

DIVERSITY AND DISTRIBUTION OF THE PEDUNCULATE BARNACLE OCTOLASMIS IN THE SEAS ADJACENT TO SINGAPORE

William B. Jeffries, Harold K. Voris, and Chang Man Yang

ABSTRACT

Early in 1981 marine Crustacea (Decapoda) indigenous to Singapore waters were examined for epizoic pedunculate barnacles of the genus *Octolasmis* (Gray, 1825). Twenty-seven of the 56 decapod species examined were hosts of up to 7 *Octolasmis* species each. The *Octolasmis* species observed included *O. angulata*, *O. bullata*, *O. cor*, *O. lowei*, *O. neptuni*, *O. tridens*, *O. warwickii*, and three unnamed species. Of the 10 *Octolasmis* species one (rarely two) was found externally on the body and appendages and nine species were found internally in the gill chambers. Host specificity varied, but most *Octolasmis* species occurred on several host species. With one exception, significantly more barnacles were found on the inner side than on the outer side of the host gills. Barnacles were unevenly distributed over the proximal, medial, and distal portions of the gills. Generally barnacle species had distinctive distribution patterns over the gills. In the crab *Scylla serrata* densities of two *Octolasmis* species were highly correlated, whereas in *Charybdis cruciata* the correlation between two other species of barnacles was less pronounced.

According to Darwin (1851), species of the genus *Octolasmis* are found in ". . . Eastern and Western warmer oceans in the Northern hemisphere, attached to crustacea, sea-snakes, etc." As a result of our work with *O. grayii* found on sea snakes (Jeffries and Voris, 1979), we became interested in other *Octolasmis* species and their hosts in Southeast Asian seas. Early references to *Octolasmis* from the Malay Archipelago were made by Aurivillius (1892, 1894), Lanchester (1902), Annandale (1905, 1909, 1916), and Hoek (1913). Information on collections from the same general region, and Singapore waters in particular, was given in more recent works by Broch (1931), and Nilsson-Cantell (1934a, 1934b, 1937, and 1938). In general these researchers noted only the hosts and the general location of the epizoites. Further information about the numbers of individuals or precise attachment sites was not given. Work on *O. grayii* (Jeffries and Voris, 1979) and *O. muelleri* (Jeffries and Voris, in press) showed that the epizoites are not randomly distributed on the body of the snakes or on the gills of the crabs. This suggests that at least regarding site selection, factors other than chance are at work. These results led us to inquire about the specificity between the host and the epizoic barnacles, and in particular whether *O. grayii* is found on Crustacea.

This study was undertaken to: (1) assess the diversity of *Octolasmis* species in one relatively limited geographic area, namely, the tropical seas around the Republic of Singapore, (2) describe and evaluate barnacle infestation rates over a crustacean host fauna, and (3) compare barnacle species in terms of the distributions of their attachment sites on their respective host species.

MATERIALS AND METHODS

From January to March 1981, Crustacea were collected from the sea and intertidal zone adjacent to the Republic of Singapore. In addition, crustaceans were purchased at several Singapore fish markets including the large Central Fish Market at Jurong and from local fishermen at Tuas. *Octolasmis* were on twenty-seven out of 56 crustacean species examined. Decapod sample sizes varied from 1-62 and included 53 species of crabs, 2 species of lobsters, and 1 shrimp species. Hosts were identified using Barnard (1950) and Sakai (1936, 1937, 1938, and 1939). A complete list of host species and the numbers collected is given below.

Brachyura

Dromiacea.—Dromiidae: *Dromidia unidentata* (Ruppell, 1830), 1; *Dromidiopsis cranioides* (De Man, 1888), 23.

Oxystomata.—Dorippidae: *Dorippe frascione* (Herbst, 1785), 4. Calappidae: *Calappa philargius* (Linné, 1758), 4; *Matuta lunaris* (Forskål, 1775), 2; *Matuta planipes* Fabricius, 1798, 4. Leucosiidae: *Leucosiu cranioluris* (Linne, 1764), 1.

