Bulletin of the Mizunami Fossil Museum, no. 30 (2003), p. 121-135, 16 figs.
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First record of Calappoidea, Portunoidea and Dromioidea in the Upper Cretaceous (Upper Maastrichtian) of NW Madagascar

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Abstract

We describe a rich sample of isolated elements of chelae of brachyuran crustaceans, discovered in some outcrops of the Berivotra Formation, datable to the Upper Cretaceous (Upper Maastrichtian) and located in Mahajanga region (NW Madagascar). Since the specimens are incomplete, their study allows only a systematic ascription at different crab groups, and only in some cases was possible a comparison with already known fossil genera. The studied specimens are subdivided in three groups of brachyurans, Calappoidea fam. gen. et sp. indet., Portunoidea fam. gen. et sp. indet. and Dromioidea fam. gen. et sp. indet., reported for the first time in the Cretaceous of Madagascar. Moreover, we report the presence of many specimens ascribed to Xanthoidea fam. gen. et sp. indet. The only study on decapod assemblage from the Cretaceous of Madagascar was carried on by Secretan (1964) who recognised, in the rich studied sample, three brachyuran families, Raninidae de Haan, 1839, Dynomenidae Ortmann, 1892, and Xanthidae MacLeay, 1838, discovered in outcrops different from the study ones. Therefore, we point out that the description of our sample, even though incomplete, increases the knowledge on brachyuran fauna from NW Madagascar. Finally, we report, to have a complete vision of the faunal assemblage of the Berivotra Fm., the presence of three groups of isolated elements of chelae "*incertae sedis*".

Key words: Crustacea, Decapoda, Late Cretaceous, Madagascar

Introduction

The studied sample, gathered by one of the author (G. Pasini) in three field collecting, in the nineties, 2001 and 2002, comes from the surrounding area of the village of Berivotra, located about 50 km S of the city of Mahajanga, along the National Road 4 towards Antananarivo (Fig. 1). This area, located NW of Madagascar, is usually known in geology as "Mahajanga Basin" (Besairie, 1972). The specimens, collected in the nineties and 2001, were gathered on the surface, along the eroded sides of low hills that do not exceed 250 m in height, located E and W of the small village of Berivotra (Fig. 2), while the most part of specimens, collected in 2002, were gathered in the area where at present there is the cemetery of Berivotra, located W of the village. The collecting was made at the levels, included between 170 and 180 meters (Fig. 2 - see the square; Figs. 3a, b) on the surface since the minimum inclination of the outcrop and estimating minimum the rainwater transport.

Geological setting

The studied outcrops of Mahajanga Basin belong to Maevarano

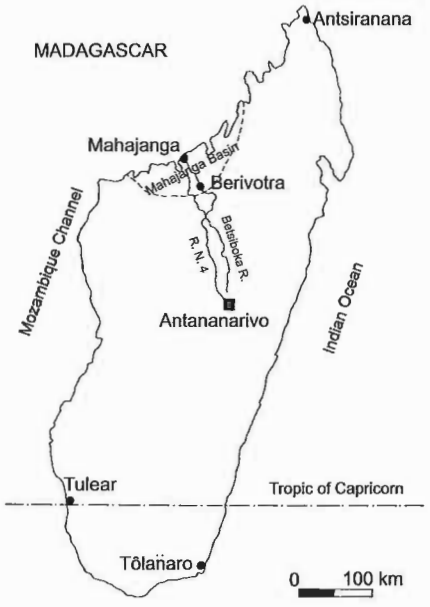


Fig. 1. Geographical map of Madagascar with Mahajanga Basin in which there is Berivotra village, area of the studied specimens (modified by Krause, 1996).

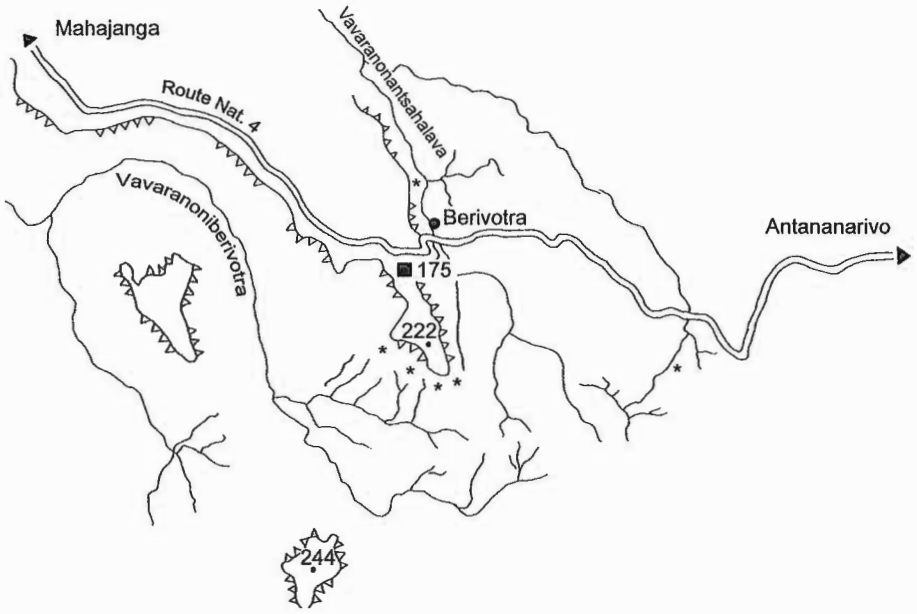


Fig. 2. Berivotra area. The asterisks indicate the areas where many specimens were collected during the two fields collecting in the nineties and 2001, while the square indicates the area where other specimens were collected during the third field collecting in 2002 (modified by Lavocat, 1955).

and Berivotra Formations, dated to the Upper Cretaceous (Krause et al., 1996, 1997, 1999). In accordance with Rogers and Hartman (1998), these Formations are covered with Paleocaenic marls 10 m thick, dated to the Danian and characterised with a marine invertebrate fauna (regular and irregular echinoderms and molluscs). So we proposed in this study the following subdivision:

The nonmarine Maevarano Fm. (variegated and white beds at the top)

Age: Maastrichtian - Upper Maastrichtian

Faunal assemblage of terrestrial and freshwater vertebrates; continental facies with fragmentary or complete specimens of fishes, amphibians, turtles, crocodiles, snakes, dinosaurs and birds.

The marine Berivotra Fm. (bearing beds)

Age: Upper Maastrichtian

The lower part of the unity is characterised with a rich faunal assemblage of grypheids, ostreids, decapod crustaceans, teeth of sharks, fragments of teleosts, interambulacral plates and primary spines of regular echinoderms (Figs. 3c, d, e, f).

The upper part of the unity is characterised with bivalves, neogastropods, cephalopods, echinoderms and chondrichthyes.

Faunal assemblage

The faunal assemblage of Berivotra Fm. was gathered by one of the author (G. Pasini) during three recent geological prospecting in the nineties, 2001 and 2002, having as result a rich sample of invertebrates and vertebrates (about 1800 specimens). The invertebrates of the marine Berivotra Fm. include not only isolated elements of chelae of brachyurans, subject of this study, but also some incomplete regular echinoderms, isolated radiols, some cephalopods, many bryozoans, fragments of bivalves (grypheids and ostreids) and neogastropods. The vertebrates include teeth of chondrichthyes (over 1000 specimens), some complete rostral teeth of pristiophoroids and rare isolated teeth, ascribed to teleosts. Moreover, teeth and osteoderms of crocodiles, unidentified bones of turtles, birds and teeth, claws and bones of different dinosaurs were recognised in the Maevarano Fm. (white beds). All gathered specimens are now analysed by the Department of Invertebrate Palaeontology of the Museo Civico di Storia Naturale di Milano, and the study of decapod crustaceans is the first description of the interesting fauna of Berivotra Fm.

