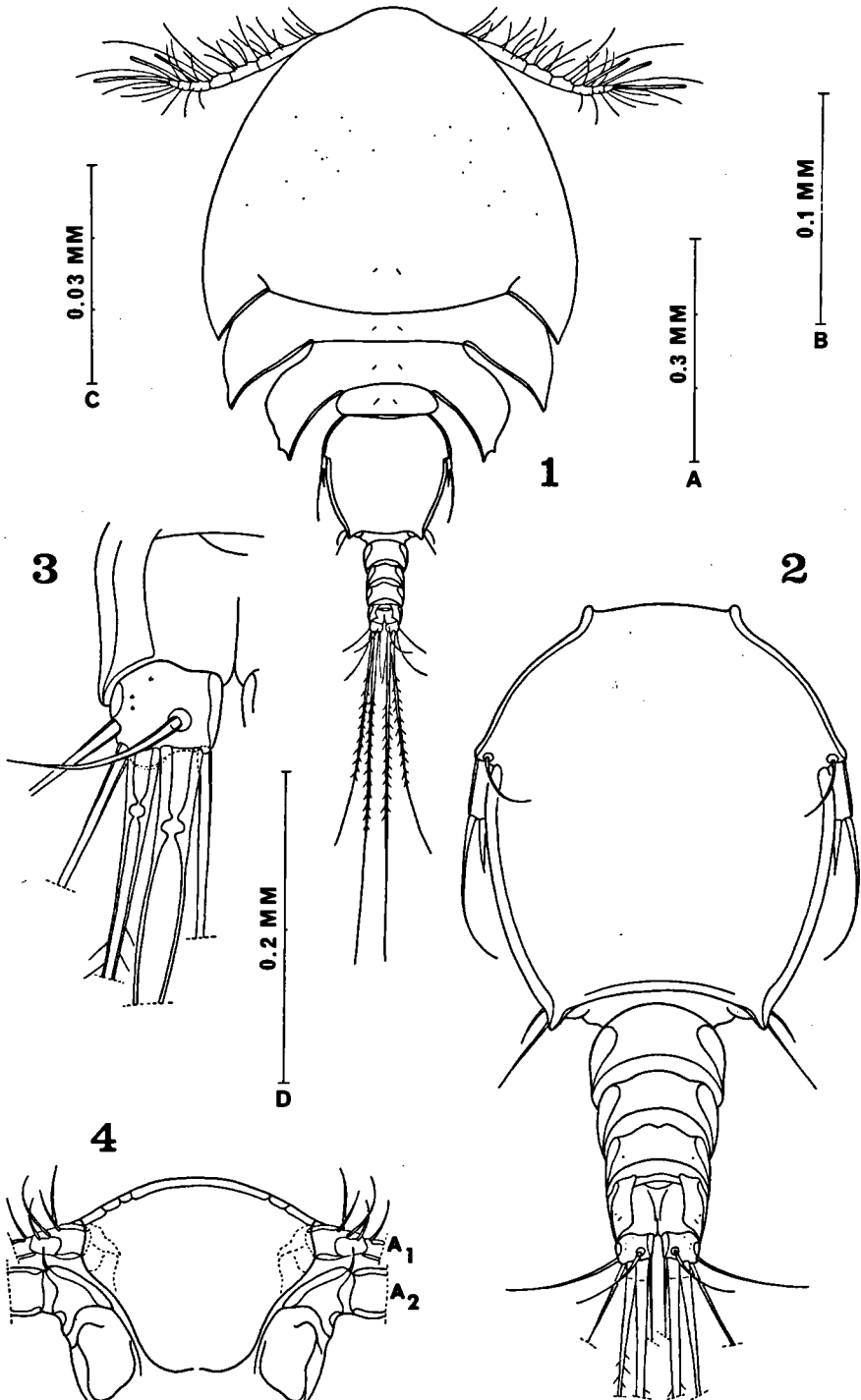
Stellicola flexilis n. sp.

Figs. 1—20

Type material: 11 ♂♂ from one sea star, *Linckia guildingi* Gray, in 4 m, Marsegoe Island, western Ceram, Moluccas, 2°59'30"S, 128°03'30"E, 15 May 1975. Holotype and seven paratypes deposited in the Zoölogisch Museum, Amsterdam; three dissected paratypes in the collection of the author.

Other specimens: 5 ♂♂ from one *Linckia multiflora* (Lamarck), in 5 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'45"S, 129°51'55"E, 2 May 1975; 1 ♂ from one *Linckia multiflora* in 10 m, Goenoeng Api, 4°32'05"S, 129°52'30"E, 26 April 1975; 2 ♂♂ from one *Linckia laevigata* (Linnaeus), in 3 m, Goenoeng Api, 4°31'55"S, 129°52'12"E, 8 May 1975.