Brachygnatha.—Majidae: *Cnmposcia retusa* Latreille, 1829, 6; *Doclea canalifera* Stimpson, 1857, 2; *Doclea gracilipes* Stimpson, 1857, 1; *Hyastenus aries* (Latreille, 1825), 5; *Chlorinoides germaini* (Bouvier, 1906), 2. Parthenopidae: *Parthenope longimanus* (Linne, 1764), 3; *Parthenope tumidus* (Lanchester, 1900), 1; *Parthenope pelagicus* (Ruppell, 1830), 1. Portunidae: *Charybdis (Charbydis) cruciata* (Herbst, 1794), 28; C. (*Charybdis*)*natator* (Herbst, 1794), 1S; C. (*Charybdis*)*anisodon* De Haan, 1850, 1; C. (*Charybdis*)*helleri* (A. Milne Edwards, 1867), 41; *Podophthalmus vigil* (Fabricius, 1798), 1; *Portunus (Portunus) pelagicus* (Linne, 1758), 47; P. (*Portunus*)*sanguinolentus* (Herbst, 1783), 62; *Scylla serrata* (Forskål, 1755), 45; *Thalamitu crenata* (Latreille, 1829), 7; *Thalamita sima* H. Milne Edwards, 1834, 4; *Thalamita spinimana* Dana, 1852, 14; *Thalamita danae* Stimpson, 1858, 24. Goneplacidae: *Carcinoplax longimanus* (De Haan, 1835), 1. Xanthidae: *Etisus dentatus* (Herbst, 1785), 1; *Etisus laevimanus* Randall, 1839, 1; *Etisus utilis* Lucas, 1852, 5; *Pilumnus vespertilio* (Fabricius, 1793), 34; *Galene bispinosa* (Herbst, 1794), 1; *Atergatis integerrimus* (Lamarck, 1818), 1; *Eriphia smithi* Mac Leay, 1838, 1; *Leptodius exaratus* (A. Milne Edwards, 1834), 55; *Leptodius sanguineus* (H. Milne Edwards, 1834), 11; *Lophozozymus pictor* (Fabricius, 1798), 2; *Menippe rumphii* (Fabricius, 1798), 6; *Myomenippe hardwicki* (Gray, 1831), 20; *Ozium guttatum* H. Milne Edwards, 1834, 3. Ocypodidae: *Dotilla myctiroides* (H. Milne Edwards, 1852), 1; *Ocypode ceratophthalmus* (Pallas, 1872), 11; *Uca (Uca) vocans* (Linne, 1758), 28; *Uca (Minuca)annulipes* (H. Milne Edwards, 1852), 20. Grapsidae: *Grapsus strigosus* (Herbst, 1799), 4; *Metopograpsus oceanicus* (Jacquinot, 1853), 37; *Neopisesurma (Neopisesarma)palawanensis* (Rathbun, 1914), 10.

Anomura

Porcellanidae: *Porcelluna* sp., 1; *Petrolisthes teres* (Melin, 1939), 17; *Petrolisthes lamarckii* (Leach, 1915), 1.

Palinura

Palinuridae: *Panulirus polyphagus* Herbst, 1796, 40. Scyllaridae: *Thenus orientalis* (Lund, 1793), 52.

Astacura

Callianassidae: *Upogebia* sp., 6

Caridea

Palaemonidae: *Macrobrachium rosenbergii* (De Man, 1879), 4.

Each decapod was examined as soon as possible after its death and representative living barnacles were removed. Five species of crabs and the two lobsters, each represented by samples of 15 or more, were selected for an evaluation of barnacle distribution. These animals were fixed in 10% neutral formalin, later rinsed in water, and transferred to 70% ethanol for storage.

