ANNALS OF THE SOUTH AFRICAN MUSEUM
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume 101 Band
August 1991 Augustus
Part 3 Deel

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The ANNALS OF THE SOUTH AFRICAN MUSEUM

are issued in parts at irregular intervals as material becomes available

Obtainable from the South African Museum, P.O. Box 61, Cape Town 8000

Die ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

word uitgegee in dele op ongereelde tye na gelang van die beskikbaarheid van stof

Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad 8000

OUT OF PRINT/UIT DRUK

1, 2(1–3, 5–8), 3(1–2, 4–5, 8, t.–p.i.), 5(1–3, 5, 7–9), 6(1, t.–p.i.), 7(1–4), 8, 9(1–2, 7), 10(1–3), 11(1–2, 5, 7, t.–p.i.), 14(1–2), 15(4–5), 24(2, 5), 27, 31(1–3), 32(5), 33, 36(2), 43(1), 45(1), 67(5), 84(2)

ISBN 0 86813 123 7

Printed in South Africa by The Rustica Press, Pty., Ltd., Old Mill Road, Ndabeni, Cape

In Suid-Afrika gedruk deur Die Rustica-pers, Edms., Bpk., Old Mill-weg, Ndabeni, Kaap

D661

A NEW SPECIES OF *CALANUS* (COPEPODA, CALANOIDA) FROM SOUTH AFRICAN WATERS*

By

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(With 7 figures and 2 tables)

[*MS accepted 15 October 1989*]

ABSTRACT

A new calanid species belonging to the *Calanus helgolandicus* species-group is described. *Calanus agulhensis* sp. nov. is reported from the Agulhas Bank waters and its seasonal distribution is briefly presented.

CONTENTS

INTRODUCTION

The major part of research on the taxonomy of the family Calanidae in the Southern Hemisphere has been performed by Brodskii (e.g. 1959, 1961, 1964, 1965, 1972, 1976). He divided (1959) the superspecies *Calanus finmarchicus* s.l. of Yashnov (1958) into a number of taxa of specific and lower rank. Small morphological differences, together with differences in geographical distribution, formed the basis for his classification within the genus *Calanus* s.s. The species and varieties of *Calanus* that Brodskii recognized in the Southern Hemisphere are *C. australis* Brodskii, 1959, *C. chilensis* Brodskii, 1959, as well as *C. australis atlanticus* Brodskii, 1959, and *C. australis pacificus* Brodskii, 1959. Although Brodskii's work undoubtedly increased our knowledge on calanids, his classification (e.g. Brodskii 1976) raised controversy (see Bradford & Jillett 1974; Bradford 1988).

Calanus finmarchicus (Gunnerus, 1765) was first reported from South African waters by Cleve (1904: 185), who described the species as 'common south of the Cape Colony, rare east and west'. This was confirmed by De

* This paper is partially based on an earlier manuscript by Dr A. H. B. De Decker.
† Dr De Decker died on 3 January 1986.

Ann. S. Afr. Mus. **101** (3), 1991: 27–44, 7 figs, 2 tables.

Decker (1964: 18) who found that 'a fairly numerous colony is consistently present over the Agulhas Bank' and that 'off the West Coast and off Natal it occurs only at certain times and in small numbers'.

Senô *et al.* (1963) reported 4 915 individuals of *C. finmarchicus* from the northernmost station (37°43'S 20°05'E) occupied during an Africa–Antarctica transect of the 1956–57 'Umitaka-Maru' Expedition. Although beyond the continental shelf, this station is located in an area influenced by the Agulhas Current system. The area directly south of South Africa is known for the formation of eddies and rings as a consequence of the Agulhas Current retroflexion and considerable latitudinal variation in the position of the Subtropical Convergence (e.g. Bang 1970; Lutjeharms 1985). Therefore, transport of Agulhas Bank water and its plankton away from the shelf is not unexpected.

Carter (1978) found the species to be rare off Durban but occurring fairly frequently 150 km further south, off Port Edward.

The northernmost record of *Calanus* populations off South Africa is at 30°S (Port Nolloth) in the Atlantic Ocean and at 28°S (Cape St Lucia) in the Indian Ocean (unpublished data).

Various authors, e.g. Brodskii (1959), Yashnov (1972), and Fleminger & Hulsemann (1977), have presented convincing evidence that *C. finmarchicus* and *C. helgolandicus* (Claus, 1863) are indeed separate species and that both species are restricted to the North Atlantic.

De Decker (1973) first considered the South African specimens to be *C. finmarchicus* s.l., but subsequently (De Decker 1984: 320) used the name *C. finmarchicus* s.l. in referring to the South African form to 'designate a form of uncertain taxonomic status showing morphological resemblances with both *Calanus australis* (Brodskii, 1959) and *Calanus pacificus pacificus* (Brodskii, 1959)'. He suggested that it might represent a separate taxon. Hutchings (1985) reported the species off Cape Town under the name *C. finmarchicus* v. *australis*.

De Decker (pers. comm. *in* Bradford 1979) indicated that the South African form could not be identified with any described species of *Calanus*. Careful comparison with material from New Zealand, Australia and California have revealed differences of the same order as those used in Brodskii's system. These differences, together with the geographical isolation of the population, permit its recognition as a distinct species.

MATERIAL AND METHODS

Material for the study was obtained from monthly routine surveys of the then Division of Sea Fisheries around the Cape, during the period July 1963–June 1965. The sampling stations were located at ±20-mile intervals (Fig. 1). The three eastern transects, viz. lines 72, 76 and 80, covered the western part of the Agulhas Bank. Regular plankton sampling was done only during daylight. Plankton samples were taken with a Nansen vertical closing net (mouth opening 70 cm) of 0,200-mm mesh size and preserved in 4 per cent