Priem (1907, 1924) reported the presence of shark teeth, ascribing them to some genera, such as *Corax, Lamna, Notidanus, Oxyrhina* and *Scapanorhynchus*. Recently, Gottfried (1997) described one incomplete rostral tooth (family Pristiophoridae, genus *Pristiophorus*), gathered at the bottom of the marine Berivotra Fm., suggesting so an Upper Maastrichtian age. The preliminary study of the rich sample of teeth of chondrichthyes, housed in the palaeontological collection of Museo Civico di Storia Naturale di Milano, allows to observe close morphological analogies with the specimens, discovered in the phosphate deposits of Morocco and North Africa, usually with the presence of possible endemisms (Cigala Fulgosi, pers. com.). Usually, the groups are ascribed to an Upper Cretaceous fauna, datable exactly to Maastrichthian - Upper Maastrichtian (Cappetta, 1987). Moreover, the preliminary study of the genera of sharks suggests a litoral-neritic environment of tropical or subtropical sea (Arambourg, 1952).

Finally, even though Krause (1996, 1997) reported the presence of teeth of actinopterygians, pycnodonts and teleosts, coming surely from the Maevarano Fm., he reported only the presence of sharks, regarding them however as foreign elements of the fauna, coming for natural erosion from the overlooking Berivotra Fm., dated to the Upper Maastrichtian. The recent collecting, carried on by one

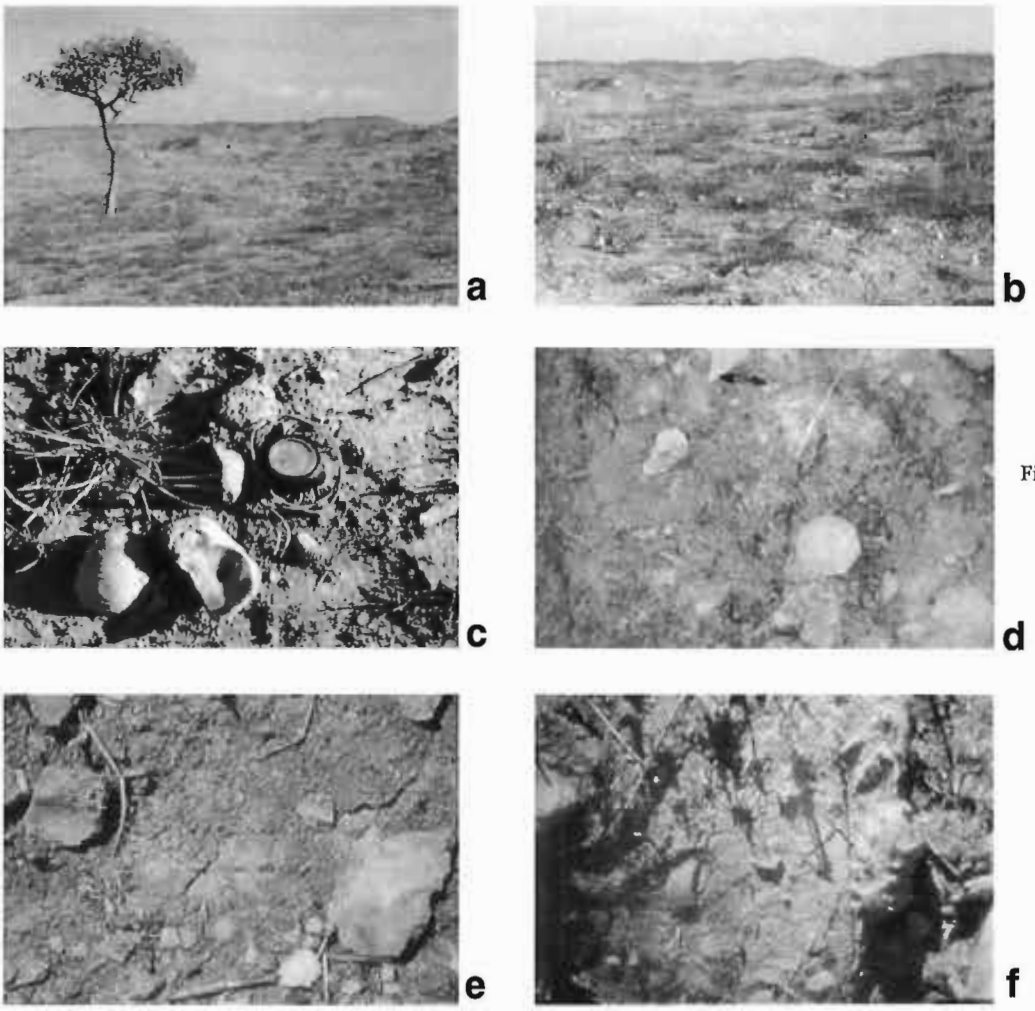


Fig. 3. a) area of the field collecting in 2002; b) detail of the level with grypheids and ostreids; c) superficial mound of grypheids and ostreids; d) level 170: faunal assemblage (the yellow point indicates one chela, while the red point indicates a tooth of shark surrounding of bryozoans and fragments of grypheids - coin diameter, 2.3 cm); e) level 175: faunal assemblage (the green point indicates one chela, surrounding of bryozoans and fragments of grypheids); f) level 180: isolated chela with fragments of grypheids and ostreids.

of the author (G. Pasini) in 2002 with the discovery *in situ* of the faunal assemblage of the Berivotra Fm., confirms its ascription to the Upper Maastrichtian. This assemblage is composed of isolated elements of chelae of decapod crustaceans, many grypheids and ostreids, incomplete regular echinoderms, many complete bryozoans of the class Gymnolemes and teeth of chondrichthyes.

Previous studies of decapod crustaceans from the Cretaceous of Madagascar

At present, the only complete study on the decapod fauna from the Cretaceous of Madagascar was carried on by Secretan (1964). The author studied the decapod crustaceans from the Lower and Middle Cretaceous of Sitampiky Basin and Analalava region and from the Upper Cretaceous of Menabe region and Mangoky-Onilahy area (SW Madagascar), recognising macruran, brachyuran and thalassinidean crustaceans. Missing out the macrurans and the thalassinideans, not present in the studied sample, two brachyuran families are identified from the Lower and the Middle Cretaceous, the families Raninidae de Haan, 1839, with *Notopocorystes* M'Coy, 1849, and Dynomenidae Ortmann, 1892, with *Xanthosia* Bell, 1863, and *Dromiopsis* Reuss, 1859, while from the Upper Cretaceous, the families Raninidae de Haan, 1839, with *Notopocorystes* M'Coy, 1849, Dynomenidae Ortmann, 1892, with *Xanthosia* Bell, 1863, and Xanthidae MacLeay, 1838 with *Caloxanthus* A. Milne Edwards, 1864 (*nom. subst. pro Carpiliopsis* Fisher-Benzon, 1866), *Titanocarcinus* A. Milne Edwards, 1863, and an unidentified xanthid.

Only Krause (1996) reported the presence of decapod crustaceans in the same quarries, subject of this study, without giving their systematic description.