The mouthparts, branchial chambers, and gills of the five portunid crab species were examined in a systematic search for barnacles as described previously (Jeffries and Voris, in press). The mouthparts and branchial chambers of the two lobster species were examined, the last two pairs of maxillipeds and the five pairs of walking legs removed along with the associated podobranchs, arthrobranchs, and pleurobranchs, in the search for barnacles. The species, numbers of barnacles, and their sites of attachment were recorded.

When barnacles matched descriptions in the literature, those species names were applied. References most useful in barnacle identification were Annandale (1905), Arudpragasm (1967), Aurivillius (1894), Hiro (1937), Newman (1960), and Nilsson-Cantell (1934a, 1934b, 1937, and 1938). When specimens deviated significantly from literature descriptions or when there were conflicting descriptions of varieties in the literature, temporary designations were used (see Table 1). Our *Octolasmis* sp. a is similar to *O. transversa sensu* Annandale (1906). *Octolasmis* sp. b in terms of valve morphology is unlike any described *Octolasmis*, while *Octolasmis* sp. c is similar to *O. cor* var. *c sensu* Annandale (1909). Voucher specimens of each of the named barnacle species, as well as the tentatively designated species, have been deposited at the United States National Museum of Natural History and the

Table 1. The number of crustaceans surveyed, percentage infested by *Octolasmis*; and for those examined in detail, the number of animals hosting particular species of *Octolasmis*.

Host	Total no. surveyed	Infested		No. hosts examined in detail	Barnacle species									
		No.	%		<i>O. angulata</i>	<i>O. bullata</i>	<i>O. cor</i>	<i>O. lowei</i>	<i>O. neptuni</i>	<i>O. tridens</i>	<i>O. worwickii</i>	<i>O. sp. a</i>	<i>O. sp. b</i>	<i>O. sp. c</i>
<i>Dorippe frascone</i>	4	2	50	4						2				
<i>Calappa philargius</i>	4	2	50	4							2			
<i>Matuta lunaris</i>	2	1	50	2									1	
<i>Leucosia cruniolaris</i>	1	1		1							1			
<i>Cumposcia retusa</i>	6	1	17	6	1									
<i>Doclea gracilipes</i>	1	1		1						1				
<i>Scylla serrata</i>	45	45	100	10			10							8
<i>Portunus pelagicus</i>	47	42	89	11	4			1	9	8	11			
<i>Portunus sanguinolentus</i>	62	35	57	10	4				4	1	10			
<i>Charybdis cruciata</i>	28	20	71	10	4		1		9	1	10			
<i>Charybdis helleri</i>	41	5	12	41						5				
<i>Charybdis anisodon</i>	1	1		1					1					
<i>Charybdis natator</i>	15	10	67	8	5			2	6	4	7			
<i>Podophthalmus vigil</i>	1	1		1	1		1	1	1	1	1			
<i>Lophozozymus pictor</i>	2	2		2	2									
<i>Atergatis integerrimus</i>	1	1		1	1									
<i>Galene bispinosa</i>	1	1		1									1	
<i>Thalamita crenata</i>	8	6	75	8	4		2	1	2	4	3			1
<i>Thalamita spinimana</i>	14	14	100	14	9		1		11	12	5			
<i>Thalamita sima</i>	4	1	25	4			1			1				1
<i>Thalamita danae</i>	18	4	22	18	4					1				
<i>Leptodius exaratus</i>	55	4	7	55	3					1				
<i>Etisus utilis</i>	5	1	20	5	1									
<i>Menippe rumphii</i>	6	6	100	6	5					4				
<i>Myomenippe hardwicki</i>	20	15	75	20	10			1	1	9				
<i>Panulirus polyphagus</i>	40	18	48	10		10								
<i>Thenus orientalis</i>	52	43	83	7			7		7	5	1			

Table 2. The number of barnacles (*Octolasmis*) of each of eight species is given for samples of seven host species.

