

OCCASIONAL PAPERS
OF
BERNICE P. BISHOP MUSEUM
HONOLULU, HAWAII

Volume XXIII

July 12, 1968

Number 15

**Studies on *Portunus pelagicus* (Linnaeus) and
P. sanguinolentus (Herbst)**

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INTRODUCTION

This work began by consideration of the identity of *Callinectes alexandri* Rathbun 1907 (p. 61, Pl. 2, Fig. 1; Pl. 9, Figs. 3, 3a, 3b) from Tahiti and Fiji, which Rathbun later recorded from the Indian Ocean (1911, p. 206, Pl. 17, Fig. 4). Because a suspicion arose that the later paper referred to a different species from the earlier one, the two are kept separate below.

Although Stephenson and Campbell (1959) were disinclined to recognize *Callinectes* Stimpson 1860 as separate from *Portunus* Weber 1795, Garth and Stephenson (1966) have recognized it as a valid genus. It is diagnosed by the following combination of features: (1) Possessing a very narrow L-shaped male abdomen; (2) Possessing strong lateral projections of the anteroexternal angles of the meri of the third maxillipeds; and (3) Lacking an inner spine on the wrist of the cheliped. This has been confirmed by Stephenson, Williams, and Lance (1968) in a numerical study.

From Rathbun's (1907) description and figures it is clear her type does not belong to the genus *Callinectes*, and that it is either *P. sanguinolentus* (Herbst 1796) or *P. pelagicus* (Linnaeus 1766). The author has examined the type of *C. alexandri* in the U. S. National Museum, labeled "Papeete, shore, Nov. 9, 1899, Acc. No. 45248, 1 ♂ juv., Cat. No. 32854." No traces remain of the three red spots on the carapace, which are diagnostic for fresh and recently preserved specimens of *P. sanguinolentus*. Distinction between juveniles of *P. sanguino-*

lentus and *P. pelagicus*, then, have to be based upon the following features listed by Stephenson and Rees (1967). (1) Frontal teeth are more equal in size and more evenly spaced in *P. sanguinolentus* than in *P. pelagicus*; and (2) The merus of the third maxilliped is hirsute in *P. sanguinolentus*, as against its relative smoothness in *P. pelagicus*. By these criteria, the male type (and also the female cotype from Fiji) clearly belong to *P. sanguinolentus*.

Rathbun's later photograph of *C. alexandri* (1911, Pl. 17, Fig. 4) is of much better quality than her earlier one, and by its general facies and particularly by the form of the front and carapace granulation, seems clearly to be a specimen of *P. pelagicus*. It was this photograph which primarily influenced Stephenson and Campbell (1959) to give *C. alexandri* as a probable synonym of *P. pelagicus*.

One of the noticeable differences between *C. alexandri* of Rathbun 1907, and *C. alexandri* of Rathbun 1911, is that the former has a much broader carapace. *P. sanguinolentus* is suspected to be a broader crab than *P. pelagicus*, and, to confirm this, measurements were made.

ACKNOWLEDGMENTS

I am deeply grateful to the individuals and institutions listed in the Appendix for loan and supply of specimens, and particularly to Dr. E. P. Ryan for allowing me to use his unpublished biometric data, for supplying color transparencies, and for purchasing on my behalf freshly collected specimens of Hawaiian material.

I am also very grateful to Miss May Rees of the Zoology Department, University of Queensland, for valuable assistance in most phases of the work.

Thanks are also due to the Photography Section of the University of Queensland and to the Research Grants Committee of this University for financial support.

LENGTH/BREADTH RATIOS OF *P. pelagicus* AND *P. sanguinolentus* USING QUEENSLAND MATERIAL

In December, 1964, large numbers of *P. pelagicus* were trawled from Moreton Bay, Queensland, and somewhat smaller numbers of *P. sanguinolentus* from Southport, Queensland. Supplementary col-

lections were made in the same areas in February, 1966. Using dial calipers, lengths and breadths of carapaces were measured to the nearest 0.1 mm. Using breadth groups at 10 mm. intervals, data were sought for up to 10 males and 10 females of each species for each breadth grouping.

