

CLASSIFICATION OF NEW ZEALAND ARIONACEA

(MOLLUSCA : PULMONATA)

A REVISION OF SOME ENDODONTID GENERA

(ENDODONTIDAE PILSBRY, 1894)

VOL. 1

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1969

A THESIS PRESENTED FOR THE DEGREE OF DOCTOR OF

PHILOSOPHY IN ZOOLOGY

AT CANTERBURY UNIVERSITY, CHRISTCHURCH,

NEW ZEALAND

"The creation of natural hierarchical systems of organisms is based on hierarchic combinative differentiation of characters, more precisely, of the systems of characters. None of the characters taken alone can serve as a criterion for the determination of the rank of a taxonomic category. Objective criteria exist for the species only, due to the presence of continuous variability within the species and in its absence between the species."

(B. A. Wainstein, Zool. Zh., Vol. 39 (1960) p. 1778)

GENERAL INTRODUCTION

The following systematic revisions of New Zealand taxa within the Arionacean subfamilies Flammulininae Climo, 1969, Otoconchinae Cockerell, 1893 and Endodontinae Suter, 1913 (family Endodontidae Pilsbry, 1894) are based on quantitative reappraisals of shell morphology and studies on radular and soft-part morphology.

The last major revision of these New Zealand pulmonate taxa was presented by Suter (1913) in his *Manual of the New Zealand Mollusca*, and illustrated in his *Atlas of Plates* which appeared in 1915. Suter's work was, as were the great majority of earlier pulmonate systematic studies, based on studies of shell and radular morphology, and was the major contribution towards the erection of a systematic hierarchy which illustrated the indigenous nature of the New Zealand endodontid fauna. Systematic studies on Australian and New Zealand endodontids by the contemporary worker T. Iredale resulted in the replacement of Suter's hierarchy which was influenced by the earlier works of H. A. Pilsbry.

Iredale's higher classification of the New Zealand endodontid fauna has been followed in Australia and New Zealand to the present day, but not without question. The introductory paper in the series

which comprises this thesis elaborates on, and shows that the doubts held about the Iredalian higher systematics can be substantiated.

I was influenced by statements made by Solem (1959) to undertake an anatomical study of the New Zealand representatives of the family Endodontidae Pilsbry, 1894. Solem and other workers have mentioned that the distinction between Charopidae Iredale, 1937 and Flammulinidae Iredale, 1937 was artificial. Solem also stated that to understand the generic relationships within the large, diverse group of molluscs which he classified in the redefined subfamily Endodontinae Suter, 1913 (Charopidae and Flammulinidae), anatomical studies would have to be undertaken.

Having shown that the distinction between Charopidae and Flammulinidae was artificial (Part I), I then proceeded to systematically dissect all available New Zealand species within the redefined subfamily Endodontinae. The results of these dissections have provided information which enables the Endodontinae to be divided into two taxa: the subfamilies Endodontinae and Flammulininae Climo. Having established this higher systematic platform I then revised the existing taxa in light of the new anatomical data and information provided by studies in shell variation. The revisions as here presented are part of a long term study which will eventually

result in a review of the entire New Zealand endodontid fauna. Lack of material and the time necessary to revise some genera in the Flammulininae, and the large punctid complex (Punctinae Morse, 1864) has made it impracticable to include a revision of these taxa in this thesis.

METHODS

In preparation for dissection, animals were first drowned in tap water. When drowned, the animal is fully extended from the shell and as a consequence all ducts of internal organs are extended and easily separable. Dead snails were preserved in a mixture of 70% ethyl alcohol and five parts by volume of glycerine, the latter to prevent hardening of tissues. Before dissection, which was carried out while the animal was submerged in 70% ethyl alcohol, the shell was crushed. The only dissection instruments used in the study were mounted entomological pins.

Photographic equipment used was a Pentax camera with bellows unit and a reversed 35 mm lens. The object to be photographed was placed on an inverted petri-dish which rested on a black velvet mat. Lighting was provided by a dual flash unit; one flash set at 12 inches provided horizontal lighting, and another set at about the same distance but 12 inches higher than the object, provided

filling-in lighting. All photographs were taken on Ilford Pan F film (ASA 50), which was developed for 10 minutes in half-strength ID 11 at 20°C. Prints were made on grade 5 Ilford paper, using half-strength Afga 108, or Bromophen developers. All line block illustrations were drawn with the aid of a gridded eye-piece, with the exception of the radular teeth which were too small to occupy a useable portion of any available grid.

Radulae were mounted immediately after removal from the buccal mass; organic matter clinging to the radular ribbon having first been removed by entomological pins. The radulae were mounted in a liquid medium composed of glycerine and picric acid, and the coverslip was sealed with "Cutex" nail polish.

GENERAL LIST OF CONTENTS

The pages in each section of this thesis are numbered separately and each section is clearly indicated by a projecting coloured card. The systematic sections of this study (Parts I - VII) each have their own title page and comprehensive list of contents. This list of contents is presented to show the general lay-out of the topics covered in the study. Because of the large number of figures involved in such a systematic study, it has been necessary to present the work in two volumes; up to and including Part IV in the first, the rest in the second.

Introduction and Methods

- * Part I The Higher Classification
- * Part II A Revision of Charopa subgenus
Ptychodon Ancey, 1888
- * Part III A Revision of the genera Charopa Albers,
1860 (excluding subgenus Ptychodon Ancey,
1888), Phenacharopa Pilsbry, 1892 and
Flammocharopa n. gen. (Endodontidae :
Endodontinae)

- Part IV A Revision of the genera Flammoconcha
Dell, 1952 and Flammulina Martens, 1873:
with Description of a new endodontinid subgenus
and a new flammulininid genus (Endodontidae
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- Part V Reviews of the genera Gerontia Hutton, 1883,
Obanella Dell, 1952, Ranfurlya Suter, 1903,
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- Part VI A Revision of the genus Allodiscus Pilsbry, 1892
(Endodontidae : Flammulininae)
- Part VII A Revision of the subfamily Otoconchinae
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- Concluding Review
- General Acknowledgements
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CLASSIFICATION OF NEW ZEALAND ARIONACEA

(MOLLUSCA : PULMONATA)

PART I

THE HIGHER CLASSIFICATION

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Attached article:

Climo, F. M. "Classification of New Zealand Arionacea (Mollusca: Pulmonata). I. The Higher Classification" *Records of the Dominion Museum, Wellington* 6.14 (1969): 175-258.

CLASSIFICATION OF NEW ZEALAND ARIONACEA

(MOLLUSCA : PULMONATA)

PART II

A REVISION OF CHAROPA SUBGENUS PTYCHODON

ANCEY, 1888

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CLASSIFICATION OF NEW ZEALAND ARIONACEA

(MOLLUSCA : PULMONATA)

PART III

A REVISION OF THE GENERA CHAROPA ALBERS,
1860 (EXCLUDING SUBGENUS PTYCHODON ANCEY,

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Attached article:

Climo, F. M. "Classification of New Zealand Arionacea (Mollusca: Pulmonata). III. A revision of the genera *Charopa* Albers (1860)" *Records of the Dominion Museum*, Wellington 6.18 (1970): 285-366.

CLASSIFICATION OF NEW ZEALAND ARIONACEA

(MOLLUSCA : PULMONATA)

PART IV

A REVISION OF THE GENERA FLAMMOCONCHA DELL, 1952

AND FLAMMULINA MARTENS, 1873 : WITH DESCRIPTION OF

A NEW ENDODONTINID SUBGENUS AND A NEW FLAMMULININID

GENUS (ENDODONTIDAE PILSBRY)

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CLASSIFICATION OF NEW ZEALAND ARIONACEA

(MOLLUSCA : PULMONATA)

IV A Revision of the genera Flammoconcha Dell, 1952 and
Flammulina Martens, 1873 : with Description of a new
endodontinid subgenus and a new flammulinid genus
(Endodontidae Pilsbry)

By F. M. Climo

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ABSTRACT

The genus Flammoconcha Dell, 1952 is expanded to include the relatively large, loosely coiled, imperforate to narrowly perforate endodontinids resembling the flammulinid genus Flammulina Martens; Flammoconcha s. str. being retained at the subgeneric level for the original two species with a cut-away shell base. A new subgenus, Delloconcha, is erected for the species which have a columella and no base-aperture. A new flammulinid species, Protoflammulina johnsi, is described and designated the type of the monotypic new genus Protoflammulina. Flammoconcha (Flammoconcha) marstoni, F. (Delloconcha) albina and F. (D.) viridula are described as new species. Flammulina sorenseni

Powell, 1935 is shown to be a punctid and is transferred to the genus Laoma Gray, 1850. Amphidoxa (Calymna) feredayi var. glacialis Suter, 1891 is elevated to specific rank.

INTRODUCTION

In a previous paper (Part III), I transferred Flammulina pilsbryi Suter, 1894 to the genus Charopa Albers, 1860, having synonymized it with Flammulina costulata parva Suter, 1909. A new genus, Flammocharopa, was erected for Amphidoxa costulata Hutton, 1883 and Patula bianca var. montana Suter, 1891.

In Part I of this series (Climo, 1969a) I stated that Flammulina Martens, as used in the New Zealand literature, was polyphyletic and concluded that it was composed of species from two different subfamilies. Some species had an epiphallus on the penis and were defined as belonging to the Endodontinae Suter, 1913, while others had no epiphallus and were defined as members of a new subfamily (Flammulininae Climo, 1969).

Interpretation of the systematic positions of species within Flammulina has been complicated by several factors:

- (i) there has been parallel shell reduction, development of similar tooth structure and development of crisp radial riblets in two morphological lines;

- (ii) correlated with reduction in the number of shell whorls there has often been reduction in shell thickness which has revealed periostracal and calcite deposition patterns. These cross-hatched patterns, particularly evident in transmitted light, provide a tempting criterion for unification of a group of species. I have rejected the systematic importance of these patterns above the specific level because species from both subfamilies display them;
- (iii) closely related species can have different food preferences; some are carnivorous, the gut contents composed entirely of insect remains, and others are herbivorous, the guts containing detritus, fungi and higher plant remains;
- (iv) some species are rare and in the absence of preserved material it has not been possible to check their systematic positions by dissection.

The distinction between Flammulina and Flammoconcha (Delloconcha) can only be resolved with certainty by anatomical studies. In Part I of this series I stated that in the absence of anatomical information it was not possible to place accurately the genus Flammoconcha Dell within the Endodontidae Pilsbry, 1894. Since then, I have dissected specimens of F. stewartensis Dell and

F. cumberi (Powell), and in the light of the new anatomical information I here transfer Flammoconcha from its provisional placing in the Flammulininae, to the Endodontinae. The penis of both species is provided with a strong epiphallus.

The species of Flammulina with an epiphallus are closely related to Flammoconcha and differ only in having less reduced shells. In Flammoconcha the base of the shell is reduced, the columella is lost and the aperture continues as a spiral opening to the protoconch. To restrict Flammoconcha to F. cumberi and F. stewartensis, and to erect a new genus for the flammulinids with an epiphallus would not show the close relationship that exists between the two groups of species. For that reason, the definition of Flammoconcha is expanded to include all species with an epiphallus, Flammoconcha s. str. being retained in its restricted sense at the subgeneric level for the three (two described and one new) species with cut-away shell bases. A new subgenus, Delloconcha, is erected for the species which have a columella. The subgenus is named after Dr R.K. Dell who has noted (Dell, 1955) that the genus Flammulina, as used in New Zealand systematics, is polyphyletic.

The protoconch sculpture of Flammulina jacquetta (Hutton, 1883) is similar to that of Flammoconcha stewartensis and although the former has not been dissected, it can be placed fairly safely in

Delloconcha. The diagonally reticulate protoconch surfaces of jacquenetta and stewartensis are unique among described New Zealand endodontinid pulmonates.