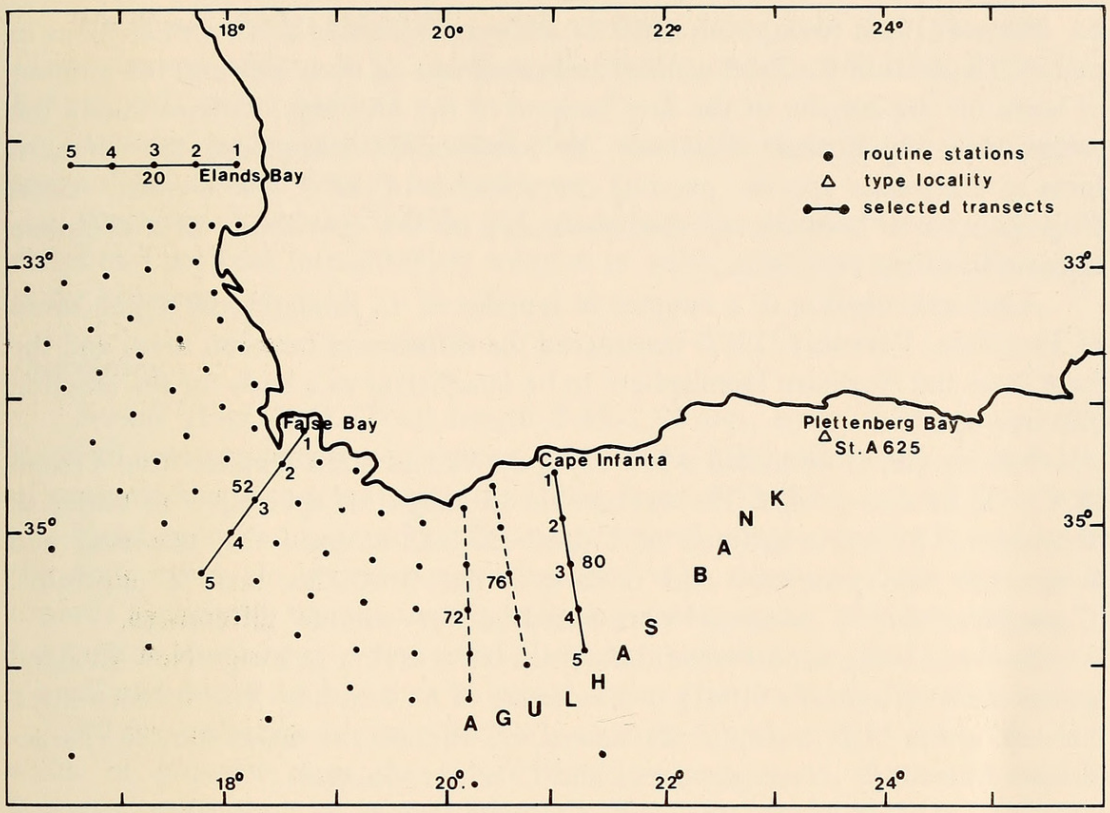

Fig. 1. Routine monthly stations and the type locality of *Calanus agulhensis* sp. nov.

formaldehyde solution. The net was built according to specifications provided in the Discovery Reports (Kemp *et al.* 1929). At the vast majority of stations a single haul from 100 m depth to the surface was made.

A total of 1 840 samples were checked for the presence of the species. Adult females, adult males and copepodites V were counted separately. However, total numbers of adults are presented here, as numbers of males were insignificant at all stations. For the purpose of the present study, data from only three transects, viz. lines 20, 52 and 80, are presented.

TAXONOMY

The extensive material studied by Brodskii (1964, 1967) from the Southern Hemisphere was mostly collected by the Soviet Antarctic Expedition of 1955–1958. However, the only region sampled in the Atlantic Ocean was off the South American coast (Brodskii 1964). Nevertheless, he implied distribution of *C. australis* in South African waters, although he never mentioned having specimens from this region.

In addition to Brodskii's studies, occurrences of copepods belonging to the *Calanus helgolandicus* species-group have been reported elsewhere in the Southern Hemisphere.

Farran (1929) found both sexes of a species recorded as *C. finmarchicus* in material from New Zealand waters, and remarked on body size and the number of teeth on the lamella of the first basipod of the fifth legs, without taking the comparison any further. However, he conditionally recognized the southern form as a separate species, pending the outcome of the *C. finmarchicus* versus *C. helgolandicus* controversy. He speculated on the probability of a complete separation of the two forms.

After examination of a number of females of '*C. fin*marchicus' taken south of Tasmania, Vervoort (1957) considered the differences between these and the form from the Northern Hemisphere to be insufficient as a basis for the erection of a new species.

Wiborg (1964) identified a few copepodites and adult females from Tristan da Cunha as *C. australis*. He was unable to assign his specimens to either of Brodskii's (1959) two varieties of *C. australis*—*C. australis* var. *atlanticus* and *C. australis* var. *pacificus*, and remarked that Brodskii's taxa '*C. australis*', '*C. pacificus*' and '*C. chilensis*' were based on 'very minute' differences.

Deevey (1966) experienced difficulties when trying to assign New Zealand specimens to Brodskii's (1961) two varieties of *C. australis*. The females fitted the description of *C. australis* var. *atlanticus*, whereas the males showed characteristics of both *C. a.* var. *atlanticus* and *C. a.* var. *pacificus*.

Grice & Hulsemann (1967) found a single female specimen about mid-way between South Africa and Australia (35°09'S 69°59'E), which they assigned to *C. australis* var. *atlanticus* Brodskii, 1959.

Vidal (1968) reported *C. australis* s.l. from the tropical waters off northern Chile. He mentioned differences between his specimens and Brodskii's (1959) description of that species that seem to be of the same order as those on which Brodskii recognized separate species.

Bradford (1979) could find no distinguishing characters between the females of *C. australis* and *C. chilensis*.

Description of the new species, *Calanus agulhensis*, and comparative remarks on affinities to closely related species follow.

Family **Calanidae**

Calanus agulhensis sp. nov.

Figs 2–7

Calanus finmarchicus (non Gunnerus) Cleve, 1904: 185. Senô *et al.*, 1963: 58, table 2. De Decker, 1964: 7, 14, 18, 26, 31.

Calanus finmarchicus sensu lato De Decker, 1973: 213, 218; 1984: 315, 320, 321, 322, 323, 331. Carter, 1978: 35, 45, 48, 52, 53, 69, 71.

Calanus finmarchicus var. *australis* Hutchings, 1985: 12, 29, 31, 37, 38, figs 9, 15, table 5.

Material

Type material from the Agulhas Bank is deposited at the South African Museum, Cape Town.

Holotype. SAM–MC00001, adult female, dissected and mounted on 11 microscope slides. R.V. *Africana II*, Station A625, 34°12,5′S 23°24,5′E, 8 April 1960, depth 94–0 m.

Allotype. SAM–MC00002, adult male, dissected and mounted on 11 microscope slides. Station data as for holotype.

Paratypes. SAM–MC00003, 148 adult females, 19 adult males, 184 juveniles in 4 per cent formaldehyde solution in water with glycerine. Station data as for holotype.

Description

Female (Figs 2–4). Total length 2,45–2,95 mm, mean 2,73 mm, n = 50. Ratio of prosome length to maximum width 3,00–3,21, mean 3,06, n = 9. Ratio of prosome length to total length (including furca) 0,78–0,83, mean 0,80, n = 9.

