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A NEW GENUS FOR CAVE-DWELLING CRABS PREVIOUSLY ASSIGNED TO *SESARMOIDES* (CRUSTACEA: DECAPODA: BRACHYURA: SESARMIDAE)

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ABSTRACT. **–** The semi-terrestrial crab genus *Sesarmoides* is restricted to three species of Indo-West Pacific intertidal mangrove and estuarine crabs, *S. kraussi*, *S. longipes* and *S. borneensis*. Twelve other species previously placed in *Sesarmoides* are here transferred to a new genus, *Karstarma*. The species of *Sesarmoides* are distinguished from those of *Karstama* by the presence of a stridulatory structure consisting of a longitudinal crest on the cheliped merus that is used to rub against a ridge of suborbital granules. This form of stridulation is apparently unique within the Sesarmidae, although common in the Varunidae. Other features distinguishing species of *Sesarmoides* sensu stricto from those of *Karstama* are their relatively smaller adult carapace size, a relatively shallower median epigastric groove, the presence of a longitudinal row of small granules or ridge on the outer surface of the cheliped pollex, and a relatively more slender male first gonopod.

KEY WORDS. **–** Taxonomy, Sesarmidae, new genus, caves, stridulation, intertidal, mangrove.

INTRODUCTION

Ng (2002) recently reappraised the sesarmid crab genus *Sesarmoides* Serène & Soh, 1970, and recognised 14 species, *S. balicus* Ng, 2002, *S. boholano* Ng, 2002, *S. borneensis* (Tweedie, 1950), *S. cerberus* (Holthuis, 1964), *S. emdi* Ng & Whitten, 1995, *S. guamensis* Ng, 2002, *S. jacksoni* (Balss, 1934), *S. jacobsoni* (Ihle, 1912), *S. kraussi* (De Man, 1887), *S. longipes* (Krauss, 1843), *S. loyalty* Ng, 2002, *S. novabritannia* Ng, 1988, *S. sulu* Ng, 2002 and *S. ultrapes* Ng, Guinot & Iliffe, 1994 all from the Indo-West Pacific. Naruse & Ng (2007) subsequently described another new species from Sulawesi, *S. microphthalmus*.

However, Ng (2002: 420) commented that there were two species groups in *Sesarmoides*. One group included three species usually associated with mangroves, estuarine areas and sometimes coastal caves, viz., *S. longipes*, *S. kraussi* and *S. borneensis*. These species are morphologically distinguished by their smaller adult carapace size, a relatively shallower median epigastric groove, the presence of a longitudinal row of small granules or ridge on the outer surface of the pollex and the male first gonopod being relatively more slender. The second group of species are typically larger, have a swollen epigastric region separated by a deeper median groove, often possess a row of granules on the dorsal margin of the dactylus of the chelipeds and lack a longitudinal row of granules or ridge on the outer surface of the pollex (Ng, 2002). This group included the remaining 12 species listed above, and all are typically found in anchialine cave systems (Ng, 2002; Naruse & Ng, 2007).

In this paper, we argue that these two groups of *Sesarmoides* must be recognised as distinct genera. In addition to the characters listed by Ng (2002), species of *Sesarmoides* sensu stricto possess a unique stridulatory mechanism consisting of a ridge on the inner surface of the merus of the cheliped and a milled suborbital ridge.

All the specimens listed in Ng (2002) were utilised for the present study and the reader should consult this reference for this specimen data. As such, we only list additional material which is deposited in the Queensland Museum (QM), Brisbane and the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research, National University of Singapore. Measurements (in millimetres, mm) are of the carapace width and length respectively. The abbreviations G1 and G2 are used for the male first and second gonopods respectively.

TAXONOMY

Family SESARMIDAE Dana, 1851

Sesarmoides Serène & Soh, 1970

Type species. – *Sesarma krausii* De Man, 1887, by original designation; gender masculine.

Diagnosis. – Carapace distinctly trapezoidal in shape, posterolateral margins strongly converging towards posterior carapace margin; epigastric region with relatively shallow median groove; dorsal margin of cheliped dactylus smooth or almost so; outer surface of pollex of males with longitudinal row of small granules, spinules, or ridge; inner surface swollen, with patch of distinctly raised granules; cheliped merus with inner dorsal angle forming small tooth but not prominent expansion, inner surface with distinctly raised ridge just behind inner margin (Fig. 1); suborbital margin distinctly milled, without setae; G1 relatively stout, short.

Included species. – *Sesarmoides borneensis* (Tweedie, 1950), *S. kraussi* (De Man, 1887) and *S. longipes* (Krauss, 1843).

