ON A NEW SPECIES OF *NESOKALIELLA* AND FURTHER COMMENTS ON THE AFFINITIES OF THE GENUS (GASTROPODA: LIMACOIDEA)

JUSTIN GERLACH[1]

Abstract *A third species of the Seychelles endemic limacoid genus* Nesokaliella *is described. The systematic position of the genus is re-examined using a cladistic analysis of the Limacoidea s.l., concluding that* Nesokaliella *belongs to the Gastrodontoidea, but its precise position remains unresolved.*

Key words Nesokaliella, *Silhouette, Limacoidea, Gastrodontoidea*

INTRODUCTION

The Seychelles endemic genus *Nesokaliella* was described in 1998 (Gerlach, 1998) on the basis of material from the islands of Mahé and Silhouette. The available material was sufficient to distinguish two species and to recognise the genus as distinct from *'Kaliella'*, the genus in which the Seychelles forms had been placed previously. However, the affinities of *Nesokaliella* remained obscure due largely to the poor definition of the limacoid (or 'zonitoid') families. It was concluded that the Seychelles genus was probably a euconulid on the basis of an arrangement of cerebral ganglia which appears to be unique to the euconulids within the Limacoidea s.l. (although the restricted number of genera examined was noted). The 1998 revision gave brief consideration to the distribution of the two species, recording *N. minuta* from the north of the island of Mahé and *N. subturritula* from south Mahé and from the islands of Silhouette and Felicite. Adult spirit material was only available from Mahé and the Silhouette population was ascribed to *N. subturritula* on conchological characters alone. The Felicite population is known only from one report (Nevill, 1870), apparently without surviving voucher specimens (Gerlach, 1998). New material from Silhouette led to a reappraisal of the distributions of *Nesokaliella* species, recognising the Silhouette form as a distinct species and allowing a re-examination of the anatomical characters which may facilitate further resolution of the affinities of this genus.

Abbreviations

BM(NH)	British Museum (Natural History)
NPTS	Nature Protection Trust of Seychelles
UMZC	University Museum of Zoology, Cambridge

SYSTEMATIC DESCRIPTION

Nesokaliella intermedia sp. nov.
Fig 1

Helix (Conulus), n. sp.? Nevill 1870: 63 (partim)
Kaliella subturritula Martens 1898: 16 (partim)
Kaliella subturritula Sykes 1909: 62 (partim)

[1]133 Cherry Hinton Road, Cambridge CB1 7BX, UK.