Host	N	Total number of barnacles	Barnacle species							
			<i>O. angulata</i>	<i>O. bullata</i>	<i>O. cor</i>	<i>O. lowei</i>	<i>O. nep-juni</i>	<i>O. tridens</i>	<i>O. sp. a</i>	<i>O. sp. c.</i>
<i>S. serrata</i>	10	2,661			1,324					1,337
<i>P. pelagicus</i>	11	1,186	16				1	71	1,098	
<i>P. sanguinolentus</i>	10	444	50					50	344	
<i>C. cruciata</i>	10	1,038	33		1			510	494	
<i>C. natator</i>	8	646	62				3	201	380	
<i>P. polyphagus</i>	10	134		134						
<i>T. orientalis</i>	7	2,383				638		1,718	27	

Zoological Reference Collection, National University of Singapore. Voucher specimens of the decapod hosts are in the Zoological Reference Collection. A manuscript naming the new barnacle species is in preparation.

RESULTS

Among the 56 species of decapods examined for *Octolasmis*, 27 species were hosts for the barnacles. The hosts were distributed among crab families as follows: Portunidae 12; Xanthidae 7; Calappidae 3; Dorippidae 1; Leucosiidae 1; and Majidae 1. The lobster families Palinuridae and Scyllaridae were each represented by one species. Table 1 lists these 27 species, the number of specimens examined, the infestation rates, and the number of hosts that had one or more of each of 10 species of *Octolasmis*.

Generally, *Octolasmis* species occurred on more than one host species. *O. warwickii* and *O. angulata* were found on 16 and 15 species of hosts, respectively, and showed very little host specificity. Six of the remaining eight *Octolasmis* species had two or more host species.

Among 16 species of decapods for which five or more individuals were examined, rates of infestation ranged from 0–100%. Table 1 presents these data for those actually infested. One hundred per cent of the *Scylla serrata*, *Thalamita spinimana*, and *Menippe rumphii* had *Octolasmis*. *Portunus pelagicus* and *Thalamita crenata* had 89% and 86% infestation rates, respectively. *Charybdis helleri* (12%) and *Leptodius exaratus* (7%), represented by samples of 41 and 55 crabs, respectively, were the best documented examples of relatively low infestation rates.

Seven species of crustaceans represented by samples with seven or more infested individuals were looked at in detail (Table 2). *O. warwickii* was commonly found on all seven hosts, but was excluded from the census because it was sometimes lost in handling. The lobster *Panulirus polyphagus* hosted only *O. bullata*. *Scylla serrata* carried only *O. cor* and *O. sp. c.*, but in about equal numbers. *Charybdis cruciata* had about equal numbers of *O. sp. a* and *O. tridens* and low numbers of two other species. *Portunus pelagicus*, *P. sanguinolentus*, and *Charybdis natator* had large populations of *O. sp. a*, and somewhat fewer *O. tridens* and *O. angulata*.

Members of the genus *Octolasmis* were found in different locations on the crustacean hosts. Thus, *O. warwickii* invariably was attached externally to the spinous carapace, the antennae, the proximal segments of the walking legs, and, rarely, to the abdominal segments of the decapods. *O. tridens* was attached ex-

Table 3. The distribution of the two most common species of *Octolasmis* over regions of the gills for each of five species of crabs.

Host	N	<i>Octolasmis</i>	Location on gills				
			Outside	Inside	Proximal	Medial	Distal
<i>S. serrata</i>	10	<i>O. cor</i>	7	1,016	238	562	223
		<i>O. sp. c</i>	727	450	150	496	531
<i>P. pelagicus</i>	11	<i>O. sp. a</i>	417	535	341	487	124
		<i>O. tridens</i>	3	21	19	5	0
<i>P. sanguinolentus</i>	10	<i>O. sp. a</i>	21	254	85	177	13
		<i>O. angulata</i>	1	45	20	22	4
<i>C. cruciata</i>	10	<i>O. sp. a</i>	147	262	193	117	99
		<i>O. tridens</i>	3	247	115	113	23
<i>C. natator</i>	8	<i>O. sp. a</i>	77	93	104	41	25
		<i>O. tridens</i>	1	67	42	19	6