Material examined. – In addition to the material of the *Sesarmoides* species listed in Ng (1988, 2002), Ng et al. (1994) and Naruse & Ng (2007), we add the following: *Sesarmoides kraussi*: 1 male (ZRC 1964.9.8.7), Pasir Ris, Singapore, coll. M. W. F. Tweedie, 1950; 1 damaged specimen (ZRC 1987.560), Mandai, Singapore, coll. P. K. L. Ng, Mar.1986; 1 female (ZRC 1968.11.22.1), Buloh Besar River, Singapore, coll. C. L. Soh, 20 Mar.1966; 1 female (ZRC 1968.11.22.2), River Simpang Mak Wai, Singapore, coll. C. L. Soh, 18 Mar.1966; 2 females (ZRC 1965.8.3.49–50), Prai, Province Wellesley, Peninsular Malaysia, coll. Dec.1938; 1 male (ZRC 1965.8.3.50), Port Swettenham, Peninsular Malaysia, coll. M. W. F. Tweedie, Dec.1934; 1 male (ZRC 1965.8.3.51), Port Swettenham, Peninsular Malaysia, coll. M. W. F. Tweedie, Dec.1934; 1 male (ZRC 1965.8.3.52), Port Swettenham, Peninsular Malaysia, coll. M. W. F. Tweedie, Dec.1934; 10 specimens (ZRC 1965.8.3.53–60), Port Swettenham, Peninsular Malaysia, coll. M. W. F. Tweedie, Dec.1934; 25 juveniles (ZRC 1965.8.3.53–60), Port Swettenham, Peninsular Malaysia, coll. M. W. F. Tweedie, Dec.1931; 1 male (ZRC 1965.8.3.61), Kuantan, Pahang, Peninsular Malaysia, coll. Sep.1935; 1 male, 1 female (ZRC 1970.1.20.5–6), Port Swettenham, Peninsular Malaysia, coll. Sase Kuman, 10 Jan.1970; 1 female (ZRC 1999.1136), Matang mangroves, Perak, Peninsular Malaysia, Jun.1995.

Sesarmoides borneensis: 1 male (20.3 × 15.9 mm) (QM W5365), Pulgul Ck., south of Urangan, Hervey Bay, southeast Queensland, Australia, 25°19'S 152°54'E, coll. P. Shanco & E. Hegerl, 19 Jul.1975; 1 male (12.3 × 9.7 mm) (ZRC), Kampung Ladong, Pulau Tekong, Singapore; 1 male (Museum of Florence), lateral branch, St. Paul N. P. Cave, Palawan Island, Philippines, coll. Borri & C. Volpi, 25 Feb.1991; 1 female (Museum of Florence), Palawan Island, Philippines, coll. G. Messana, 25 Jan.1991; 1 male (ZRC 1970.1.20.4), Johor Straits, Singapore, coll. C. L. Soh, 18 Jan.1970; 1 male (ZRC 1968.11.23.1), Seletar River, Singapore, coll. C. L. Soh, 22 Jun.1967; 2 males, 1 female (ZRC 1970.1.23.12–13), Johor Straits, Singapore, coll. C. L. Soh, 21 Jan.1970; 1 male (ZRC 1999.0567), T. Pandan Besar, Bako, Sarawak, East Malaysia, Borneo, coll. P. K. L. Ng, 28 Jun.1994; 2 males, 2 females (ZRC 2000.2056), Ajkwa River, Irian Jaya, Indonesia, coll. D. L. Rahayu, 11 Jan.2000; 2 males, 2 females (ZRC 2003.0496), station A33/II/C1, mangrove, Ajkwa River, Irian Jaya, coll. D. L. Rahayu, 23 Oct.2002; 1 male, 1 ovigerous female (ZRC 2003.0494), Irian Jaya, Indonesia, coll. D. L. Rahayu, 17 Oct.2001; 4 males (ZRC 2003.0495), Irian Jaya, Indonesia, coll. D. L. Rahayu, 19 Oct.2001.

Remarks. – The genus *Sesarmoides* Serène & Soh, 1970, was originally established for species which have a relatively flattened carapace with strongly divergent lateral margins, a narrow frontal margin which is shorter than the posterior carapace margin, long and slender ambulatory legs (especially the third), a basal antennal segment which is swollen and globular with a sub-longitudinal peduncle and an epistome with a distinct transverse rim and deep median notch. As discussed earlier, Ng (2002) had noted that there were two groups of species in the genus but preferred not to separate them at that time. The present discovery of a unique stridulatory mechanism (Fig. 1) in one group (but not the other) now requires that the two groups be recognised as separate genera. Ng's (2002) first group must retain the name *Sesarmoides* as it contains *Sesarma krausii* De Man, 1887, the type species of *Sesarmoides*. Thus a new genus, *Karstama,* is established here for the second group previously placed in the genus and which typically live in caves in limestone or karst systems.

