

A NEW SPECIES OF THE HERMIT CRAB GENUS *PAGURUS* (DECAPODA: ANOMURA: PAGURIDAE) FROM PAKISTAN

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ABSTRACT. – A new species of the hermit crab genus *Pagurus* Fabricius, 1775, *P. nisari*, is described from shallow waters of Pakistan, northern Arabian Sea. It is most closely related to *P. decimbranchiae* Komai & Osawa, 2001, a species considered to be endemic to Japan. Both species are characterized by the possession of a single rudimentary arthrobranch above the base of the third maxilliped, rather than the typical pair of arthrobranches typical for the genus *Pagurus*. The strongly bi-spined interocular lobe and the absence of spines on the ventrolateral and ventromesial margins of the merus of the left cheliped distinguish the new species from *P. decimbranchiae*, although colouration in life is very similar. The new species is placed in the *P. anachoretus* group, as was *P. decimbranchiae*.

KEYWORDS. – Decapoda, Anomura, Paguridae, *Pagurus*, new species, Pakistan, *Pagurus anachoretus* group.

INTRODUCTION

During faunal surveys of coastal waters of Pakistan, an unusual species of pagurid hermit crab was collected. At present, the pagurid fauna of Pakistan is meagre with only *Pagurus kulkarnii* Sankolli, 1962 and *Pagurus* sp. (Siddiqui & Kazmi, 2003). In contrast, the Diogenidae is well represented (Tirmizi & Siddiqui, 1982; Siddiqui & Kazmi, 2003; Siddiqui *et al.*, 2004). Therefore, the discovery of the third pagurid species is remarkable for the regional fauna. The second author has determined that the species was new to science and found it to be closely related to *P. decimbranchiae* Komai & Osawa, 2001, a species considered to be a Japanese endemic (Komai & Osawa, 2001; Komai & Takeda, 2006). Shared characters include a characteristic pattern of gill reduction, which is quite unusual for *Pagurus* Fabricius, 1775 (Komai & Osawa, 2001; Komai & Rahayu, 2004). Also, general morphology and colouration in life are also very similar. Relationships among the new species, *P. decimbranchiae* and the two species *P. moluccensis* Haig & Ball, 1988 and *P. fungiformis* Komai & Rahayu, 2004, are briefly discussed. The new species is placed in the *Pagurus anachoretus* group, as was *P. decimbranchiae* (see Komai & Rahayu, 2004).

MATERIALS AND METHODS

A single male specimen of this new species was first collected in 1991 from Pacha (24°50.54'N 66°43.00'E), and another single male specimen was encountered during the sorting of a collection, which was obtained in 1997 from Paradise Point (24°50.35'N 66°46.37'E), through the funding of the ONR Project (Office of Naval Research Program USA1997–1998). Later, six specimens (four males and two ovigerous females) and two specimens (one male and one female) were collected from Buleji (24°50.12'N 66°49.12'E) on 29 September 2004 and 19 June 2007, respectively. All specimens were collected by hand from the intertidal zone.

The holotype of the new species is deposited in the collection of the Raffles Museum of Biodiversity Research, National University of Singapore (ZRC). Paratypes are housed in the Marine Reference Collection & Resource Centre, University of Karachi (MRCUK), Natural History Museum and Institute, Chiba (CBM) and ZRC. The shield length, abbreviated as sl, is measured from the tip of the rostrum to the midpoint of the posterior margin of the shield. For detailed observation of the surface structure on the integument, the specimens (including removed appendages) were stained with methylene blue. Terminology used in the description, for the most part, follows that of McLaughlin (2003), with exception of the

numbered thoracic sternites and pleon for abdomen. The drawings were made with the aid of a drawing tube mounted on a Leica MZ8 stereomicroscope.

TAXONOMY

FAMILY PAGURIDAE

Pagurus Fabricius, 1775

Pagurus nisari, new species (Figs. 1–4)

Material examined. – Holotype: female (sl 2.0 mm), ZRC 2007.0702, Buleji, Pakistan, 24°50.12'N 66°49.12'E, intertidal, rocky cum sand, hand, coll. M. Zafar, 19 Jun.2007.

Paratypes: 1 male (sl 1.7 mm), ZRC 2007.0703, same data as holotype; 1 ovigerous female (sl 2.3 mm), CBM-ZC 9410, Buleji, intertidal, rocky cum sand, coll. F. A. Siddiqui, 29 Sep.2004; 4 males (sl 2.0–3.0 mm), 1 ovigerous female (sl 2.0 mm), MRCUK ANOM 324, same data as ovigerous female (sl 2.3 mm); 1 male (sl 2.5 mm; photographed), MRCUK ANOM 328, Paradise Point, 24°50.35'N 66°46.37'E, Pakistan, intertidal, rocky cum sand, coll. F. A. Siddiqui, 17 Sep.1997.