Male: The body (Fig. 1) has a moderately broad prosome. The length (excluding the setae on the caudal rami) is 0.71 mm (0.65—0.78 mm) and the greatest width is 0.48 mm (0.44—0.55 mm), based on 10 specimens in lactic acid. The ratio of the length to the width of the prosome is 1.08: 1. The segment of leg 1 is fused with the cephalosome. The epimera of the segments of legs 1-3 are pointed posteriorly. The segment of leg 4 is small and lacks expanded epimera. The ratio of the length of the prosome to that of the urosome is 1.84:1.



Figs. 1—4. *Stellicola flexilis* n. sp., male. 1, dorsal (A); 2, urosome, dorsal (B); 3, caudal ramus, dorsal (C); 4, rostrum, ventral (D).

The segment of leg 4 (Fig. 2) is fused with the genital segment, the compound segment measuring $180 \times 159 \mu\text{m}$. The four postgenital segments from anterior to posterior are 36×60 , 31×55 , 26×49 , and $26 \times 45 \mu\text{m}$. The posteroventral margin of the anal segment is smooth.

The caudal ramus (Fig. 3) is $13 \times 15 \mu\text{m}$, a little wider than long. The outer lateral seta is $40 \mu\text{m}$, the dorsal seta $31 \mu\text{m}$, the outermost terminal seta $70 \mu\text{m}$, and the innermost terminal seta $50 \mu\text{m}$, all naked. The two long median terminal setae are $100 \mu\text{m}$ (outer) and $400 \mu\text{m}$ (inner), both weakly haired and inserted dorsally to a small ventral flange with a marginal row of very small spinules.

The body surface bears a few small hairs (sensilla) and refractile points as indicated in figures 1 and 2.

The rostrum (Fig. 4) is broad and not clearly defined posteriorly.

The first antenna (Fig. 5) is $236 \mu\text{m}$ long. The lengths of its seven segments (measured along their posterior nonsetiferous margins) are: 31 ($26 \mu\text{m}$ along the anterior margin), 95 , 31 , 35 , 23 , 11 , and $10 \mu\text{m}$ respectively. The formula for the armature is: 4 , 13 , 6 , 3 , $4 + 1$ aesthete, $2 + 1$ aesthete, and $7 + 1$ aesthete. The setae are naked except for four on the terminal segment which are lightly feathered.

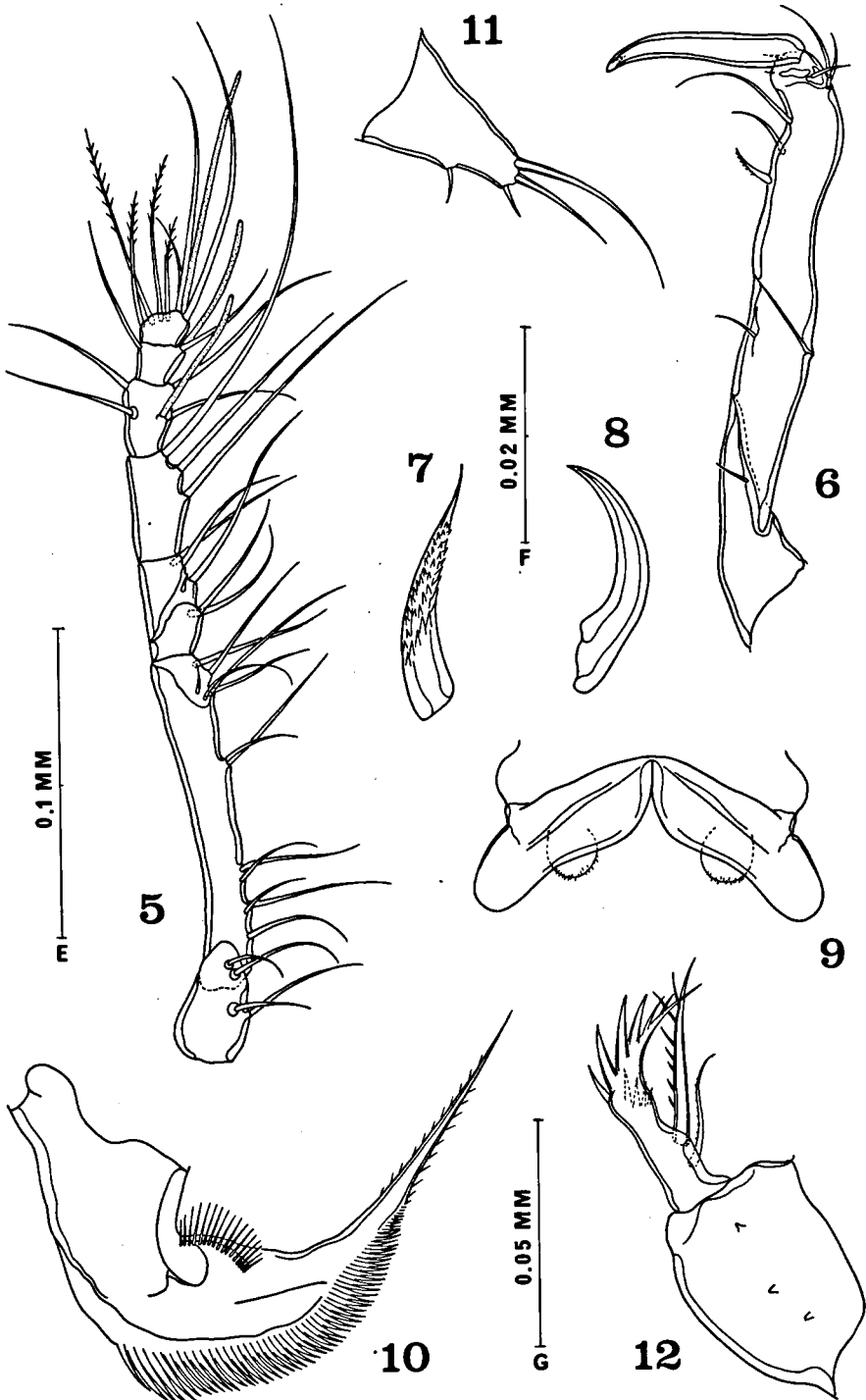
The second antenna (Fig. 6) is $200 \mu\text{m}$ long and 3-segmented. The first two segments bear a small naked seta. The slightly sinuous third segment, $130 \mu\text{m}$ along its outer side, $88 \mu\text{m}$ along its inner side, and approximately $26 \mu\text{m}$ wide, bears three inner setae, two naked and one with spinules as in figure 7; terminally there is a single claw $99 \mu\text{m}$ along its axis and in flat view recurved (Fig. 8). Five small naked setules are located near the base of the claw.