Material

The present study is based on 192 specimens, discovered in some outcrops (around the Berivotra village - Fig. 2), located in the famous Mahajanga basin (NW Madagascar), already known in literature for the discovery of very interesting vertebrates among which the most important are dinosaurs. The specimens are represented by three-dimensional fragments of chelae, usually dactyli

and fixed fingers. Since one the author (G. Pasini) has never discovered complete chelae in three field collecting (the nineties, 2001, 2002), the study of the fragmentary chelae allowed the ascription only to some different brachyuran groups. Probably, the lack of complete chelae can be due to the decay and not transport which determined the degree of fragmentation and disarticulation after several weeks, as pointed out by Allison (1990, Fig. 3). We recognised Xanthoidea 1 fam. gen. et sp. indet. (93 dactyli), Xanthoidea 2 fam. gen. et sp. indet. (48 fixed fingers), Calappoidea fam. gen. et sp. indet. (42 dactyli), Portunoidea fam. g en. et sp. indet (1 dactylus) and Dromioidea fam. gen. et sp. indet. (8 fixed fingers). Moreover, we report, to have a complete vision of the faunal assemblage, 137 specimens belonging to three different groups "*incertae sedis*". Finally, we distinguished, for the four different groups, if dactyli or fixed fingers are right or left, we reported three line drawings, the inner, the outer and the occludent views of dactylus or fixed finger, and a transversal section, obtained by resin cats, all cutting to the same length (8 mm from the curved tip). The sample is housed in the palaeontological collection of the Museo Civico di Storia Naurale di Milano (MSNM).

Systematic Palaeontology

Infraorder Brachyura Latreille, 1802

Xanthoidea 1 fam. gen. et sp. indet.

(Figs. 4, 9, 10, 11)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

Occurrence and measurements: we ascribe to Xanthoidea 1 fam. gen. et sp. indet. 93 dactyli (86 dactyli left and 7 dactyli right). The

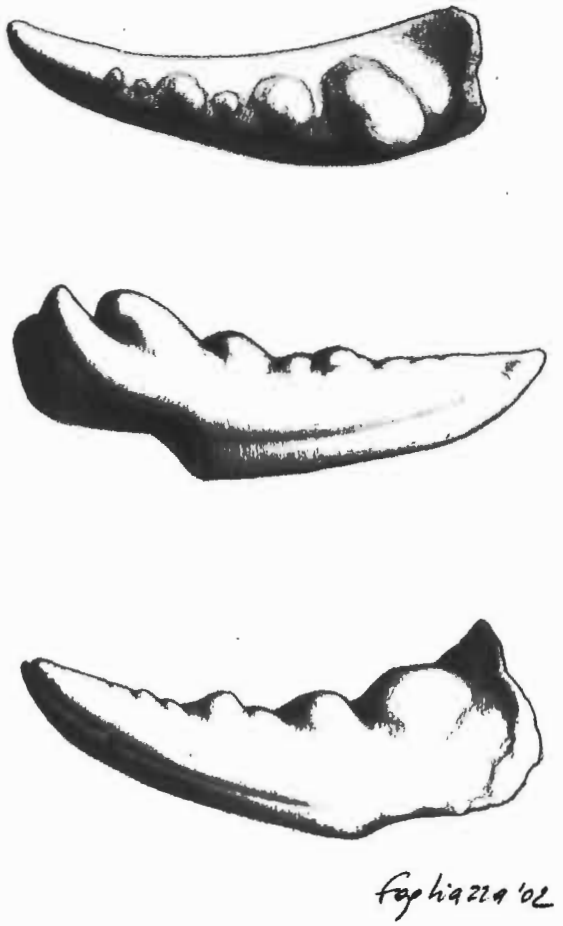


Fig. 4. Xanthoidea 1 fam. gen. et sp. indet. Dactylus, right chela: views of occludent margin, outer and inner surfaces.

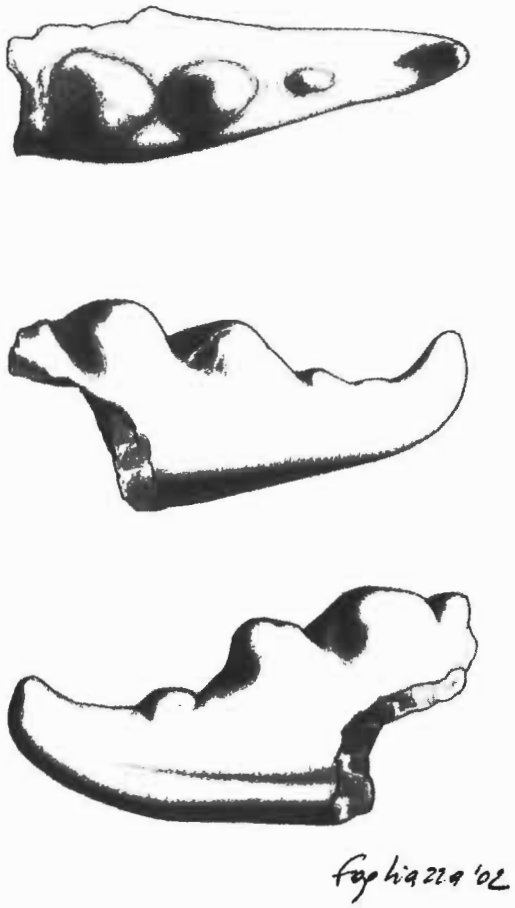


Fig. 5. Xanthoidea 2 fam. gen. et sp. indet. Fixed finger, right chela: views of occludent margin, outer and inner surfaces.

length of dactylus left ranges from 7 mm to 15 mm, while the length of dactylus right ranges from 7 mm to 14 mm.

Description: Dactylus with oval section, slightly curved forward and with a ventrally curved tip. Inner and outer surfaces smooth. Two weak lateral grooves run parallel along the inner and outer surfaces, joining at the curved tip. Occludent margin of the dactylus with different teeth decrease toward the curved tip. Large proximal tooth of the occludent margin, subsquare in shape, overflows from the inner surface, elevating respect the other teeth.

Remarks: The shape of dactylus with two grooves along the inner and the outer surfaces, and the large proximal tooth, strongly overflowing from the inner surface, allow to compare the study specimens with members of Eriphiidae MacLeay, 1838 and Pilumnidae Samouelle, 1819.

Xanthoidea 2 fam. gen. et sp. indet

(Figs. 5, 9, 12, 13)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

Occurrence and measurements: we ascribe to Xanthoidea 2 fam. gen. et sp. indet. 48 fixed fingers (5 fixed fingers left and 43 fixed fingers right). The length of fixed finger left ranges from 7 mm to 14 mm, while the length of fixed finger right ranges from 7 mm to 13 mm.

Description: Short and strong fixed finger with oval section, and with a ventrally pointed curved tip. Inner and outer surfaces smooth. Two grooves run parallel along the inner and outer surfaces. Occludent margin with five conical teeth, decreasing in sizes inward.

Calappoidea fam. gen. et sp. indet.

(Figs. 6, 9, 13, 14)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

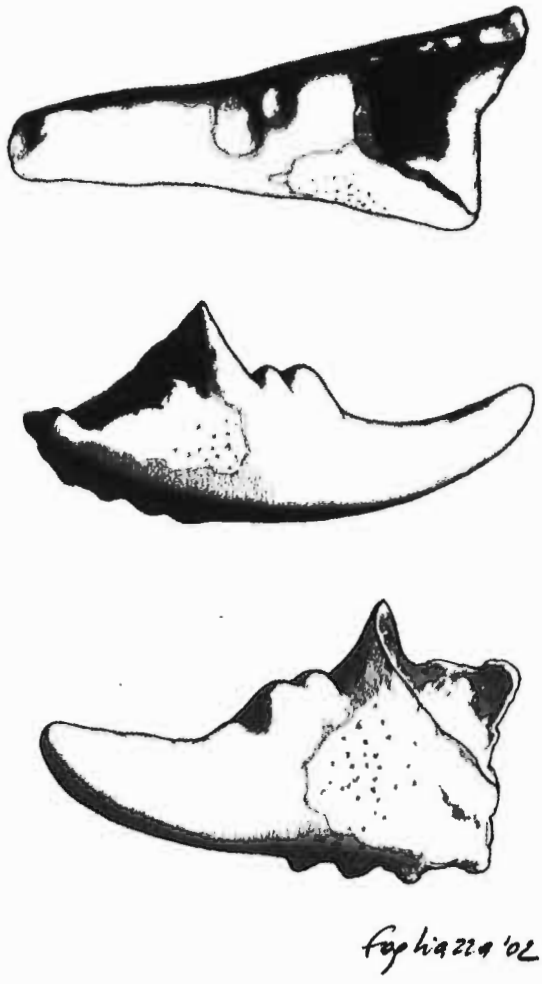


Fig. 6. Calappoidea fam. gen. et sp. indet. Dactylus, right chela: views of occludent margin, outer and inner surfaces.