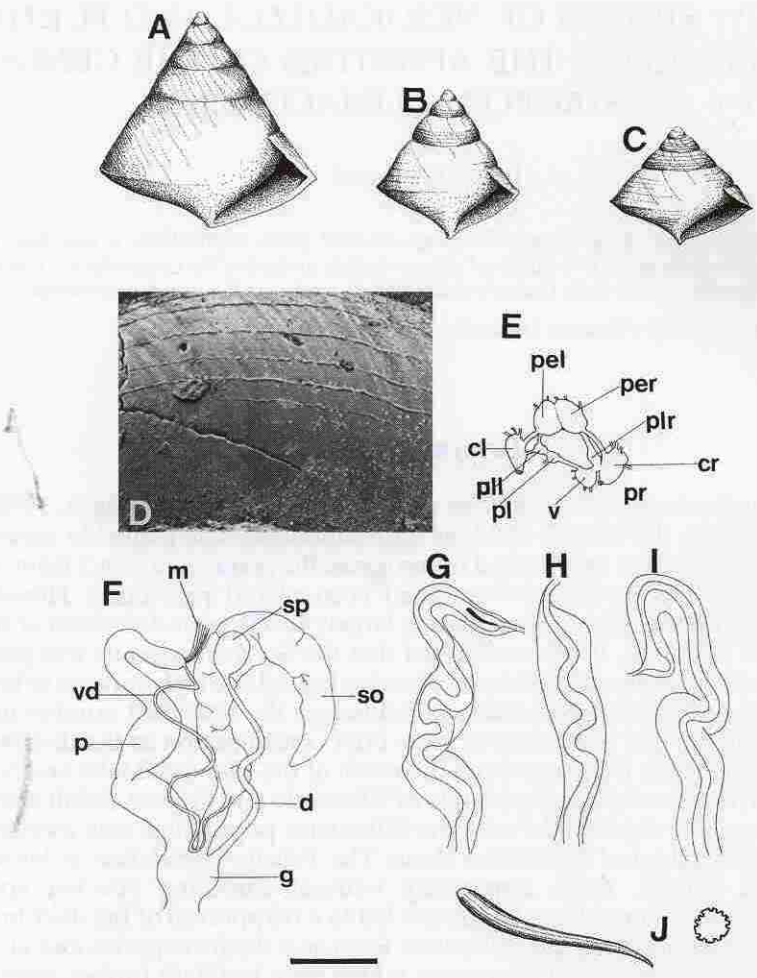

Fig. 1 *Nesokaliella* shells and anatomy. Scale bar: A–C = 2 mm; D = 0.2 mm; E–I = 1 mm; J = 0.15 mm.
A. *N. subturritula*
B. *N. minuta*
C. *N. intermedia*
D. Shell sculpture of *N. intermedia*
E. Arrangement of cerebral ganglia of *N. intermedia* - cerebral commisures cut.
F. Reproductive anatomy of *N. intermedia*
G. Penis of *N. intermedia*, showing location of spermatophore
H. Penis of *N. subturritula*
I. Penis of *N. minuta*
J. Spermatophore from *N. intermedia*, side view and cross section

Key **cl** left cerebral ganglion; **cr** right cerebral ganglion; **d** spermatheca duct; **g** genital atrium; **m** penial retractor muscle; **p** penis; **pel** left pedal ganglion; **per** right pedal ganglion; **pl** left parietal ganglion; **pll** left pleural ganglion; **plr** right pleural ganglion; **pr** right parietal ganglion; **so** spermoviduct; **sp** spermatheca; **v** visceral ganglion; **vd** vas deferens.

Kaliella subturritula Germain 1921: 433 (partim)
Kaliella subturritula Germain 1934: 122 (partim)
Kaliella subturritula Lionnet 1984: 241 (partim)
Kaliella subturritula Gerlach 1987: 17 (partim)
Nesokaliella subturritula Gerlach 1998: 18 (partim)

Holotype NPTS M1999.1 (Jardin Marron, Silhouette 18/1/99, collected by J. Gerlach).

Paratypes NPTS M1999.2 (Jardin Marron, Silhouette 18/1/99, collected by J. Gerlach); NPTS M1998.5, Gratte Fesse, Silhouette, 3/8/98, collected by J. Gerlach), UMZC I.22,528 (Jardin Marron, Silhouette 18/1/99, collected by J. Gerlach).

Other material Silhouette: 1 adult (BM(NH) un-numbered (ex Sykes colln. 1908), 11 juveniles (NPTS M1997.3, Jardin Marron 2/7/90–2/8/90; NPTS M1999.3; Jardin Marron 18/1/99).

Measurements (mm)

	Height	Diameter	Whorls	N
Holotype	2.8	3.2	6	
Range	2.0–2.8	2.2–3.2	6	4
Mean ± sd	2.35±0.41	2.65±0.44	6±0	

Description Shell (Fig. 1C & D) conical with 6 almost straight sided whorls, protoconch of 2 smooth whorls. Whorls ornamented with fine regular radial growth lines (50 mm^{-1}), and 10 fine spiral striae (44 mm^{-1} on body whorl), only the basal 7 striae are distinct. Sculpture continues onto the underside. Keel sharply angled. A sutural ridge is present on all whorls. Umbilicus open but very small (5% of shell diameter). Shell very thin, slightly glossy, translucent, with a thin, horn coloured periostracum. Mouth edge simple.

Body. Tail slightly flattened, no caudal horn. Sole tripartite. Light brown, tentacles darker. Mantle brown, without darker mottling. Mantle border brown.

Radula formula = 54+9+1+9+54.