Other than the characters given by Serène & Soh (1970) and Ng (2002) (for his first group of *Sesarmoides*), we note that the three species of *Sesarmoides* sensu stricto recognised here, share a stridulatory structure that is unique within the Sesarmidae (to our knowledge). Stridulation has been long known, or postulated, to occur in sesarmids although the mechanisms have been little studied. Tweedie (1954: 123) observed "The crab [*Perisesarma eumolpe*] rose on its feet, twisted one cheliped downwards so that the upper margin of the chela was vertical or even a little overturned, and rubbed the upper margin of the dactylus of the other chela up and down against that of the downturned one, at first rather slowly, but with increasing speed, so that the active chela appeared to be almost vibrating at the end of the performance." This behaviour was later verified as stridulatory by Mulstay (1980) and Siebel & Salmon (1982) for the American species *Sesarma reticulatum* and *S. cinereum*. The dactylar tubercles are rasped over the pectinated crests on the upper surface of the palm. Other sesarmids that lack such pectinated crests,

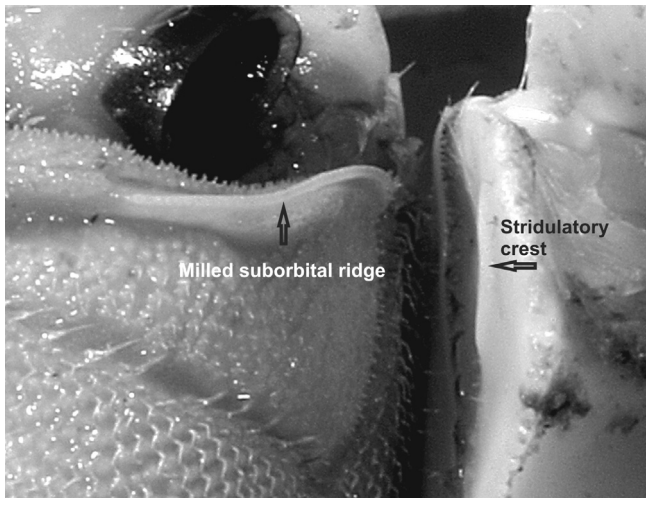

Fig. 1. The stridulatory ridge and orbit of *Sesarmoides borneensis*, a key character unique to *Sesarmoides* species (QM W5365, male, 20.3 × 15.9 mm).

appear to also stridulate by rubbing the inner face of the palm against the pterygostome or suborbital crest (pers. obs.), although the "pars stridens" (file) and the corresponding "plectrum" (see Guinot-Dumortier & Dumortier, 1960) are less obvious.

In *Sesarmoides*, the inner surface of the cheliped merus, just adjacent to the inner distal margin, has a short but distinct smooth ridge. This ridge can be stridulated against the milled (finely, evenly, and smoothly granulated) suborbital margin (see Fig. 1). In *Karstama* species, there is no trace of any such stridulatory ridge on the cheliped merus. These species also have a very prominent sublamelliform distal process on the merus of the cheliped, which in *Sesarmoides* sensu stricto is shorter and dentiform. The suborbital margin of *Karstama* species is not distinctly milled as in *Sesarmoides* sensu stricto, but typical of other sesarmids in being granular under a dense lining of short setae which almost completely obscure the margin. The unusual stridulatory structure of *Sesarmoides* sensu stricto is a clear indication that they are generically different from the other species that have been included in the genus.

In addition, *Sesarmoides* sensu stricto species have trapezoidal carapaces (Fig. 2A), whereas those of *Karstama* species are generally quadrate or rounded (Fig. 2B). *Sesarmoides* species have a smaller adult carapace size, a relatively shallower median epigastric groove, the presence of a longitudinal row of small granules/teeth or ridge on the outer surface of the pollex and a relatively more slender male first gonopod. *Karstama* species are typically larger, have a swollen epigastric region separated by a deeper median groove, often possess a row of granules on the dorsal margin of the dactylus of the chelipeds and lack a longitudinal row of granules or ridge on the outer surface of the pollex (Ng, 2002).