The following described species are placed in the genus Flammulina Martens, 1873: Flammulina chiron (Gray, 1850); F. perdita (Hutton, 1883); F. crebriflammis (Pfeiffer, 1853); F. zebra (Le Guillou, 1842). In an earlier paper (Climo 1969a), I misinterpreted the thickened vas deferens within the penial sheath of perdita as an epiphallus and excluded it from the Flammulininae.

Flammulina alpina Suter, 1904, F. lateaperta Dell, 1955 and F. cornea (Hutton, 1883) cannot be placed with certainty into either subfamily because their reproductive anatomy is not known. The above three species are placed in a separate incertae sedis section of this paper; no subfamilial position being given.

A radula from one of the original specimens of Flammulina sorenseni Powell, collected from Campbell Island, was mounted by the writer. The tooth structure of the species is unmistakably punctid and it is here transferred to the Punctinae Morse, 1864.

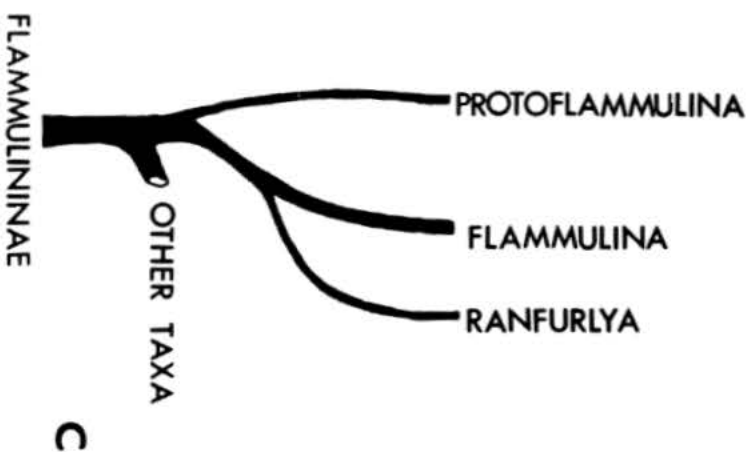
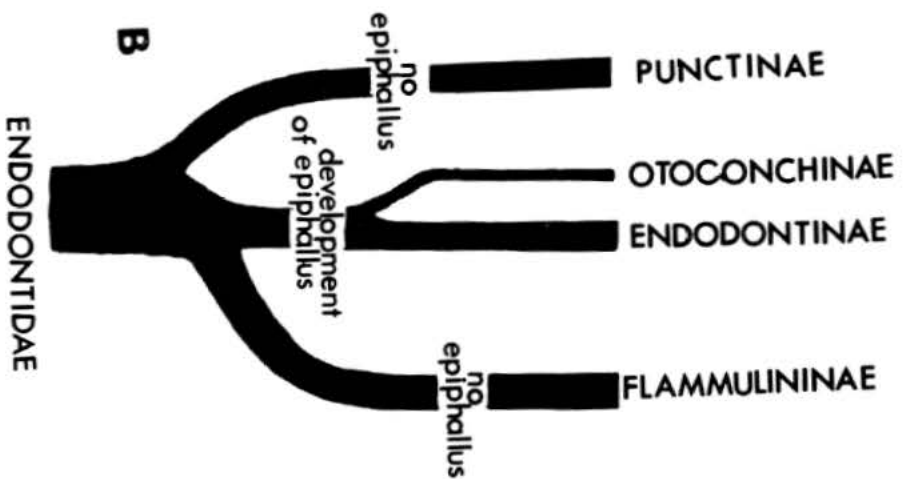
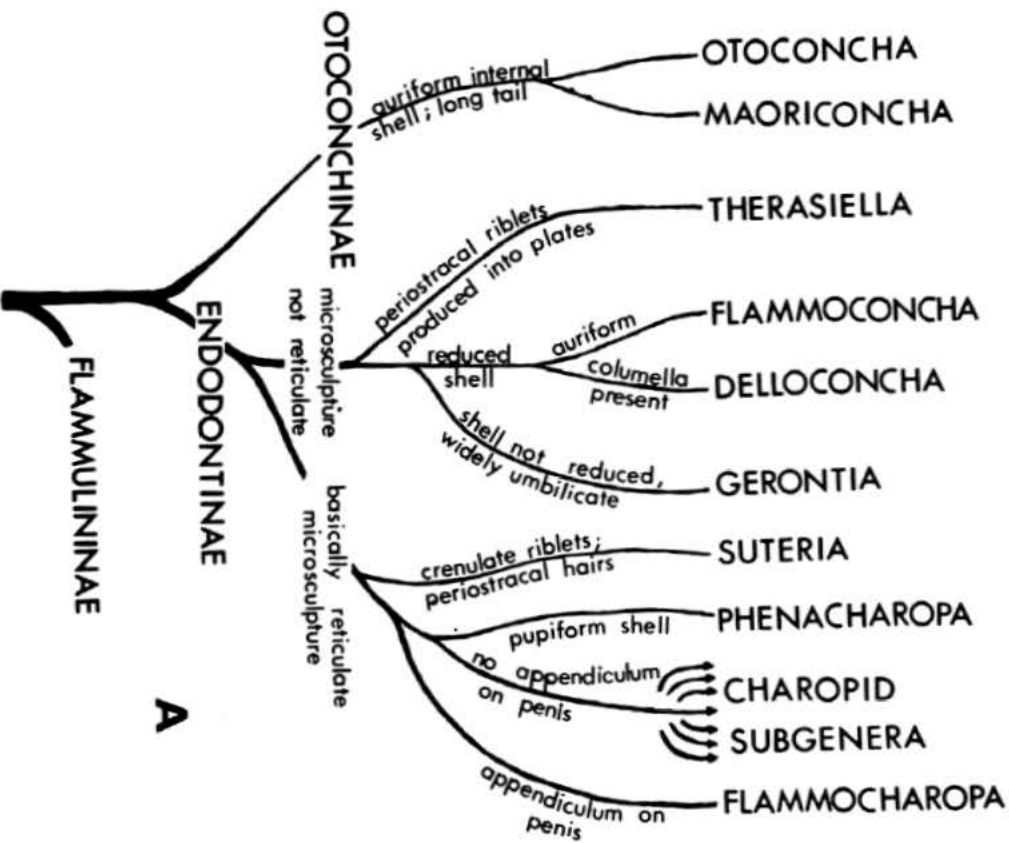
When Part I of this series was written, Therasiella Powell, 1948 had not been dissected, and it was retained in the taxon previously called Flammulinidae. Dissection of two species has

shown that Therasiella should be placed in the Endodontinae Suter, there being a strong epiphallus on the penis. The absence of a reticulating microsculpture has induced me to derive the genus from ancestors of the Flammoconcha and Gerontia lines (Fig. 1, **A**).

A new monotypic flammulinid genus, Protoflammulina, is described below from the Snares Islands. It is a large shell (over 9 mm in diameter), radially ribbed, tightly coiled (5 whorls), flammulated by reddish-brown markings and has a strongly radially costate protoconch. The radula is endodontid in structure and there is no epiphallus on the penis. It shows the same relationship to Flammulina as Gerontia Hutton, 1883 does to Flammoconcha Dell; the radially costate protoconch being the only discordant feature. It is not closely related to any known New Zealand endodontid pulmonate but does resemble superficially the south-western Pacific genus Rhytidopsis Ancey, 1882. In the absence of preserved material of Rhytidopsis, the Snares Islands snail is designated as the type of a new genus; faunal linkage between the tropical Pacific and the Snares Islands appearing unlikely.

A morphogenetic tree is provided (Fig. 1) which illustrates the relationships of genera and subgenera discussed to date. Fig. 1 is not necessarily phylogenetic.

Fig. 1 Morphological relationships in New Zealand Endodontidae Pilsbry. A, taxa within the subfamilies Otoconchinae Cockerell and Endodontinae Suter; B, subfamilial relationships; C, systematic positions of Ranfurlya Suter, Protoflammulina n. gen. and Flammulina Martens.



SYSTEMATICS

Family ENDODONTIDAE Pilsbry, 1894

Subfamily PUNCTINAE Morse, 1864

Genus Laoma Gray, 1850

Type species : Bulimus ? (Laoma) leimonias Gray, 1850

Laoma sorenseni (Powell, 1955)

Fig.10, E; Plate 3, B.

1955 Flammulina sorenseni Powell, Cape Expedition Series,

Bull. 15, D. S. I. R., Wellington, p.122

Shell small, depressed, widely umbilicate, tightly coiled, shining, smooth except for numerous very weak radial growth folds and obsolete spiral striae on the lower surface. Colour pale yellowish-olive. Whorls $4\frac{1}{2}$, including a low rounded smooth protoconch of $1\frac{1}{2}$ whorls. Spire less than half height of aperture. Whorl outlines convex. Suture deeply impressed. Umbilicus about one-fifth diameter of base.

Height 1.25 mm; diameter 2.7 mm (Holotype). Modified from Powell, 1955, pp.122-123.

Most specimens examined by the writer had very weak spiral striae on the lower surface; these are not mentioned in Powell's diagnosis.

Reproductive system characterized by an ovate penis with a very long, thin, tapering base; vas deferens long and convoluted; atrium moderately long; penis retractor muscle inserted in apex of penis. The reproductive system is described from dry specimens which were softened. The female part of the system was fused into one solid mass and it was not possible to determine the point of origin of the spermathecal duct.

Radula with the formula $17+1+17$; central tooth tricuspid, smaller than first 6 outer teeth, all cusps weak; all other teeth of radula bicuspid, the first 6 - 7 larger than the others, with a larger inner cusp; cusps nearly equal in development on the outer teeth.

Type material: Holotype and paratypes in Auckland War Memorial Museum.

Type locality: Campbell Island (Cape Exped., J. H. Sorensen).

Remarks: In shell shape, sorenseni resembles some of the larger New Zealand mainland species of Paralaoma Iredale, 1913; it lacks, however, the sharp membranous riblets of Paralaoma. Until New Zealand representatives of the Punctinae are revised, sorenseni is probably best assigned to the genus Laoma Gray. It does not closely resemble any of the species in the laomid subgenera Phrixgnathus Hutton, 1883 or Taguahelix Powell, 1955.

Material examined: Beneath rocks, back of beach at Monument Harbour, Campbell Island (J.H. Sorensen 15/XI/45); 10 specimens, Dominion Museum Collection M 3275.

Subfamily ENDODONTINAE Suter, 1913

Genus Flammoconcha Dell, 1952

Type species : Helicarion (Peloparion) cumberi Powell, 1941

Shell minute to relatively large (2.4 - 14.0 mm), of few whorls (2 - 4), depressed, thin, unicoloured horny to light brown, auriform in Flammoconcha s. str., imperforate to narrowly perforate.

Shell surface devoid of a raised sculpture pattern, with growth ridges, or with sharp, thin, arcuate membranous radial riblets; shell criss-crossed in some species by a series of internal or superficial diagonal lines, strongly developed in Flammoconcha (Flammoconcha) and F. (Delloconcha) jacquetta (Hutton) where the lines are developed as striae on the shell surface; interstices of radially ribbed species with the above mentioned criss-crossing lines, with fine secondary radials, or smooth; development of true spiral striae in some species, Spire raised to some extent in all species, shell depressed in outline. Whorls 2 - 4, rapidly increasing; periphery rounded to keeled. Aperture large, ovate or subrhomboidal. Columella absent in Flammoconcha (Flammoconcha), the aperture extending as a spiral opening (base-aperture) to the protoconch.

Penis with a strong epiphallus.