ternally to the mandibles, maxillae, and maxillipeds, and internally on the inner carapace margin, on adjacent leg segments, on the bases of the epipodites, podobranchs, and arthrobranchs, and lining the excurrent branchial apertures of *Thenus orientalis*. On crabs, *O. tridens* was internal, attached to the inner sides of the gills. *Octolasmis angulata* and *O. sp. a* frequently were attached to the membranous branchial lining of crabs, and *O. bullata* was similarly located in *Panulirus polyphagus*. The remaining species of *Octolasmis* under study here were usually attached to the gills of their decapod hosts. Detailed census data were collected on those seven host species listed in Table 2. Chi-square was used to compare observed and expected distributions.

Tests Assuming an Even Distribution

In these tests the most common species of barnacles for each crab species were used. In every crab species except one the total number of barnacles located on the outer side of the gills differed significantly (chi-square test, $p < 0.01$) from the number located on the inner side of the gills (Table 3). In each case the inner side of the gills supported greater numbers of barnacles. In *C. natator* the numbers were not significantly different ($p > 0.05$).

Similar tests were undertaken on the distributions of barnacles over the proximal, medial, and distal portions of the gills. In these cases the observed distributions of the two common barnacle species over the three gill portions were tested against a distribution of 1:1:1. In all cases the observed distributions (Table 3) differed significantly (chi-square tests, $p < 0.001$) from this distribution. For example, *S. serrata* had about 50% of its *O. cor* on the medial one-third of its gills and the remainder about evenly distributed between the proximal and distal portions. *Portunus pelagicus* and *P. sanguinolentus* had the most *O. sp. a* on the medial portions (50% and 65%, respectively) and the least on the distal portions (13% and 5%, respectively) of their gills (Table 3). The two *Charybdis* had most of their *O. sp. a* on the proximal portion of the gills with fewer on the medial and still fewer on the distal portion.

Tests Comparing Species Distributions

Table 3 presents distribution data for the two most common barnacle species found on each decapod species. The less common barnacle species was used to

generate expected values for comparison to the observed distribution of the more common species. For every crab species, tests show that the distribution of the most common barnacle species over the inner and outer sides of the gills, as well as over the proximal, medial, and distal portions of the gills, differed significantly ($p < 0.05$) from the distribution of the next most abundant barnacle species (Table 3).

Barnacle Density

In the crab species *S. serrata* and *C. cruciata* the second most abundant barnacle species occurred in sufficient numbers to permit a comparison of the densities of barnacle species over individual crabs. Our question was, if an individual crab has many of one barnacle species, is it also likely to have many of another barnacle species? A Spearman Rank Correlation Test comparing *S. serrata* ranked according to *O. cor* densities and the same crabs ranked according to *O. sp. c* densities resulted in a correlation of 0.985 ($p < 0.001$). For *C. cruciata* the ranks established by *O. sp. a* and *O. tridens* yielded a correlation of 0.515 ($p < 0.05$). Thus *S. serrata* densities of *O. cor* and *O. sp. c* were strongly correlated and in *C. cruciata* densities of *O. sp. a* and *O. tridens* showed a weak correlation.

DISCUSSION AND CONCLUSIONS

The shallow seas adjacent to Singapore support at least 10 species of *Octolasmis* on crustaceans, and one species on marine snakes. This compares favorably with previous reports for the genus, nine species (varieties) recorded from the Java Sea (Aurivillius, 1894) and 10 species (varieties) recorded from the Madras Coast (Daniel, 1955). Host diversity is also large. In the present study we have found 27 species of decapods bearing *Octolasmis*, and in an earlier study 13 species of marine snakes were found with *O. grayii*.