Head produced anterodorsally, ventrolateral margin slightly divergent in the oral region. In dorsal aspect, forehead with sides anteriorly converging towards a smoothly rounded apex; in lateral aspect evenly rounded, bulging in front of the attachment of the rostral filaments. Posterior margin of head carrying a small mid-dorsal knob, which in lateral aspect appears skewed posteriorly.

All five pedigerous segments clearly separated, with straight sides. Greatest width of prosome near the suture between pedigerous segments 1 and 2. Posterior projections of last pedigerous segment narrowly rounded in lateral view; in dorsal view their dorsal and ventral margins converging in perpendicular or slightly obtuse-angled directions to meet in a rounded tip, extending over not more than one-third of the genital segment.

Genital segment in dorsal view nearly as broad as long, with moderately bulging sides, its maximum width anterior of the middle; in lateral view with pronounced ventral bulge culminating at the anterior third of the segment, carrying the genital pore on its summit. Ventral surface of genital segment posterior to genital pore straight or slightly convex in lateral view. Antral cover with short straight sides joining distally in a semicircle. Spermathecae oblong to bean-shaped; size variable; often distorted or dislodged. Spermatophore as illustrated in Figure 4H.

Furcal rami about twice as long as broad, their inner margin with a row of long, delicate hairs, which are often partly or wholly missing in preserved specimens.

First antennae reaching as far as the tips of the furcal rami or no more than one segment beyond. Second antennae, oral appendages and legs 1 to 4 of the usual shape for the genus, although second maxillae appear stouter than usual, with sides of the lobes touching over nearly their whole length.

Serrate lamina on inner margin of basipod 1 of leg 5 with 14–18 teeth (mean 16, n = 13). Some individual variation exists in the curvature of the lamina; its median part usually bends on to the posterior surface of the joint and turns backwards, so that its teeth become oriented at right angles to the proximal and distal ones. Proximal teeth bent down in the shape of a hawk's

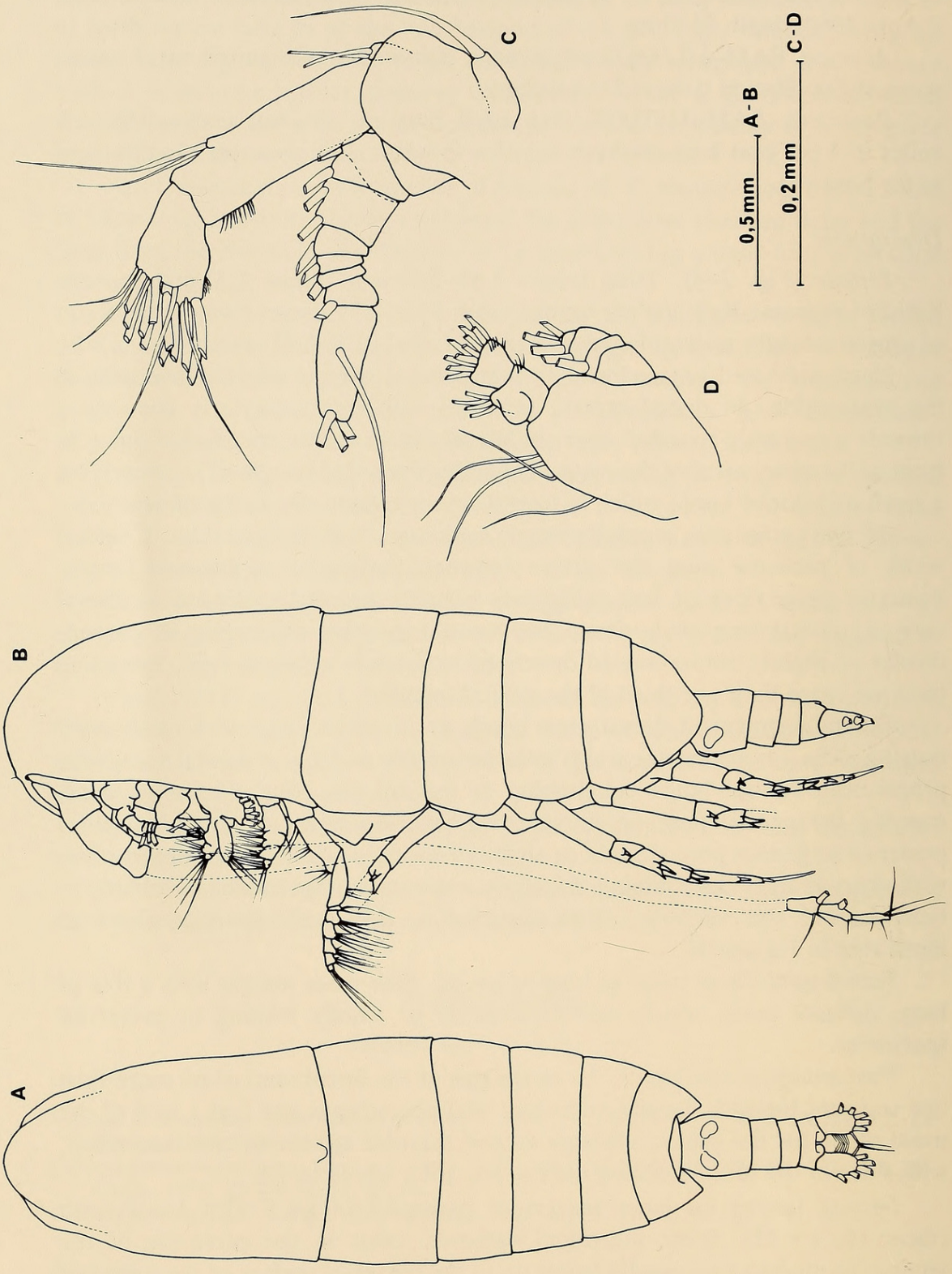

Fig. 2. *Calanus agulhensis*, ♀. A. Body, dorsal view. B. Body, lateral view. C. 2nd antenna. D. Mandible.