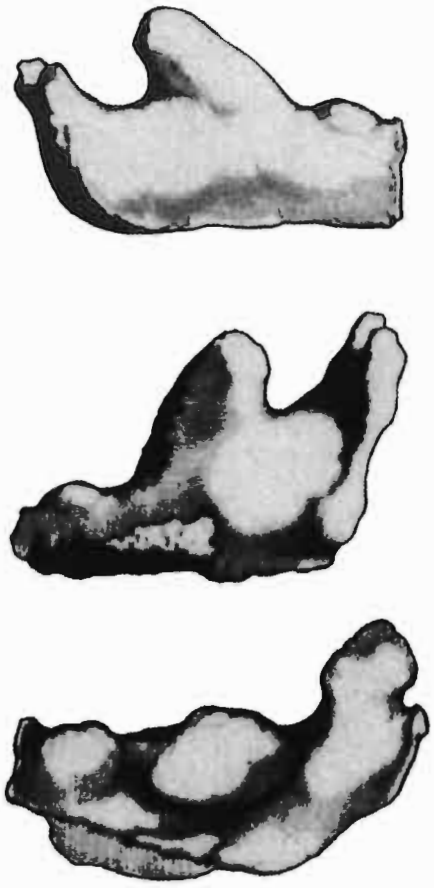


Fig. 7. Portunoidea fam. gen. et sp. Indet. Dactylus, right chela: views of outer and inner surfaces and occludent margin.

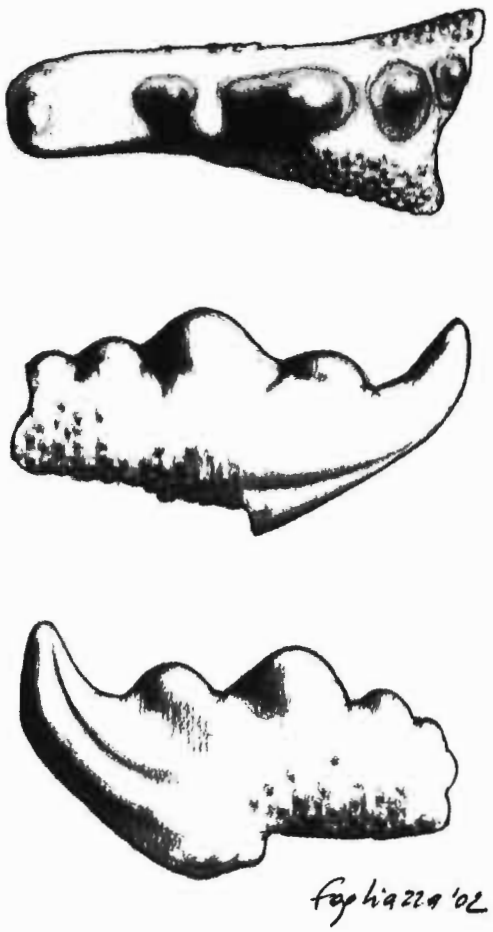


Fig. 8. Dromioidea fam. gen. et sp. indet. Fixed finger, right chela: views of occludent margin, outer surface and inner surfaces.

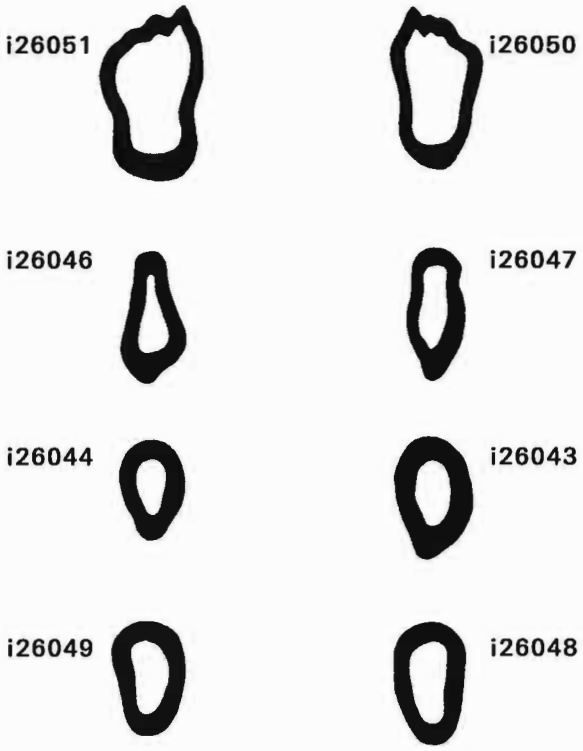


Fig. 9. Transversal section. 1, Calappoidea (MSNM i26051, dactylus of the right chela; MSNM i26050, dactylus of the left chela); 2, Dromioidea (MSNM i26046, fixed finger of the right chela; MSNM i26047, fixed finger of the left chela); 3, Xanthoidea 1 (MSNM i26044, dactylus of the right chela; MSNM i26043, dactylus of the left chela); 4, Xanthodea 2 (MSNM i26049, fixed finger of the right chela; MSNM i26048, fixed finger of the left chela).

Occurrence and measurements: we ascribe to Calappoidea 42 dactyli (18 dactyli left and 24 dactyli right). The length of dactylus left ranges from 7 mm to 17 mm, while the length of dactylus right ranges from 6 mm to 17 mm.

Description: Strong and well developed dactylus with oval section, and with a ventrally curved tip. Dactylus asymmetric respect an axial plane. Ventral, inner and outer surfaces covered of strong tubercles, not present on the surface of the teeth of occludent margin and of the curved tip. Subsquare distal tooth larger than the previous one, and not perfectly in axis with the curved tip. One longitudinal groove runs along the occludent margin in inner lateral position, while one inner lateral incision runs to the curved tip.

Remarks: The presence of strong tubercles along the ventral, the inner and the outer surfaces, and the presence of subsquare teeth, not aligned with the curved tip, allow to compare the study specimens with the representatives of Calappidae de Haan, 1833 and Necrocarcinidae Förster, 1968 (Förster, 1979; Collins et al., 1995; Kato and Karasawa, 1998).

Portunoidea fam. gen. et sp. Indet.

(Fig. 7)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

Occurrence and measurements: we ascribe to Portunoidea 1 incomplete right dactylus.

Description: Dactylus with subrectangular section. Inner and outer surfaces smooth. Strong and large proximal curved tooth of the occludent margin, subsquare in shape, overflows from the inner surface, elevating respect the other teeth.

Remarks: The shape of dactylus with a strong and large proximal curved tooth, strongly overflowing respect the other teeth, allow to compare the study specimen with members of Portunidae Rafinesque, 1815.

Dromioidea fam. gen. et sp. indet.

(Figs. 8, 9, 14)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

Occurrence and measurements: we ascribe to Dromioidea 8 fixed fingers (2 fixed fingers left and 6 fixed fingers right). The length of fixed finger left ranges from 7 mm to 8 mm, while the length of fixed finger right range from 8 mm to 12 mm.

Description: Short and strong fixed finger, with oval section, and a ventrally pointed curved tip. Fixed finger asymmetric respect an axial plane. Ventral, inner and outer surfaces with tubercles, located along the surface of the teeth of occludent margin. Occludent margin with strong different conical teeth. Distal tooth smaller that the previous one. One incision runs along the outer ventral surface, breaking before the curved tip.