Description. – Gills biserial; 9 pairs of functional gills, including 2 arthrobranchs on each first to fourth pereopod and 1 pleurobranch on sixth thoracic somite; 1 rudimentary arthrobranch above base of third maxilliped (Fig. 1E). Calcified parts of integument of body and appendages often with low, blister-like tubercles of various shape and size.

Cephalothorax somewhat depressed dorsoventrally. Shield (Fig. 1A) 1.1 times longer than broad; anterior margin between rostrum and lateral projections shallowly concave; anterolateral margins slightly terraced; posterior margin roundly truncate; rostrum broadly triangular, blunt, slightly exceeding lateral projections; lateral projections broadly triangular, without terminal spine; dorsal surface flat to slightly convex, with tufts of stiff setae laterally; paragastric grooves weak. Posterior carapace membranous except for weakly calcified anterior part of posteromedian plate and submedian parts either side of posteromedian plate; submedian parts with numerous small, blister-like tubercles; branchial region with tufts of setae; cardiac sulci converging posteriorly, reaching nearly to posteromedian margin of carapace; sulci cardiobranchialis short, somewhat divergent posteriorly.

Ocular peduncles (Fig. 1A) about 0.7 times as long as shield, moderately slender, weakly inflated basally; corneas not dilated, narrower than basal width of ocular peduncles; dorsal surfaces each with tufts of stiff setae mesially. Ocular acicles (Fig. 1B) subovate, with prominent submarginal spine; dorsal surfaces slightly concave. Interocular lobe prominent, with paired long processes each terminating acutely, reaching to distal margins of ocular acicles.

Antennular peduncles (Fig. 1A) stout, slightly overreaching

distal corneal margins; ultimate segment 1.5–1.6 times as long as penultimate segment, slightly broadened distally in lateral view, with some stiff setae on dorsal surface; basal segment with distolateral margin slightly produced, ventromesial distal margin unarmed, statocyst lobe unarmed on lateral face.

Antennal peduncles (Fig. 1A) nearly reaching distal corneal margins. Fifth segment moderately stout, with few short setae. Fourth segment with few short setae. Third segment with small tubercle at ventromesial distal angle and few short setae. Second segment with dorsolateral distal angle produced, reaching midlength of fourth segment, terminating in small spine; dorsomesial distal angle unarmed, mesial surface with numerous short setae. First segment unarmed or armed with spinule on laterodistal margin (not visible in dorsal view); ventrodistal margin produced, with 1 spinule. Antennal acicle arcuate, not reaching base of cornea, terminating in small spine, with row of stiff setae on mesial margin. Antennal flagella long, overreaching extended right cheliped; each article with short setae distally.

Mouthparts not dissected. Third maxilliped (Fig. 1C) with moderately stout endopod; ischium (Fig. 1D) with crista dentata composed of row of sharp, relatively large corneous teeth and with 1 accessory tooth; merus and carpus unarmed on dorsodistal or ventromesial margins.

Chelipeds unequal in males, subequal in females, right larger. Right cheliped (Fig. 2C, D) moderately stout, not markedly elongate even in males. Chela (Fig. 2A, B) subovate in dorsal view, length about twice of greatest breadth. Dactylus slightly longer than palm; dorsal surface slightly convex, with row of small spines or tubercles on midline; dorsomesial margin not delimited, with few small spiniform tubercles proximally; surfaces with tufts of stiff setae; in males (Fig. 2B) cutting edge with row of low, calcareous teeth, terminating in large corneous claw; in females (Fig. 2A) cutting edge with obsolete calcareous teeth and subdistal, corneous plate, terminating in small corneous claw. Palm shorter than carpus; dorsal surface slightly convex, with several small spines or spiniform tubercles, forming irregular row (submedian row extending onto fixed finger), and with tufts of stiff setae partially obscuring armature; dorsolateral margin (including fixed finger) delimited by row of small spines or spiniform tubercles (delineation less developed in males); dorsomesial margin with row of small spines in females, unarmed in males; lateral face with tufts of stiff setae; mesial face nearly smooth, with few tufts of setae dorsally and distally; ventral surface weakly convex, with few short setae. Cutting edge of fixed finger with row of low, blunt calcareous teeth, terminating in large corneous claw in males (Fig. 2B), terminating in corneous claw fused with subdistal corneous plate in females (Fig. 2A). Carpus (Fig. 2E) subequal in length to merus, somewhat broadened distally in dorsal view; dorsolateral margin not delimited, with 1 moderately large spine distally, dorsomesial margin with 3 moderately large spines; dorsal surface with stiff, often spiniform, setae; lateral face with few tufts of long setae dorsally, otherwise smooth; mesial margin faintly concave, with few tufts of stiff setae dorsally and distally, ventromesial margin smooth,