Results showed considerable individual variations, with no obvious indications of sexual dimorphism, and hence data on males and females of each species were pooled. Smoothed curves through the mean L/B values of the size groups are given in Figure 1A and B. These curves: (a) Are irregularly shaped, indicating complex relationships between the variables; and (b) Clearly indicate that *P. sanguinolentus* is generally broader than *P. pelagicus*.

Because of individual variation, relative breadth of carapace has little diagnostic value. However, from the data upon *C. alexandri* plotted on Figure 1, it can be inferred that the Pacific material shows "extreme" *P. sanguinolentus* proportions, and the Indian Ocean material "extreme" *P. pelagicus* proportions.

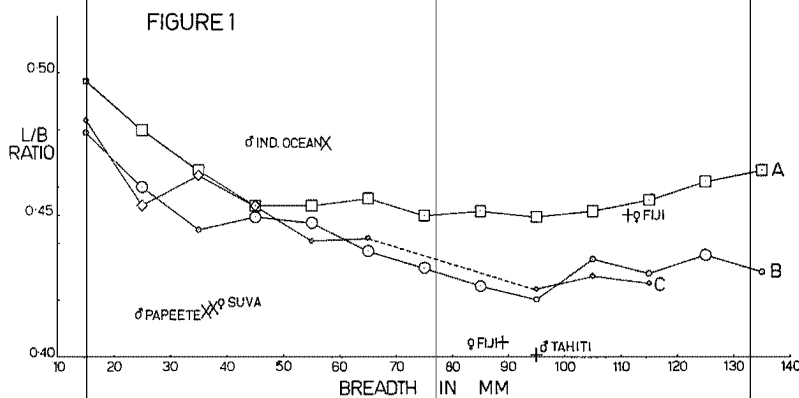


FIGURE 1.—Length/breadth ratios of carapaces of *Portunus* against carapace breadths. Breadths are grouped in 10 mm. intervals and plotted at the center of each group. A, *P. pelagicus* from Queensland. Large squares indicate mean data upon 15-25 specimens, and small squares upon 6-14 specimens. B, *P. sanguinolentus* from Queensland. Large circles based on 15-25 specimens, and small upon 6-14. C, *P. sanguinolentus* from Hawaii. Large diamonds based on 15-25 specimens, and small upon 6-14. X indicates individual specimens of *Callinectes alexandri*. + indicates individual specimens of *P. sanguinolentus*.

COMPARISON OF *P. sanguinolentus*
FROM DIFFERENT AREAS

(a) *Comparison of Queensland and Hawaiian specimens.*—Because a sufficient size range of Queensland material was not readily obtainable, and because Ryan (1965) has given an abstract of morphometric data on *P. sanguinolentus*, Dr. E. P. Ryan was approached for Hawaiian material. He kindly provided numerous specimens and his own data, from which Figure 1C is derived. The general form of the curve resembles Figure 1B for Queensland material, although with different deviations from the general U shape. It is uncertain whether or not these indicate different moulting lengths.

Meanwhile, during 1964, the author saw a color transparency of a specimen of *P. sanguinolentus* from Hawaii in the possession of Dr. John S. Garth. The pigmentation differed from that of live Australian material, from Japanese material shown by Sakai (1939, Col. Pl. 48, Fig. 1; 1965, Col. Pl. 53), and evidently from Batavian material (see Delsman and de Man, 1925, Pl. 12a). The difference was confirmed by examination of color transparencies of Hawaiian material kindly provided by Dr. E. P. Ryan, and by examination of specimens recently preserved in formalin, which he later supplied. Meanwhile, Tinker (1965) has given a plate (p. 99, upper) which clearly shows the characteristic pattern of the Hawaiian form. The color differences between Queensland and Hawaiian material concern primarily the dorsal surface of the carapace and the chelipeds, with the position complicated by the fact that large males show secondary sexual features in cheliped pigmentation. Relevant data upon fresh or recently preserved specimens are given in Table 1, and photographs are given in Figure 2A, B, respectively.