Radula with a tricuspid central tooth, central cusp long, extending to or below basal plate, lateral cusps weak; lateral teeth bi- or tricuspid, the bicuspid condition resulting from suppression of the outer cusp, inner cusp becoming larger outwards; marginal teeth at first bi- and tricuspid, cusps directed obliquely inwards, central cusp longest; outer marginals tri- and multicuspid, the multicuspid condition arising by division of the outer lateral cusp which is weak or absent on the lateral teeth and inner marginals; cusps on marginal teeth all fused to some extent at base. The one exception to this tooth structure is F. laingi (Suter) which has bicuspid marginal teeth resulting from development of the outer lateral cusp and suppression of the inner.

Subgenus Flammoconcha Dell, 1952

Type species : Helicarion (Peloparion) cumberi Powell, 1941

Shell thin, auriform, horny brown in colour, with or without sparse, sharp, membranous, fragile, arcuate radial riblets; columella absent, aperture extending as a spiral opening (base-aperture) to the protoconch.

Flammoconcha (Flammoconcha) cumberi (Powell, 1941)

Figs. 2, C; 7, F; 9, F-G; 10, D; 13, F.

1941 Helicarion (Peloparion) cumberi Powell, Rec. Auckland Inst. Mus., 2, (5), p. 262.

1952 Flammoconcha cumberi (Pwll.): Dell, Dom. Mus. Rec. Zool., 1, (7), p. 65.

Powell's (1941) diagnosis adequately describes the shell and Dell (1952) describes the radula.

Shell small, depressed, auriform, hyaline, pale-yellow, glossy, radially ribbed, having a widely open base-aperture which is narrowly membranous.

Height 1.75 mm; major diameter 4.1 mm; minor diameter 2.9 mm (Holotype).

Reproductive system characterized by an ovate penis, tapering at base and a very long vagina; retractor muscle inserted apically into penis, as is epiphallus, the latter about half length of penis.

Type material: Auckland War Memorial Museum.

Type locality: Maruia Springs, Lewis Pass, Nelson.

Distribution and remarks: To date, the species has only been recorded from Maruia Springs, Nelson (Type) and Balloon Hut, Mt Arthur Tableland, Nelson (Dell 26/I/48). I have dissected a juvenile specimen from the Gouland Downs, Nelson (Marston 27/I/69). These records indicate that the species is widespread in the mountain block of north Nelson.

Flammoconcha (Flammoconcha) stewartensis Dell, 1955

Figs. 2, C; 7, G; 9, E; 10, C.

1952 Flammoconcha stewartensis Dell, Dom. Mus. Rec. Zool.,
1, (7), p. 66.

The specific diagnosis given by Dell (1952) adequately describes the shell.

Shell very small, thin, fragile, auriform, golden yellow, largely external, of $2\frac{1}{2}$ whorls.

Height 1.25 mm; major diameter 1.95 mm; minor diameter 1.4 mm (Holotype).

Reproductive system characterized by a large ovate penis tapering at both ends, provided with an apical retractor muscle and subapical epiphallus, the latter about three-quarters of penis length; atrium short and wide; base of spermathecal duct swollen, the combined width of spermatheca and oviduct bases as wide or wider than penis.

Radula with the formula 8 - 9 + 5 - 6 + 1 + 5 - 6 + 8 - 9; central tooth tricuspid, central cusp reaching lower edge of basal plate, lateral cusps weak; inner lateral teeth similar to central but asymmetrical, the inner lateral cusp larger than the outer; inner lateral cusp on lateral teeth increasing in size outwards, the outer lateral cusp decreasing in size; inner marginal teeth tricuspid, or

bicuspid by complete suppression of obsolete outer lateral cusp, cusps directed obliquely inwards and central cusp the largest; outer marginal teeth tri- or multicuspid, the three inner cusps fused in one block, the outer 4th cusp, when present, separated a little apart from the larger inner three.

Type material: Holotype in Dominion Museum, Wellington.

Type locality: Ferny Gully, Halfmoon Bay, Stewart Island.

Distribution and remarks: The species was described from a single specimen. I have examined a further two specimens from the type locality (M. Leighton private collection). A radula mount was made and the reproductive system described from a softened animal of one of the Leighton specimens. The species appears to be restricted to Stewart Island.

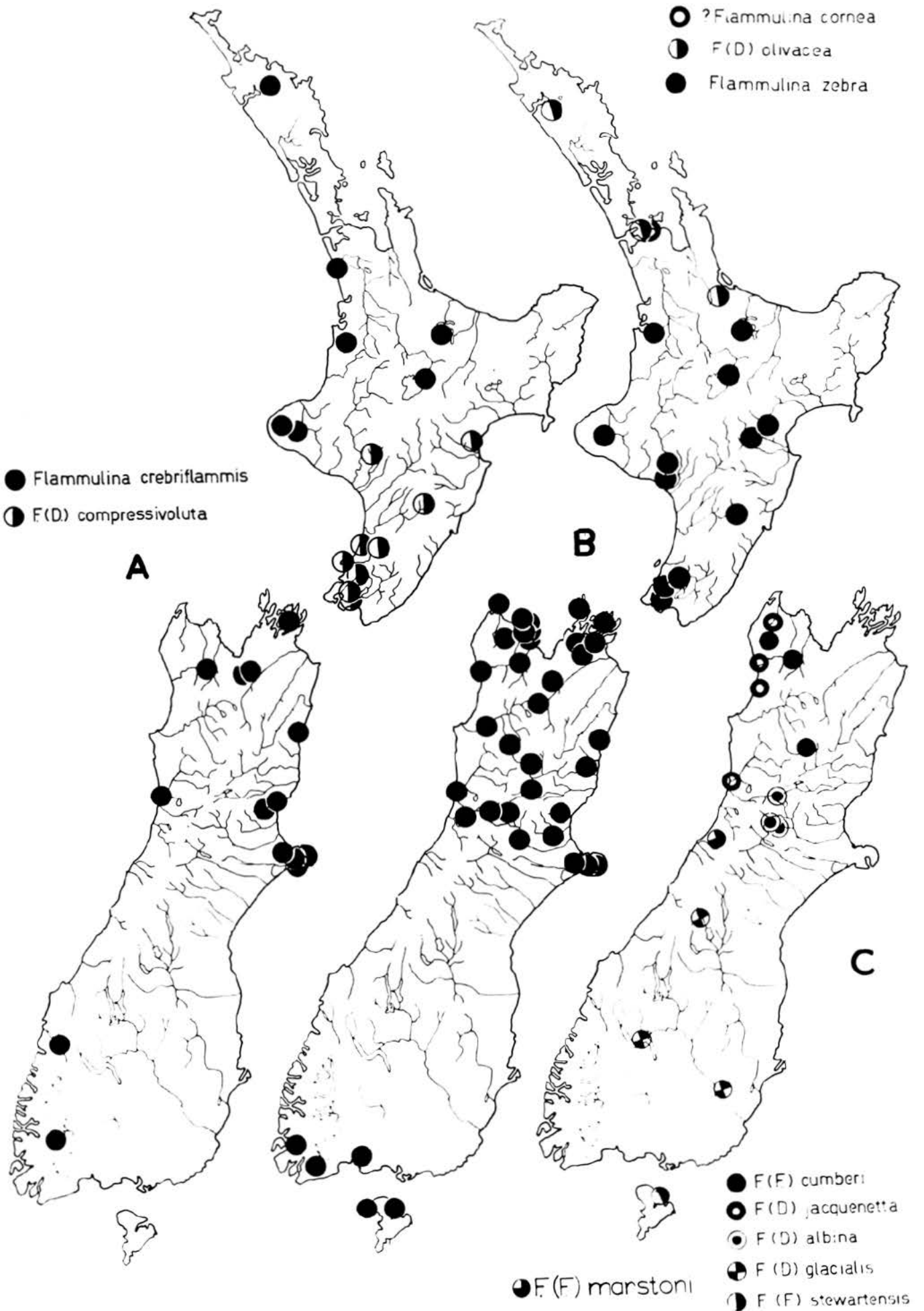
The type specimen is not a fully grown shell. Both specimens from the Leighton collection measured 2.4 mm in diameter.

Flammoconcha (Flammoconcha) marstoni n. sp.

Figs. 2, C; 13, A-B.

The species is most easily distinguished by comparison with stewartensis. It differs from the described species in having strong arcuate riblets (more continuous than in cumberi), a much weaker cross-hatched sculpture pattern and a spirally striate protoconch.

Fig. 2. Species distribution maps. A, Flammulina crebriflammis (Pfeiffer); Flammoconcha (Delloconcha) compressivoluta (Reeve); B, ? Flammulina cornea (Hutton); Flammoconcha (Delloconcha) olivacea (Suter); Flammulina zebra (Le Guillou); C, Flammoconcha (Flammoconcha) cumberi (Powell); F. (F.) stewartensis Dell; F. (F.) marstoni n. sp.; F. (Delloconcha) jacquetta (Hutton); F. (D.) albina n. sp.; F. (D.) glacialis (Suter).



Type material: Unique holotype (M 22464) in Dominion Museum,
Wellington.

Type locality: Mt Greenland, N. Westland.

Remarks: The single specimen was collected by Mr J. Marston from under Dracophyllum bark in the subalpine scrub zone, and is named after the discoverer.

Subgenus Delloconcha n. subgen.

Type species : Helix compressivoluta Reeve, 1852

The subgenus comprises that group of flammoconchid species which have a columella. The aperture is not extended as a spiral opening around the shell base.

Flammoconcha (Delloconcha) albina n. sp.

Figs. 2, C; 8, A; 10, A-B; Table 1.

Shell very small (diameter 2.4 mm), depressed, hyaline, pale horny, imperforate, sparsely radially ribbed. Sculpture consisting of sparse (RI 8.0 - 9.0), sharp, membranous, weakly arcuate radial riblets, weak below periphery; interstices with extremely fine secondary radials. Colour pale horny in life, dead shells whitish. Whorls $3\frac{1}{4}$, rapidly expanding; periphery and base rounded; protoconch of $1\frac{1}{2}$ very weakly spirally striate whorls. Spire weakly raised, shell

depressed in outline. Suture impressed. A minutely perforate umbilicus is present in juveniles but older shells are imperforate. Aperture large, ovate.

Exposed animal pure white except for golden brown flecks on optic tentacles, around pulmonary opening and on mantle lip.

Reproductive system characterized by a long, thin penis with apical retractor muscle and a short subapical epiphallus which projects at right-angles to the axis of the penis; spermathecal duct inserted half-way between uterus and point of insertion of penis; atrium short and wide.

Radula with the formula $11 + 7 + 1 + 7 + 11$; central tooth tricuspid, central cusp reaching to lower edge of basal plate, lateral cusps weak; lateral teeth tricuspid, inner lateral cusp increasing in size outwards, outer lateral cusp obsolete on outer laterals; inner marginal teeth tricuspid, the two inner cusps the largest; outer marginal teeth low and wide, multicuspid, with up to six cusps, the two inner cusps always the largest.

Type material: Holotype (M 22473) and dissected paratype in Dominion Museum, Wellington.

Type locality: First clearing below Cass Saddle Hut, Cass River, Canterbury. Under logs in open. Map reference: N. Z. M. S. 19, Sheet 5; Long. $171^{\circ} 13'$ East; Lat. $43^{\circ} 5'$ South.

Distribution and remarks: F. albina has been recorded from the following areas: Cass River, 3,000 - 3,500 feet, Canterbury (Type. Climo 27/III/67); Black Range, 4,500 feet, Canterbury (K. & T. Climo 26/III/67); Temple Basin, 4,400 feet, Arthur's Pass National Park, Westland (Climo 11/III/67).