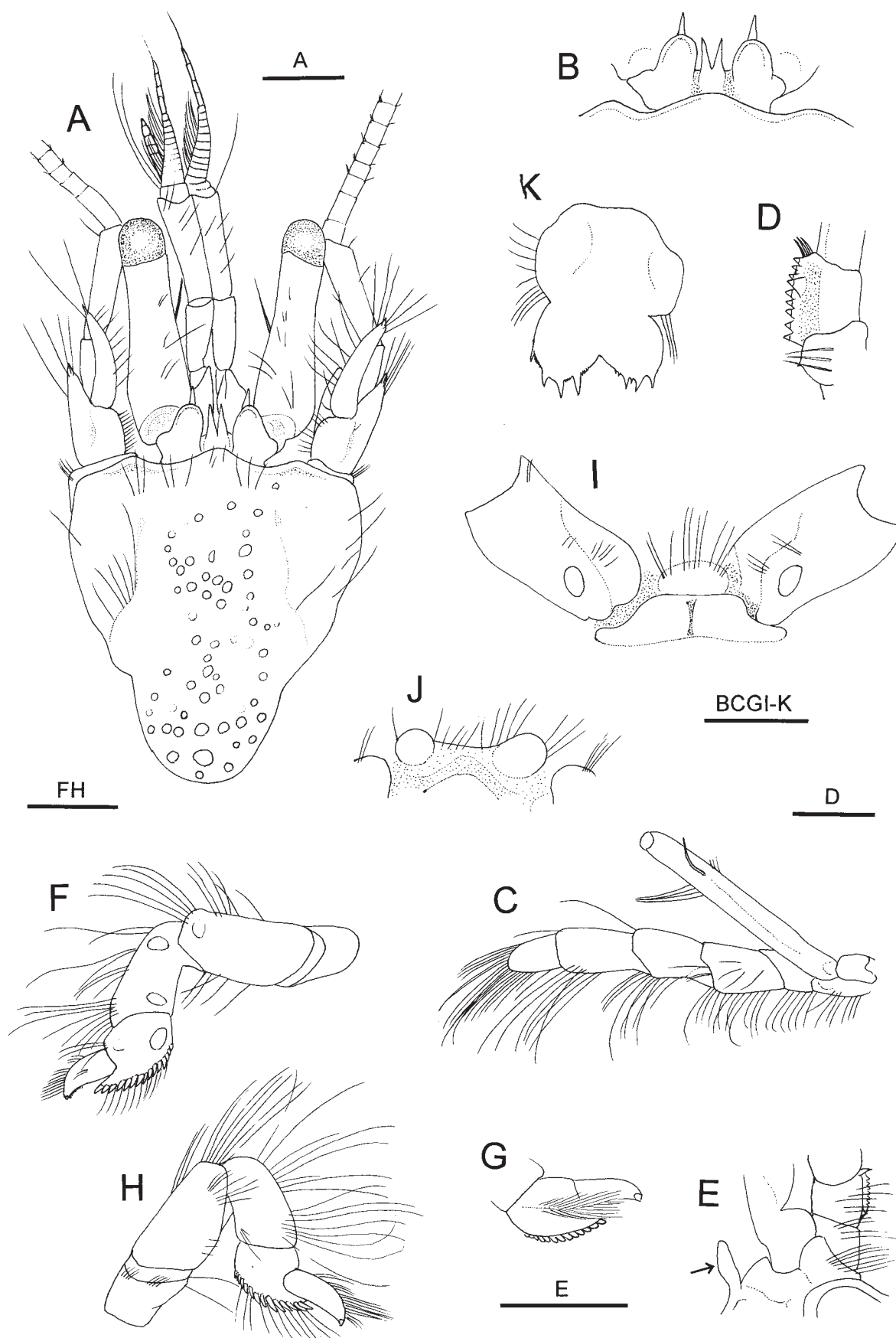


Fig. 1. *Pagurus nisari*, new species, holotype, female (sl 2.0 mm), ZRC 2007.0702, Buleji, Pakistan: A, shield and cephalic appendages, dorsal view; B, ocular acicles and interocular lobe, dorsal view (setae omitted); C, left third maxilliped, lateral view; D, same, ischium and basis, ventral view; E, base of right third maxilliped, arrow indicating rudimentary bud of arthrobranch; F, left fourth pereopod, lateral view; G, same, dactylus and propodus, mesial view (setae partially omitted); H, right fourth pereopod, lateral view; I, coxae of third pereopods and sixth thoracic sternite, ventral view; J, eighth thoracic sternite, ventral view; K, telson, dorsal view. Scale bars: 0.5 mm.

