

Fig. 15. *Lyreidus rosenkrantzi* sp. nov. from the Maastrichtian at Agatkløft. A: paratype, MGUH 21.600, carapace with typical bopyriform swelling on left branchial region, $\times 1$; B: paratype, MGUH 21.601, dorsal view, $\times 1.5$.

700 of similar age are from Agatkløften (Loc. 1 and 2), altitude 405–410 m. The concretions are all of the same sedimentological character as the holotype.

Description. The carapace is almost elliptical in outline, strongly curved in transverse section, slightly convex in side view, without a postfrontal ridge or depression and highest at the anterior third. Breadth, at base of lateral spines, about five eighths total length (overall width rather more than the total length). There is a small protuberance on the anterolateral margin set rather closer to the lateral spine than to the front; from this protuberance the margin is concave and converges rapidly towards the front. The frontal margin is about half the carapace width; the rostrum is simple, triangular, pointed and slightly concave dorsally. There are two fissures in the upper orbital margin and the slightly protruding spine between them is broad, flat, and rounded apically. The outer orbital spine leading immediately from the outer fissure is as long, or just longer than the rostrum and slightly incurved. The orbital peduncle is short and curved. The very long, straight to slightly curving lateral spine occurs a little more than one third distant from the front; it forms an angle with the longitudinal axis of between 23° – 39° , and 0 – 15° upwards from the horizontal plane; in some specimens the

distal end curves slightly forwards. In juvenile specimens with a carapace length of 10 mm to about 22 mm the spine shows a positive allometric growth rate compared to the length of carapace. In larger specimens the length of the spine does not increase, but remains between 5 and 10 mm. The uniform length of right and left spine and the undamaged point shows that this is not the result of damage or a reduced size after regeneration.

From a shallow constriction immediately behind the spines the posterolateral margins are weakly convex and subparallel for about half their length when they become concave and converge to narrowly rounded posterior angles. Along the concave portion the marginal edges are sharp. The posterior margin is about as wide as the front.

Very shallow cervical furrows curve from each side of the dorsal midline from a point a little less than half the overall carapace length, they are directed towards, and at a similar angle to the midline of the lateral spines, becoming obsolete about mid-orbital width; a pair of posterior gastric pits occur at their basal third. Short cardiac furrows are generally more distinct. Faint impressions of attractor epimeralis muscle scars are seen in well preserved specimens and internal casts also show attachments for posterior gastric and internal mandible adductor muscles. The ornament of the dorsal surface

including rostrum and spines, consists of small scattered pits. The lateral margins, outer orbital spines, and ventral surface of the lateral spines are granulated, but only rarely are granules found on the frontal margin.

The pterygostomial process has two deep submarginal furrows and is granulated, as is the rather narrow branchiostegite which has a median fold. A broadly triangular epistome intrudes about half way into the buccal cavity.

The abdomen reaches almost to the bases of the chelipeds, its width is distinctly narrower than the posterior margin and further restricted between the first and second somites. The first somite is short and rather wide with margins converging anteriorly, the anterior edge is straight, the posterior one concave. The succeeding somites are long and more curved round the axis with distinct pleural areas forming an angle with the dorsal surface. The edges of the second and dorsal surface of the third to fifth somites are faintly granulated and the fourth has a prominent median tubercle. The sixth somite is long, narrow and spatulate with concave sides fitting between the bases of the first pair of pereopods. The triangular telson has serrated sides and a scattering of fine pits over the surface. Overall, the abdomina are insufficiently preserved to allow determination of the sexes.

Antennules and antennae are vestigial and only indicated in a single individual where the rostrum is broken off. The mandibles, exposed in very few specimens, have a rather long gnathobase with undivided masticatory surface. The third maxillipeds have a short, triangular protopodite, a long, flat, undivided exognath and an endognath with a long, flattened ischiognath and merognath.

The chelipeds are robust and the left and right are more or less equal in size; the coxa is short with a granulated surface and a prominent tubercle on the inner side; the basi-ischium is curved, granulated and divided into five lobes; the long, almost cylindrical merus is flattened on the inner side proximally, it is finely granulated on this surface and sometimes on the distal part of the outer side. the proximal articulation forms an angle of about 45° with the angle of the joint. The proximal and distal articulations of the short, curved carpus are almost perpendicular to each other, but still well separated on the underside. The palmar portion of the large, flattened propodus is subquadrate; the upper margin is sharp, almost in line with the carpal articulation and there is a small spine distally; the fixed finger extends almost at right angles to the upper margin and is almost as long as the palmar width; on the lower margin up to four, though generally three, spines increase in size distally; the surface is ornamented simi-

larly to the merus. The dactylus is long, slender, gently curved with a rim along the upper margin and there are a few pits along the serrate opposing margin.