Reproductive anatomy (Fig 1F.). Genital atrium slightly inflated. Spermoviduct elongate, simple in shape. Spermatheca duct long and narrow, arising from base of spermoviduct. Spermatheca oval, 0.8 mm longest dimension. Penis elongate (3 mm), very narrow (0.1 mm). Penis enclosed by tunica. No epiphallus detectable externally or indicated by internal structure. No penial diverticulae or ornament. Penial retractor muscle terminal. A small, elongate structure was present in tip of penis, this was initally interpreted as a spicule but its position and ornament suggest that it is the distal portion of a spermatophore. This structure is elongate (0.4x0.05 mm), slightly curved; grey with fine longitudinal striae.

Derivation of name *intermedia*, Latin for **intermediate,** referring to its apparent similarity to both *N. subturritula* and *N. minuta*.

Distribution Silhouette (Jardin Marron, Mon Plaisir, *Pisonia sechellarum* forest, Gratte Fesse). Arboreal species, rarely found in leaf litter on the ground.

Comparisons *N. intermedia* resembles *N. minuta* superficially in its small size and uniform brown colouration. Adult shells were initially mistaken for juvenile *N. subturritula* due to the presence of radial microstriae which are found in *N. subturritula* but not

N. minuta. Penial shapes do not differ greatly, re-examination of dissections shows that the apparent differences figured in Gerlach (1998) are due to the accidental removal of the penial tunica in the specimen of *N. minuta* and the obscuring of the true penis shape by the retained tunica in *N. subturritula*, corrected figures are given in Fig. 1. Differences between the taxa are summarised below:

	N. subturritula	*N. minuta*	*N. intermedia*
Spiral striae	0	5	10
Radial striae	present	absent	present
Height/diameter	0.94–1.04	1.14–1.3	0.88–0.91
Mantle colour	grey+black	mottled brown	uniform brown
Radula marginals	27	39	54
Genital atrium	normal	normal	inflated
Penis shape	elongate	terminally inflated	elongate

DISTRIBUTION PATTERNS AND THE FELICITE RECORD

The presence of three distinct species on two islands suggests that isolated populations readily diverged to species level. This suggests that the Felicite form should be described as a new taxon, however, this is prevented by the lack of specimens. Felicite is a small, relatively low (250 m) island in contrast to Mahé and Silhouette which reach 996 m and 774 m respectively. On these islands *Nesokaliella* is restricted to high altitude forests above 250 m. The islands of Praslin and La Digue are near Felicite and superficially appear to offer more suitable high-forest habitats, however, no members of the genus have ever been recorded from these islands, raising questions as to the accuracy of the Felicite record.

The Felicite record rests on a single report of *'Helix (Conulus)*, n. sp.?' (Nevill 1870). This was not described at the time and the Felicite record was omitted from the subsequent description of *'Helix sub-turritula'* (Nevill & Nevill, 1871). Furthermore, no Felicite specimens were listed by Nevill (1878), suggesting that the 1870 record was an error; either a misidentification or a labelling mistake, subsequently corrected but not elaborated on by Nevill. No *Nesokaliella* were collected on Felicite by subsequent visitors to the island (Sykes, 1909; Lionnet, pers. comm.).

If Felicite is removed from the distribution of *Nesokaliella* the genus is restricted to the high forests of Mahé and Silhouette and belongs to the relict high-altitude and mist forest fauna of these islands.

AFFINITIES

The affinities of *Nesokaliella* are difficult to determine, largely because of the lack of clear diagnostic characters for the limacoid families. As discussed in Gerlach (1998) the genus appears to be euconulid. A more detailed dissection of the Silhouette material has provided some new information which may clarify the situation.