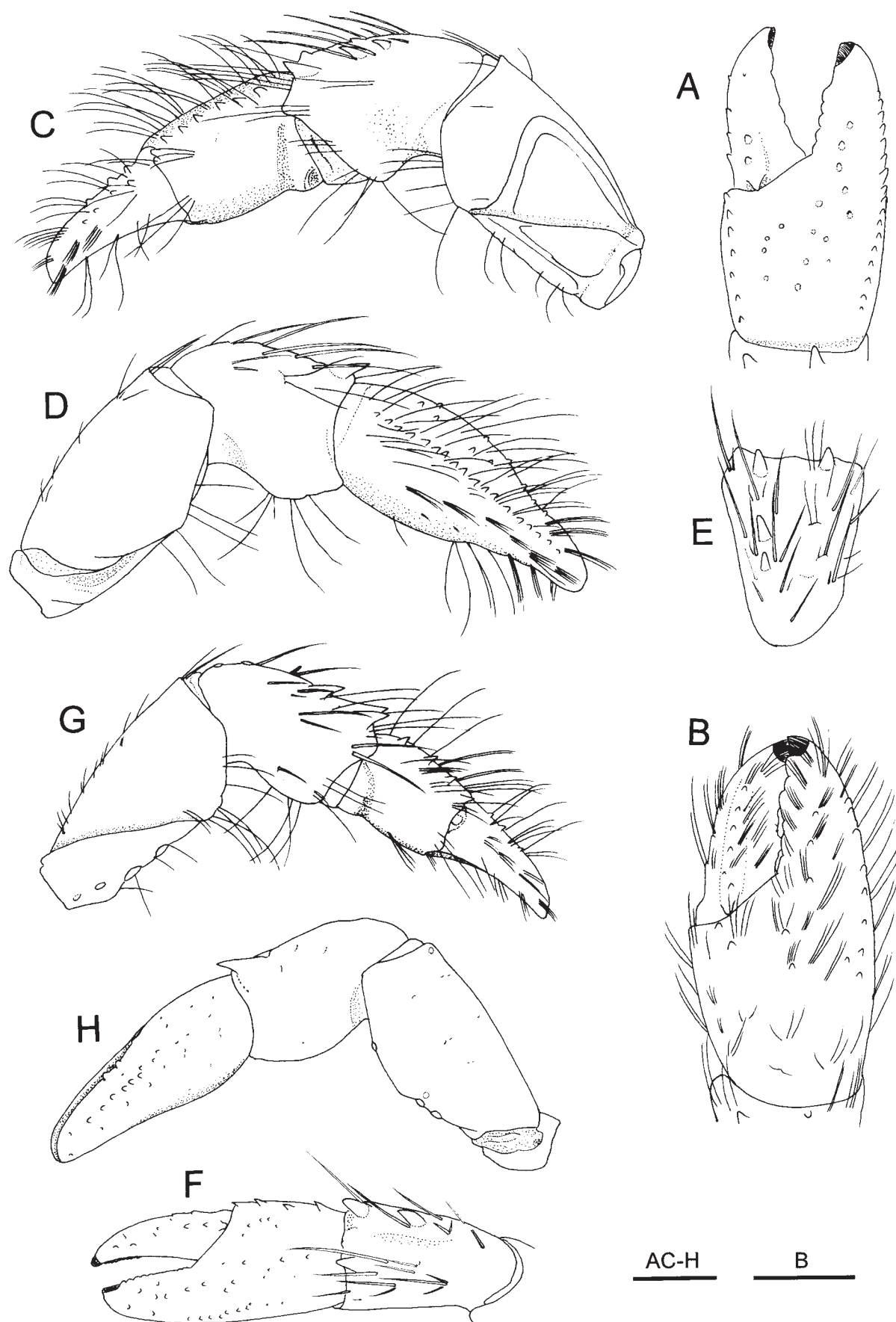


Fig. 2. *Pagurus nisari*, new species. Chelipeds. A, C–F, holotype, female (sl 2.0 mm), ZRC 2007.0702, Buleji, Pakistan; B, paratype, male (sl 1.7 mm), CBM-ZC 2007.0703, same locality. A, B, chela of right cheliped, dorsal view (setae omitted in A); C, right cheliped, mesial view; D, same, lateral view; E, carpus of right cheliped, dorsal view; F, chela and carpus of left cheliped, dorsal view (setae on chela omitted); G, left cheliped, mesial view; H, same, lateral view. Scale bars: 0.5 mm.