Host specificity varies in the genus *Octolasmis*. *Octolasmis cor* and *O. sp. c* were found in large numbers only on *S. serrata*. *O. grayii* occurred on numerous species of marine snakes, but never on a crustacean. On the other hand, *O. warwickii* and *O. angulata* showed little host specificity and were numerous on a variety of hosts (16 and 15 decapod species, respectively).

Crustacean hosts were utilized to varying extents by *Octolasmis*. *Scylla serrata* and *P. pelagicus* had a high incidence of barnacle infestation and they also consistently had the highest densities of barnacles. Although individual crabs often harbored hundreds of barnacles, usually only two or three species were represented. However, the exceptions to this are noteworthy. Seven species of *Octolasmis* were found on the single specimen of *Podophthalmus vigil* sampled. In addition, one of eight *C. natator* had five *Octolasmis* species, and a sample of eight *T. crenata* included one crab with six and one with five species.

Generally the samples of crabs were not large enough to evaluate and compare in depth degrees of utilization by barnacles. However, the pattern of crustacean host-barnacle relationships that emerges from these data suggests that *Octolasmis* is an adaptively complex genus that is interacting with an extremely diverse host community. Future information on the degree of host utilization and spatial relationships of barnacles on hosts will likely add order to our present view of distributions which implies more resource sharing on the part of the barnacles than may in fact be taking place.

The patterns of distribution observed between the outer and inner sides of the gills and the proximal, medial, and distal portions of the gills are comparable to patterns exhibited by *O. muelleri* on the blue crab *Callinectes sapidus* (Humes,

1941; Walker, 1974; Jeffries and Voris, in press). The barnacles are not randomly scattered over the surface area available. Factors such as current and the amount of unutilized substrate (not unrelated factors since high numbers of barnacles likely alter water flow through the chamber) may be important factors in the determination of the distributions.

ACKNOWLEDGEMENTS

We wish to thank the staff of the Department of Zoology of the National University of Singapore for their hospitality and cooperation. In particular, we are grateful to Professor Lam Toong Jin (Department Head) and Dr. Tan Wee Hin for their generous cooperation. We also thank Mr. Yeo Keng Loo for his assistance in the field and laboratory. Help from Professor W. Stephenson on the identification of certain portunid crabs is much appreciated. Support from the Dickinson College Faculty Research Fund, the Allen-Heath Memorial Foundation, and the Wrigley Marine Biology Research Fund made this investigation possible.