Remarks: The study specimens can be compared with the family Dromiidae de Haan, 1833 for the straight course of fixed finger curved upward to the anterior extremity, for the few tubercles located on the outer surface, and for the four conical teeth (Kato and Karasawa, 1998).

INCERTAE SEDIS

? Infraorder Anomura MacLeay, 1838

? Paguroidea fam. gen. et sp. Indet.

(Fig. 15)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

Occurrence: we ascribe in dubitative form to ? Paguroidea 85 incomplete dactyli or fixed fingers.

Remarks: The study specimens can be compared to the family Paguridae Latreille, 1802 for the presence of four/five strong, large and swollen teeth, divided by well developed grooves (Ingle, 1993). Since the specimens are very incomplete, it is not possible to compare them with other Cretaceous genera or species known to date. Only the discovery of more complete specimens will allow a more precise systematic ascription.

? Infraorder Astacidea Latreille, 1802

? Nephropoidea 1 fam. gen. et sp. indet.

(Figs. 15, 16)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

Occurrence: we ascribe in dubitative form to Nephropoidea 48 incomplete dactyli or fixed fingers.

Remarks: The study specimens are ascribed in dubitative form to Nephropoidea since they resemble the median and distal extremity of the cutter chela, characterised by strong spaced out teeth, typical of some living genera of this family (Holthuis, 1991). However, at the same time the specimens can resemble the distal extremity of stellaroids. Since the specimens are very incomplete, it is not possible to compare them with other Cretaceous genera or species known to date, belonging to astacideans or to different kind of stellaroids. Only the discovery of more complete specimens will allow a more precise systematic ascription.

? Infraorder Astacidea Latreille, 1802

? Nephropoidea 2 fam. gen. et sp. indet.

(Fig. 16)

Locality: around Berivotra village.

Geological age: Upper Maastrichtian - Berivotra Fm.

Occurrence: we ascribe in dubitative form to Nephropoidea four incomplete dactyli or fixed fingers.

Remarks: The study specimens are ascribed in dubitative form to Nephropoidea since they resemble the distal extremity of the cutter chela, characterised by a median row of small teeth decreasing forwards, typical of some living genera of this family (Holthuis, 1991). Since the specimens are very incomplete, represented by the distal extremity, it is very difficult to compare them with other Cretaceous genera or species known to date, belonging to the infraorder Astacidea Latreille, 1802. Only the discovery of more complete specimens will allow in the future a more precise systematic ascription.

Acknowledgements

We wish to thank for the useful co-operation the Ministere de l'Energie et des Mines and the Direction des Mines et de la Géologie de Madagascar, making possible this study. Moreover, we wish to thank the people of Berivotra village for the precious co-operation in the collecting of study sample. Photographic materials by G. Pasini and L. Spezia.

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Manuscript accepted on 29th September, 2003

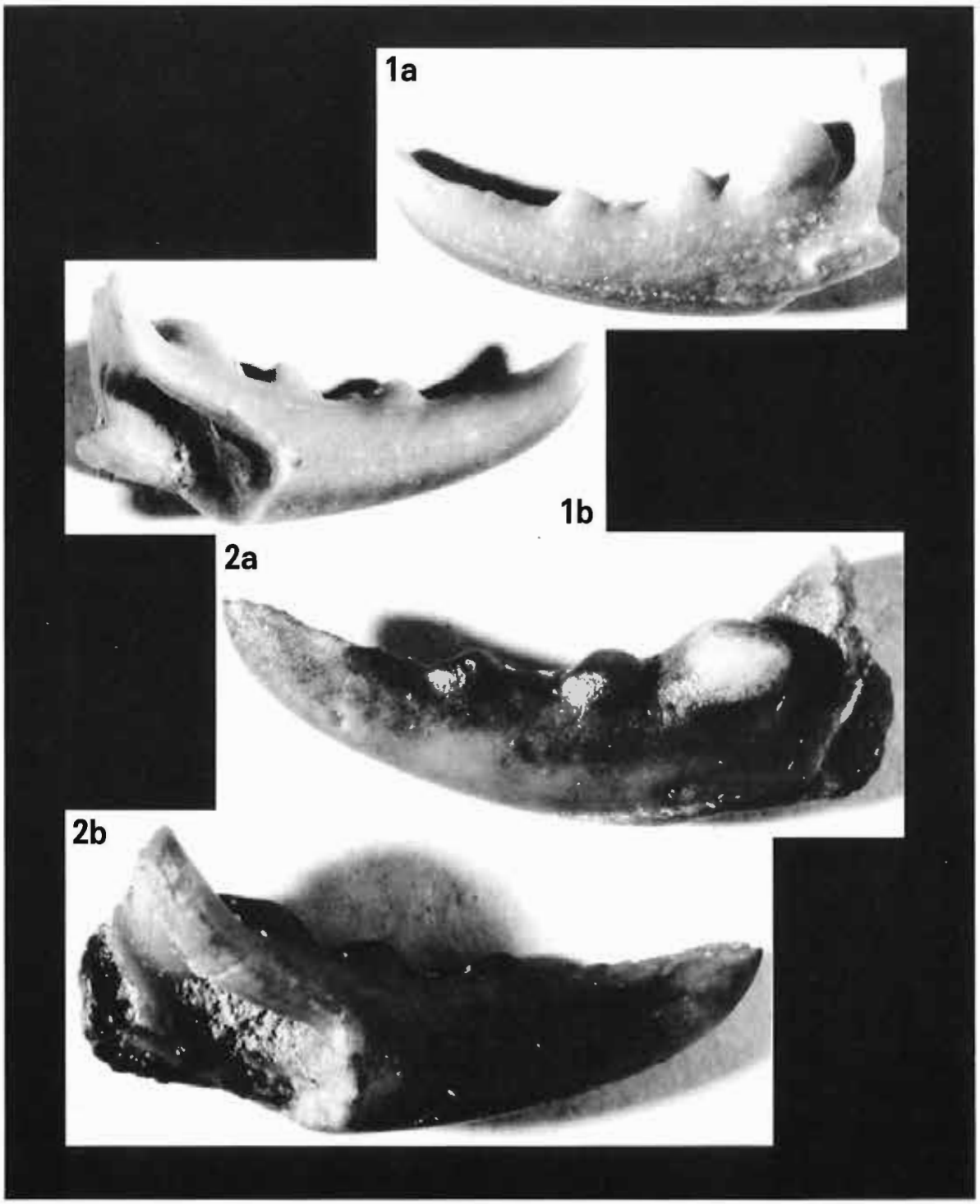


Fig. 10. Xanthoidea 1 fam. gen. et sp. indet. Dactyli of the rigth chela. MSNM i26004: 1a, outer view - 1b, inner view (×8); MSNM i26045: 2a, outer view - 2b, inner view(×10).