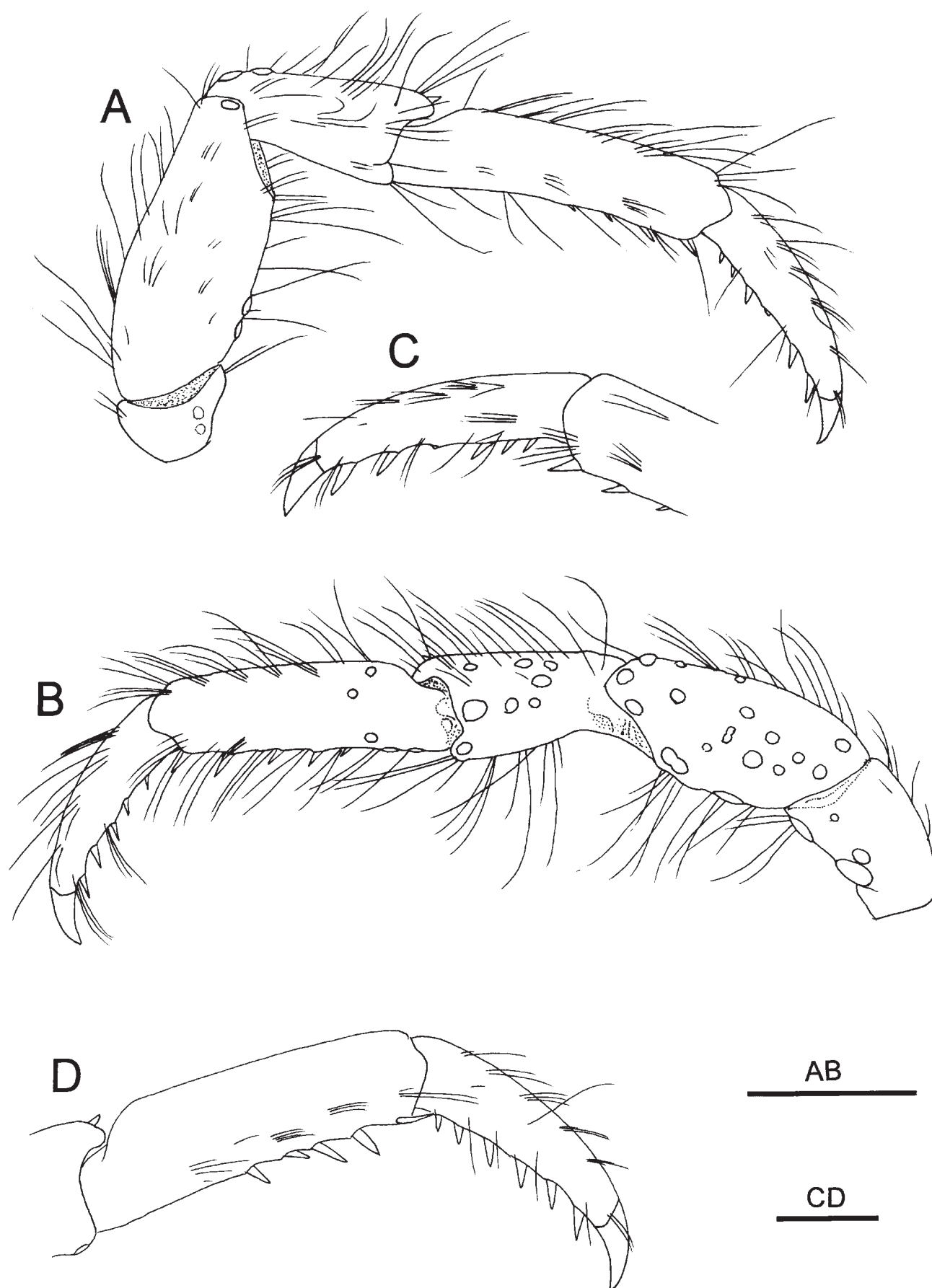


Fig. 3. *Pagurus nisari*, new species. Ambulatory legs. Holotype, female (sl 2.0 mm), ZRC 2007.0702, Buleji, Pakistan. A, right second pereopod, lateral view; B, left third pereopod, lateral view; C, dactylus and distal part of propodus of right second pereopod, mesial view; D, dactylus and propodus of left third pereopod, mesial view (setae omitted). Scale bars: A and B = 1 mm; C and D = 0.5 mm.