The first to fourth pairs of pereopods are slender and closely placed. The coxa is short, the basi-ischium slightly curved and subdivided by furrows into four lobes. The long slender merus is elliptical in section and is granulated along its sharp upper margin. The carpus is flat and expanded distally, that on the second pereopod has a distal spine on the upper margin. There is a backwardly projected prolongation of the propodus along the distal part of the carpus, and the propodus and dactylus together with the distal part of the carpus form a paddle. The more dorsally placed fifth pair of pereopods are small and very slender; the lower and inner margins of the coxa, basi-ischium and merus are granulated. The merus and carpus are slightly elliptical in section. The propodus and dactylus are not preserved and there is no indication of expansion towards the distal end. The carapace length from the base of the rostrum to the posterior margin ranges from 10.5 mm to 37.8 mm. The width averages 0.63 of the length and remains constant throughout growth.

By and large this species seems to have attained a larger size than *L. succedanus*. As growth advances in both species there is a marked tendency for the front to become narrower in proportion to the width and there is a slight progression of the lateral spine towards the front.

Discussion. See general discussion following *Lyreidus bispinulatus* sp. nov.

Lyreidus bispinulatus sp. nov.

Figs 16A-D

Derivation of name. With reference to the single lateral spine on either side.

Diagnosis. A *Lyreidus* with a truncated, almost elliptical carapace with a pair of lateral spines one third distant from the front.

Material. Six more or less incomplete carapaces. Holotype, a carapace (MGUH 21.602); it shows the complete dorsal surface of the carapace except its posterior end (which is preserved on two paratypes from the same locality) from a sandstone bed of the Turrillakløft Member of the Middle Paleocene Agatdal Formation in the large Turrillakløft section, central Nügssuaq. Additional specimens, four carapaces from the type locality, and one from the corresponding sandstone bed in

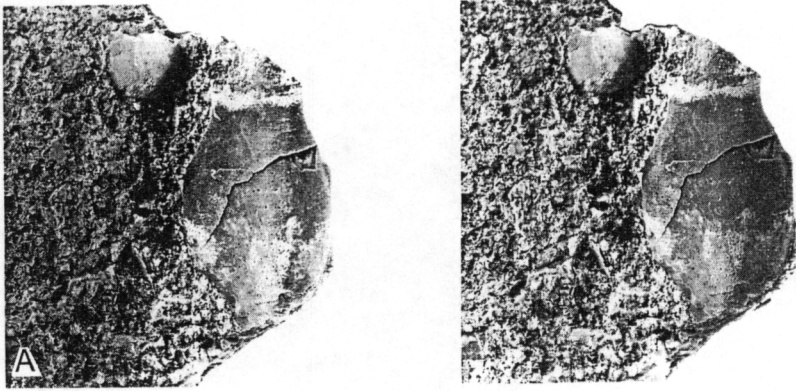
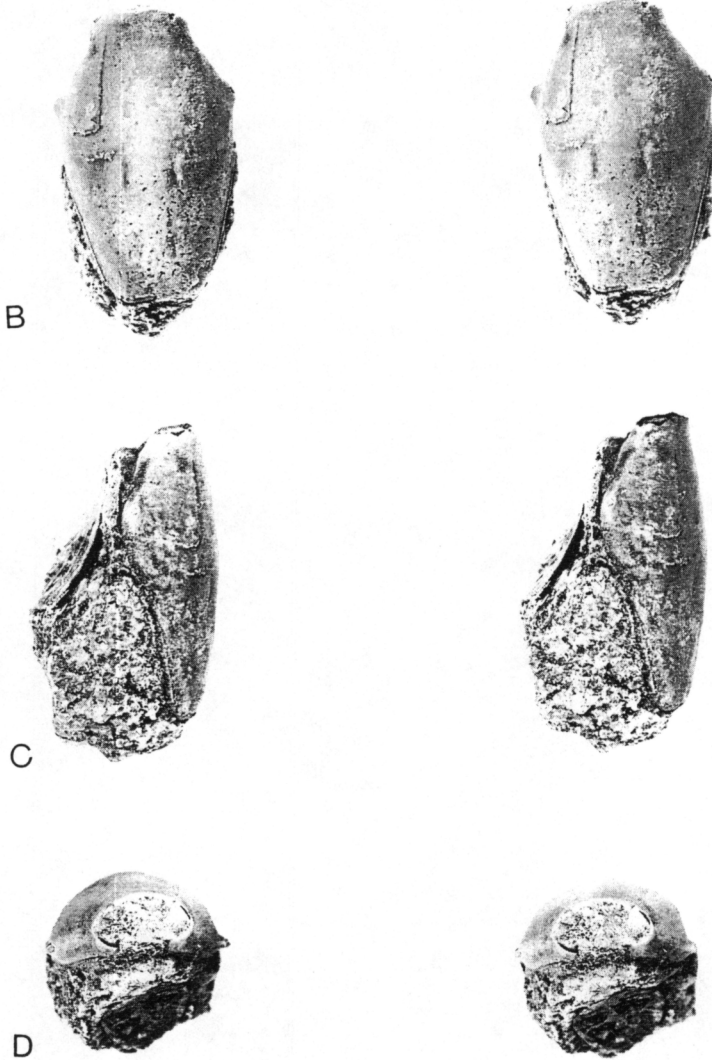