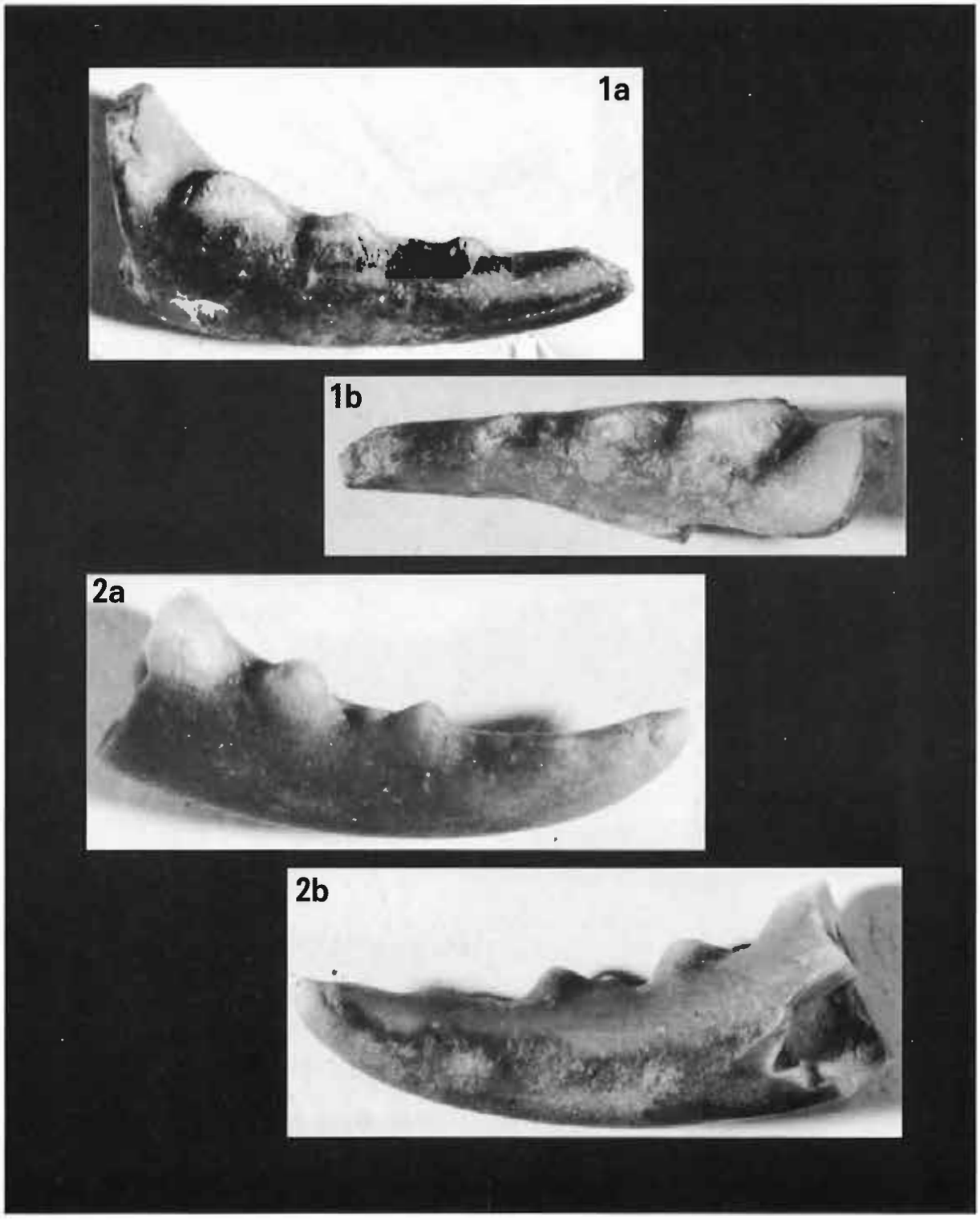


Fig. 11. Xanthoidea 1 fam. gen. et sp. indet. Dactyli of the left chela. MSNM i25979: 1a, outer view - 1b, inner view (×8); MSNM i26044: 2a, outer view - 2b, inner view (×10).

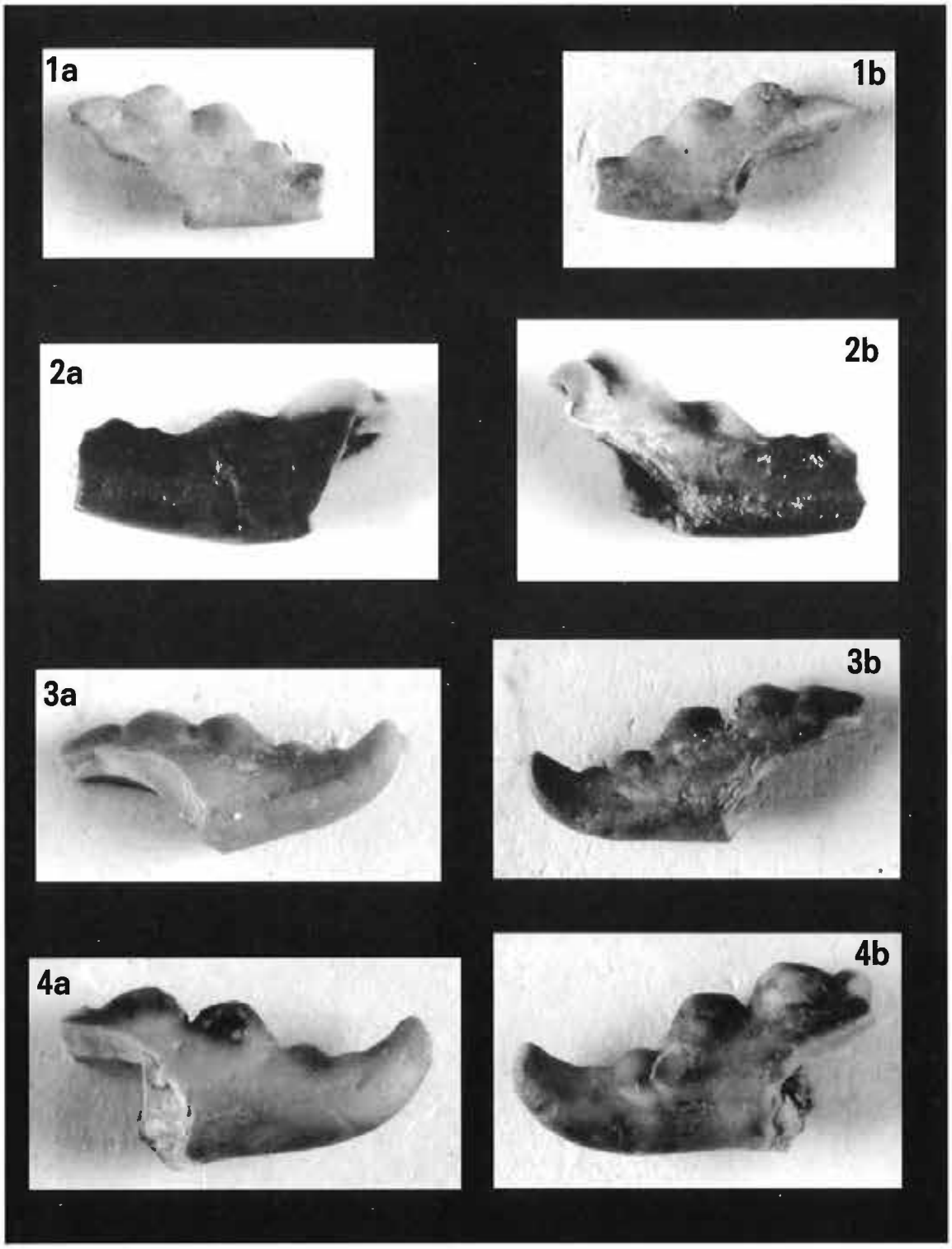


Fig. 12. Xanthoidea 2 fam. gen. et sp. indet. Fixed finger of the left chela. MSNM i26006: 1a, outer view - 1b, inner view (×5); MSNM i26048: 2a, outer view - 2b, inner view (×5). Fixed finger of the right chela. MSNM i25999: 3a, outer view - 3b, inner view (×6); MSNM i26049: 4a, outer view - 4b, inner view (×6).