Apart from color differences, forms from the two areas are remarkably similar. In many Hawaiian specimens the fingers of the chelipeds are more distinctly grooved than in Queensland material, but some Queensland specimens are also deeply grooved. The same indefiniteness applies to the frontal teeth (usually sharper in Hawaiian material, especially the median teeth), to the eighth anterolateral teeth (usually longer and sharper in Hawaiian material) and to the second to seventh anterolateral teeth (often sharper in Hawaiian material). The only difference which appears to have constancy is that the epistomial projection in Hawaiian specimens is shorter and more slender than in Queensland material.

TABLE 1
 COLOR DISTINCTIONS BETWEEN *P. sanguinolentus* FROM QUEENSLAND AND FROM HAWAII

COLOR FEATURE	QUEENSLAND SPECIMENS	HAWAIIAN SPECIMENS
Carapace		
(1) Background	Dull greenish fawn	Mottled, numerous pale rounded blotches, surrounded by darker meshwork
(2) Three red spots	Uniformly red	Centers pale, edges deeply pigmented
(3) Posterior branchial red spots	Almost circular	Almost right-angled posterior-mesial boundary
(4) Central (cardiac) red spot	Lozenge-shaped	Elongate, shaped as broad dagger
Cheliped features not showing dimorphism		
(5) Upper surfaces arm, wrist, hand	Without mottling	Mottled
(6) Hand, inner surface at movable finger articulation	Small purple-red spot	Large purple-red spot
(7) Hand outer surface, near movable finger articulation	Small purple-red mark	Large purple-red mark
Cheliped features showing sexual dimorphism		
<i>(a) Large males</i>		
(8) Arm, dorsal portion of anterior under surface	Mottled purple-red	Densely purple-red
(9) Wrist, inner surface	Relatively faint purple-red	Deep purple-red
(10) Palm, proximal area, inner surface	Mottled, typically faintest toward lower border	Densely pigmented extending to lower border
(11) Immobile finger, inner side	Dense pigment, terminating well before articulation with movable finger	Dense pigment extending proximally on lower surface almost to articulation with movable finger
(12) Movable finger, inner side	Pigment terminating before articulation, extending distally almost to tip	Pigmented to articulation, tip white
<i>(b) Females and small males</i>		
(13) Arm, dorsal portion of anterior under surface	Unpigmented	Mottled purple-red
(14) Wrist, inner surface	Very faint purple-red	Deep purple-red
(15) Palm, proximal area, inner surface	Very small discrete pigmented area	Fairly small discrete pigmented area
(16) Immobile finger, inner side	Unpigmented	Pigmented
(17) Movable finger, inner side	Discrete pigment bar, ca. $\frac{1}{3}$ way along	Pigment in proximal half extending to articulation