Fig. 16. *Lyreidus bispinulatus* sp. nov. from the Middle Paleocene at Turritellakløft, $\times 2$. A: holotype, MGUH 21.602, dorsal view of carapace; B-D: paratype, MGUH 21.603, B: dorsal view, C: lateral view; D: frontal view.



the smaller profile on the south side of the gorge, opposite the Turritellakløft section.

Description. The carapace is truncated elliptical, length (at base of rostrum) rather less than twice the width and widest just behind the lateral spines about one third distant from the front. From the rather short curved spine at the lateral angle the anterolateral margins are strongly convergent, slightly convex to nearly straight for about two thirds their length then become almost parallel to the front. No secondary spinule or elevation is developed. The front, being rather more than half the carapace width, is rather wide for the genus. The rostrum is simple, broadly triangular without a median furrow. The orbits are forwardly directed and there is a rounded tooth between the two upper orbital fissures. The outer orbital spine if complete, as it appears to be on the holotype, is rather small. The posterolateral margins are convex and converge to well rounded posterior angles leading to the posterior margin which is about as wide as the front.

The most complete carapace has a length of 19.0 mm (excluding rostrum) and the greatest breadth (excluding spines) of 11.5 mm; the orbitofrontal width is 6.5 mm. The holotype is a little smaller, the greatest width being 10.0 mm and in the other, less complete, specimens it ranges from 8.2 mm to 12.0 mm.

The dorsal surface is finely porose with sometimes a fine granulation along the well rounded anterolateral edge and along the posterolateral edge well behind the lateral spines. Faint, slightly curving lateral cardiac furrows (epimeral attractor muscle scars) are situated a little posterior to midlength.

Discussion. Both *L. succedanus* and *L. rosenkrantzi* retain elements of a cervical furrow almost identical with that of *Lyreidus tridentatus*. This and the advanced nature of the sternites – essentially *Lyreidus* – the position of the lateral spines, the narrow front and its armature, clearly places *succedanus* and *rosenkrantzi* in *Lyreidus*. The presence of *L. succedanus* in the Lower Campanian substantially extends the known stratigraphic range of the genus and the geographical range of the genus is considerably extended northwards.

Glaessner (1960) and Griffin (1970) subdivided *Lyreidus* into three groups according to the presence or absence of lateral spines and Feldmann & Zinsmeister (1984, fig. 6) provided a complete table detailing ten fossil and/or Recent species. Of these the first group contains one Recent species, *Lyreidus stenops*, with no lateral spines, in the second group, typified by *L. trispinosus*, five species have one pair of spines and in the

third group, that of *Lyreidus channeri* Wood-Mason, 1885, four species have two pairs of spines.