The labrum (Fig. 9) has two slender, widely divergent posteroventral lobes.

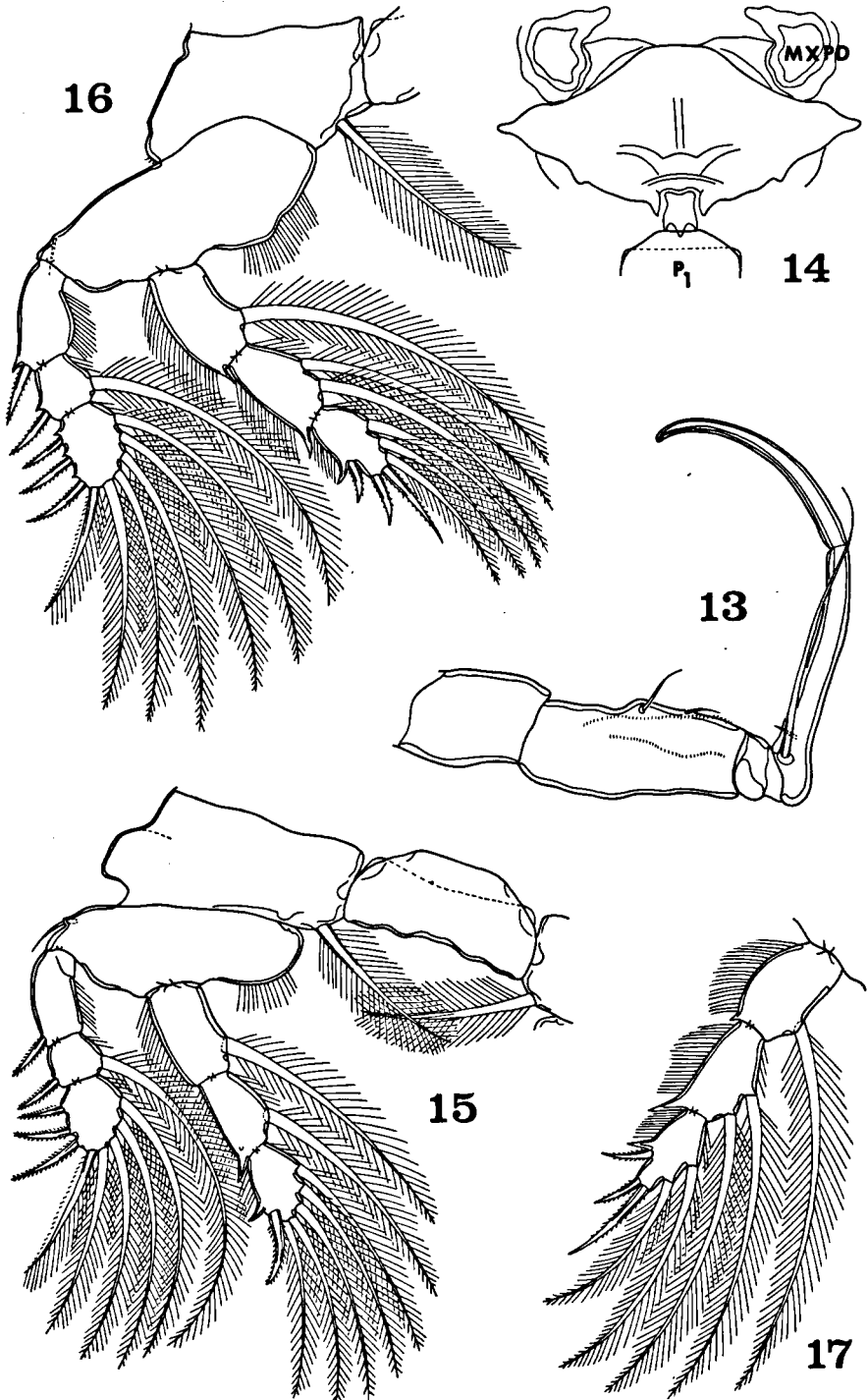
The mandible (Fig. 10) resembles that of *Stellicola illgi* Humes and Stock, 1973, but a few proximal teeth in the outer serrated fringe are longer than the other more distal teeth. The paragnath (Fig. 9) is a small lobe with a few minute hairs. The first maxilla (Fig. 11) has four smooth setae. The second maxilla (Fig. 12) resembles in general that of *S. illgi*, with small differences in the size of the teeth on the terminal lash and of the spinules on the inner spine. The maxilliped (Fig. 13) is slender and 4-segmented, assuming that the proximal half of the claw represents a fourth segment. The first segment is unornamented. The second segment bears two small naked setae and two rows of minute spinules. The small third segment is unarmed. The recurved claw, $125 \mu\text{m}$ long and divided about midway, bears two very unequal proximal naked setae, the longer two-thirds the length of the claw.