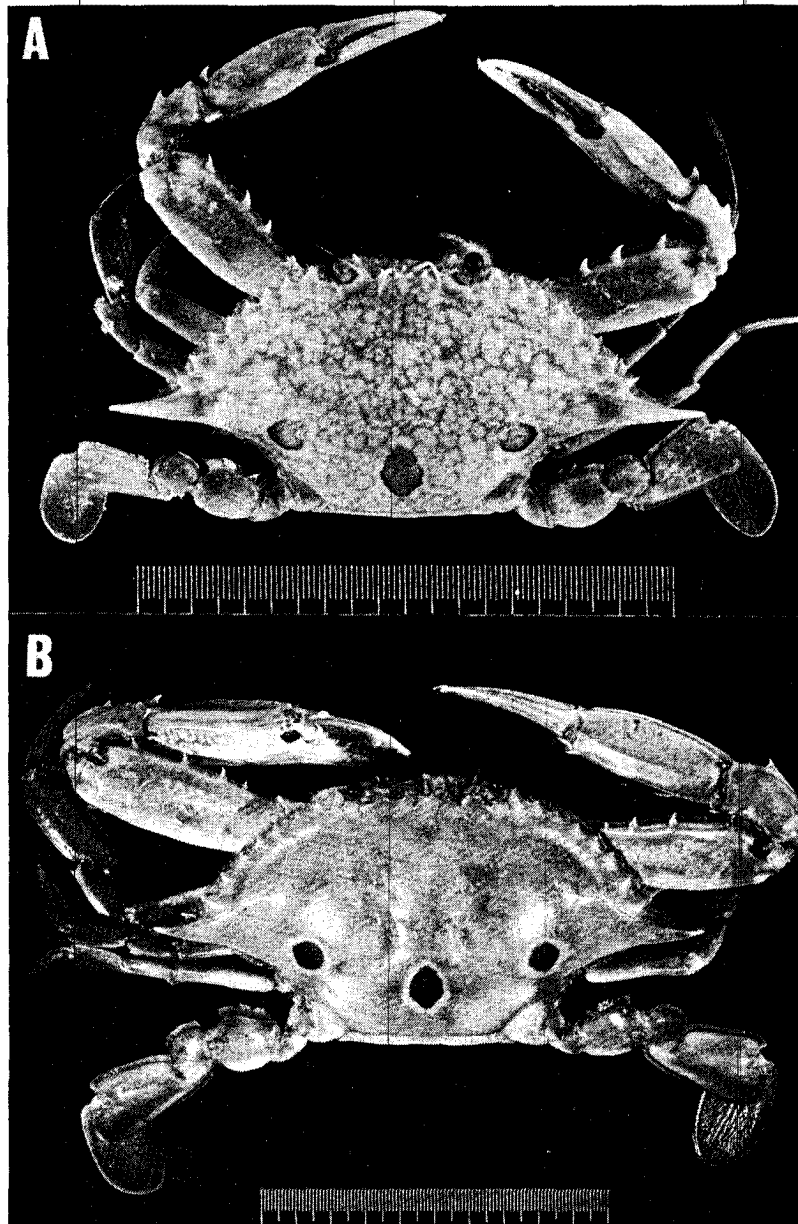


FIGURE 2.—Dorsal views. Scale 1 div. = 1 mm. A. *Portunus sanguinolentus hawaiiensis* subsp. nov. (paratype, male, 107 mm., purchased from Honolulu Fish Market, Dec. 1965). B. *P. sanguinolentus* (male, 97 mm., between Mud I. and St. Helena I., Moreton Bay, 30-31/iii/1966, J. McLean and L. Wale).