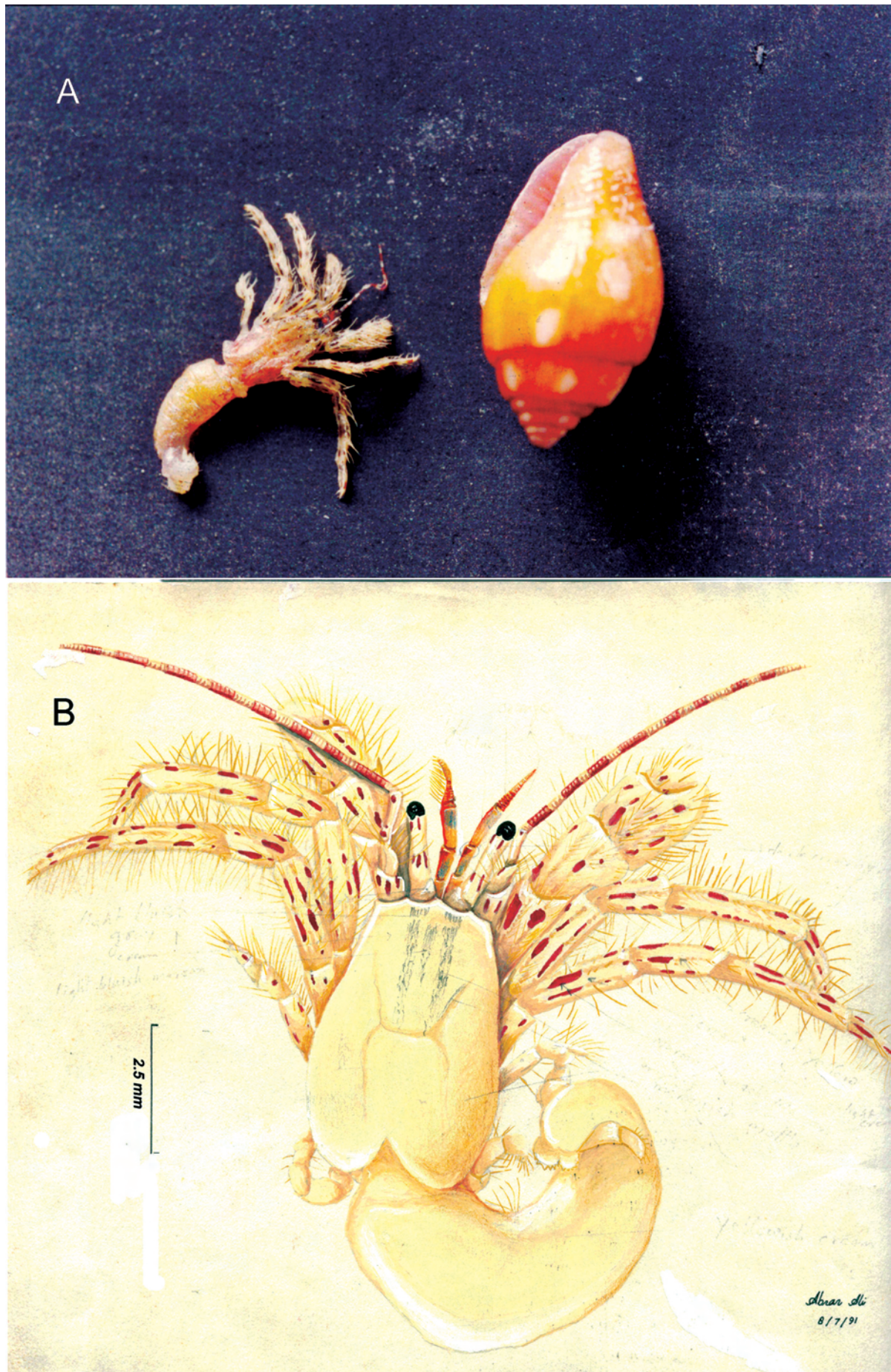


Fig. 4. *Pagurus nisari*, new species. A, paratype, male (sl 2.5 mm, MRCUK-ANOM 328) and gastropod shell used as housing, Paradise Point, Pakistan; B, drawing of male specimen in dorsal view, Pacha, Pakistan, showing colour pattern in life (specimen not preserved).

not produced into wing-like expansion; ventral surface with tufts of stiff setae. Merus with some tufts of setae on nearly smooth dorsal surface, dorsodistal margin unarmed; lateral face smooth, ventrolateral margin unarmed; mesial face also smooth, ventromesial margin unarmed; ventral surface with some blister-like tubercles and tufts of stiff setae. Ischium unarmed on ventromesial margin; all surfaces with few short setae. Coxa smooth or with low blister-like protuberances on ventral surface.