Goeke (1985) transferred the Recent *Lyreidus bairdii* Smith, 1881 (= *Raninoides nitidus* A. Milne Edwards, 1880) and *Lyreidus channeri* Wood-Mason, 1885 which have two pairs of spines to *Lysirude*. Goeke 1985, and included *Lyreidus griffini* Goeke, 1985. One of the distinguishing characters of *Lysirude* is the presence of an obsolete spine on the anterolateral margin "represented by a distinctly irregular marginal shape and often a small tubercle" (Goeke, 1985). Although such a spine is found on *Lyreidus succedanus* and *L. rosenkrantzi*, it is the only diagnostic feature (preserved) in common with *Lysirude*. Feldmann (1989) was of the opinion that "the distinguishing characters selected by Goeke (1985) to characterise his new genus ... would be used to make distinctions between taxa at the species not the genus level", and considers *Lysirude* a junior subjective synonym of *Lyreidus*.

Both *L. succedanus* and *L. rosenkrantzi* belong to the third of the above mentioned groups – that of *L. channeri*, a Recent species. The difference in the angle of the spines, 38°–43°, in *L. succedanus* and 23°–39° in *L. rosenkrantzi*, together with the median 'ridge' and inflated branchial regions of the former, readily distinguishes these two species. Feldmann (1989) published a considerable revision of *Lyreidus alseanus* Rathbun, 1932 from Eocene to Oligocene deposits of Washington and Oregon and there is in the development of a distinct median ridge a close similarity between that species and *L. succedanus*; it differs, however, in having rather more prominent anterior spines, the outer orbital spines are finer and straighter, and in details of the sternites. Feldmann (1989) considered that *L. alseanus* was closely morphologically related to the Recent *L. channeri* and it is evident that this lineage must be extended to include *L. succedanus*.

Lyreidus bispinulatus and the German Danian *Lyreidus* sp. have only a single pair of spines and are the oldest known members of the *L. trispinosus* group. Gripp (1969) described the anterolateral margin of *Pseudoraninella* sp. [= *L.* sp.] as being weakly concave; the frontal margin is remarkably wide, almost two thirds of the carapace width. The long, almost straight lateral margin and concave posterolateral margin approaches that of *Lyreidus paronai* Crema, 1885 which also has long spines and a comparatively wide front. *L. bispinulatus* differs from both of the previous species in having a narrower frontal region and a more evenly rounded posterolateral margin and in this respect compares favourably with that of the Miocene *Lyreidus antarcticus* Feldmann & Zinsmeister 1984 (the most southerly

known member of the genus), but has a comparatively wider front and is somewhat narrower in proportion to length. *L. bispinulatus* is also similar to the Miocene *Lyreidus elegans* Glaessner, 1960 (synonymised by Griffin, 1970 with *L. tridentatus*), but differs in having a wider orbitofrontal margin.

Genus *Notopocorystes* M'Coy, 1849
Subgenus *Cretacorantina* Mertin, 1941

Type species. *Raninella? schloenbachi* Schlüter, 1879, by original designation.

Range. Middle Albian to Santonian.

Notopocorystes (Cretacorantina)
paututensis sp. nov.
Figs 17A-B

Derivation of name. From Pautût, the type locality.

Diagnosis. A *Cretacorantina* with an elongate rostrum, weakly bifid apically. The cervical furrow is entire and

the frontal area is depressed leaving the anterior margin of the hepatic region lobulate.

Material. Holotype. The impression of the dorsal surface of a carapace. MGUH 21.604, and paratype, MGUH 21.605, an impression of the surface of a carapace. Both specimens found on slabs of red-burned shale in the old landslide fan at Pautût, 480 m above sea level, on the south coast of Nûgssuaq. The sediments are referred to the Upper Santonian or Lower Campanian.

Description. The carapace is subovate in outline, the width about two thirds the length and widest shortly behind the cervical notch about one third distant from the front. There is no median carina, instead the dorsal surface is slightly tumid, almost flat, but this may to some degree be due to secondary flattening in the shale. The short anterolateral margin is imperfectly preserved, but basal scars indicate there was a spine a little behind the outer orbital spine, one just before the cervical notch, one on the epibranchial lobe and another very small one immediately behind it. The posterolateral



Fig. 17. *Notopocorystes (Cretacorantina) paututensis* sp. nov. from the Lower Campanian at Pautût, $\times 3$. A: holotype, MGUH 21.604, dorsal view of carapace; B: paratype, MGUH 21.605, dorsal view of silicone rubber cast of the carapace.