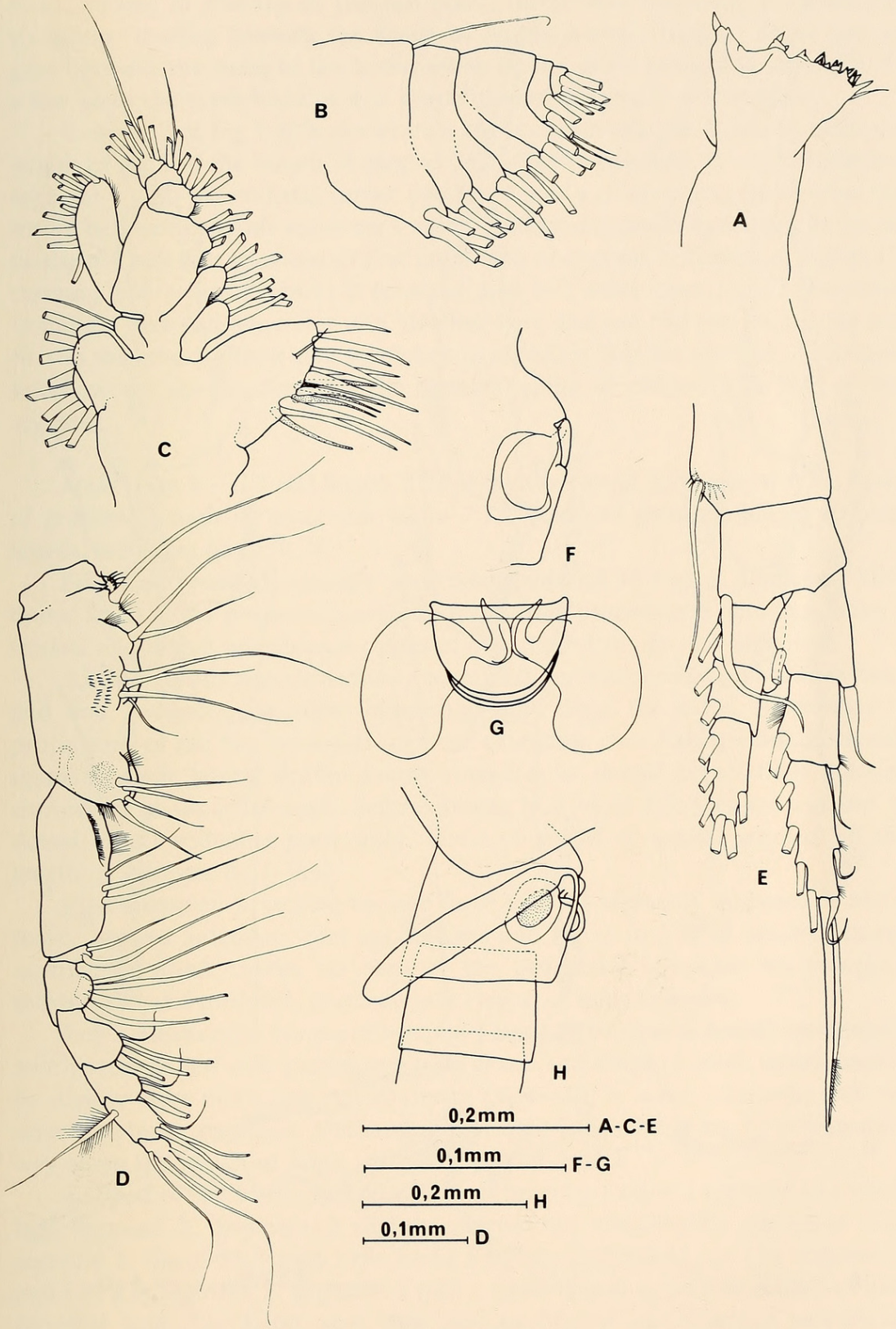

Fig. 3. *Calanus agulhensis*, ♀. A. Mandible gnathobasis. B. 2nd maxilla. C. 1st maxilla. D. Maxilliped. E. 1st leg. F. Seminal receptacle, right lateral. G. Seminal receptacle, ventral. H. Genital segment with spermatophore, right lateral.