The species is distinguished from the closely related new species, viridula, by its lighter shell coloration, more sparse riblets, weaker striae on the protoconch, different foot coloration and different reproductive morphology.

Flammoconcha (Delloconcha) compressivoluta (Reeve, 1852)

Fig. 2, A; Plate 2, B.

- 1852 Helix compressivoluta Reeve, Conch. Icon., 7, pl.130, fig.791.
- 1853 Helix omega Pfeiffer, Monog. Heliceorum viventium, 3, p.33.
- 1873 Helix (Paryphanta) omega (Pfr.): Hector, Cat. Land Moll. N.Z., p.4.
- 1878 Nanina (Paryphanta) omega (Pfr.), Nomencl. Hel. Viv., p.35.
- 1880 Patula omega (Pfr.): Hutton, Man. N.Z. Moll., p.10.
- 1884 Amphidoxa compressivoluta (Rve.): Hutton, Trans. N.Z. Inst., 16, p.198.
- 1886 Paryphanta omega (Pfr.): Tryon, Man. Conch., (2), 1, p.128.
- 1893 Flammulina compressivoluta (Rve.): Hedley & Suter, Proc. Linn. Soc. N.S.W., (2), 7, p.643.

Shell relatively large (diameter 9.5 mm), depressed, imperforate, almost smooth, thin, shining, pellucid. Sculpture virtually absent, consisting of oblique, retractive growth striae which weakly crenulate the suture, and weak scratch-like spiral striae reticulated by exceedingly fine diagonal lines; the reticulating microsculpture is periostracal. Colour horny-brown, adnate portion of inner lip whitish. Periostracum thin and polished. Spire low, broadly convex. Whorls 4, flatly convex, rapidly increasing; periphery acutely convex; base flatly rounded, impressed in middle. Suture impressed, false-margined. Aperture large, lunately oval, wider than high. Columella short, oblique, and arcuate. Inner lip slightly thickened, adnate in the umbilical region.

Foot uniformly bluish-grey.

Reproductive system characterized by a relatively large penis abruptly tapering at half its length, the basal portion about half the width of the upper portion; penis retractor muscle and epiphallus inserted at apex of penis; atrium very short; vagina short, bulbous; hermaphroditic duct rugose and thickened; ovotestis in two sections, each with 2 - 3 lobular subsections.

Radula with the formula 20-21 + 10-11 + 1 + 10-11 + 20-21; central tooth tricuspid, lateral cusps small but sharp; central cusp thin and reaching to lower edge of basal plate; central tooth basal portion nearly same size as that of first lateral, but central cusp

shorter and thinner; lateral teeth similar to central, tricuspid, inner lateral cusp slightly larger than outer and gradually increasing in size outwards; marginal teeth tricuspid, central cusp largest, lateral cusps equally developed and about half the length of the central cusp.

Type material: British Museum (Nat. Hist.)

Type locality: New Zealand.

Distribution and remarks: The species is restricted to the south and south-east of the North Island. The three most closely related species are ?Flammulina cornea (Hutton, 1883) and the two South Island species Flammoconcha jacquetta (Hutton, 1883) and F. laingi (Suter, 1904).

The marginal teeth of compressivoluta can be interpreted as representing an intermediate stage between the more typically strongly bicuspid condition with weak outer cusps, and the virtually unicuspid condition in laingi.

Material examined: Ohakune, Wellington (Dom. Mus. Coll. 10/I/24); Kapiti Island (Dom. Mus. Coll. 10/XI/17); above Field Hut, Tararua Range, 3,200 feet, Wellington (Holloway 4/XII/52); Wainuiomata Hill, Wellington (Climo & Ponder 18/X/67); Days Bay, Wellington (Climo 5/V/69); hills north of Ngaio, Wellington (Climo -/V/69).

Flammoconcha (Delloconcha) feredayi (Suter, 1891)

Figs. 4, B; 8, C; 9, A-B; Plate 1, B; Table 1.

1891 Amphidoxa (Calymna) feredayi Suter, Trans. N. Z. Inst., 23, p. 91.

1893 Gerontia (Calymna) feredayi (Suter): Pilsbry, Man. Conch., (2),
8, p. 74.

1893 Flammulina (Calymna) feredayi feredayi (Suter): Hedley &
Suter, Proc. Linn. Soc. N. S. W.,
(2), 7, p. 645.

1913 Flammulina feredayi feredayi (Suter), Man. N. Z. Moll., p. 677.

Shell small (diameter 3.5 mm), globosely depressed, imperforate, shining, pale horny, sharply costate, hyaline. Sculpture consisting of thin, inequidistant, arcuate membranous radial riblets (RI 15.5-21.8), becoming obsolete on base; interstices with weak microscopic reticulating diagonal striae. Colour uniformly pale horny. Spire low, broadly convex. Whorls up to $3\frac{1}{2}$, usually less, rapidly increasing, rounded; periphery convex; base impressed in middle; protoconch of $1\frac{1}{4}$ - $1\frac{1}{2}$ strongly spirally striate whorls. Suture impressed. Aperture large, oblique, ovate. Columella short, arcuate. Shell imperforate.

Exposed animal yellowish-grey with fine black squarish spots; surface of visceral spire intensely mottled by various shades of brown with scattered black and white spots.

Reproductive system characterized by a relatively large penis, with apical retractor muscle and subapical epiphallus; epiphallus about three-quarters of penis length and directed downwards; insertion

of spermathecal duct into female system at or above half-way point between junction of vagina and penis and junction of oviduct and vas deferens; atrium long and thin; ovotestis finely lobular and in two sections.

Radula with the formula 13-15 + 6-7 + 1 + 6-7 + 13-15; central tooth tricuspid, central cusp nearly reaching lower edge of basal plate, lateral cusps minute but sharp; lateral teeth tricuspid, the outer cusp minute, inner cusp becoming progressively larger outwards and eventually fusing with the larger central cusp at base; marginal teeth tricuspid and multicuspid, all cusps fused to some extent at base.

Type material: Dominion Museum, Wellington.

Type locality: Forty-mile Bush, Wellington.

Distribution, variation and remarks: The species is widespread and has been recorded from the Hunua Range in the north of the North Island to Caswell Sound, Southland, in the south of the South Island. The species has been recorded from Stewart Island but it is probable that specimens from this locality are a new flammulinid species. A snail resembling a large feredayi, from Ferny Gully, Halfmoon Bay, Stewart Island, was dissected. It had no epiphallus on the penis and the radula was more typical of Flammulina than Flammoconcha. The Stewart Island record for feredayi is not accepted at this stage.

North Island specimens of feredayi have taller spires and generally more whorls than South Island specimens and in this respect closely resemble viridula n. sp. For a given number of shell whorls, however, viridula is smaller than feredayi. Dissected specimens of feredayi from Chateau Tongariro, North Island had the same reproductive morphology as Canterbury specimens and were readily distinguishable from viridula in this respect. F. feredayi occurs sympatrically with viridula in some Canterbury localities.

F. feredayi is a carnivorous snail. The stomach contents of all specimens dissected were composed entirely of arthropod remains. Material examined: Type material, Dominion Museum, Wellington; Chateau Tongariro, N. Wellington (Forster 18/XII/48); east of Salisbury Hut, Mt Arthur Tableland, Nelson (Marston 10/I/67); Middle Waipara Gorge, Canterbury (Climo 6/IV/68); Ashley Gorge, Canterbury (Climo 30/VIII/67); Kowai Bush, Canterbury (Climo 21/IV/68); Cass, Canterbury (Climo 25/III/67); Arthur's Pass, Canterbury (Climo 3/XII/67); Hooker Hut, 3,700 feet, Hooker Valley, Canterbury (Climo 16/XI/68).

Flammoconcha (Delloconcha) glacialis (Suter, 1891)

Figs. 2, C; 8, B; 9, D; Plate 1, C; Table 1.

1891 Amphidoxa (Calymna) feredayi var. glacialis Suter, Trans. N. Z.

Inst., 23, p. 92.

1893 Flammulina (Calymna) feredayi glacialis (Suter): Hedley &
 Suter, Proc. Linn. Soc. N. S. W.,
 (2), 7, p. 645.

1913 Flammulina feredayi glacialis (Suter), Man. N. Z. Moll., p. 678.

Shell small (diameter 3.5 mm), globosely depressed, imperforate, silky, fragile, hyaline, finely radially costate. Sculpture consisting of extremely fine, close, arcuate radial riblets (RI 46.9-56.3), continuing onto base; interstices with weak diagonal intersecting striae, clearly visible only on dry shells. Spire usually weakly convex but more strongly so in old specimens where the body whorl is descending. Whorls $3\frac{1}{2}$, rapidly expanding, rounded; base with a depression in the centre; protoconch of $1\frac{1}{2}$ spirally striate whorls. Suture impressed. Aperture oblique, rotundly lunate. Shell imperforate.

External animal uniformly dark grey; visceral spire pigmented as in feredayi.

Reproductive system characterized by a thin cylindrical penis with apical retractor muscle; epiphallus thin, nearly as long as penis and inserted in upper quarter of organ; atrium and vagina thick and short.

Radula with the formula $15 + 9 + 1 + 9 + 15$; central tooth tricuspid, central cusp reaching lower edge of basal plate, lateral cusps sharp and moderately developed; lateral teeth tricuspid, the inner lateral cusp larger than the outer and increasing in size outwards,

outer lateral cusp becoming obsolete outwards and disappearing on outer laterals; inner marginal teeth bicuspid, the cusps fused at base and directed obliquely inwards; outer marginal teeth multicuspid, all cusps fused at base.

Type material: Dominion Museum, Wellington.

Type locality: Hooker Valley, Canterbury.

Distribution and remarks: Suter recorded the species from the Hooker Valley, Canterbury only. In addition to specimens collected from 3,700 feet in the Hooker Valley, I have collected a single specimen from the '10-mile', Lake Wakatipu, Otago, and have examined two specimens from the Mataura Range, Southland. The species appears to be restricted to isolated pockets in the South Island, but this distribution pattern may be the result of inadequate collecting.

F. glacialis is not commonly found in litter and this may explain its apparent rarity. All specimens collected by the writer were living in small cavities under stable scree, in open areas.

The stomach contents of Hooker Valley specimens were composed entirely of plant remains; unlike feredayi, glacialis appears to be a herbivore.

Material examined: Type material, Dominion Museum, Wellington; Mataura Range, Southland (Cresswell 27/XII/67); '10-mile', Lake Wakatipu, Otago (Climo 12/IV/68); vicinity of Hooker Hut, 3,700 feet, Hooker Valley, Canterbury (Climo 16/XI/68).

Flammoconcha (Delloconcha) jacquetta (Hutton, 1883)

Fig. 2, C; Plate 2, A.

1883 Amphidoxa jacquetta Hutton, N. Z. Jour. Sci., 1, p. 476.1893 Gerontia (Calymna) jacquetta (Hutt.): Pilsbry, Man. Conch.,
(2), 8, p. 76.1893 Flammulina jacquetta (Hutt.): Hedley & Suter, Proc. Linn. Soc.
N. S. W., (2), 7, p. 643.

Shell relatively large (diameter 8.0 mm), narrowly perforate, juveniles flattened and keeled, older shells depressed, and angled at periphery, thin and fragile. Sculpture consisting of delicate growth striae and faint, distant, shallow spiral striae; whole shell surface diagonally reticulated by fine scratch-like striae. Colour pale brown. Spire flat in juveniles (as in type), weakly convex in older specimens. Whorls $3\frac{1}{2}$, rapidly expanding; periphery keeled in juveniles, angled in older specimens; base rounded. Aperture large, subrhomboidal. Columella oblique, arcuate. Umbilicus narrowly perforate, nearly covered by reflection of inner lip.