The ventral surface between the maxillipeds and the first pair of legs (Fig. 14) is not protuberant.

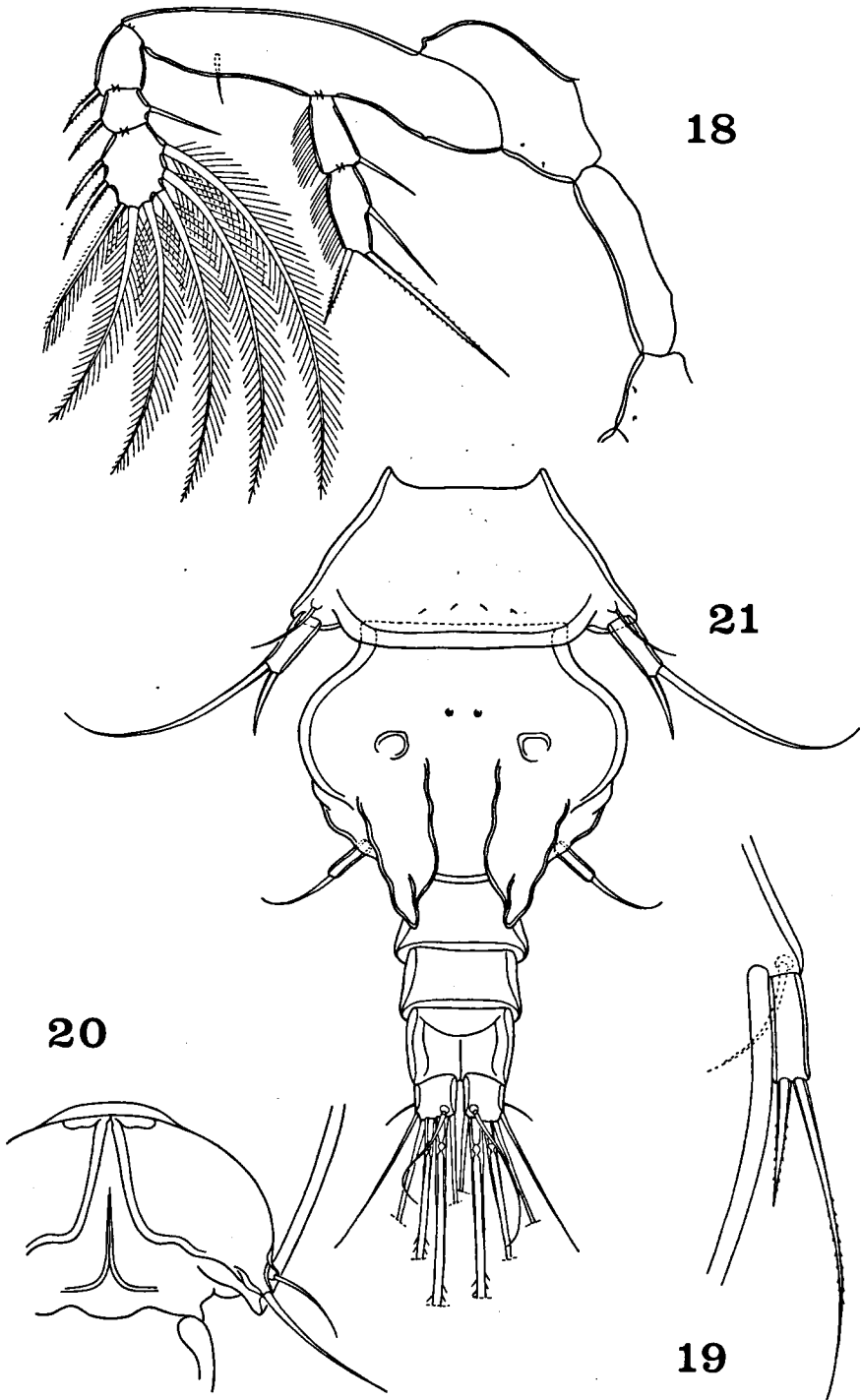
Legs 1-4 (Figs. 15, 16, 17, 18) are segmented as in *S. illgi* and have the same spine and setal formula as in that species. These legs show only small differences from those of *S. illgi*. The first segment of the endopod of leg 1 lacks an outer distal spiniform process. The inner seta on the second segment of the endopod of leg 4 is smooth rather than feathered as in *S. illgi*.