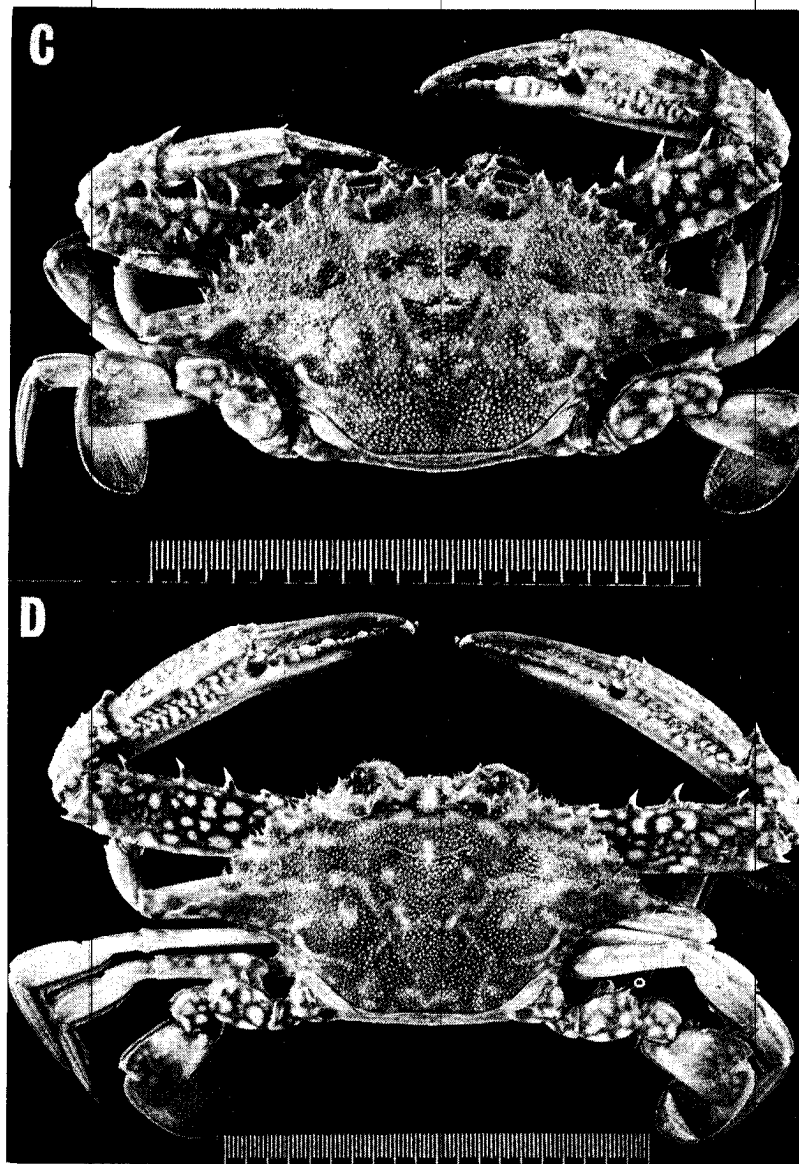


FIGURE 2 (Continued).—Dorsal views. Scale 1 div. = 1 mm. C. *P. pelagicus* (female, 106.3 mm., Uranouchi Inlet, Tosa Bay, Japan). D. *P. pelagicus* (male, 117.4 mm., Uranouchi Inlet, Tosa Bay, Japan).

(b) *Fijian records.*—The characteristic mottled carapaces of the Hawaiian forms are exhibited by the following dried specimens from Fiji in the collections of the Macleay Museum, Sydney:

♀ (89 mm.), Nululau, Laucala Bay, Viti Levu, Fiji; ♀ (110 mm.), Fiji.

The specimens are very different in the L/B ratios of their carapaces (see Fig. 1).

It should be noted that Rathbun's cotype of *C. alexandri* came from Fiji.

(c) *Tahitian records.*—Forest and Guinot (1961) are the latest authors dealing with portunids from Tahitian waters, and Mme. Guinot has kindly forwarded the following specimen for examination:

♂ (95.4 mm.) labeled "*Neptunus sanguinolentus* (Herbst), Ranson coll., Tahiti, Guinot et Forest det."

It is a particularly broad specimen (L/B = 0.40; see Fig. 1) and the carapace is strongly granular.

In pigmentation it combines certain features of Hawaiian forms with those of Queensland forms. Hawaiian features are those of Table 1 numbered (1), (2), (5), (13), (14), (15). Queensland features are (4), (6), (7). Intermediate features are (3), (17).

While, on balance the resemblance is closer to the Hawaiian forms, the mottling of the carapace (Feature 1) and upper surfaces of the cheliped (Feature 5) is much finer, less obvious, and with greater areas of background color.

It seems possible that the Tahitian material is another color form of the species, but to determine this considerable numbers of fresh or recently preserved specimens would have to be examined.

(d) *Japanese material.*—The only relevant information is from Sakai's two colored plates of males (1939, Pl. 48, Fig. 1; 1965, Pl. 53). These show pigmentation greatly resembling the Queensland specimens, but with differences as follows:

- (1) Whitish spots on anterior of carapace more distinct;
- (2) Pigment spot on distal upper surface of arm of cheliped more diffuse;
- (3) Inner surface of palm blue, without purple markings;
- (4) Inner side of immovable finger with pigment extending either to or almost to articulation of movable finger (in this it tends toward the Hawaiian material);

(5) Inner side of movable finger pigmented up to the articulation (in this it is similar to the Hawaiian material).