Left cheliped (Fig. 2G, H) reaching base of dactylus of right cheliped in males, overreaching midlength of dactylus of right cheliped in females. Chela (Fig. 2F) about 2.1 times longer than broad. Dactylus 1.2–1.4 times longer than palm; dorsal surface convex, with row of tiny tubercles on midline in proximal half; dorsomesial margin not delimited, with few tiny tubercles or unarmed; surfaces with tufts of long, stiff setae; cutting edge (Fig. 2F) with row of very small calcareous teeth, terminating in corneous claw fused with subdistal corneous plate. Palm distinctly shorter than carpus; dorsal surface slightly convex, with several tiny tubercles and numerous tufts of long stiff setae; dorsolateral margin (including fixed finger) not markedly delimited, but with row of tiny tubercles around base of fixed finger; dorsomesial margin with row of 4 small spines; lateral face with sparse tufts of stiff setae, otherwise smooth; mesial face also smooth, with tufts of stiff setae dorsally and distally; ventral surface slightly concave, with some tufts of stiff setae. Cutting edge of fixed finger (Fig. 2F) smooth in proximal half, armed with row of minute corneous teeth, terminating in large corneous claw. Carpus shorter than merus, slightly broadened distally in dorsal view; dorsolateral margin with 1 moderately large distal spine and tufts of spiniform setae; dorsomesial margin with 2 moderately large spines and tufts of spiniform setae; dorsal surface faintly sulcate; lateral face with tufts of long stiff setae dorsally, otherwise nearly smooth, ventrolateral margin unarmed; mesial face nearly flat, with stiff setae dorsally and distally, ventromesial margin unarmed; ventral surface weakly convex, with few tufts of long setae. Merus with tufts of short setae on dorsal surface; dorsodistal margin unarmed; lateral face with few tufts of short to moderately long setae, ventrolateral margin unarmed; mesial face smooth, ventromesial margin faintly tuberculate, without conspicuous spines; ventral surface with some blister-like tubercles and tufts of long setae. Ischium with few blister-like tubercles on ventromesial margin; all surfaces with few short setae. Coxa similar to that of right.

Second and third pereopods (Fig. 3A, B) moderately stout, overreaching tip of right cheliped, generally similar from right to left, with stiff setae. Dactyli (Fig. 3C, D) 0.8–0.9 times as long as propodi, weakly curved ventrally in lateral view and nearly straight in dorsal view, terminating in large corneous claws; dorsal surfaces each with tufts of short to long, stiff setae; lateral and mesial faces each with rows of tufts of setae dorsally and ventrally, lacking longitudinal sulcus, mesial face unarmed; ventral margins each with 5–7 moderately large corneous spines. Propodi distinctly longer than carpi; dorsal surfaces unarmed, with tufts of short to long setae; lateral faces with few very short setae; ventral

surfaces each with 3 or 6 large corneous spines, ventrodistal margins each with 1 or 2 corneous spines. Carpi each with small dorsodistal spine; dorsal surfaces each with row of tufts of short setae; lateral faces convex, with few tufts of short setae; ventral surfaces each with tufts of long setae (setae longer and more numerous in third than in second). Meri each with row of tufts of long setae on dorsal and ventral surfaces; lateral faces each with tufts of very short setae; ventrolateral distal margins concave, unarmed or occasionally armed with 1 small distal spine in second. Ischia each with sparse setae on dorsal and ventral margins. In females moderately large paired gonopores present on third pereopods (Fig. 1I).

Fourth pereopods (Fig. 1F, G) semichelate, subequal in size, but dissimilar in setation. Dactyli broad, nearly straight or slightly curved, terminating in small corneous claw; dorsal margins each with long setae; ventral margins each with row of minute corneous teeth; preungual process absent. Propodi each with long setae on dorsal surface; mesial face divided in two flattened sections by weakly elevated midline bordered by row of long setae in left (Fig. 1G), entirely flattened with only few setae in right; ventral margins convex; propodal rasps each composed of single row of corneous scales. Carpi and meri with numerous long setae on dorsal surfaces.

Fifth pereopods chelate; in males, paired gonopores partially obscured by tufts of short setae.

Anterior lobe of sixth thoracic sternite broadly semicircular; posterior lobe broader than anterior lobe. Eighth thoracic sternite (Fig. 1J) with 2 subovate lobes broadly separated, each lobe having flattened ventral surface.

Pleon dextrally twisted, with 3 unpaired pleopods in males, each having well-developed exopod and rudimentary endopod. Females with 4 unpaired pleopods, both rami well developed in second to fourth pleopods; fifth pleopod smaller than others, with rudimentary exopoda.

Telson (Fig. 1K) with distinct transverse indentations. Posterior lobes slightly unequal, separated by moderately broad, deep median cleft; lateral margins convex, with few setae; terminal margins weakly convex, each with 3–5 prominent spines and interspersing spinules.

Colouration in life. – Colour in general light yellowish-cream with maroon or dark brown stripes (Fig. 4A, B). Shield with 3 bluish-gray longitudinal stripes on maroon-gray background; posterior carapace tinged with light brown. Ocular peduncles each with dark maroon stripes on proximal half and just proximal to base of cornea; ocular acicles and interocular lobes bluish-gray. Ultimate segment of antennular peduncle blue in distal half, orange in proximal half; penultimate segment also blue in distal half, yellowish-orange in proximal half; dorsal flagellum orange, ventral flagellum maroon. Antennal peduncles each with dark maroon longitudinal patch on lateral and mesial faces of fifth segment; fourth segment dark maroon on lateral and mesial faces and with dark maroon spot on dorsal surface; antennal acicles cream; antennal flagella alternately banded with dark maroon and