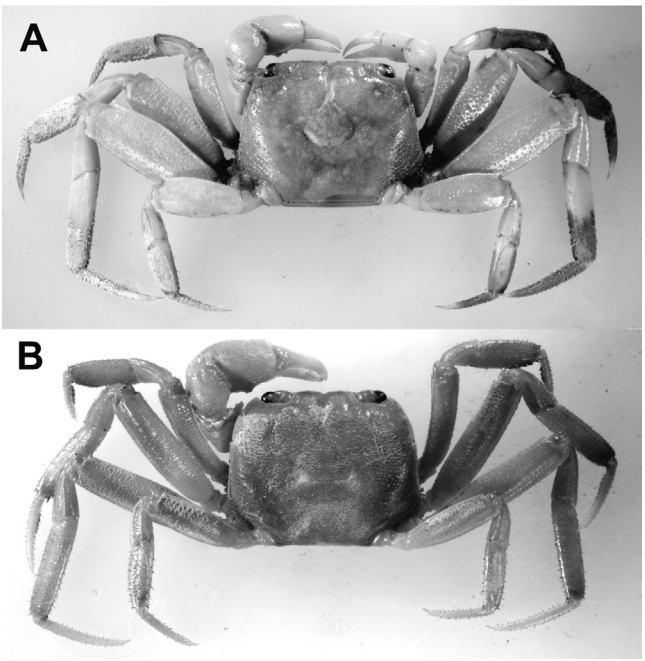

Fig. 2. Dorsal views of representatives of *Sesarmoides* and *Karstarma* showing typical differences in overall carapace shape: A, *Sesarmoides borneensis*, note the more trapezoidal carapace (QM W5365, male, 20.3 × 15.9 mm); and B, *Karstarma guamense*, with a generally more quadrate and anterolaterally rounded carapace (QM W27549, male, 15.2 × 12.3 mm).

Ng (2002) also noted an interesting correlation in habitat-preferences. The three species of *Sesarmoides* sensu stricto are typically coastal or mangrove species (see Tweedie, 1950; Barnard, 1950; Tan & Ng, 1994; Ng & Sivasothi, 1999; Ng, 2002), although *S. borneensis* has been found in a cave near mangroves in the Philippines (Ng, 2002: 428). In contrast, all the members of *Karstama* have only been found in karst areas or limestone caves, sometimes some distance from the sea (Holthuis, 1964; Ihle, 1912; Naruse et al., 2004; Naruse & Ng, 2007).

Key to the species of *Sesarmoides* sensu stricto

1. Carapace with one epibranchial tooth; length of third ambulatory leg less than 3 times extraorbital width, propodus about 2–3 times as long as broad; anterior frontal margin nearly straight; male abdomen with telson slightly shorter than broad at base; length of segment 6 slightly less than twice width [East Africa] ..... *S. longipes*
– Carapace with two epibranchial teeth; length of third ambulatory leg more than 3 times extraorbital width, propodus about 4 times as long as broad; anterior frontal margin weakly sinuous; male abdomen with telson slightly shorter than broad at base; length of segment 6 not as above 2
2. Outer surface of pollex with a longitudinal row of 8–13 small conical tubercles; adult male abdomen with segment 6 a little shorter than half its proximal breadth [Indian Ocean and Southeast Asia as far as the Ryukyu Islands] ..... *S. kraussi*
– Outer surface of pollex with a longitudinal row of 3–5 elongated tubercles; adult male abdomen with segment 6 slightly longer than half its proximal breadth [Southeast Asia and northern Australia] ..... *S. borneensis*

Karstarma, new genus

Type species. – *Sesarmoides boholano* Ng, 2002, by present designation.

Diagnosis. – Carapace more or less rectangular, with rounded anterolateral margins, posterolateral margins weakly converging towards posterior carapace margin; epigastric region with a relatively deep median groove; dorsal margin of cheliped dactylus usually with a row of granules; outer surface of pollex smooth; inner surface of palm smooth or with scattered very small granules, never swollen; cheliped merus with inner dorsal angle prominently expanded to form sub-lamelliform lobe, inner surface smooth, without ridge; suborbital margin granulated, densely lined with setae which obscures margin; G1 relatively slender, elongate.

Etymology. – The name is derived from the typical habitat of most of the constituent species, i.e. karst systems, in arbitrary combination with the genus name *Sesarma*. Gender neuter.

Remarks. – *Karstama* is distinguished from *Sesarmoides* by a combination of carapace and cheliped characters (see remarks for *Sesarmoides* sensu stricto).