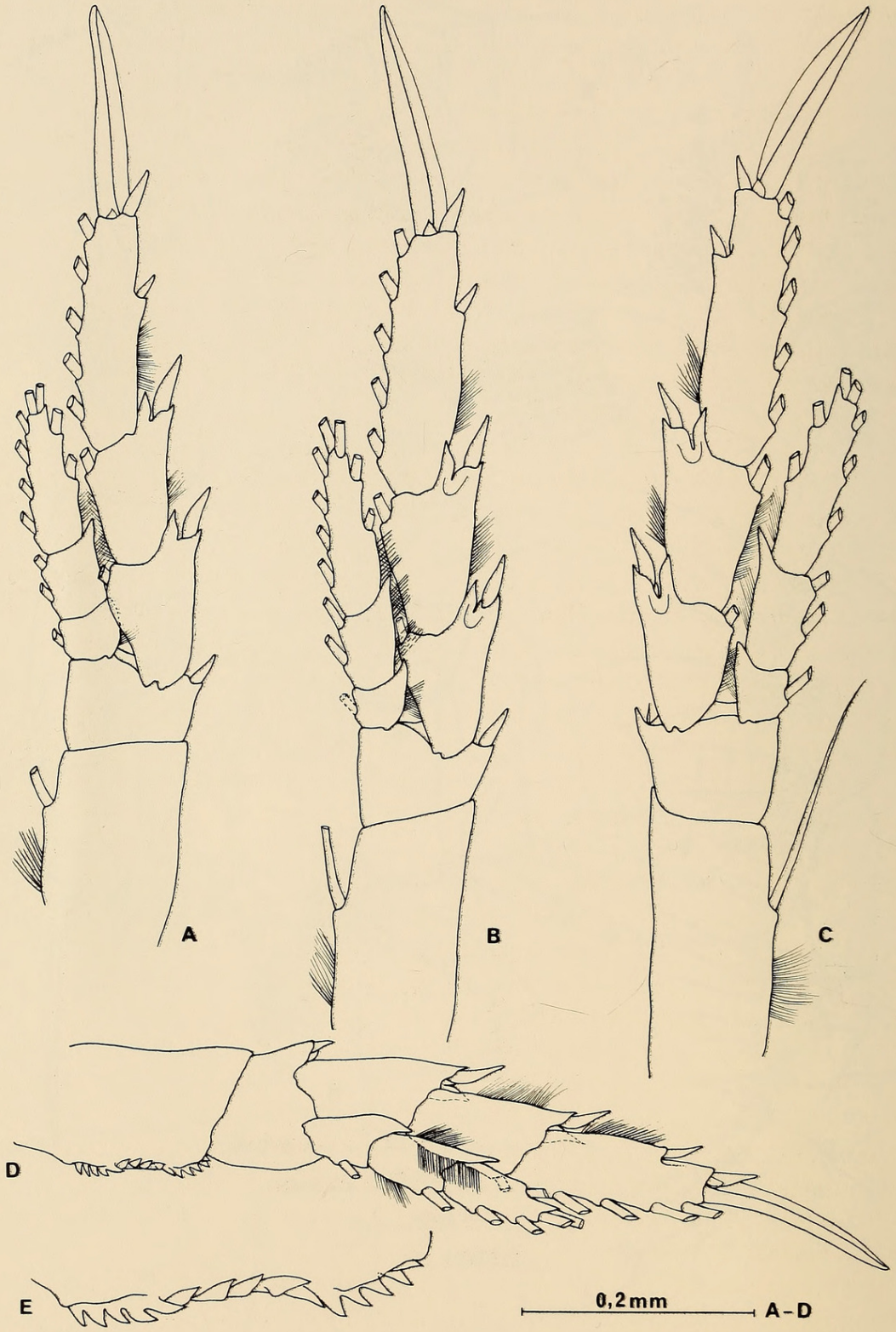

Fig. 4. *Calanus agulhensis*, ♀. A. 2nd leg. B. 3rd leg. C. 4th leg. D. 5th leg. E. Basipodal segment, inner margin, 5th leg.

beak, ending in a sharp or blunted point; distal ones becoming progressively straighter, tending towards the shape of an equilateral triangle. There are no gaps between the bases of the teeth, which do not differ noticeably in length. In a few cases the teeth were oval in shape instead of curved or triangular.

Basipod 2 of leg 5 with moderately convex inner margin. Ratio of endopod length of leg 5 to the length of exopod 0,60–0,69 (mean 0,66, n = 13). Endopod segment 1 with exterodistal corner produced into a sharp point; tip reaches the suture between exopods segments 1 and 2. Endopod segment 3 reaching as far as, or slightly beyond, insertion of first inner seta of exopod 3. Endopod segment 3 carrying 5–6 setae: 2 inner, 2 terminal and 1–2 outer ones (of 12 specimens examined, five had one outer seta, five had two, and two had one on one leg and two on the other). Great care was taken to ascertain that the absence of a second seta was not due to damage. The terminal spine of exopod 3 as long as the segment.

Male (Figs 5–7). Total length 2,74–3,00 mm (mean 2,78 mm, n = 7). Ratio of prosome length to maximum width 2,72. Ratio of prosome length to total length, including furca: 0,78.

Forehead rounded, strongly protruding anterior to rostral filaments. Mid-dorsal knob at the posterior margin of head more pronounced than in female; a further mid-dorsal prominence opposite insertion of the second antennae.

All pedigerous segments clearly separated, but the separation between head and first pedigerous segment becoming faint along the sides. Posterolateral projections of the last prosomal segment extending over half the first urosomal segment; their lateral profile evenly rounded, in dorsal aspect their margins converging at an acute angle before joining in a blunt tip. Genital segment in dorsal aspect widening posteriorly. Ratio of length of genital segment to the length of urosome 0,31–0,32.

First antennae stretching beyond furca by 3–3½ segments, segments 1 and 2 fused. Second antennae, oral appendages and legs 1 to 4 as in female, except maxilliped, which carries on each of the two distal segments the enlarged, retroflected and profusely plumose seta typical of male calanids.

Leg 5 with serrate lamina of basipod 1 less curved than in female, sometimes nearly straight and with greater variation in size and shape of teeth, which tend to be slightly more numerous: 16–20 (mean 18, n = 9); in some specimens they are separated by narrow gaps. Distal margin of right basipod 2 of leg 5 reaching half-way along the length of inner margin of left basipod 2.

Exopod of left leg 5 extending beyond furca by its distal segment and about half segment 2. Segment 2 slightly shorter but considerably narrower than segment 1, the width/length ratio being ⅓ to ¼ in segment 1, ¼ to ⅕ in segment 2, and ½ to ⅓ in segment 3. Segment 3 with a small lateral spine and short and long terminal seta, the latter very thin and easily lost in preserved specimens. Endopod of left leg 5 excluding terminal setae, not extending beyond segment 1 of exopod; setation: 1, 1, 6.