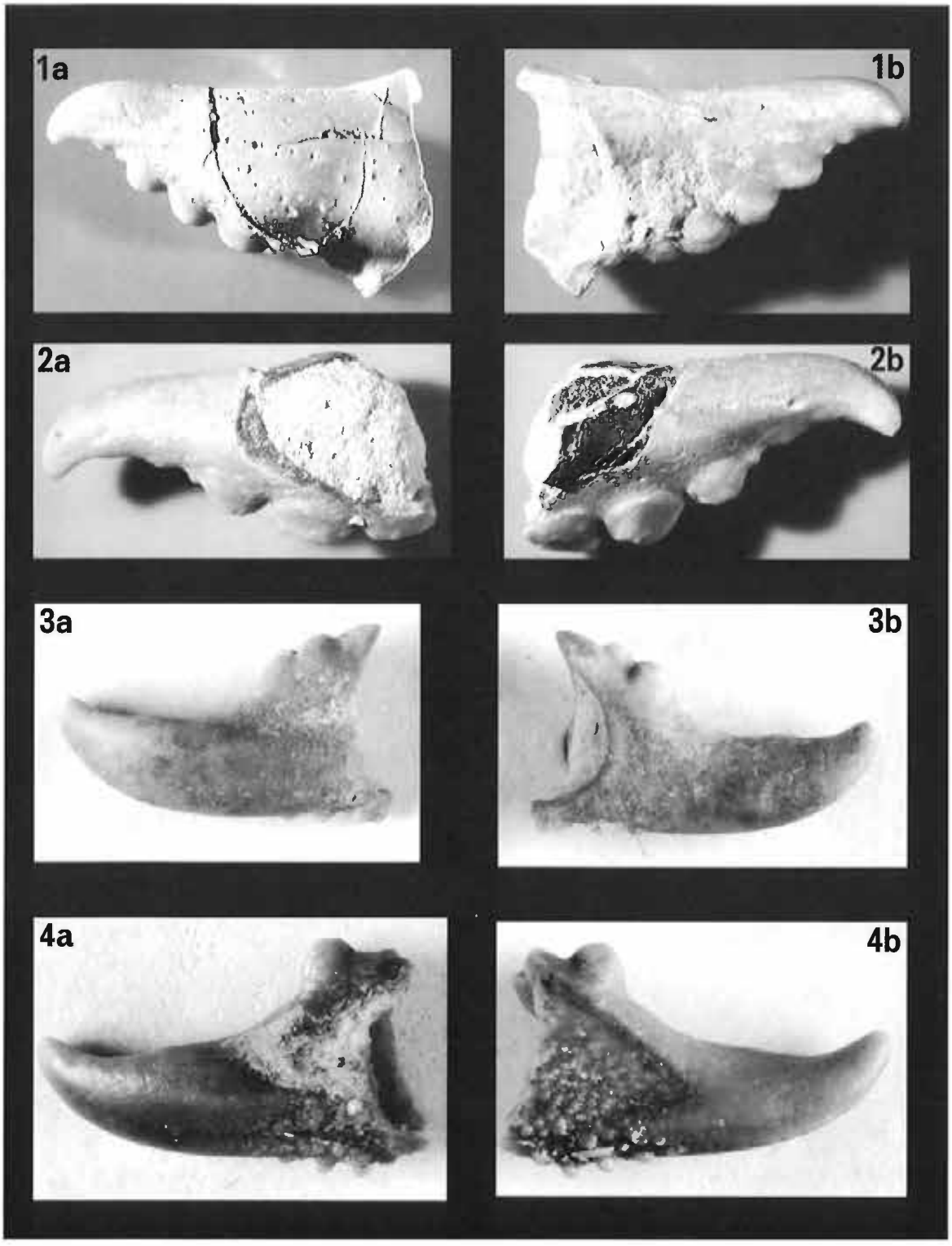


Fig. 13. Xanthoidea 2 fam. gen. et sp. indet. Fixed finger of the right chela. MSNM i26169: 1a, outer view - 1b, inner view (×7); MSNM i26170: 2a, outer view - 2b, inner view (×6.5). Calappoidea fam. gen. et sp. indet. Dactyli of the right chela. MSNM i26008: 3a, outer view - 1b, inner view (×5); MSNM i2626050: 4a, outer view - 4b inner view (×8).

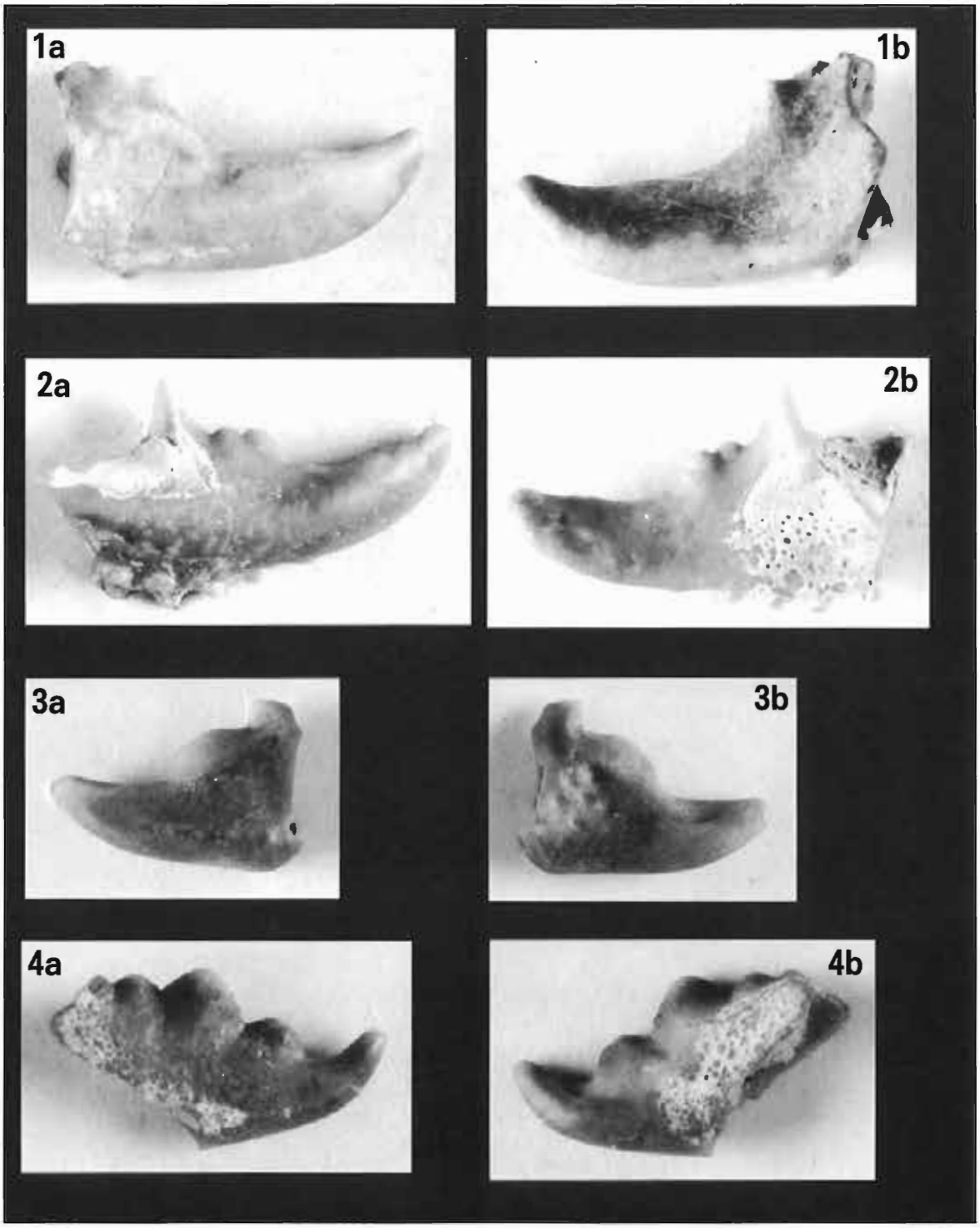


Fig. 14. Calappoidea fam. gen. et sp. indet. Dactyli of the left chela. MSNM i26007: 1a, outer view - 1b, inner view (×6); MSNM i26051: 2a, outer view - 2b, inner view (×6.5). Dromioidea fam. gen. et sp. indet. Fixed finger of the left chela. MSNM i26047: 3a, outer view - 3b, inner view (×4). Fixed finger of the right chela. MSNM i26046: 4a, outer view - 4b, inner view (×5).