LITERATURE CITED

- Annandale, N. 1905. Malaysian barnacles in the Indian Museum with a list of the Indian Pedunculata.—Memoirs of the Asiatic Society of Bengal 1: 73–84.
- . 1906. Natural history notes from the R.I.M.S ship “Investigator” Capt. T. H. Heming, R.N., Commanding. Series iii, no. 13. Two new barnacles dredged in 1905–06.—Annals and Magazine of Natural History 17: 389–400.
- . 1909. An account of the Indian Cirripedia Pedunculata. Part I. Family Lepadidae.—Memoirs of the Indian Museum 2: 59–137.
- . 1916. Barnacles from deep-sea telegraph cables in the Malay Archipelago.—Journal of the Straits Branch of the Royal Asiatic Society 74: 281–302.
- Arudpragasam, K. D. 1967. Distribution and variation in form of the cirripede *Octviasmis* cvr (Aurivillius, 1893) in relation to the respiratory current of its host *Scylla serrata*.—Ceylon Journal of Science 7: 105–115.
- Aurivillius, C. W. S. 1892. Neue Cirripeden aus dem Atlantischen, Indischen und Stillen Ocean.—Kungliga Svenska Vetenskapsakademiens Forhandlingar 49: 123–134.
- . 1894. Studien iiber Cirripeden. I. Morphologie und Systematik neuer oder wenig bekannter Cirripeden.—Kongliga Svenska Vetenskapsakademiens Handlingar 26: 1–89.
- Barnard, K. H. 1950. Descriptive catalogue of South African Decapod Crustacea.—Annals of the South African Museum 38: 1–937.
- Broch, H. 1931. Papers from Dr. Th. Mortensen's Pacific Expedition 1914–16. LVI. Indomalayan Cirripedia.—Videnskabelige Meddelelser Fra Dansk Naturhistorisk Forening 91: 1–146.
- Daniel, A. 1955. The Cirripedia of the Madras Coast.—Bulletin of the Madras Government Museum 6: 1–40.
- Darwin, C. 1851. A monograph on the sub-class Cirripedia. I. The Lepadidae.—Ray Society, London. Pp. 1–400.
- Hiro, F. 1937. Studies on cirripedian fauna of Japan. II. Cirripeds found in the vicinity of the Seto Marine Biological Laboratory.—Memoirs of the College of Science, Kyoto Imperial University, (B) 12: 385–478.
- Hoek, P. P. C. 1913. The Cirripedia of the Siboga-Expedition.—Siboga Expeditie, 31b: 129–275.
- Humes, A. G. 1941. Notes on *Octolasmis mülleri* (Coker), a barnacle commensal on crabs.—Transactions of the American Microscopical Society 60: 101–103.
- Jeffries, W. B., and H. K. Voris. 1979. Observations on the relationship between *Octolasmis grayii* (Darwin, 1851) (Cirripedia, Thoracica) and certain marine snakes (Hydrophiidae).—Crustaceana 37: 123–132.
- , and ———. (In press). The distribution, size and reproduction of the pedunculate barnacle, *Octviasmis mülleri* (Coker, 1902) on the blue crab, *Callinectes sapidus* (Rathbun, 1896).—Fieldiana.
- Lanchester, W. F. 1902. Crustacea of the “Skeat Expedition”.—Proceedings of the Zoological Society of London 2: 369–377.
- Newman, W. A. 1960. Five pedunculate cirripeds from the western Pacific, including two new forms.—Crustaceana 1: 100–116.
- Nilsson-Cantell, C. A. 1934a. Indo-Malayan cirripeds in the Raffles Museum, Singapore.—Bulletin of the Raffles Museum 9: 42–73.

- . 1934b. Cirripeds from the Malay Archipelago in the Zoological Museum of Amsterdam. — Zoologische Mededelingen 17: 31–63.
- . 1937. On a second collection of Indo-Malayan cirripedes from the Raffles Museum. — Bulletin of the Raffles Museum 13: 93–96.
- . 1938. Cirripedes from the Indian Ocean. — Memoirs of the Indian Museum 13: 1–81.
- Sakai, T. 1936. Studies on the crabs of Japan. I. Dromiacea. — Science Reports of the Tokyo Bunrika Daigaku, (B) 3(Supplement 1): 1–66.
- . 1937. Studies on the crabs of Japan. II. Oxystomata. — Science Reports of the Tokyo Bunrika Daigaku, (B) 3(Supplement 2): 67–192.
- . 1938. Studies on the crabs of Japan. III. Brachygnatha, Oxyrhyncha. — Tokyo, Yokendo, Limited. Pp. 193–364.
- . 1939. Studies on the crabs of Japan. IV. Brachygnatha, Brachyrhyncha. — Tokyo, Yokendo, Limited. Pp. 365–471.
- Walker, G. 1974. The occurrence, distribution and attachment of the pedunculate barnacle *Octolasmis mülleri* (Coker) on the gills of crabs, particularly the blue crab, *Callinectes sapidus* Rathbun. — Biological Bulletin 147: 678–689.

RECEIVED: 2 May 1982.

ACCEPTED: 13 July 1982.

Addresses: (WBJ) Department of Biology, Dickinson College, Carlisle, Pennsylvania 17013; (HKV) Department of Zoology, Field Museum of Natural History, Chicago, Illinois 60605; (CMY) Zoology Department, Kent Ridge, National University of Singapore, Singapore 0511.