Figs. 5—12. *Stellicola flexilis* n. sp., male. 5, first antenna, ventral (E); 6, second antenna, anterior (B); 7, seta on third segment of second antenna, posterior (F); 8, claw of second antenna, posterior flat view (B); 9, labrum and paragnaths, ventral (G); 10, mandible, posterior (C); 11, first maxilla, ventral (C); 12, second maxilla, anterior (G).



Figs. 13—17 *Stellicola flexilis* n. sp., male. 13, maxilliped, anterior (E); 14, area between maxillipeds and first pair of legs, ventral (B); 15, leg 1 and intercoxal plate, anterior (E); 16, leg 2, anterior (E); 17, endopod of leg 3, anterior (E).



Figs. 18—20. *Stellicola flexilis* n. sp., male. 18, leg 4 and intercoxal plate, anterior (E); 19, leg 5, ventral (G); 20, leg 6, ventral (E).

Fig. 21. *Stellicola caeruleus* (Stebbing, 1900), female. 21, urosome, dorsal (D).

Leg 5 (Fig. 19) has an unornamented free segment $22 \times 8 \mu\text{m}$. The two terminal elements are $24 \mu\text{m}$ (inner) and $77 \mu\text{m}$ (outer), both finely barbed.

Leg 6 (Fig. 20) consists of the usual posteroventral flap on the genital segment, bearing two naked setae $30 \mu\text{m}$ and $47 \mu\text{m}$.

The spermatophore is unknown.

The color in living specimens is opaque, the eye red.

Female: Unknown.

Etymology: The specific name *flexilis*, Latin = flexible or bent, alludes to the sinuous appearance of the third segment of the second antenna in this species.

Comparison with other species in the genus: *Stellicola flexilis* differs from all species in the genus where males have been described. Recognition characters of each of these species by which they may be distinguished from the new species are as follows:

S. pollex Humes and Ho, 1967. The third segment of the second antenna has an inner thumblike process.

S. femineus Humes and Ho, 1967. The maxilliped is female-like, without a long claw.

S. caeruleus (Stebbing, 1900). The first segment of the second maxilla has three processes, their tips spinulose.

S. novaecaledoniae Humes, 1976, and *S. illgi* Humes and Stock, 1973. The terminal segment of the maxilliped is not clawlike.

S. parvulipes Humes, 1976. The segment of leg 5 is small and fused with the body.

S. holothuriae (Ummerkutty, 1962). The maxilliped is small, not much larger than that of the female, the claw short.

S. oreastriphilus Kossmann, 1877. The claw of the maxilliped is as long as but not longer than the second segment. The free segment of leg 5 is subquadrate, $10 \times 8 \mu\text{m}$. Descriptive information is found in Humes & Cressey (1961) and Humes & Ho (1967).