Animal incapable of withdrawing completely into shell; mantle broadly reflexed over shell margin; eye peduncles short and stout, separated at their bases; exposed animal orange-yellow, the upper sides marbled with black; oculiferous and lower tentacles black. Other details of soft-part morphology unknown.

Radula with the formula $28 + 1 + 28$, laterals about nine; central tooth tricuspid; lateral teeth tricuspid, the outer lateral cusp becoming smaller outwards; marginal teeth at first bicuspid then becoming multicuspid.

Type material: Canterbury Museum, Christchurch.

Type locality: Greymouth, N. Westland.

Distribution and remarks: The species has been collected from the following localities: Greymouth (Type); Oparara, near Karamea, Nelson (O'Connor 1949); Karamea Bluff, Nelson (Climo -/X/67); Bainham, Nelson (O'Connor -/XI/46).

F. jacquetta is superficially similar to F. compressivoluta but differs in having fewer whorls, a more angled periphery, different microsculpture, a different foot coloration and in lacking an adnate inner lip.

Flammoconcha (Delloconcha) laingi (Suter, 1905)

Figs. 4, A; 8, F; 11, A-B; 13, C; Plate 2, C.

1905 Flammulina (Thalassohelix) laingi Suter, J. Malac., 12, p.19.

1913 Thalassohelix laingi (Suter), Man. N.Z. Moll., p.630.

Shell relatively large (diameter 14.0 mm), globosely depressed, semi-transparent, smooth, imperforate. Sculpture consisting of fine growth ridges crossed by spiral striae. Colour horny brown, adnate inner lip white. Periostracum thin and shining. Spire weakly convex.

Whorls 4, the last rapidly expanding, flatly convex; periphery rounded; base impressed in centre. Suture impressed, irregularly crenulated by the growth ridges. Protoconch of $1\frac{1}{2}$ spirally striate whorls, the striae crossing radial growth folds. Aperture oblique, broadly lunately oval. Shell imperforate, inner lip adnate, covering the umbilical region in a broad white callus.

Reproductive system characterized by a large cylindrical penis, tapering slowly towards base, lower three-quarters of organ with numerous circumferential rugosities; penis retractor muscle inserted in apex of organ; epiphallus as long as penis but rather ill-defined, inserted near base of retractor muscle; vagina about half as long as penis, thin; spermathecal duct swollen at base; hermaphroditic duct greatly thickened; apical reproductive structures telescoped, albumen gland, uterus and prostatic gland closely fused.

Radula with the formula $28 + 7 + 1 + 7 + 28$; central tooth tricuspid, central cusp reaching lower edge of basal plate, lateral cusps minute but sharp; lateral teeth similar to central, tricuspid; marginal teeth bicuspid, the inner cusp having been lost, the central cusp large, the outer cusp minute, sharp and curved.

Type material: Dominion Museum, Wellington.

Type locality: Longwood Range, near Otautau, Southland.

Distribution and remarks: The species appears to be restricted to the Longwood Range area of Southland, inland from Te Wae Wae Bay.

I have examined a large series of specimens from Blue Cliffs,
Te Wae Wae, Southland (Marston 3/I/68).

Flammoconcha (Delloconcha) olivacea (Suter, 1892)

Figs. 2, B; 7, E; 11, E; Plate 3, C.

1892 Amphidoxa (Calymna) olivacea Suter, Trans. N.Z. Inst., 24, p. 290.

1892 Gerontia (Calymna) olivacea (Suter): Pilsbry, Man. Conch., (2),
8, p. 75.

1893 Flammulina (Calymna) olivacea (Suter): Hedley & Suter, Proc.
Linn. Soc. N.S.W., (2), 7, p. 645.

1913 Flammulina olivacea (Suter), Man. N.Z. Moll., p. 679.

Shell small (diameter 5.0 mm), globosely depressed, narrowly perforated, thin and shining, radially costate. Sculpture consisting of close, membranous, arcuate radial riblets, crossed on the upper surface by a few, wide, distinct spiral grooves. Spire slightly elevated, shell depressed in outline. Colour uniformly yellow-olive. Periostracum thin and shining. Whorls 3, rapidly expanding, convex, the last weakly flattened above; periphery rounded; base rounded, deeply impressed in umbilical area; protoconch of $1\frac{1}{2}$ smooth to weakly spirally striate whorls. Suture deep. Aperture oblique, rotundly ovate. Columella nearly vertical, weakly arcuate; inner lip thin and sharp, not reflexed. Umbilical perforation very narrow, shallow.

Exposed animal yellowish-white with sparse light grey smudges.

Reproductive system characterized by a very large epiphallus, longer than penis; epiphallus subapically inserted, with a rosette of leaf-like markings at its apex; penis ovate, tapering at base, with a small appendage near base of epiphallus (not homologous with the appendiculum in Flammocharopa Climo); a penis retractor muscle could not be detected in the specimen dissected; base of spermathecal duct bulbous; ovotestis in two lobulate sections.

Radula with the formula 17-18 + 8-9 + 1 + 8-9 + 17-18; central tooth tricuspid, slightly smaller than first lateral tooth, central cusp long, reaching base of basal plate, lateral cusps moderately developed; lateral teeth tricuspid, inner lateral cusp progressively increasing in size outwards, outer lateral cusp about same size along teeth; inner marginal teeth tricuspid, outer lateral cusp gradually increasing in size outwards; outer marginal teeth with 3 - 5 cusps, the 2 inner cusps the largest, all cusps fused to some extent at base.

Type material: Dominion Museum, Wellington.

Type locality: Hillyer's Creek, Auckland.

Distribution and remarks: To my knowledge, the species has been collected from: Hillyer's Creek, Auckland (Type); Kaimai Range, Auckland (O'Connor Coll.); Mangamuka Gorge, Northland (Climo 1/V/68). The species is apparently rare, as Suter (1913, p. 679)

mentions, only one specimen having been collected from each of the last two localities mentioned above.

The small appendage on the apex of the penis is not structurally homologous with that occurring in Flammocharopa Climo. In F. olivacea the appendage is a sac-like extension of the penial sheath; in Flammocharopa, a stalked structure with a diffuse globular tip, separated from the penial sheath.

Flammoconcha (Delloconcha) viridula n. sp.

Figs. 4, A; 8, D; 9, C; Plate 1, A; Table 1.

Shell small (diameter 2.8 mm), globosely depressed, imperforate, shining, horny-bronze with a greenish hue, sharply and sparsely costate. Sculpture consisting of thin, raised, inequidistant, arcuate, membranous radial riblets (RI 11.5 - 14.6), becoming obsolete on base; interstices nearly smooth, with very faint reticulating diagonal lines. Colour horny-bronze with a greenish hue, shining. Spire raised, shell depressed in outline, protoconch bulbous. Whorls $3\frac{1}{4}$, rapidly expanding, rounded; periphery convex; base impressed in middle; protoconch of $1\frac{1}{2}$ spirally striate whorls. Suture impressed. Aperture large, oblique, ovate. Columella short, arcuate. Shell imperforate.

Exposed animal dark grey, with black, squarish spots; surface of visceral spire pigmented as in feredayi.

Reproductive system similar to that of feredayi except that the spermathecal duct arises in the crotch of the "V" formed between the penis and the rest of the reproductive system, and not half-way between penis and uterus.

Radula with the formula 13-15 + 6-7 + 1 + 6-7 + 13-15; teeth similar to those of feredayi, except the central tooth which differs slightly in being relatively thinner and in having a different apical contour.

Type material: Holotype (M 22476) and 3 paratypes (M 22477) in Dominion Museum, Wellington.

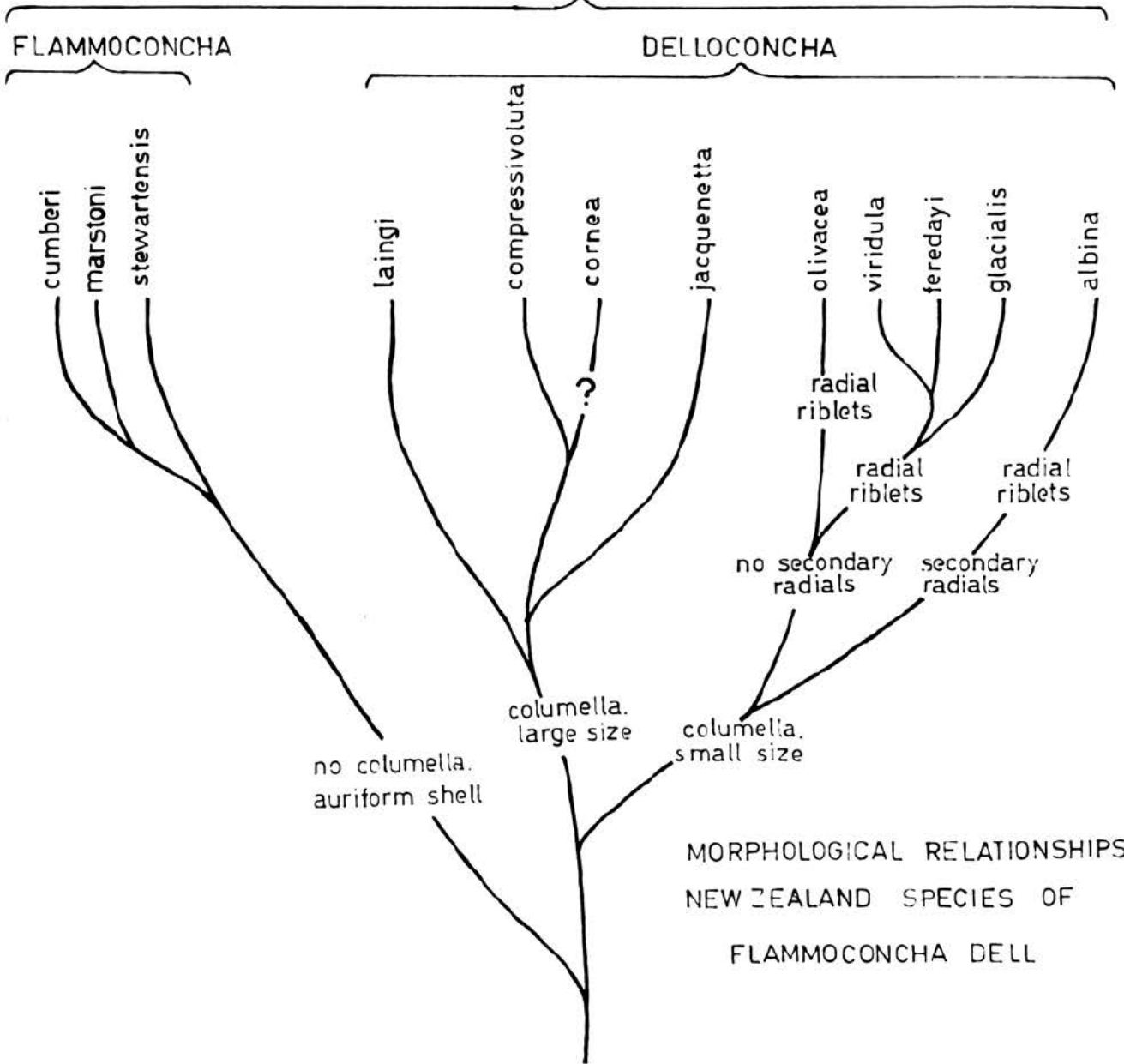
Type locality: Arthur's Pass, Canterbury, 2,000 - 2,500 feet.

Distribution and remarks: The writer has anatomically confirmed records of the species from: Arthur's Pass, Canterbury (Type); Ashley Gorge, Canterbury (Climo 30/VIII/67); Kowai Bush, Canterbury (Climo 21/IV/68). A shell only has been examined from Karamea, Nelson (Marston 7/I/67).