The previous discussion of *Nesokaliella* demonstrated that the genus showed closest affinity to the Euconulidae, Urocyclidae and Limacoidea (Zonitoidea in Gerlach, 1998). The most distinctive feature of the new material is the presence of a portion of the spermatophore. The longitudinal striae on the spermatophore are unusual but are recorded in the Chronidae (e.g. *Orpiella macgillivrayi;* Baker, 1941). The presence of a penial tunica in *Nesokaliella* is recorded in several limacoid families but has often been overlooked (Hausdorf, 1998). The insertion of the spermatheca duct at the junction of the spermoviduct and penis is a common euconulid character and is found in *Nesokaliella*. Spermatheca duct insertion has been suggested as defining the family (Baker, 1941) although exceptions to the pattern are known (e.g. Verdcourt, 1992) and the character is also found in the gastrodontids (Pilsbry, 1946). As noted previously (Gerlach, 1998), the

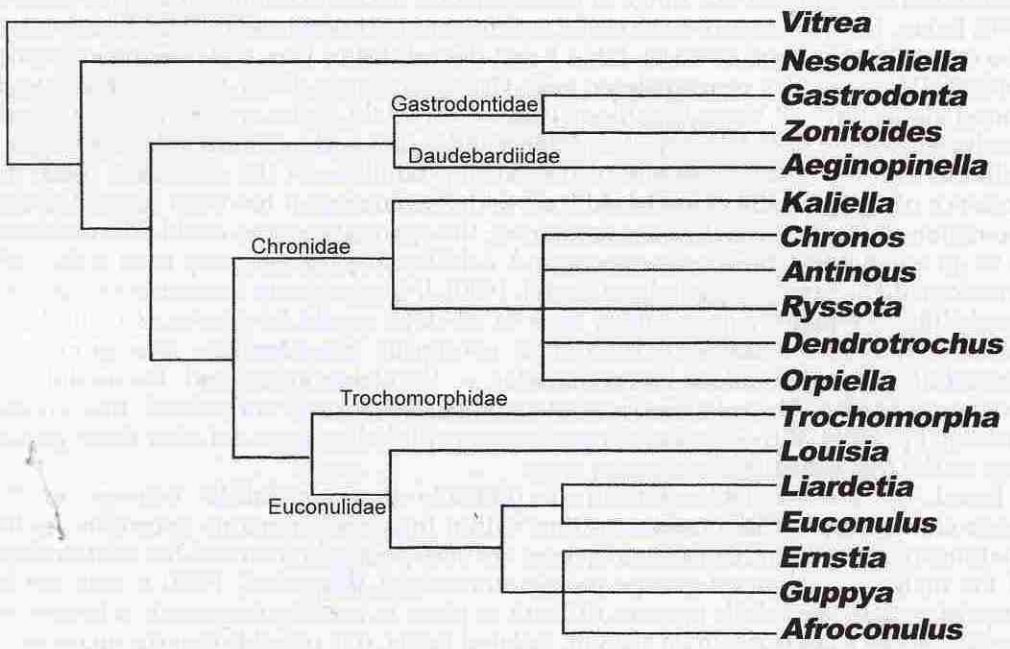

Fig. 2 Gastrodontoid phylogeny.

arrangement of cerebral ganglia in *Nesokaliella* is the only anatomical character clearly separating the limacoid families at present, although this rests on dissections of very few taxa. Available data suggest that the *Nesokaliella* pattern of short connective commissures and approximately equidistant pleural, pedal and cerebral ganglia and the visceral ganglion contacting the right parietal ganglion are found only in the euconulids. Of these apparently euconulid characters the close proximity of the left parietal ganglion to the left pleural relative to the visceral is also found in the gastrodontids, as is the proximity of the right pleural and cerebral ganglia (although there is some variation in gastrodontids). The former character has been interpreted as being plesiomorphic (Tillier, 1989) and may not be useful in determining affinities. The latter is apparently restricted to some gastrodontids, euconulids, trochomorphids and urocyclids.