There are four poorly described species of *Stellicola* with which the new species can not be compared in detail, since only females of these are known. In the females of these four species, *S. curticaudatus* (Thompson and A. Scott, 1903), *S. longicaudatus* (Thompson and A. Scott, 1903), *S. pleurobranchi* Kossmann, 1877, and *S. thorelli* Kossmann, 1877, the available information suggests that the third segment of the second antenna is straight rather than sinuous. Unless the sinuosity in the new species is a male sexual character, the straight form of the female second antenna would serve to distinguish the four species from *S. flexilis*.

Stellicola caeruleus (Stebbing, 1900)

Figs. 21—25

Specimens from the Moluccas: From *Linckia laevigata* (Linnaeus): 177 ♀♀, 195 pairs in amplexus, 51 ♂♂, 263 copepodids from 9 hosts, in 3 m,

Natsepa, Ambon, 3°37'05"S, 128°17'00"E, 23 April 1975; 18 ♀♀, 33 pairs in amplexus, 2 ♂♂ from 2 hosts, in 5 m, Goenoeng Api, Banda Islands, 4°32'05"S, 129°52'30"E, 26 April 1975; 17 ♀♀, 19 pairs in amplexus, 4 ♂♂ from 2 hosts, in 5 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'45"S, 129°51'55"E, 2 May 1975; 102 ♀♀, 121 pairs in amplexus, 5 ♂♂ from one host, in 3 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'45"S, 129°51'55"E, 8 May 1975; 133 ♀♀, 104 pairs in amplexus, 152 ♂♂, 112 copepodids from 7 hosts, in 2 m, Natsepa, Ambon, 3°37'05"S, 128°17'00"E, 11 May 1975; 12 ♀♀, 26 pairs in amplexus, 10 ♂♂, 20 copepodids from 5 hosts, in 3 m, Poelau Gomumu, south of Obi, 1°50'00"S, 127°30'54"E, 30 May 1975; 6 ♀♀, 4 pairs in amplexus, 2 ♂♂, 10 copepodids from one host, in 3 m, Poelau Gomumu, south of Obi, 1°50'00"S, 127°30'54"E, 30 May 1975. From *Linckia guildingi* Gray: 4 ♀♀, 15 ♂♂ from one host, in 4 m, Poelau Marsegoe, western Ceram, 2°59'30"S, 128°03'30"E, 15 May 1975. From *Linckia multiflora* (Lamarck): 1 ♀, 1 ♂ from one host, in 5 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'45"S, 129°51'55"E, 2 May 1975.

The redescription of this species by Humes and Ho (1967) was based upon syntypes (1 ♀, 1 ♂) preserved in alcohol for many years and not in the best of condition. The abundant material collected in the Moluccas has made possible further study of this copepod, with a more accurate representation of the second maxilla of the male.

Female: The urosome (Fig. 21) is characterized by the two prominent dorsal posterior processes on the genital segment. Near the middle of this segment there is in some females a pair, in others two pairs (Fig. 22) of sclerotized pits. The tips of the processes on the first segment of the male second maxilla (Fig. 24) appear to be placed over or perhaps inserted in these pits during amplexus. The male adheres tightly to the female when in amplexus. When specimens in alcohol are forcible separated, the sclerotized pits may be pulled away along with the second maxilla of the male, with the result that the female genital segment appears to have fewer than the actual number of such pits.

Male: The urosome (Fig. 23) is characterized by the elongated compound segment resulting from a fusion of the segment of the fifth legs and genital segment, with the area of the genital segment having parallel sides in dorsal view.

The second maxilla in this species is remarkable. There are three elongated processes on the first segment (Fig. 24). Each process has a spinulose tip which is apparently placed on or inserted in sclerotized pits on the dorsal side of the genital segment of the female during amplexus. The maxilliped is relatively small compared to the second maxilla (Fig. 25) and seems to play little role in amplexus.

Remarks: This species has been hitherto known only from the types collected at the eastern end of New Guinea. Stebbing (1900) described it as *Linckiomolgus caeruleus* from a "blue *Linckia*" at Feather Island, China