Where the two species occur sympatrically, viridula always has a lower RI than feredayi. This feature, in conjunction with a more tightly coiled shell and darker foot coloration, make the species easily separable; the different foot colorations being a rule of thumb identification for individual specimens.

Fig. 3 New Zealand species of Flammoconcha Dell.

FLAMMOCONCHA



MORPHOLOGICAL RELATIONSHIPS IN
NEW ZEALAND SPECIES OF
FLAMMOCONCHA DELL

Key to New Zealand species of Flammoconcha Dell, 1952

- Base of shell cut away 1
- Base of shell entire 2
1. Subgenus Flammoconcha Dell, 1952
- Shell very small (diameter 2.0 mm); radially ribbed
. marstoni n. sp.
- Shell very small (diameter 2.4 mm); not radially ribbed
. stewartensis
- Shell small (diameter 4.1 mm); radially ribbed
. cumberi
2. Subgenus Delloconcha n. subgen.
- Shell relatively large, diameter greater than 6.2 mm 3
- Shell small, diameter 5 mm or less 6
3. Shell 13.0 - 15.0 mm in diameter, imperforate, with fine
growth ridges crossed by spiral striae, inner lip adnate,
restricted to extreme south-west of South Island
. laingi
- Shell 6.2 - 9.5 mm in diameter 4
4. Shell diameter 8.0 mm, imperforate but inner lip not
adnate, whole surface including protoconch diagonally
reticulated by fine striae, sparse true spiral striae
also present on body whorl; restricted to north-west of
South Island jacquetta

- Protoconch surface not diagonally reticulated by striae;
restricted to North Island 5
5. Shell diameter 9.5 mm, inner lip adnate, sculpture
consisting of growth ridges which crenulate the false-
margined suture, and exceedingly fine scratch-like
diagonal reticulating striae; restricted to south and
south-east of North Island compressivoluta
- Shell diameter 6.3 mm, suture not false-margined or
crenulated; restricted to Auckland area of North Island
. cornea
6. Shell diameter 5 mm, narrowly perforate, of 3 whorls,
spirally marked by a few distant spiral striae, radial
sculpture consisting of close arcuate radial riblets;
restricted to north of North Island olivacea
- Diameter less than 4.0 mm, shell imperforate 7
7. Shell 2.4 mm in diameter, pale horny to white in colour,
with sparse arcuate membranous radial riblets,
interstices with very fine secondary radials; restricted
to alpine regions of central Canterbury albina n. sp.
- Interstitial sculpture consisting of exceedingly fine
diagonal reticulating striae 8
8. Shell diameter 3.5 mm, sculpture consisting of very fine,
close arcuate radial riblets (RI 45.0 - 60.0); restricted
to South Island, south of Hooker Valley glacialis

- Shell 3.0 - 3.5 mm in diameter, RI less than 22.0 9
9. Shell 3.0 mm in diameter, with sparse arcuate
membranous radial riblets (RI 11.5 -14.6); colour
horny-bronze with a greenish hue; protoconch
bulbous; restricted to alpine areas from central
Canterbury to southern Nelson viridula n. sp.
- Shell 3.5 mm in diameter, with sparse arcuate
membranous radial riblets (RI 15.5 -21.8); colour
horny brown; protoconch not bulbous; widespread in
North and South Islands feredayi

Subfamily FLAMMULININAE Climo, 1969

Genus Protoflammulina n. gen.

Type species: Protoflammulina johnsi n. sp.

Shell relatively large (diameter 8 -10 mm), tightly coiled, radially
ribbed, umbilicate, flammulated by reddish-brown markings.

Sculpture consisting of sharp, elevated radial riblets; interstices
with fine secondary radials but reticulating spiral sculpture absent;
deep, sparse, pairs of spiral striae present on all post-nuclear whorls;
protoconch strongly radially costate.

Reproductive system dimorphic, a penis present in some forms,
absent in others; no epiphallus on penis.

Radula similar to that of Flammulina Martens, the majority of the marginal teeth tricuspid; outer 3 or 4 marginal teeth with a 4th minute outer cusp.

Protoflammulina johnsi n. sp.

Figs. 8, G; 12, A-B; Plate 4.

Shell relatively large (diameter up to 10 mm), juveniles weakly discoidal, adults subdiscoidal, umbilicate, strongly radially costate, flammulated by dark reddish-brown markings. Sculpture consisting of sharp, raised, equidistant, arcuate radial riblets (RI 8.6 - 10.0), flexuous on base; interstices with 6 - 10 rounded secondary radials; whole shell surface marked by sparse, deep, spiral striae, usually appearing as striae-pairs on the body whorl but more crowded and not obviously paired on apical whorls. Colour light brown, flammulated by broad, reddish-brown zig-zag markings, equally strong on upper and lower surfaces. Spire weakly sunken in juveniles, flat or very weakly convex in adults. Whorls $5\frac{1}{2}$, at first slowly, then more rapidly expanding; body whorl width at aperture about one-third of maximum diameter; periphery obtusely rounded; base flatly convex; protoconch of $1\frac{1}{2}$ strongly radially costate whorls, interstices with strong spiral striae. Suture deeply impressed. Aperture large, subrhomboidal. Columella short, oblique; inner lip thickened within, slightly reflexed

over edge of umbilicus. Parietal wall of aperture covered by a finely granular white callus through which the brown zig-zags are clearly visible. Umbilicus open, moderately wide (UI 5.3-6.0).

Reproductive system unique within the Endodontidae Pilsbry, in being dimorphic. Some specimens have a large penis with an apical retractor muscle, the vas deferens also apically inserted, while others have no penis, the vas deferens entering directly into the atrium. Apart from the above gross structural difference the rest of the reproductive system in both 'structural types' is the same and is described below: base of spermathecal duct thickened and covered by a dense mat of muscle fibres, as is the atrium, oviduct and vagina; spermatheca large, heart-shaped; prostatic gland constructed of numerous finger-like projections; uterus sac-like, surface area increased by folds; albumen gland a rather diffuse organ composed of many fine finger-like projections; hermaphroditic duct long and thickened, bifurcating at tip just before entering the two lobular sections of the ovotestis (sperm and ova are present in the gonads of both 'structural types'.)

External animal light grey, with smudges of darker grey on the upper surface; visceral spire greyish (preserved specimens).

Radula with the formula 20 - 21 + 7 + 1 + 7 + 20 - 21; central tooth tricuspid, central cusp reaching base of wide basal plate, lateral cusps moderately developed; lateral teeth tricuspid, inner lateral

cusps progressively increasing in size outwards, outer lateral cusp becoming smaller in the same direction; majority of marginal teeth tricuspid, with two large inner cusps, fused at base and directed obliquely inwards, and a small outer cusp; outer 3 - 4 marginal teeth with an extra minute cusp on the outer edge of the teeth.

Jaw arcuate, composed of 45 - 50 thin, fused, microscopically papillate plates.

Type material: Holotype (M 22453) and 5 paratypes (M 22454) in Dominion Museum, Wellington; 2 paratypes in each of Canterbury and Auckland Museums.

Type locality: West Ridge, Snares Islands; under Olearia logs (P. M. Johns 26/I/67).

Remarks: To date, this new genus has been recorded only from the Snares Islands. No other endodontid snails from the other subantarctic islands, Stewart Island or the New Zealand mainland have been described which closely resemble Protoflammulina.

The dimorphism in reproductive morphology is a puzzling phenomenon. If this were correlated with differences in shell and radular morphology I would have no hesitation in describing two species from the Snares Islands. The one gross difference in reproductive morphology, however, is the only distinguishing character between otherwise identical animals. Five of eight specimens dissected had

no penis, the other three displayed the usual hermaphroditic condition. Breeding experiments would have to be carried out in this case to determine whether the two 'structural types' were reproductively isolated. At present, P. johnsi is interpreted as one dimorphic species. Owing to lack of material it has not been possible to evaluate the situation further.

Genus Flammulina Martens, 1873

Type species: Vitrina zebra Le Guillou, 1842

Amphidoxa of New Zealand authors; not of Albers,

1850, Calymna Hutton, 1884; not of Hubner, 1816.

The following generic diagnosis is modified from that cited by Suter (1913, p. 671): Shell narrowly umbilicate, or imperforate, depressed, thin, fragile, subpellucid, composed of a few rapidly widening whorls, which are either smooth and glossy or radially ribbed; aperture large, rotundly lunate; inner lip thin, simple, slightly expanded at the columellar insertion; colour pale horny, shining bronze with faint darker radial streaks, or strongly flammulated by reddish-brown markings.

Jaw arcuate, composed of numerous, thin, interlocking, microscopically papillate plates.

Radula with a tricuspid central tooth, the central cusp long, reaching base of basal plate, lateral cusps small; lateral teeth similar

to central but the inner lateral cusp is larger; marginal teeth usually tricuspid, the two inner cusps the largest, fused at base and projecting obliquely inwards; third, outer cusp, minute; there is sometimes a fourth minute cusp on the outer edge of the outer marginal teeth; cusps on outer marginal teeth fused to some extent.

Penis lacking an epiphallus.

Flammulina chiron (Gray, 1850)

Figs. 4, A; 7, B; Plate 5, A.

- 1850 Zonites chiron Gray, Proc. Zool. Soc. Lond., p.166.
- 1853 Helix chiron (Gray): Pfeiffer, Monog. Heliceorum viventium,
3, p.194.
- 1873 Helix (Paryphanta) chiron (Gray): Hector, Cat. Land Moll.
N. Z., p.10.
- 1878 Nanina (Paryphanta) chiron (Gray): Pfeiffer, Nomencl. Hel.
Viv., p. 35.
- 1880 Paryphanta chiron (Gray): Hutton, Man. N. Z. Moll., p.23.
- 1884 Amphidoxa chiron (Gray): Hutton, Trans. N. Z. Inst., 16, p.199.
- 1886 Eloea chiron (Gray): Tryon, Man. Conch., (2), 1, p.129.
- 1893 Flammulina chiron (Gray): Hedley & Suter, Proc. Linn. Soc.
N. S. W., (2), 7, p.644.

Shell small (diameter 6.0 mm), umbilicate, radially ribbed, shining, thin and fragile, pellucid. Sculpture consisting of elevated, thin, membranous arcuate radial riblets (RI 5.0-6.0); interstices with a few weak secondary radials, and rarely, indistinct spiral striae. Colour olive-horny, occasionally with faint light brown simple zig-zag lines following the direction of the riblets; periostracum thin, transparent, glossy. Spire weakly elevated, nearly flat. Whorls $3\frac{1}{2}$, rather convex, rapidly increasing; periphery rounded; base convex; protoconch of $1-1\frac{1}{2}$ smooth convex whorls. Suture deeply impressed. Aperture large, slightly oblique, rotundly lunate. Peristome separated from the last whorl by a slight incision, the beginning of the nearly canaliculate suture. Columella vertical, arcuate; inner lip reflexed above. Umbilicus moderately wide (UI 2.8-3.5).

Exposed animal bluish-black, the sole and lateral margins of the foot bluish-white; visceral spire predominantly sooty-black merging into bluish-black in places, with occasional lighter spots.

Reproductive system characterized by a short ovate penis with terminal epiphallus and terminal insertion of vas deferens (illustration in Climo, 1969a, Fig. 1, D).

Radula with the formula $12 - 16 + 5 - 6 + 1 + 5 - 6 + 12 - 16$; central tooth tricuspid, smaller than first lateral tooth, with a long

central cusp reaching base of basal plate, and two weak lateral cusps; lateral teeth tricuspid, inner lateral cusp progressively increasing in size outwards, outer lateral cusp about same size throughout lateral tooth series; marginal teeth tricuspid; inner marginals with two large inner cusps, fused at base and pointing obliquely inwards, the outer cusp small but sharp; outer marginal teeth tricuspid the cusps progressively fusing into one mass outwards.