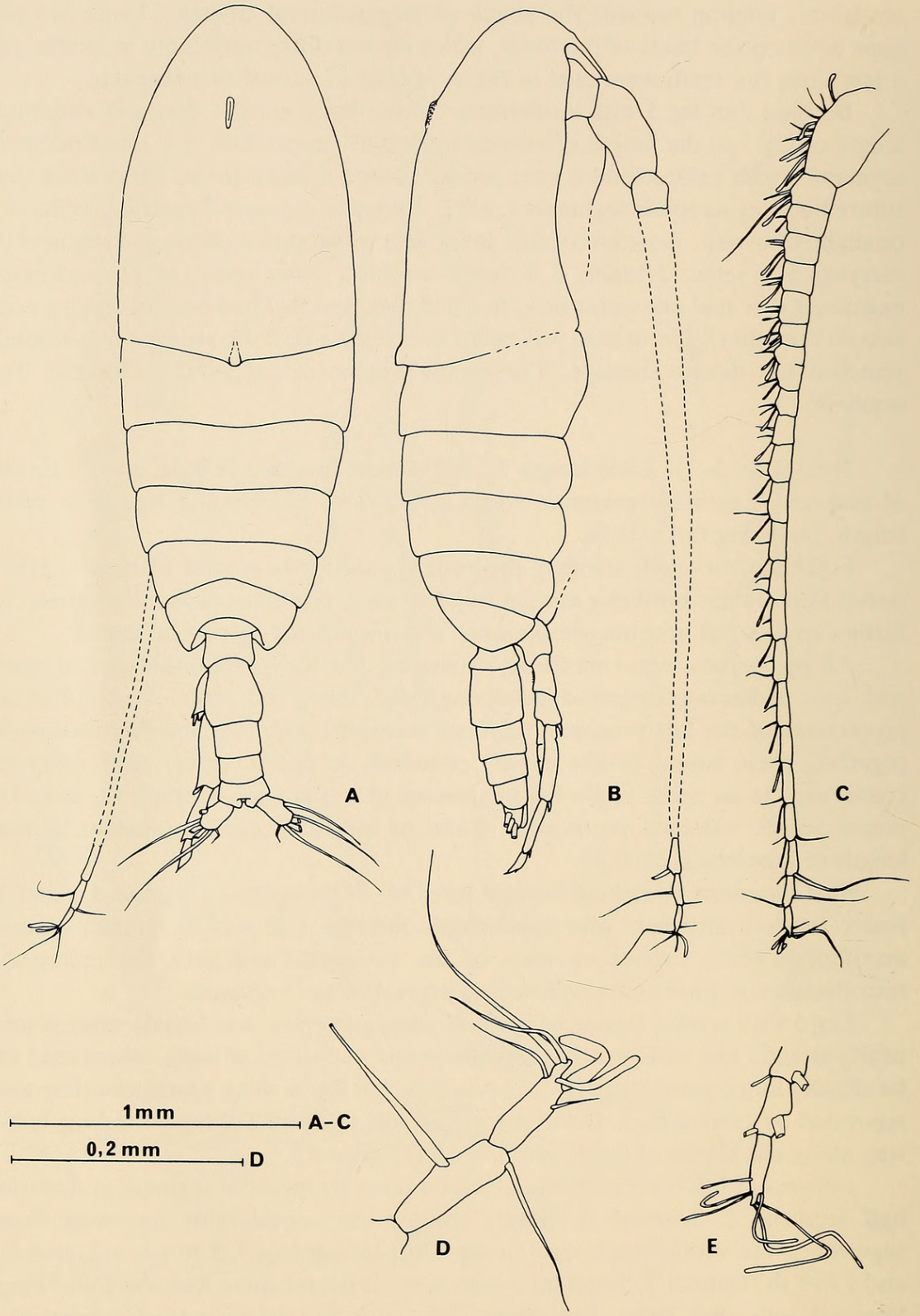

Fig. 5. *Calanus agulhensis*, ♂. A. Body, dorsal view. B. Body, lateral view. C. 1st antenna. D. 1st antenna, segment 24. E. 1st antenna, segment 25.

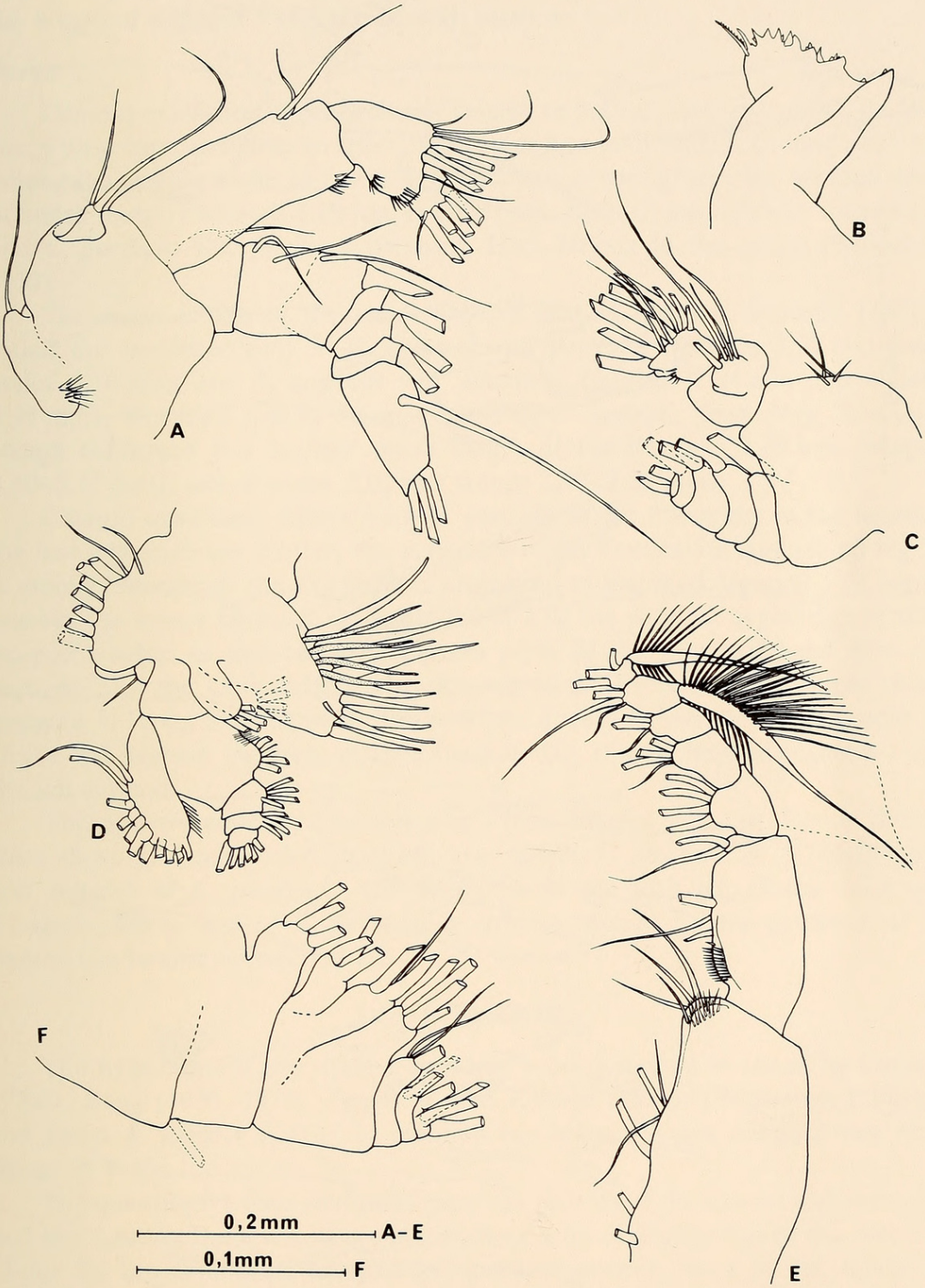

Fig. 6. *Calanus agulhensis*, ♂. A. 2nd antenna. B. Mandible gnathobasis. C. Mandible. D. 1st maxilla. E. Maxilliped. F. 2nd maxilla.