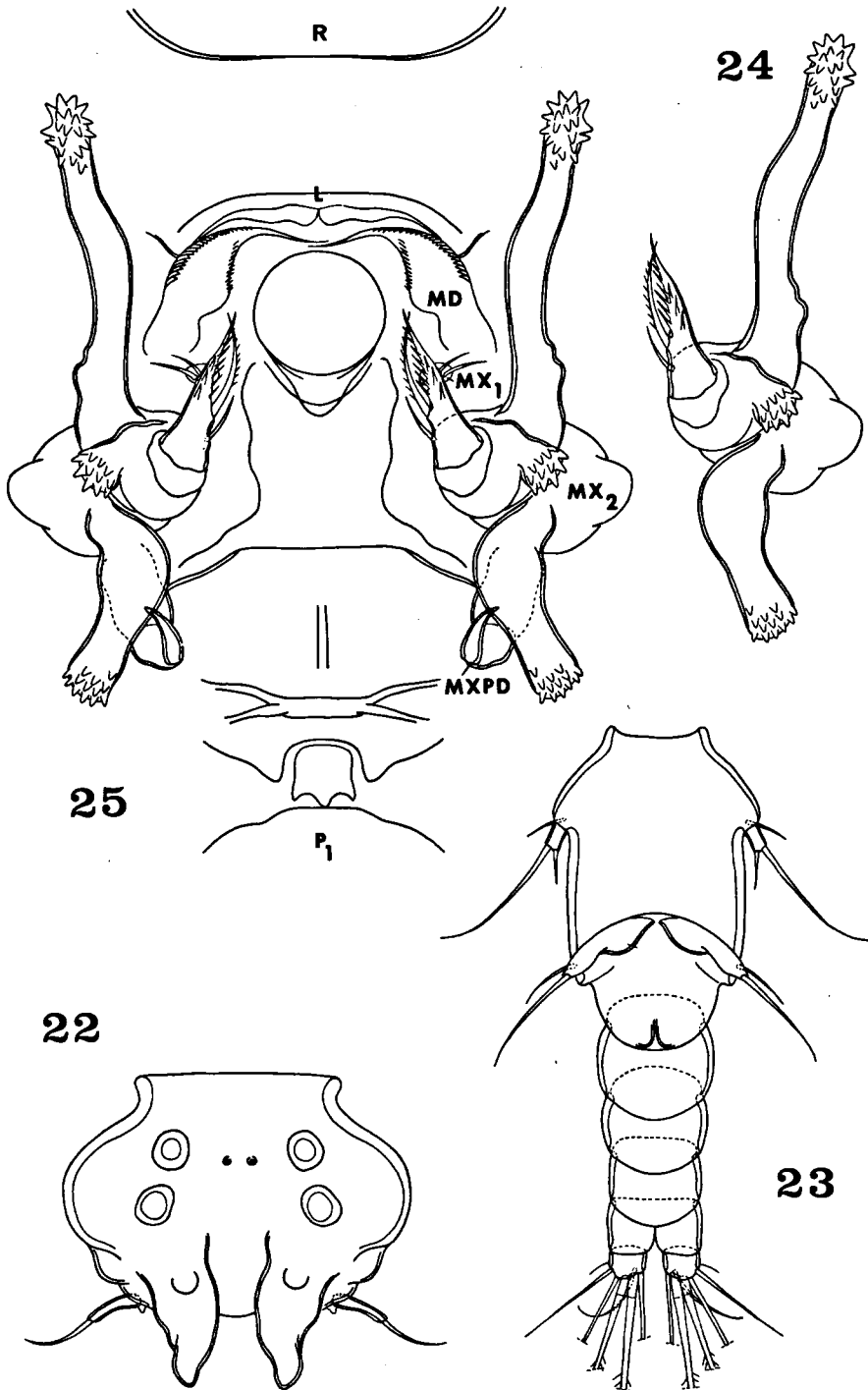


Fig. 22. *Stellicola caeruleus* (Stebbing, 1900), female. 22, genital segment, dorsal (D).
Figs. 23—25. *Stellicola caeruleus* (Stebbing, 1900), male. 23, urosome, ventral (B); 24, second maxilla, ventral (G); 25, mouth parts *in situ*, ventral (G).

Straits, eastern New Guinea. The host of Stebbing's specimens is believed to have been *Linckia laevigata* (Linnaeus) (see Clark, 1921: 636).

***Stellicola illgi* Humes & Stock, 1973**

Specimens from the Moluccas: 3 ♂♂ from one *Linckia laevigata* (Linnaeus), in 10 m, Poelau Parang, eastern Ceram, 3°17'00"S, 130°44'48"E, 23 May 1975.

Remarks: This species has been previously known from the same host in the Palau Islands and Fiji (Humes & Stock, 1973).

***Stellicola novaecaledoniae* Humes, 1976**

Specimens from the Moluccas: From *Linckia guildingi* Gray: 3 ♀♀, 12 ♂♂ from one host, in 4 m, Poelau Marsegoe, western Ceram, 2°59'30"S, 128°03'30"E, 15 May 1975. From *Linckia multiflora* (Lamarck): 3 ♀♀ from one host, in 5 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'45"S, 129°51'55"E, 2 May 1975; 3 ♀♀ from one host, in 10 m, southern shore of Goenoeng Api, Banda Islands 4°32'05"S, 129°52'30"E, 26 April 1975.