margin is weakly convex and bordered by a well rounded ridge which narrows considerably as it approaches the posterior angles and bounds the posterior margin. The posterior margin is narrower than the front and moderately concave. The orbitofrontal margin is incomplete, but appears to have occupied about two thirds the carapace width. There is a distinct long, narrow rostrum weakly bifid apically with a prominent ridge separated by fine grooves from the raised margins which continue as a rim across the inner slightly concave portion of the upper orbital margin and end in a point at the inner orbital fissure. The two wide fissures are separated by a flat, broad-based, probably pointed tooth. The base of the outer fissure is rather deeper than the inner and, together with the projected base of the outer orbital spine suggests the orbits were directed obliquely outwards. The rostral grooves run back and delimit the anterior mesogastric process.

From the margin the cervical furrow runs obliquely forward, then back in a gentle curve to a little forward of the outer angle of the mesogastric lobe, then turns sharply to the angle and just as sharply inward, forming a zig-zag; it is interrupted near the midline by a pair of longitudinal processes uniting the meso- and urogastric lobes and ends in a pit at the midline. The hepatic furrow issues from the groove delimiting the mesogastric lobe just above the 'zig-zag' and progresses to the margin in a series of three loops, the outermost enclosing a node at the base of the first anterolateral spine. The areas contained within the loops are tumid – a condition more noticeable on internal moulds. Deep grooves, with a pit anteriorly, on either side of the rather wide urogastric lobe converge to the widest part of the cardiac region. The branchiocardiac furrow commences just lateral to the (urogastric) pit and runs back to the lateral margin at an angle divergent from the cervical furrow. There is a small median granule on the urogastric lobe and the internal mould shows two feeble granules on the widest part of the cardiac region and another on its much attenuated base. The epibranchial lobe, vaguely discernible on the outer surface, is lozenge-shaped and a granulated depression separates the meso- from the metabranchial lobe.

Apart from the generally depressed areas, other granules on the outer surface are concentrated towards the lateral margins, in continuation with the rostral grooves and along the margins of the cervical and hepatic furrows; the bases of these furrows and the mid-dorsal areas are smooth.

Discussion. In retaining an entire cervical furrow *N. (C.) paututensis* would appear to be close to the early, Albian species *N. (C.) broderipii* (Mantell, 1844), the

Cenomanian *N. (C.) syriacus* Withers, 1928 and *N. (C.) ornatus* Wright & Collins, 1972, and the more or less contemporary *N. (C.) harveyi* (Woodward, 1896) from the Senomanian, Nanaimo group of Vancouver Island and Hornby Island, British Columbia. *N. (C.) broderipii* and *N. (C.) syriacus* differ from the present species in having a shorter rostrum and a more or less obscure median ridge running the whole length of the carapace. While lacking a median ridge *N. (C.) ornatus* is immediately distinguished by its coarse ornament. The median ridge of *N. (C.) harveyi* is described by Woodward (1898) as faint, but this large species may further be distinguished in having a deeply incised rostrum and its shorter distance from the inner orbital notch. The anterolateral spines of *N. (C.) paututensis* have been determined from undulations along the margin and observations are therefore questionable, but by and large they agree with those of *N. (C.) harveyi*, although in the latter the anterior pair are close together, almost bifid.

Genus *Laeviranina* Lörenthey & Beurlen, 1929

Type species. *Ranina (Laeviranina) budapestiniensis* Lörenthey & Beurlen, 1929, by subsequent designation of Glaessner, 1929.

Range. Paleocene Danian to Recent.

Laeviranina borealis sp. nov.
Figs 18A-C

Derivation of name. Indicating a northern species.

Diagnosis. Carapace with a sinuous postorbital ridge in front of the lateral spines and weak cardiac furrows; dorsal surface finely granulated.

Material. Holotype, a more or less complete carapace (MGUH 21.606) and 7 additional specimens found in calcarenite concretions from the Turritellakløft Member of the Agatdal Formation in the great profile of Qær-sutjægerdal in Nûgssuaq. They were found in the uppermost sandstone with concretions just below the Abraham Member of black shales and tuff.

Description. The carapace is subovate, almost elliptical in outline; width about two thirds of the carapace length, widest at or a little anterior to midlength. It is rather strongly curved in transverse section; a noticeable postorbital depression is bounded by a slightly sinuous ridge, convex medially, reaching the margin just anterior to the lateral spine, from the depression