yellowish cream every 3 or 4 articles. Right cheliped generally cream with short maroon longitudinal stripes; dactylus at least with 2 stripes on mesial face basally; palm and fixed finger with some stripes on dorsal surface; lateral and mesial faces of palm also with few short stripes; carpus also with few longitudinal stripes or spots on dorsal surface, lateral and mesial faces each with 2 or 3 stripes; merus with 3 or 4 stripes on each lateral and mesial faces. Left cheliped with similar marking to right cheliped, but stripes or spots fewer in number. Second and third pereopods also generally cream with maroon or dark brown short longitudinal stripes; dactyli each with 1 dorsal, 1 lateral and 1 mesial stripes, each widely disjoint at middle; propodi each with 3 stripes on lateral surface in proximal half and 3 spots in distal half, each stripe and spot aligned; carpi each with 3 stripes on lateral surface; meri each with 2 or 3 short, sometimes interrupted stripes. Pleon light yellowish-cream dorsally, mottled with light brown laterally; telson cream.

Etymology. – This new species is named after the husband of the first author, Nisar Ahmed A. Mangi, in appreciation of his cooperation and encouragement for her research activity.

Remarks. – High degree of similarity in the morphology suggests that the new species is most closely related to *P. decimbranchiae*. In particular, the reduction of the gill formula caused by the reduction of the arthrobranchs above the base of the third maxilliped to a single rudimentary bud, but not associated by the reduction of a pleurobranch, is presumably apomorphic between the two species. No similar pattern of the gill reduction is known in other species of *Pagurus*. Other shared characters include the depressed cephalothorax, weak armature of the chelipeds, general setation of the chelipeds and ambulatory legs, structure of the thoracic sternum, and the armature of the telson. Nevertheless, the strongly bi-spined interocular lobe immediately distinguishes the new species from *P. decimbranchiae*. The interocular lobe of *P. decimbranchiae* is only weakly bi-lobed. Furthermore, the lack of spines on the ventrolateral and ventromesial margins of the merus of the right cheliped distinguishes *P. nisari* from *P. decimbranchiae*.

The bi-spined interocular lobe, an unusual feature for *Pagurus*, is also seen in *P. moluccensis* and *P. fungiformis*, both known from Indonesia (Komai & Rahayu, 2004). However, these two species are readily distinguished from the new species by the armature of the chelipeds and the fully developed arthrobranchs above the base of the third maxilliped. The right chela of *P. moluccensis* bears small simple or bi- or trifold tubercles on the dorsal surface with a distinctly delimited dorsolateral margin, whereas that of *P. fungiformis* has covering of flattened, marginally multidenticulate tubercles on the dorsal surface with a poorly delimited dorsolateral margin.

It is remarkable that the colouration in life is strikingly similar between the new species and *P. decimbranchiae*. Our attempt to find significant differences in the colouration or colour pattern was not successful, although a detailed comparison using fresh specimens may eventually reveal the presence

of minor differences. Recent studies have demonstrated that the colouration in life is often very useful for discrimination of closely related or sibling species of decapod crustaceans (Knowlton & Mills, 1992), particularly in paguroid taxa (e.g., Komai & Imafuku, 1996; Rahayu & Forest, 1999; Komai, 2003; Komai & Osawa, 2006), but the two species treated in this study are not the case.

In the waters of Pakistan, *Pagurus kulkarnii* has been the sole representative of *Pagurus* identified with certainty (Siddiqui & Kazmi, 2003). Although both species exhibit striped markings on the chelipeds and ambulatory legs, the new species is readily distinguished morphologically from *P. kulkarnii* in the reduced gill formula, presence of bi-spined interocular lobe and the lack of wing-like projections formed by the ventromesial margins of the carpus and merus of the right cheliped, which is seen in the latter species.

Although one of the diagnostic characters of the genus *Pagurus* is the presence of 11 pairs of gills (e.g., McLaughlin, 2003), Komai & Osawa (2001) provisionally assigned *P. decimbranchiae* to *Pagurus* based on the morphological similarity to certain species of the *Pagurus anachoretus* group, an informal species group first proposed by Forest (1978). After comparison of several species of the *P. anachoretus* group, Komai & Rahayu (2004) supported the placement of *P. decimbranchiae* in the *P. anachoretus* group. They suggested that *P. decimbranchiae*, *P. moluccensis* and *P. fungiformis* might form a monophyletic assemblage. The discovery of the present new species seems to further support the placement of *P. decimbranchiae* in the group, because the apomorphic bi-spined interocular lobe is suggestive of the phylogenetic relationship between the new species and the two other species, *P. moluccensis* and *P. fungiformis*. The weakly bi-lobed condition of the interocular lobe found in *P. decimbranchiae* might be due to secondary reduction from the spinose condition.

Habitat. – Occupying variety of gastropod shells, such as *Pyrene* sp., *Clypeomorus* sp. and others.

Distribution. – So far known only from Pakistan; intertidal.

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