Jaw arcuate, composed of 54 - 56 thin, fused, microscopically papillate plates.

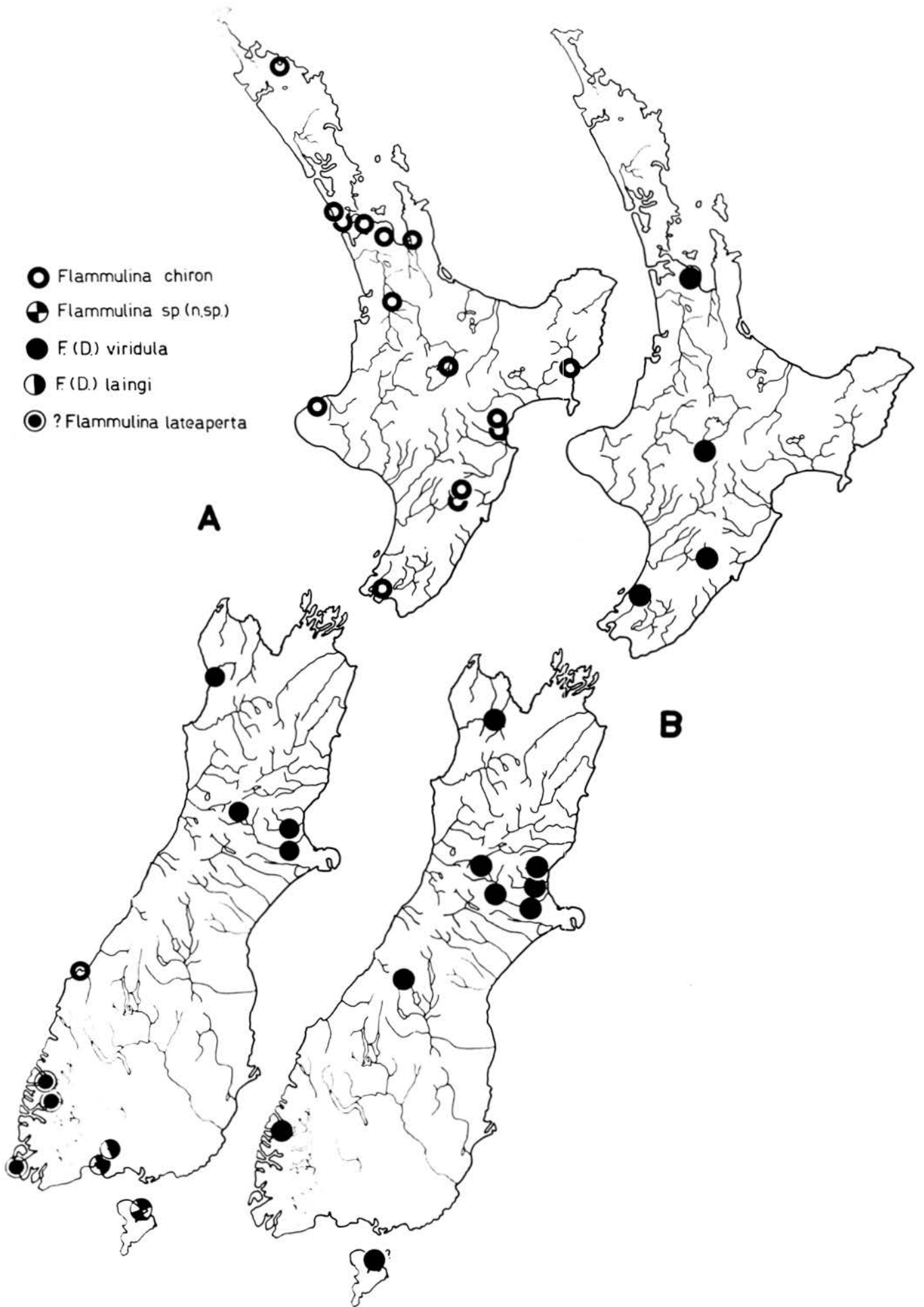
Type material: British Museum (Nat. Hist.)

Type locality: Auckland, North Island

Distribution and remarks: The writer has examined several specimens of chiron from Jackson Head, S. Westland which agree in both radular and shell characteristics with the original diagnosis based on North Island material. F. chiron has not been recorded from any other South Island locality. The species is widespread in the North Island and has been collected from Auckland to Wellington.

Material examined: Muriwai, Auckland (O'Connor 21/I/39); Patumahoe, S. Auckland (O'Connor 25/XI/45); Muretai, Taranaki (Hutchinson 2/IV/1897); Waiaua, Opotiki, Gisborne (Dom. Mus. Coll. M 4059); Te Puia, Poverty Bay, Gisborne (Hurley -/I/52); Te Pahi, Poverty Bay, Gisborne (Hutchinson 25/IV/1897); Otoka, Poverty Bay,

Fig. 4. Species distribution maps. A, Flammulina
chiron (Gray); F. sp. n. sp.; ?F. lateaperta
Dell; Flammoconcha (Delloconcha) laingi
(Suter); F. (D.) viridula n. sp.; B, F. (D.)
feredayi (Suter).



Gisborne (Hutchinson 2/II/1898); Newstead Bush, Napier, Hawkes Bay (Hutchinson 18/X/1898); Runanga, Hawkes Bay (A. Clark); Taupo, Auckland (Hutchinson 21/X/1899); Ball's Track, Hawkes Bay (Hutchinson Dom. Mus. Coll. M13288); Jackson Head, S. Westland (Climo 19/VII/67).

Flammulina crebriflammis (Pfeiffer, 1853)

Figs. 2, A; 7, C; 13, D; Plate 5, B.

- 1853 Helix crebriflammis Pfeiffer, Monog. Heliceorum viventium, 3, p. 91.
- 1873 Helix (Paryphanta) crebriflammis Pfr.; Hector, Cat. Land Moll. N.Z., p. 10.
- 1878 Nanina (Paryphanta) crebriflammis (Pfr.), Nomencl. Hel. Viv., p. 35.
- 1880 Paryphanta crebriflammis (Pfr.): Hutton, Man. N.Z. Moll., p. 24.
- 1884 Amphidoxa crebriflammis (Pfr.): Hutton, Trans. N.Z. Inst., 16, p. 199.
- 1886 Eloea crebriflammis (Pfr.): Tryon, Man. Conch., (2), 1, p. 130.
- 1893 Flammulina crebriflammis (Pfr.): Hedley & Suter, Proc. Linn. Soc. N.S.W., (2), 7, p. 644.

Shell small (diameter up to 7.0 mm), umbilicate, thin, finely striated, with brown zig-zag bands. Sculpture consisting of close inequidistant arcuate growth striae. Colour luteous, flammulated by reddish-brown markings, extending to the umbilicus; periostracum thin and glossy. Spire weakly elevated, convex, its height roughly half that of the aperture. Whorls $3\frac{1}{2}$, rapidly increasing, subdepressed; periphery narrowly convex; base convex; protoconch of $1\frac{1}{2}$ smooth whorls. Suture deeply impressed, virtually canaliculate. Aperture slightly oblique, lunately oval. Columella short, arcuate; inner lip reflexed above, and extending as a thin layer over the parietal wall. Umbilicus open (UI 3. 92-5. 71).

External animal bluish-grey; lateral margins of foot and sole bluish-white; lower portion of visceral spire bluish-grey, apical whorls brownish.

Reproductive system characterized by a short ovate penis with an apical retractor muscle; vas deferens inserted into penis subapically a short distance from the base of the retractor muscle; oviduct longer than penis, pigmented light grey; spermathecal duct relatively long, spermatheca level with tip of albumen gland.

Radula with the formula 11-13 + 7 + 1 + 7 + 11-13; central tooth tricuspid, smaller than first lateral tooth, central cusp long, reaching base of basal plate, lateral cusps moderately developed but not provided with basal bosses, in outline, the base of the tooth appearing

unicuspid; lateral teeth tricuspid, the inner lateral cusp increasing in size outwards; marginal teeth at first tricuspid with two large inner cusps, partially fused at base, and a smaller outer cusp; outer marginals tricuspid, or quadricuspid by splitting of the outer cusp; progressive fusion of cusps into one mass outwards along the marginal teeth.

Type material: British Museum (Nat. Hist.)

Type locality: New Zealand

Distribution, variation and remarks: The species is widespread in central and southern districts of the North Island, and in the South Island, north of central Canterbury. The closely related species, *F. zebra* (Le Guillou, 1842), has a similar North Island distribution but penetrates as far south as the subantarctic islands.

Umbilical width, the only parameter measured for *crebriflammis*, is relatively constant among South Island specimens, a selection of UI indices below illustrate this point: Wairoa Gorge, Nelson 4.54-5.71, N=6; Middle Waipara Gorge, Canterbury 3.92-4.71, N=11; Dyer's Pass, Christchurch 4.62-5.55, N=5; Akaroa, Canterbury 4.62-5.00, N=2.

Material examined: Te Araroa, Gisborne (Dell 30/XI/50); Atene, Wanganui, Wellington (Dell 28/VIII/49); Runanga, Hawkes Bay (A. Clark); Ohakune, Wellington (Hamilton -/IV/23); Kenepuru,

Marlborough (ex. Murdoch Coll.; compared with type in B. M. by Dr R. K. Dell); Lee Valley, Nelson (O'Connor); Riwaka, Nelson (O'Connor -/I/49); Flora Track, Mt Arthur, Nelson (Dell 21/I/48); Wairoa Gorge, Nelson (Climo 25/XI/67); Kaikoura, Marlborough (Wallace -/VIII/10); Middle Waipara Gorge, Canterbury (Climo 6/IV/68); Dyer's Pass, Christchurch (Climo 5/IV/67); Upper Hurunui River, Canterbury (Johns 20/IV/62; Climo -/IX/68); Akaroa, Canterbury (Hughson 22/IV/50); Spey River, west shore of Lake Manapouri, Southland (Otago Univ. Biol. Soc. 17/II/59); Lower Hollyford Valley, Otago (Forster 2/II/46).

Flammulina perdita (Hutton, 1883)

Figs. 5; 7, A; 11, C-D; Plate 3, A.

1883 Amphidoxa perdita Hutton, N.Z. Jour. Sci., 1, p. 476.

1892 Gerontia (Calymna) perdita (Hutt.): Pilsbry, Man. Conch., (2), 8, p. 76.

1893 Flammulina perdita (Hutt.): Hedley & Suter, Proc. Linn. Soc. N.S.W., (2), 7, p. 241.

Shell small (diameter 5.8 mm), depressed, perforated, smooth, thin and shining, pellucid. Sculpture weak, consisting of inequidistant, arcuate growth ridges, spiral sculpture lacking. Colour pale olive-horny, rarely with radially orientated reddish streaks. Periostracum thin and shining. Spire broadly convex, height up to three-quarters

that of aperture. Whorls 4, rapidly expanding, rounded; periphery narrowly convex; base flatly rounded; protoconch of $1\frac{1}{4}$ - $1\frac{1}{2}$ smooth whorls. Suture deeply impressed. Aperture oblique, lunately ovate; outer lip in advance of basal lip. Columella oblique and arcuate; inner lip reflexed above, partially covering the deep umbilical perforation. Umbilicus narrow, deep (UI 5.58-9.0).

Exposed animal bluish-grey above, sole and lateral margins of foot dirty-yellowish; visceral spire and mantle marbled with black and white.