Allowing for possible errors of artistry, it is evident that the Japanese and Queensland material belong to the same color form of *P. sanguinolentus* and, further, that within this form there may be minor variations in cheliped pigmentation.

COMPARISON OF HAWAIIAN *P. sanguinolentus* WITH *P. pelagicus*

Because the mottled carapace of the Hawaiian forms shows a resemblance to that of *P. pelagicus*, it is conceivable that the former are to some extent intermediate between *P. pelagicus* and "normal" *P. sanguinolentus*. Investigation showed that any such intermediacy applies only to pigmentation. Color similarities and differences are given below for the Hawaiian forms and *P. pelagicus* from Moreton Bay, Queensland. Japanese specimens of *P. pelagicus* kindly provided by Dr. K. Yatsuzuka of the Usa Marine Biological Station, Usa, Kochi, Japan, from Uranouchi Inlet, Tosa Bay, Japan (see Fig. 2C, D) are identical with those from Queensland. (See also Yatsuzuka, 1962, Pl. 1).

At the outset *P. pelagicus* differs noticeably from *P. sanguinolentus*, including the Hawaiian forms, in that the secondary sexual pigmentation of large males is more distinctive, and includes the color of the dorsal surface of the carapace. In these males (see Fig. 2D) the carapace has a dark blue background color, bearing a bold pattern of irregular lines of light blue.

Comparisons are made below between the Hawaiian males and smaller males (carapace breadth < 120 mm.) of *P. pelagicus*, disregarding the distinctive large males of the latter species.

SIMILARITIES

(1) *Carapace*.—Mottled, with indistinct reticulations along posterior borders.

(2) *Chelipeds*.—Inner surfaces of arm, wrist, hand, and fingers pigmented; dense patch on inner surface of hand at articulation of movable finger.

DIFFERENCES

These are given in Table 2.

TABLE 2

COLOR DIFFERENCES BETWEEN SMALL MALES OF QUEENSLAND *P. pelagicus* (BREADTH < 120 MM.) AND MALES OF *P. sanguinolentus* FROM HAWAII*

FEATURE	QUEENSLAND <i>P. pelagicus</i>	HAWAIIAN <i>P. sanguinolentus</i>
Carapace	Mottling restricted to posterior portion of carapace: dark brown or brownish green, with large light brown areas and very pale areas: three large red spots absent	Anterior and posterior portions of carapace mottled: reddish meshwork on very pale background: three large red spots present
Chelipeds		
Arm, upper surface	Strongly mottled (light spots on dark purple background)	Occasionally feebly mottled, deep red concentration on boss at wrist articulation
Arm, inner surface	Faint pigment dorsally with few scattered spots	Moderate to dense pigment dorsally
Wrist, upper surface	Strongly mottled, dark purple at base of inner spine	Dark red pigment along inner border extending distally to base of spine
Wrist, inner surface	Strongly mottled, dense concentration dark purple on under surface of inner spine	Densely and uniformly dark red
Hand, upper surface	Strongly mottled	Without conspicuous pigment, base of spine at wrist articulation dense red
Hand, inner surface	Dorsally, mottled with reddish brown or purple, ventrally blue	Proximally red patch extending slightly along ventral border
Hand, outer surface	Dorsally mottled with reddish brown or purple; large deep purple or reddish-brown spot at movable finger articulation	General surface without pigment; moderately small red spot at movable finger articulation
Immovable finger, inner surface	Pale blue dorsally, ventrally purple red, tip purple red	Proximally a red band, distally pale pink
Immovable finger, outer surface	Dorsal proximal area pale blue, ventral distal area deep purple	Unpigmented
Immovable finger, under surface	Deep purple	Pale pink
Movable finger, upper surface	Mottled, becoming deep purple in distal third	Not mottled, pigmented proximally, densest on inner border
Movable finger, inner surface	Pale blue, becoming purple dorsally and distally	Proximal two-thirds red, distal third white
Movable finger, outer surface	Dark-tipped	Not dark-tipped
Walking legs		
Dorsal portion of merus	Mottled	Not mottled
Fifth leg		
Dorsal portions of ischium, merus, and carpus	Strongly mottled	Not mottled