The only recent attempt to examine the relationships between the limacoid families (Hausdorf, 1998) provides clear definitions of most groups although some of the families used may be paraphyletic (e.g. Helicarionidae and Euconulidae). Under Hausdorf's (1998) definitions *Nesokaliella* belongs to the Dyakioidea + Gastrodontoidea based on the presence of a caudal pit and the absence of penial papillae (characters present in other Limacoidea; Hausdorf, 1998). The genus can be further restricted to the Gastrodontoidea by the lack of a stimulator and papillae. The presence of minor venation in the lung is also a character of this group but is not known in *Nesokaliella*. Within the Gastrodontoidea *Nesokaliella* appears to be closest to the Chronidae, sharing the thick walled spermatophore with *Orpiella* and the absence of a flagellum with *Ryssota* although certain characters such as the position of the spermatheca duct on the genital atrium and the inflation of the atrium could be interpreted as resembling the Microcystinae states (duct on the penis rather than the vagina and inflated 'uterus'; Hausdorf, 1998), although the long spermatheca duct would exclude it from the Microcystinae and other Euconulidae.

A cladistic analysis of the Gastrodontoidea was carried out (Fig. 2) using published

anatomical descriptions of a range of genera within the main families (Godwin-Austen, 1908; Baker, 1941; Pilsbry, 1946; Van Mol & Bruggen, 1971; Verdcourt, 1992; Riedel, 1980). The characters used are given in Table 1 and the full list of taxa and character states in Table 2. The characters were analysed with *Hennig86* (Farris, 1988), using a branch-and-bound algorithm and *Vitrea* (Pristilomatidae = Vitreidae) as the outgroup. The analysis produced a single tree of 31 steps (confidence index 0.61 and retention index 0.82) which failed to locate *Nesokaliella* in any of the existing families. Of the characters used, the presence of an epiphallus may be difficult to determine and it has been suggested that the region of the *Nesokaliella* penis containing the spermatopohore could be considered to be an epiphallus (Hausdorf pers. comm.). Additionally the outgroup used is the only pristilomatid lacking an epiphallus (Riedel, 1980). If the outgroup is assumed to have an epiphallus 16 equally parsimonious trees of 32 steps would be produced (confidence index 0.59, retention index 0.81). A strict consensus tree identifies four groupings; *Nesokaliella*, the Chronidae, Gastrodontidae + Daudebardiidae and Euconulidae + Trochomorphidae. The relationships between these groups is unresolved. Interpreting the distal portion of the *Nesokaliella* penis as an epiphallus does not alter these groupings or the tree statistics.

Based on the available data it is probable that *Nesokaliella* belongs to the Gastrodontoidea, but its precise position within this group remains uncertain. As the anatomy of many of the constituent genera are very poorly known and the relationships of the main gastrodontoid groups remain unresolved (Hausdorf, 1998) it may not be surprising that *Nesokaliella* remains difficult to place in existing taxonomic schemes. As the Seychelles islands retain an ancient, isolated fauna, it is possible that the anatomy of *Nesokaliella* reflects the plesiomorphic conditions in the Gastrodontoidea.

TABLE 1
Characters used in cladistic analysis

1. Caudal horn present
2. Mantle lobes present
3. Penis elongate (length >3xwidth)
4. Penial tunica present
5. Penial papillae present
6. Caecum on penis
7. Epiphallus present
8. Flagellum on epiphallus
9. Chalk sac present on epiphallus
10. Spermatheca duct shorter than penis
11. Spermatheca reduced (width <4xspermatheca duct width)
12. Spermatheca originating on penis
13. Genital atrium round
14. Connection between penis and spermoviduct
15. Stimulator dart present
16. Dart sac present
17. Thin walled spermatophore
18. Minor venation present on lung
19. Right ommatophoral retractor muscle passing between penis and spermoviduct

TABLE 2
Character states of taxa used in cladistic analysis

Vitrea	00111 00001 100000 001
Rhyssota	11111 01111 010000 011
Dendrotrochus	11010 01101 000000 011
Antinous	11110 01101 000000 011
Kaliella	11110 01100 000000 011
Chronos	11110 01101 000000 011
Orpiella	11110 01101 001000 011
Nesokaliella	00110 00000 001000 0?1
Liardetia	00010 11000 110000 101
Louisia	00110 11000 110000 101
Euconulus	00010 11000 110000 101
Afroconulus	10111 01001 110000 101
Guppya	10110 11000 110000 101
Ernstia	10110 11000 110000 101
Aegopinella	11110 00000 000010 000
Gastrodonta	01011 00000 000111 000
Zonitoides	01011 00000 000111 000
Trochomorpha	01100 11000 010000 101

ACKNOWLEGEMENTS

I am very grateful to B. Hausdorf for his constructive comments and suggestions on phylogeny of these confusing snails.