***Species included*. –** *Sesarmoides balicus* Ng, 2002, *S. boholano* Ng, 2002, *S. cerberus* (Holthuis, 1964), *S. emdi* Ng & Whitten, 1995, *S. guamensis* Ng, 2002, *S. jacksoni* (Balss, 1934), *S. jacobsoni* (Ihle, 1912), *S. loyalty* Ng, 2002, *S. microphthalmus* Naruse & Ng, 2007, *S. novabritannia* Ng, 1988, *S. sulu* Ng, 2002, and *S. ultrapes* Ng, Guinot & Iliffe, 1994.

***Material examined*. –** In addition to the material of the *Sesarmoides* species listed in Ng (1988, 2002), Ng et al. (1994) and Naruse & Ng (2007), we add the following: *Sesarmoides guamensis*: QM W27549, male (15.2 × 12.3 mm), Faifai Beach, Timon Bay, Guam, 13°48'N 144°45'E, 28 Jul.–1 Aug.2001, coll. P. K. L. Ng.

Key to the species of *Karstarma*
(adapted from Ng, 2002)

1. Ocular peduncle short, cornea small, eyes occupying only part of orbit 2
– Ocular peduncle and cornea of normal size and occupying entirely the orbital cavity 3
2. Lateral margin of carapace smoothly divergent, appears almost straight; no mat of setae on inner margins of ambulatory propodi and dactyli; chitinous part of G1 relatively long, directed outwards at an angle of about 45º [Java: Indonesia] .... *K. jacobsoni*
– Lateral margin of carapace distinctly convex; prominent mat of setae present on inner margins of ambulatory propodi and dactyli; chitinous part of G1 relatively shorter, directed outwards at an angle of about 30º [Sulawesi: Indonesia] .... *K. microphthalmus*
3. Tufts of setae absent between coxae of first to third ambulatory legs 4
– Distinct tufts of setae present between coxae of first to third ambulatory legs 6
4. Ambulatory legs extremely long, third ambulatory leg (merus to dactylus length) about 4.9 times carapace length [Solomon Islands] ..... *K. ultrapes*
– Ambulatory legs long, but third ambulatory leg (merus to dactylus) distinctly less than 4.5 times carapace length 5
5. Tip of external orbital tooth reaching just beyond level of frontal margin; male telson equal in length to segment 6 of male abdomen [Ambon: Indonesia] ..... *K. cerberus*
– Tip of external orbital tooth not reaching level of frontal margin; male telson shorter than segment 6 of male abdomen [New Britain] ..... *K. novabritannia*
6. Surface of carapace without obvious oblique striae on posterior branchial region; meri of second and third ambulatory legs 4.7 and 5.1 times carapace length respectively [Christmas Island: Indian Ocean] ..... *S. jacksoni*
– Surface of carapace with clear oblique striae on posterior branchial region; meri of second and third ambulatory legs less than 4.5 and less than 5.0 times carapace length respectively 7
7. Meri of first to third ambulatory legs with sharp distal dorsal spine [Palawan: the Philippines] ..... *K. sulu*
– Meri of first to third ambulatory legs without distal dorsal spine, may be angular distally but never spiniform 8
8. External orbital tooth truncate, outer margin straight to gently concave, separated from first anterolateral tooth by prominent, deep V-shaped notch [Bohol: the Philippines; southern Ryukyu Islands: Japan] ..... *K. boholano*
– External orbital tooth not truncate, outer margin almost straight to gently convex, separated from first anterolateral tooth by narrow cleft or relatively shallower notch 9
9. G1 with elongate, slender chitinous distal part 10
– G1 with relatively short, truncate chitinous distal part 11
10. External orbital tooth separated from first anterolateral tooth by very shallow notch; length to width ratios of meri of second and third ambulatory legs 3.1 and 3.5 respectively ; inner margin of G1 with gentle submedian hump [Loyalty Islands] .... *K. loyalty*
– External orbital tooth separated from first anterolateral tooth by very shallow notch; length to width ratios of meri of second and third ambulatory legs 3.3 and 3.6 respectively; inner margin of G1 almost straight [Bali: Indonesia] ..... *K. balicum*
11. Length to width ratios of merus of second and third ambulatory legs 4.3 and 4.0 respectively; length to width ratios of propodi of second and third ambulatory legs 4.1 and 4.5 respectively; G1 with chitinous distal part slightly bent downwards [Bali: Indonesia] ..... *K. emdi*
– Length to width ratios of meri of second and third ambulatory legs 3.7 and 4.1 respectively; length to width ratios of propodi of second and third ambulatory legs 3.4 and 4.2 respectively; G1 with chitinous distal part bent at right angles [Guam] .... *K. guamense*

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