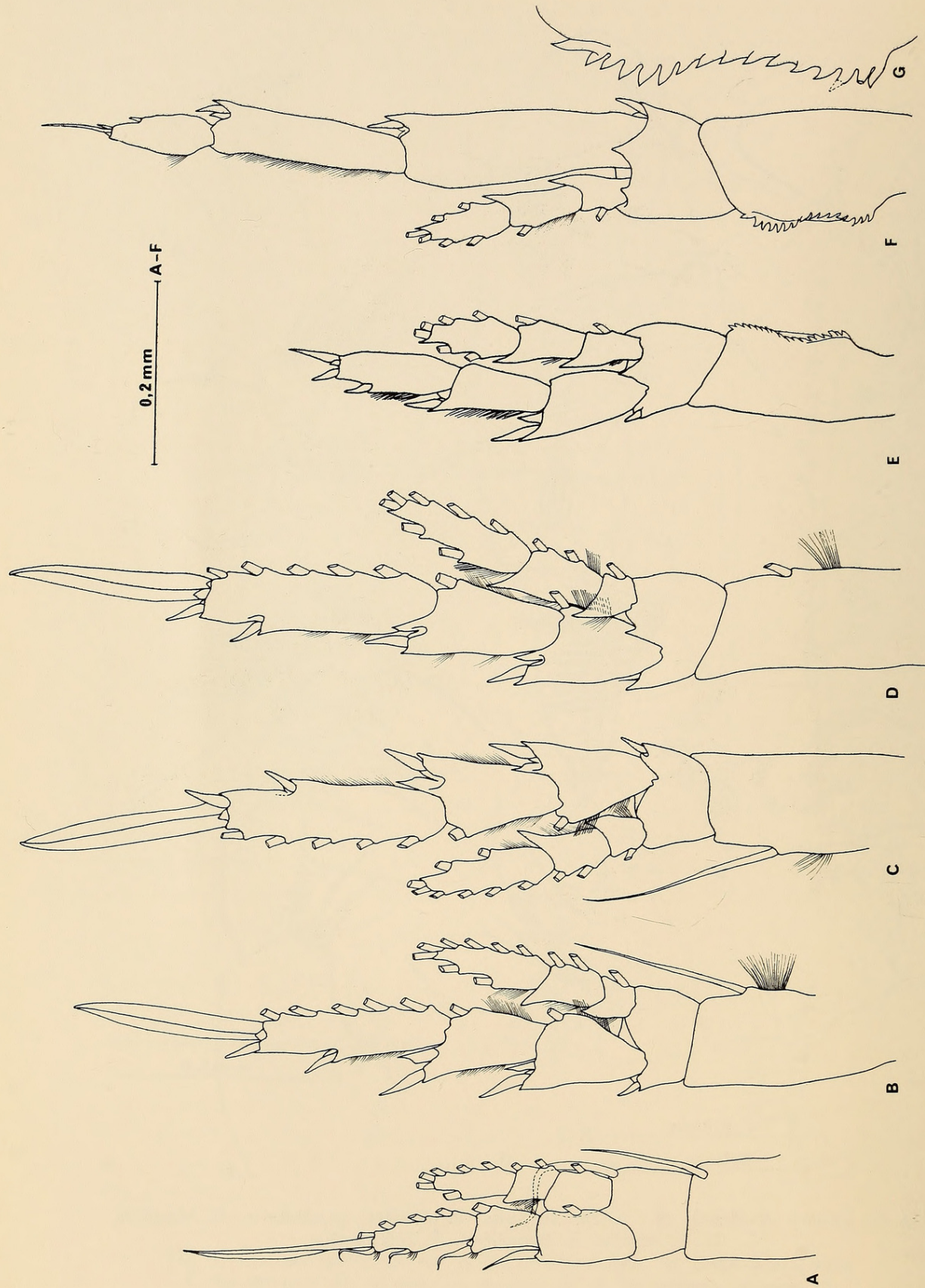

Fig. 7. *Calanus agulhensis*, ♂. A. 1st leg. B. 2nd leg. C. 3rd leg. D. 4th leg. E. Right 5th leg. F. Left 5th leg. G. Basipodal segment, inner margin, 5th leg.

Exopod of right leg 5, excluding terminal spine, extending only slightly beyond segment 1 of left exopod. Endopod of right leg 5 extending to $\frac{1}{4}$ or $\frac{1}{3}$ of the length of segment 3 of right exopod; setation: 1, 1, 6.

Remarks

Calanus agulhensis appears closely related to both *C. australis* and *C. pacificus*, with greater similarity to latter. With respect to body length, *C. agulhensis* is among the smaller forms in the *C. helgolandicus* species-group, the average size of which scarcely exceeds 3,00 mm in either sex. Both *C. australis* var. *atlanticus* and *C. pacificus* var. *pacificus* Brodskii, 1965, belong to this group (Brodskii 1959).

The mean length of the males exceeds that of females. Brodskii (1961) found this condition only in *C. australis* var. *pacificus* (females 2,95 mm and males 3,16 mm) and *C. australis* var. *atlanticus* (females 2,94 mm and males 3,05 mm). Deevey's (1966) measurements of *C. australis* from New Zealand waters confirmed this finding: mean length of females was 2,89 mm (range 2,40–3,50 mm), and of males 3,02 mm (range 2,42–3,35 mm).

Calanus agulhensis differs from *C. australis* in the following: in the female the first antennae are shorter; the curvature of the denticulate laminae on leg 5 is more pronounced; the exterodistal projection of endopod segment 1 of leg 5 reaches the suture between segments 1 and 2 of the exopod; segment 3 of the exopod reaches or exceeds the insertion point of the proximal inner seta of segment 3 of the exopod; the terminal seta of the exopod is not longer than segment 3. In leg 5 of the male, the endopod does not reach beyond segment 1 of the left exopod, the right exopod reaches only slightly beyond segment 1 of the left exopod.

The above-mentioned characters in which females of *C. agulhensis* differ from those of female of *C. australis* are, however, identical in *C. agulhensis* and females of *C. pacificus*. The similarity of the fifth leg of the male of *C. agulhensis* to that of *C. pacificus* is striking, except for the presence of a denticulate lamina on basipod 1.

DISTRIBUTION

The hydrology of the studied area has been described in detail by Orren (1966), Bang (1970, 1973), Harris & Van Foreest (1978), Lutjeharms (1981), and Swart & Largier (1987), to mention but a few. Water temperatures are shown in Table 1.

The quantitative data confirmed previous records of the species and showed that the Agulhas Bank waters are indeed the centre of distribution of the species (Table 2); the number of animals decreased westwards. West of the Agulhas Bank, the species was found irregularly throughout the year and in very low numbers, and becoming rare at the two most offshore stations. This offshore reduction in numbers was not observed over the Agulhas Bank, where the species was evenly distributed.

TABLE 1
Number of copepodites V (V) and adults (A) per haul at stations along selected transects.