REFERENCES

BAKER H.B. 1941 Zonitid snails from Pacific Islands *Bulletin of the Bernice P. Bishop Museum* **166**: 203–370.

FARRIS J.S. 1988 *Hennig86* - version 1.5.

GERLACH J. 1987 *The Land Snails of Seychelles - a field guide.* Privately published, 67pp.

GERLACH J. 1998 A new genus of Zonitoidea previously referred to *Kaliella Journal of Conchology* **36**: 17–21.

GERMAIN L. 1921 *Mission Zoologique de M. Paul carie aux îles Mascareignes: faune malacologique terrestre et fluviatile des îles Mascareignes* Gaultier & Thébert, Angers.

GERMAIN L. 1934 L'origine de la composition de la faune malacologique des îles Séchelles. *Comptes rendus du congres des Societes des Savants du Paris. Section des Sciences* **16**: 113–133.

GOETHEM J.L. van 1977 Révision systématique des Urocyclinae (Mollusca, Pulmonata, Urocyclidae) *Annales du Musée Royal de l'Afrique Centrale* **218**: 1–355.

GODWIN-AUSTEN H.H. 1908 On the animals of genera and species of Mascarene land-Mollusca belonging to the family Zonitidae, collected by Monsieur E. Dupont *Annals and Magazine of Natural History* (8) **2**: 422–436.

HAUSDORF B. 1998 Phylogeny of the Limacoidea sensu lato (Gastropoda: Stylommatophora). *Journal of Molluscan Studies* **64**: 35–66.

LIONNET G. 1984 Terrestrial testaceous molluscs of the Seychelles. *In* Stoddart D.R. (ed.) *Biogeography and ecology of the Seychelles Islands* Dr. W. Junk, the Hague, pp. 239–244.

MARTENS E. VON 1898 Land und Süsswasser-Mollusken der Seychellen nach den Sammlungen von

Dr. Aug. Brauer *Mitteilungen aus dem Zoologischen Museum. Berlin* **1**: 1–96.

NEVILL G. 1870 Additional notes on the land-shells of the Seychelles Islands *Proceedings of the Zoological Society of London* **1869**: 61–66.

NEVILL G. 1878 *Handlist of the Mollusca in the Indian Museum Calcutta. 1. Gastropoda.* Indian Museum, Calcutta.

NEVILL G. & NEVILL H. 1871. Descriptions of new Mollusca from the eastern regions *Journal of the Asiatic Society of Bengal* **40**: 1–11.

PILSBRY H.A. 1946 *Land Mollusca of North America (north of Mexico)* **2** (1): 246–425. Academy of Natural Sciences of Philadelphia, Pennsylvania. Monograph 3.

RIEDEL A. 1980 *Genera Zonitidarum. diagnosen supraspezifischer Taxa der Familie Zonitidae (Gastropoda, Stylommatophora)* W. Backhuys, Rotterdam.

SYKES E.R. 1909 The land and freshwater mollusca of the Seychelles Archipelago *Transactions of the Linnean Society of London (Zoology)* **13**: 57–64.

TILLIER S. 1989 Comparative morphology, phylogeny and classification of land snails and sluges (Gastropoda: Pulmonata: Stylommatophora) *Malacologia* **30** (12): 1–303.

VAN MOL J.J. & BRUGGEN A.C. VAN 1971 Description d'un nouveau genre d'Euconulidae d'Afrique et discussion sur les affinités systématiques de cette famille (Mollusca, Gastropoda, Pulmonata) *Revue de Zoologie et de Botanique Africaine* **84**: 285–296.

VERDCOURT B. 1992 The identity of two euconulid snails recently found in the Seychelles *Journal of Conchology* **34**: 167–174.