Remarks: This species is known from *Linckia laevigata* and *Linckia guildingi* in New Caledonia (Humes, 1976).

***Stellicola pollex* Humes & Ho, 1967**

Specimens from the Moluccas: From *Linckia laevigata* (Linnaeus): 17 ♀♀ from 2 hosts, in 5 m, southern shore of Goenoeng Api, Banda Islands, 4°32'05"S, 129°52'30"E, 26 April 1975; 18 ♀♀, 10 ♂♂, from 2 hosts, in 5 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'45"S, 129°51'55"E, 2 May 1975. From *Linckia guildingi* Gray: 25 ♀♀, 47 ♂♂ from one host, in 4 m, Poelau Marsegoe, western Ceram, 2°59'30"S, 128°03'30"E, 15 May 1975. From *Linckia multiflora* (Lamarck): 26 ♀♀, 37 ♂♂ from one host, in 5 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'45"S, 129°51'55"E, 2 May 1975; 1 ♀ from one host, in 10 m, southern shore of Goenoeng Api, Banda Islands, 4°32'05"S, 129°52'30"E, 26 April 1975.

Remarks: This species has been reported from *Linckia laevigata* in Madagascar (Humes & Ho, 1967) and from *Linckia multiflora* and *Linckia guildingi* in Hawaii (Humes & Stock, 1973). *Linckia diplax* (Müller & Troschel), recorded as a host by the latter authors, is of questionable validity according to Clark & Rowe (1971: 62) and may be a synonym of *Linckia guildingi*.

DISTRIBUTION AND HOSTS

Stellicola associated with sea stars of the genus *Linckia* have been reported from relatively few regions within the vast Indo-West Pacific. The collections

made thus far indicate, however, that the various species of *Stellicola* are common and widespread associates of *Linckia*. The geographical distribution of these copepods is summarized in table I.

Table I. Distribution and hosts of *Stellicola* on *Linckia* in the Indo-West Pacific.

	<i>L. laevigata</i>	<i>L. guildingi</i>	<i>L. multiflora</i>
<i>S. caeruleus</i>	eastern New Guinea Moluccas	Moluccas	Moluccas
<i>S. flexilis</i>	Moluccas	Moluccas	Moluccas
<i>S. illgi</i>	Palau Islands Fiji Moluccas	—	—
<i>S. novaecaledoniae</i>	New Caledonia	New Caledonia Moluccas	Moluccas
<i>S. pollex</i>	Madagascar Moluccas	Hawaii Moluccas	Hawaii Moluccas

Four of the five species of *Stellicola* occur on all three species of *Linckia* in the Indo-West Pacific. *Stellicola illgi*, however, is known only from *Linckia laevigata*.

In two instances, four species, *S. pollex*, *S. novaecaledoniae*, *S. caeruleus*, and *S. flexilis*, occurred together on a single *Linckia*. From one *Linckia guildingi* at Poelau Marsegoe, western Ceram, 117 *Stellicola* were recovered, comprising 25 ♀♀ and 47 ♂♂ of *S. pollex*, 3 ♀♀ and 12 ♂♂ of *S. novaecaledoniae*, 4 ♀♀ and 15 ♂♂ of *S. caeruleus*, and 11 ♂♂ of *S. flexilis*. On one *Linckia multiflora* at Goenoeng Api, Banda Islands, 73 *Stellicola* were found, 26 ♀♀ and 37 ♂♂ of *S. pollex*, 3 ♀♀ of *S. novaecaledoniae*, 1 ♀ and 1 ♂ of *S. caeruleus*, and 5 ♂♂ of *S. flexilis*.

The heaviest infestation occurred with *Stellicola caeruleus* on *Linckia laevigata*, where 1,941 adult *Stellicola* were recovered from 28 sea stars, each host having an average number of 69 copepods. The heaviest infestation of a single sea star was also seen here, with 349 copepods (223 ♀♀ and 126 ♂♂) on one host.

The information available, although fragmentary, permits certain general observations to be made: (1) that the *Stellicola* species on *Linckia* are widespread and common associates in the Indo-West Pacific, (2) that all three species of *Linckia* in the area may have one or more species of *Stellicola* associated with them, (3) that as many as four *Stellicola* species may coexist on a single sea star, and (4) that *Stellicola caeruleus* on *Linckia laevigata* shows the heaviest infestation.

It is probable that *Stellicola* occurs on *Linckia* through the ranges of the sea stars (from East Africa to the Hawaiian and South Pacific Islands, and from southern Japan to northern Australia, according to Clark & Rowe, 1971).

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