* Differences between females are roughly comparable, except that in female *P. pelagicus* the lateral portions of the posterior portion of the carapace show the reticulated pattern (see Fig. 2C).

DISCUSSION

The Hawaiian and Fijian specimens of *P. sanguinolentus* which have been examined differ in pigmentation from both Queensland and Japanese material. These differences are evidently of a genetic nature because they are constant throughout both series of material, and because they are independent of the environment of capture (at least in Queensland material). They include secondary sexual characteristics which are presumably significant in species and sexual recognition.

The mid-Pacific *P. sanguinolentus* show superficial resemblances to *P. pelagicus*, but closer examination shows that they differ as much in pigmentation from *P. pelagicus* as they do from Queensland *P. sanguinolentus*. They also differ in numerous nonpigmentary features, which have been listed by Stephenson and Campbell (1959), and by Stephenson and Rees (1967). To these features should be added the more granular and relatively narrower carapace of *P. pelagicus*.

The distinctions between the mid-Pacific *P. sanguinolentus* and those from other areas appear distinctive enough, providing pigmented material is examined, to merit subspecific status. Before this can be firmly assigned, the distribution of each of the color forms must be determined. Particular attention should be given to Tahitian material which shows certain unique features. In the event of confirmation of the biogeographical isolation of the mid-Pacific material, the name *Portunus sanguinolentus hawaiiensis* is proposed for these forms, and the following holotype for the subspecies is selected:

♂ (110.5 mm.), purchased Honolulu Fish Market, Dr. E. P. Ryan, December, 1965.

The remaining material of this form, as listed in the Appendix, would become paratypes.

The Fijian specimen of Rathbun's *Callinectes alexandri* would also become a paratype of *P. sanguinolentus hawaiiensis*, while her Indian Ocean specimen is added to the synonymy of *P. pelagicus*. The subspecific designation of Rathbun's Tahitian holotype of *C. alexandri* is still uncertain, but it belongs to the species *P. sanguinolentus*.

APPENDIX

The following material was examined for comparison of pigmen-

tation (exclusive of Fijian and Tahitian specimens mentioned in text).

P. sanguinolentus

A. *P. sanguinolentus sanguinolentus*

Queensland

Female (46.3 mm.), Albatross Bay, near Weipa, Gulf of Carpentaria, June, 1962–March, 1963, H. Foley, Australian Mus., P 14177. Female (86.8 mm.), Machans Beach, Cairns, dragnet inshore, S.E. wind, falling tide, 26/xii/1963, J. H. Barnes, Queensland Mus., W 2489. 5 males (29.2–71.4 mm.), Gulf of Carpentaria, C.S.I.R.O. Prawn Survey, 1963, Australian Mus. 7 males (129.3–155.4 mm.), 6 females (123.3–147.4 mm.), N.E. Jumpin Pin Bar, E. of Stradbroke I., trawled 25 fm., 16/ii/1966, G. Reisenweber, Queensland Mus., W 2479, W 2481–W 2483, W 2488, W 2490. 2 males (ca. 76, 90.6 mm.), 2 females (111.6, 117.3 mm.), ca. 5 miles E.N.E. of Scarborough blinker, on edge of Northern Banks, Moreton Bay, trawled 5 fm., 29/iii/1966, W.S. and M.R., Queensland Mus., W 2486. 3 males (ca. 97.0–137.0 mm.), 2 females (111.8, 124.1 mm.), between Mud I. and St. Helena I., Moreton Bay, trawled, 30-31/iii/1966, J. McLean and L. Wale, Queensland Mus., W 2480, W 2485.