Stn.	Stage	1963 J	A	S	O	N	D	1964 J	F	M	A	M	J	J	A	S	O	N	D	1965 J	F	M	A	M	J
80–1	V	8	2	1	3		1	–		–			3	6	146	20	204							1	
	A	35	3	3	40		2	–		–		1	17	27	124	179	113								
80–2	V	5	1	6	5	4	1	–	–	–	19		–		49	13	104		1			1			
	A	15	4	7	4	23	3	–	–	–	5		–	1	5	22	12				1				1
80–3	V	15	15			44	30	3	–	–	28	91	3	10	32	7	35	49	2		13	5			7
	A	133	69		9	24			–	–	16	11	7	27	2	31	14		1		1	2			2
80–4	V	33	13			21	53		–	–	19	35	9	3	–	86	3	45	51		16		3	35	10
	A	64	19			5	1	3	–	–	18	17	29	67	–	196	1		1				1	2	3
80–5	V	8	43			1	20	73	–	–	81	46	123	23	–	108	3	62	216		–	7	–	–	–
	A	29					1	23	–	–	20		16	78	–	84		3	87		–		–	–	–
52–1	V		–				5	6	17	–		1			1	1	1				1		–		
	A		–	1			1			–			1		1								–		
52–2	V	6	–				17	7	23	–	9	4		1	1			2	1	–		1			
	A		–	8	7	1	6	16	3	–	13		3	1	2					–		1			
52–3	V						1	3	7	–	2	2	1	52	1		9								–
	A		1	7			1	2	4	–	10	2		3	1		2								–
52–4	V		–	1		1	–	4		–	–		2				10	2							–
	A		–	1	4		–			–	–														–
52–5	V	1								–			1		5		4								
	A									–					1		1								
20–1	V			1	6					–					1	1	1	33	1			–			
	A				2					–						2		1	1			–			
20–2	V		1							–	1				5	10	15	5							
	A									–															
20–3	V				4	1				–					4	2	–	23	1						
	A				4	2				–							–	1							
20–4	V	–								–						1		1							
	A	–								–									2						
20–5	V					12				–		1			4	8		4						–	–
	A									–				2	1	6		1						–	–

* – indicates no haul made.

TABLE 2

Water temperature (°C) at the time of plankton sampling along transect 80.

Month	Depth (m)	Station no. 80–1	80–2	80–3	80–4	80–5
6 July 1963	0	15,35	15,42	16,68	16,29	16,42
	50	15,23	14,10	15,22	–	15,84
3 Aug. 1963	0	14,33	14,36	14,54	14,67	17,11
	50	14,33	14,34	14,54	–	15,79
7 Sept. 1963	0	14,99	14,79	16,21	16,21	16,33
	50	14,14	14,19	14,65	–	16,21
4 Oct. 1963	0	16,06	17,15	17,37	16,98	16,64
	50	15,59	16,46	16,60	–	16,10
6 Nov. 1963	0	18,53	18,71	19,07	–	19,26
	50	17,01	14,70	13,06	–	17,22
7 Dec. 1963	0	20,62	20,67	20,47	20,75	19,95
	50	14,46	12,79	13,23	–	12,24
14 Jan. 1964	0	21,82	21,52	21,84	22,09	22,18
	50	12,60	12,89	12,57	–	15,34
8 Feb. 1964	0	21,96	22,15	21,74	20,94	20,80
	50	12,57	11,94	11,94	–	13,99
24 Mar. 1964	0	21,60	21,70	21,40	21,20	–
	50	–	–	–	–	–
9 Apr. 1964	0	20,51	19,27	18,95	19,20	18,77
	50	12,67	10,91	10,48	–	10,51
6 May 1964	0	18,66	17,97	17,91	18,03	18,01
	50	11,85	10,94	11,21	–	11,23
6 June 1964	0	16,78	16,86	16,80	16,80	17,98
	50	12,58	12,74	16,78	–	13,61
8 July 1964	0	14,83	14,99	15,29	16,30	16,10
	50	10,81	14,99	15,18	–	15,50
9 Aug. 1964	0	14,90	15,58	15,71	16,24	16,54
	50	14,61	15,42	15,19	–	16,43
5 Sept. 1964	0	14,46	14,69	15,05	15,68	15,93
	50	14,44	14,68	14,96	–	--
8 Oct. 1964	0	16,49	16,77	16,71	18,25	17,53
	50	15,39	15,64	15,32	–	15,73
4 Nov. 1964	0	17,49	17,66	17,15	17,69	17,80
	50	16,99	17,09	16,82	–	16,60
6 Dec. 1964	0	19,15	19,60	19,07	18,91	18,81
	50	15,86	17,49	14,03	–	15,59
6 Jan. 1965	0	20,79	21,23	21,47	21,53	21,47
	50	13,72	18,15	16,83	–	18,70
3 Feb. 1965	0	21,53	21,65	22,17	22,50	22,43
	50	13,57	16,41	13,04	–	18,93
3 Mar. 1965	0	21,34	20,58	20,68	20,68	20,03
	50	21,26	11,15	17,87	–	15,99
3 Apr. 1965	0	21,15	20,87	20,88	21,35	21,58
	50	12,48	20,32	13,44	–	19,25
8 May 1965	0	18,94	18,60	18,42	18,04	18,35
	50	18,49	17,77	18,13	–	18,08
5 June 1965	0	16,72	16,64	16,75	17,54	19,78
	50	16,72	16,63	16,13	–	17,40

The seasonal occurrence of the species could only be investigated on stations of transect 80, as the species was rare west of the Agulhas Bank. On this transect a period of peak abundance was observed from August to November. At most offshore stations moderate abundances were also observed in December. The period of peak abundance applies to both the adults and copepodites V, although, during these months, differences were found in the optimum temperature ranges for adult and copepodite V stages.

During these months, adults were most abundant in water temperatures ranging from 14,44 °C to 19,00 °C at 0 m and from 13,06 °C to 16,03 °C at 50 m depth; corresponding temperatures for copepodites V were 14,9 °C–22,18 °C at 0 m and 10,51 °C–16,86 °C at 50 m depth. It appears that copepodites V were tolerant of wider temperature ranges than the adults.

SUMMARY

An isolated population of new *Calanus* species occurs over the Agulhas Bank. *Calanus agulhensis* sp. nov. belongs to the *C. helgolandicus* species-group. The species is closely related to the other calanid species from the Southern Hemisphere, viz. *C. australis*. *Calanus agulhensis* shows a close resemblance to *C. pacificus*, which is only found in the Northern Hemisphere.

ACKNOWLEDGEMENTS

The authors would like to thank Dr J. M. Bradford of the New Zealand Division of Marine and Freshwater Science, Department of Scientific and Industrial Research, Wellington, for making specimens of *Calanus* species from New Zealand available to the late Dr De Decker. We are also indebted to Dr K. Hulsemann of Biologische Anstalt Helgoland, Hamburg, Federal Republic of Germany, for reviewing the manuscript and helpful and valuable remarks.

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