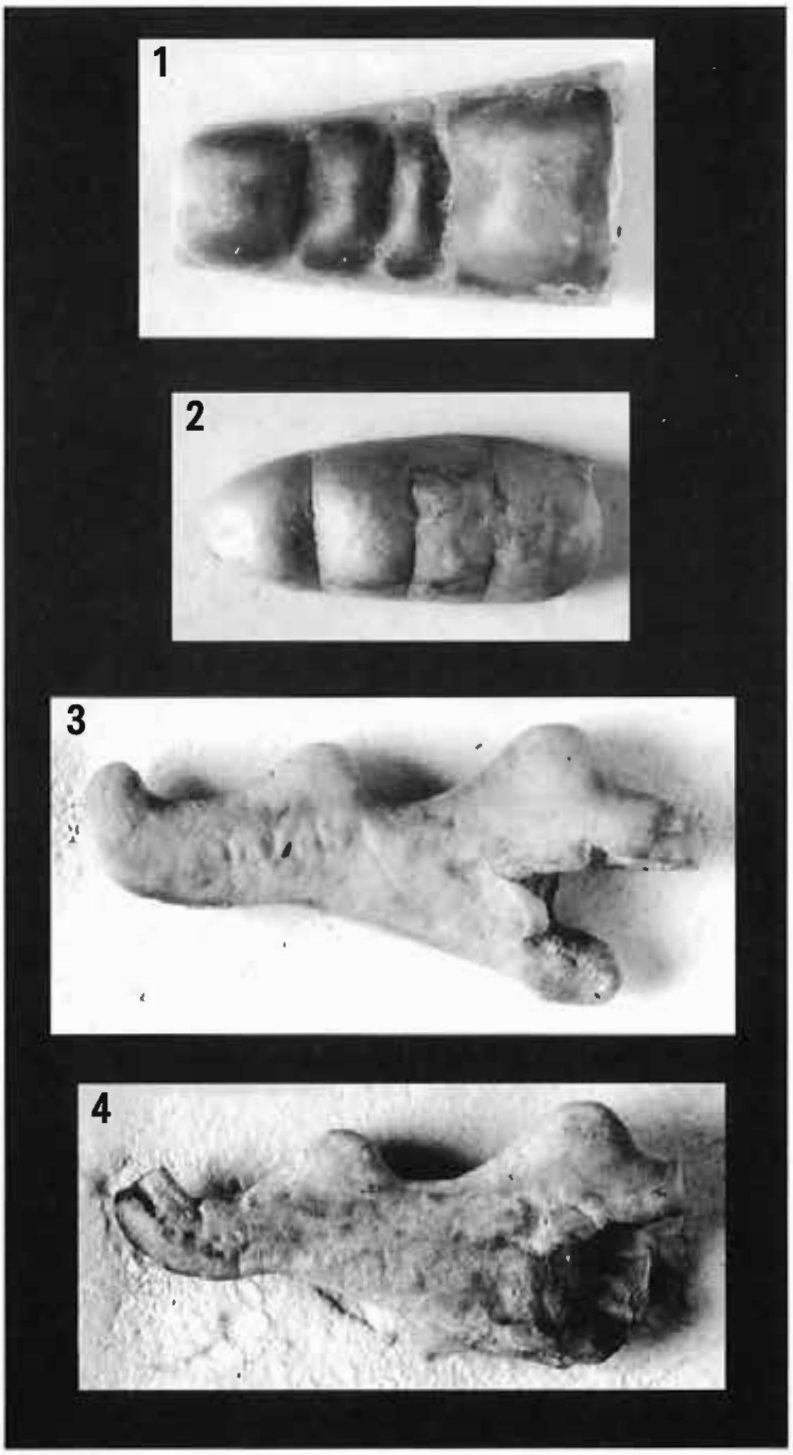


Fig. 15. ? Paguroidea fam. gen. et sp. indet. MSNM i26009: 1, occludent margin (×5.5); MSNM i26010: 2, occludent margin (×5). ? Nephropoidea 1 fam. gen. et sp. indet. MSNM i26013: 3 dactylus or fixed finger (×4); MSNM i26014: 4, dactylus or fixed finger (×4).

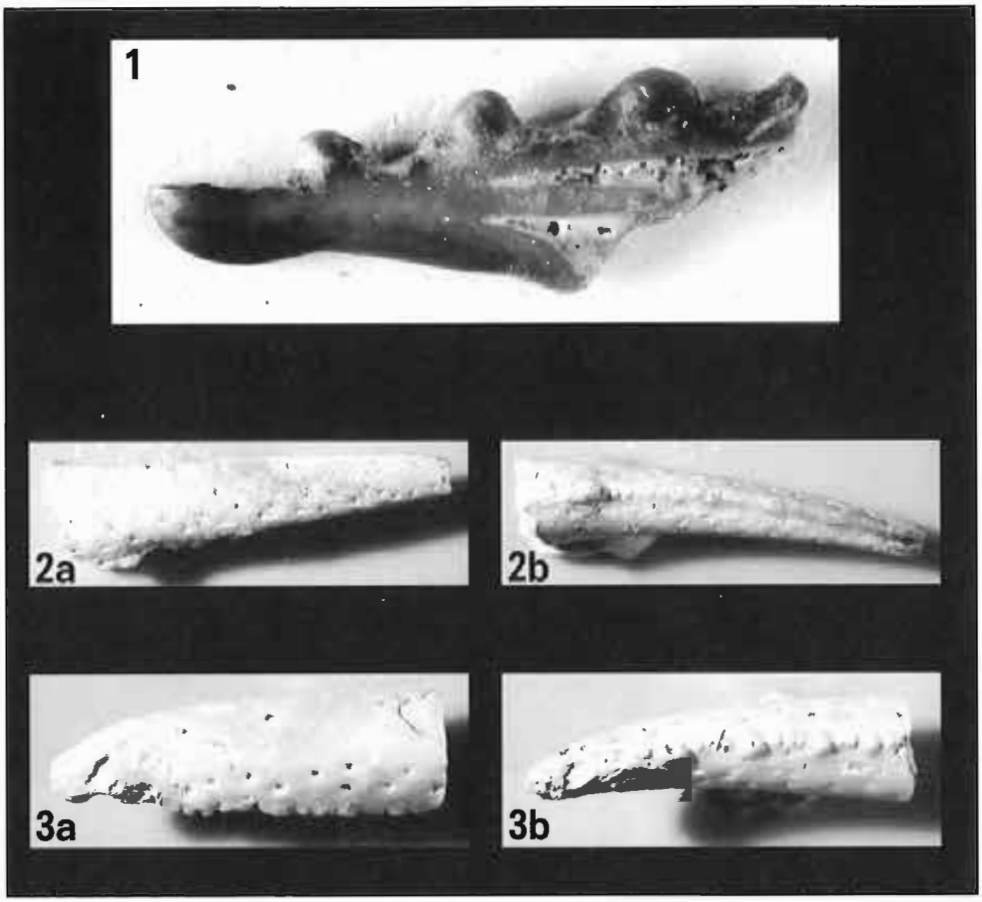


Fig. 16. ? Nephropoidea 1 fam. gen. et sp. indet. MSNM i26052: 1, dactylus or fixed finger(×4). ? Nephropoidea 2 fam. gen. et. sp. indet. Dactylus or fixed finger. MSNM i26204: 2a, outer view - 2b, occludent view (×5); MSNM i26207: 3a, outer view - 3b, occludent view (×5).