Lord Howe I.

Male (fragmented, 76.7 mm.), Lagoon Beach, May, 1964, I. Bennett, Biology Department, Univ. of Sydney.

Western Australia

2 females (65.8, 80.6 mm.), Exmouth Gulf, Dec. 1955–Feb. 1956, W. Dall and O. K. Godfrey, Queensland Mus., W 1484.

Manus I.

Male (60.7 mm.), Seadlee Harbour, C.S.I.R.O. Fisheries, beach seine, 4/xi/1949, Australian Mus. P. 14877.

B. *P. sanguinolentus hawaiiensis*

Hawaiian Is.

Ex Allan Hancock Foundation, Los Angeles, collections.

Male (83.0 mm.), Pearl Harbor, Oahu I., Samoan crab nets, 2-10/iii/1946, F.C. Zeisenhenne, No. 1034 B. Male (66.2 mm.), female (109.5 mm.), Hanalei Bay, Kauai I., 10-20 ft., diving, 1/viii/1957, F.C. Zeisenhenne. 2 males (ca. 35.5, 72.8 mm.), S. or W. shore, Oahu I., dredged 100-1,000 ft., 1959, Mrs. King.

Ex Bernice P. Bishop Museum, Honolulu, collections.

6 juveniles (14.6–15.9 mm.), Oahu Fish Market, No. 2187. Male (117.5 mm.), Oahu, Honolulu market, No. 2279. Male (62.7 mm.),

Maunalua Bay off Oahu, 18/iii/1953, No. 5877. Female (133.8 mm.), Sta. 159, *Pele* Expedition, No. 6798.

Ex Smithsonian Institution, Washington, D.C., collections.

Portion of male (ca. 90 mm.), 1 male (ca. 110 mm.), 2 females (ca. 108, 120.7 mm.), Honolulu, 1901, U. S. Fish Commission. 7 males (38.3–95.9 mm.), 5 females (ca. 52–ca. 128 mm.), Pearl Harbor, 23/iv/1902, U. S. Fish Commission Steamer *Albatross*, U.S.N.M. 29696.

Ex Dr. E.P. Ryan, Honolulu.

37 juvs. (9.8–ca. 25.5 mm.), off Kokokahi, Kaneohe Bay, Oahu I., three seine hauls, $\frac{1}{4}$ in. mesh seine, 2.5 ft., 15/ix/1962 (deposited Bernice P. Bishop Mus.). 134 juvs. (9.6–37.1 mm.), off Kokokahi, Kaneohe Bay, Oahu I., three seine hauls, $\frac{1}{4}$ in. mesh seine, 2.5 ft., silt and sand bottom, 12/vi/1963 (deposited Bernice P. Bishop Mus.). 18 males (90.0–133.5 mm.), 6 females (95.2–158 mm.), purchased Honolulu Fish Market by Dr. E.P. Ryan, Dec. 1965; of these 6 males and 2 females have been deposited in each of the following institutions: Bernice P. Bishop Mus. (inc. holotype), Australian Mus., and Queensland Mus., W 2487, W 2491.

C. P. pelagicus

Queensland

3 males (111–121.5 mm.), 2 females (116.5, 129 mm.), off St. Helena I., Moreton Bay, trawled, 28/vii/1966, L. Wale, Pres. Queensland Mus., W 2492. 47 males (75.5–157 mm.). 1 *Sacculina* infested male (129.5 mm.), 44 females (77–150.5 mm.), 6 ovig. females (108–156 mm.), trawled *Wanderer II*, shallow, muddy grounds near St. Helena I., Moreton Bay, 15–25/viii/1966, coll. L. Wale, Pres. Queensland Mus.

Japan

2 males (107.8, 117.4 mm.), 2 females (105.1, 106.3 mm.), Ura-nouchi Inlet, Tosa Bay, 10/vi/1966, Pres. Dr. K. Yatsuzuka.

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