Reproductive system characterized by a thinly ovate penis, with terminal retractor muscle and terminal insertion of vas deferens; penial sheath loose, vas deferens expanding inside sheath, below retractor muscle; internally expanded part of vas deferens not homologous with the external epiphallus of the Endodontinae Suter.

Radula with the formula 10 - 11 + 6 - 8 + 1 + 6 - 8 + 10 - 11; central tooth tricuspid, smaller than first lateral tooth, central cusp long, reaching base of basal plate, lateral cusps obsolete; lateral teeth tricuspid, inner lateral cusp increasing in size outwards, outer lateral cusp about the same size along the laterals; marginal teeth tricuspid, the two inner cusps the largest, pointing obliquely inwards on inner teeth, more vertical on outer teeth; progressive fusion of cusps into one mass out along the marginals.

Type material: Canterbury Museum, Christchurch.

Type locality: Greymouth, N. Westland.

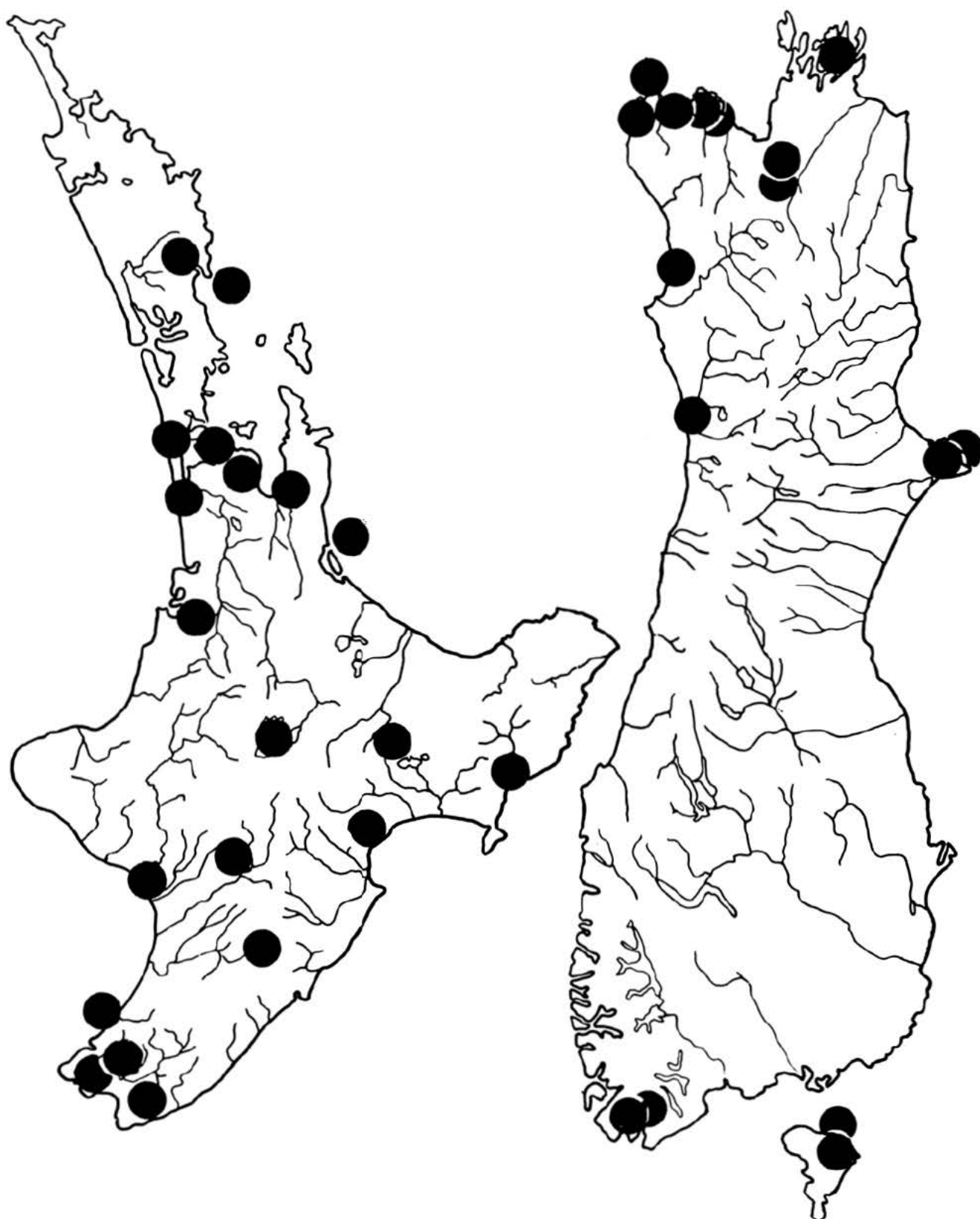
Distribution, variation and remarks: F. perdita is widespread in New Zealand and has been recorded from Northland to Stewart Island. It can be obtained readily in most low altitude areas by beating the soft ferns which grow in moist, dark areas.

Umbilical width is considerably variable within and between localities. A selection of UI indices are given below: Coronation Reserve, Whangarei 7.61, N=1; Waiopahu Reserve, Levin 7.67, N=1; Farewell Spit, Nelson, 9.00, N=1; Gorge Creek, Takaka, Nelson 5.58-6.87, N=2; Wairoa Gorge, Nelson 5.70-6.77, N=2; Dyer's Pass, Christchurch 5.60-9.00, N=7; Kaituna Valley, Banks Peninsula 6.55-9.66, N=6; Halfmoon Bay, Stewart Island 5.70-7.66, N=4. The variability of the UI index is magnified by variation in the degree of reflexion of the inner lip which partially covers the umbilicus.

In an earlier paper I (Climo, 1969a) misinterpreted the thickened *vas deferens* within the penial sheath as an epiphallus and excluded *perdita* from the Flammulininae.

Material examined: F. perdita has been examined from 21 localities in New Zealand, including: Hen Island (O'Connor Coll.); Mayor Island (Dom. Mus Coll. -/III/21); Motutaiko Island, Lake Taupo (O'Connor 1951); Kapiti Island (Dell 28/VIII/47); Pukeokaoka Island, Stewart Island (Johns 9/VIII/64).

Fig. 5 Distribution of Flammulina perdita (Hutton)



DISTRIBUTION OF *FLAMMULINA PERDITA* (HUTTON)

Flammulina zebra (Le Guillou, 1842)

Figs. 2, B; 7, D; 13, E; Plate 5, C.

- 1842 Vitrina zebra Le Guillou, Rev. Zool., 5, p.136.
- 184? Helix zebra (Le Guill.), Cat. Pulm. Brit. Mus., p.70.
- 1849 Helix phlogophora Pfeiffer, Proc. Zool. Soc. Lond., p.127.
- 1852 Helix flammigeria Pfeiffer, Proc. Zool. Soc. Lond., p.147.
- 1854 Helix multilimbata Hombron & Jacquinot, Voy. Pole Sud,
Zool., 5, p.16.
- 1873 Helix (Paryphanta) phlogophora (Pfr.): Hector, Cat. Land
Moll. N.Z., p.4.
- 1878 Nanina (Paryphanta) phlogophora (Pfr.); Nomencl. Hel. Viv.,
p.35.
- 1880 Paryphanta phlogophora (Pfr.): Hutton, Man. N.Z. Moll., p.22.
- 1893 Flammulina zebra (Le Guill.): Hedley & Suter, Proc. Linn. Soc.
N.S.W., (2), 7, p.643.
- 1913 Flammulina phlogophora (Pfr.): Suter, Man. N.Z. Moll., p.680.
- 1915 Flammulina zebra (Le Guill.): Iredale, Trans. N.Z. Inst.,
47, p.480.

Shell small (diameter up to 7.0 mm), imperforate or very narrowly perforate, thin, shining, pellucid, with brown zig-zags. Sculpture consisting of fine arcuate and retractive growth lines only. Colour

yellowish-white, with angular flame-like markings and rufous serrations, closely set together. Spire weakly convex, about two-fifths height of aperture. Whorls $3\frac{1}{2}$, convex, rapidly increasing, shell depressed in outline; base flatly convex, impressed in middle; protoconch of $1\frac{1}{2}$ smooth whorls. Suture deep, virtually canaliculate. Aperture oblique, rotundly ovate. Columella nearly vertical, arcuate; inner lip strongly reflexed, usually totally covering the narrow perforation.

Exposed animal bluish-grey, sole and lateral margin of foot variable in colour, whitish, through yellow to bright orange.

Reproductive system characterized by a short ovate penis with terminal retractor muscle, into which the vas deferens is inserted; free oviduct shorter than penis.

Radula with the formula 13 - 15 + 7 - 8 + 1 + 7 - 8 + 13 - 15; central tooth tricuspid, slightly smaller than first lateral tooth, central cusp long, reaching base of basal plate, lateral cusps weak; lateral teeth tricuspid, the inner lateral cusp becoming larger outwards; marginal teeth tricuspid, central cusp the longest, cusps becoming progressively more fused out along the marginal teeth.

Type material: British Museum (Nat. Hist.)

Type locality: Auckland Islands

Distribution, variation and remarks: The species is widespread in the North Island, south of the Waikato Plains and is common in most areas of South and Stewart Islands. F. zebra has only been recorded from the Auckland Islands, of the New Zealand subantarctic islands.

Specimens of zebra examined from many South Island localities were not imperforate, there being a minute perforation where the reflected inner lip had not quite sealed over the cavity.

I have described (Climo, 1969b) a new Cercaria from Phelussa fulminata (Hutton, 1883). Infected snails were collected from Codfish Island, Stewart Island. A specimen of F. zebra has recently been dissected by the writer from the same locality. It too was infected by the same organism. In this case, however, only metacercariae were present in the viscera of the snail, occurring in the same organ (the kidney) as in P. fulminata. There were no sporocysts in the apical whorls but there were cavities in the posterior gut gland marking previous sites of sporocyst infection.

Material examined: F. zebra has been examined from 30 localities,

Flammulina sp. n. sp.

Figs. 4, A; 8, E; 12, C-E; Table 1.

In an earlier discussion (p. 20), it was mentioned that the Stewart Island record of Flammoconcha feredayi (Suter) probably referred to an undescribed flammulinid endodontid snail.

The only specimen of this new species available to the writer, from Ferny Gully, Halfmoon Bay, Stewart Island, was completely destroyed during dissection. Enough anatomical information was

obtained to place it with certainty in the Flammulininae, but in the absence of a type specimen no formal name is proposed at this stage. Shell small (diameter 4.1 mm), depressed, radially ribbed, horny brown in colour, imperforate. Sculpture consisting of close, membranous, arcuate radial riblets becoming obsolete on base; interstices with a dense pattern of diagonal reticulating microscopic striae. Whorls $2\frac{3}{4}$, rapidly expanding, body whorl greatly inflated; protoconch of $1\frac{3}{4}$ strongly spirally striate whorls.

Exposed animal greyish-black.

Reproductive system characterized by a short ovate penis with terminal insertions of vas deferens and retractor muscle, the vas deferens entering into the base of the retractor muscle; atrium short; vagina about half length of penis; free oviduct longer than penis.

Radula with the formula $20 + 5 + 1 + 5 + 20$; central tooth tricuspid, central cusp long, reaching lower edge of basal plate, lateral cusps moderately developed, sharp; lateral teeth relatively few in number, tricuspid, inner lateral cusp rapidly increasing in size outwards; inner marginal teeth essentially bicuspid, with two very long inner cusps, pointing obliquely inwards, and a minute outer cusp; outer marginal teeth tricuspid, all cusps large but the outermost the smallest of the three.

Remarks: The species is regarded here as distinct from

? Flammulina lateaperta Dell, 1955 because of its strongly spirally

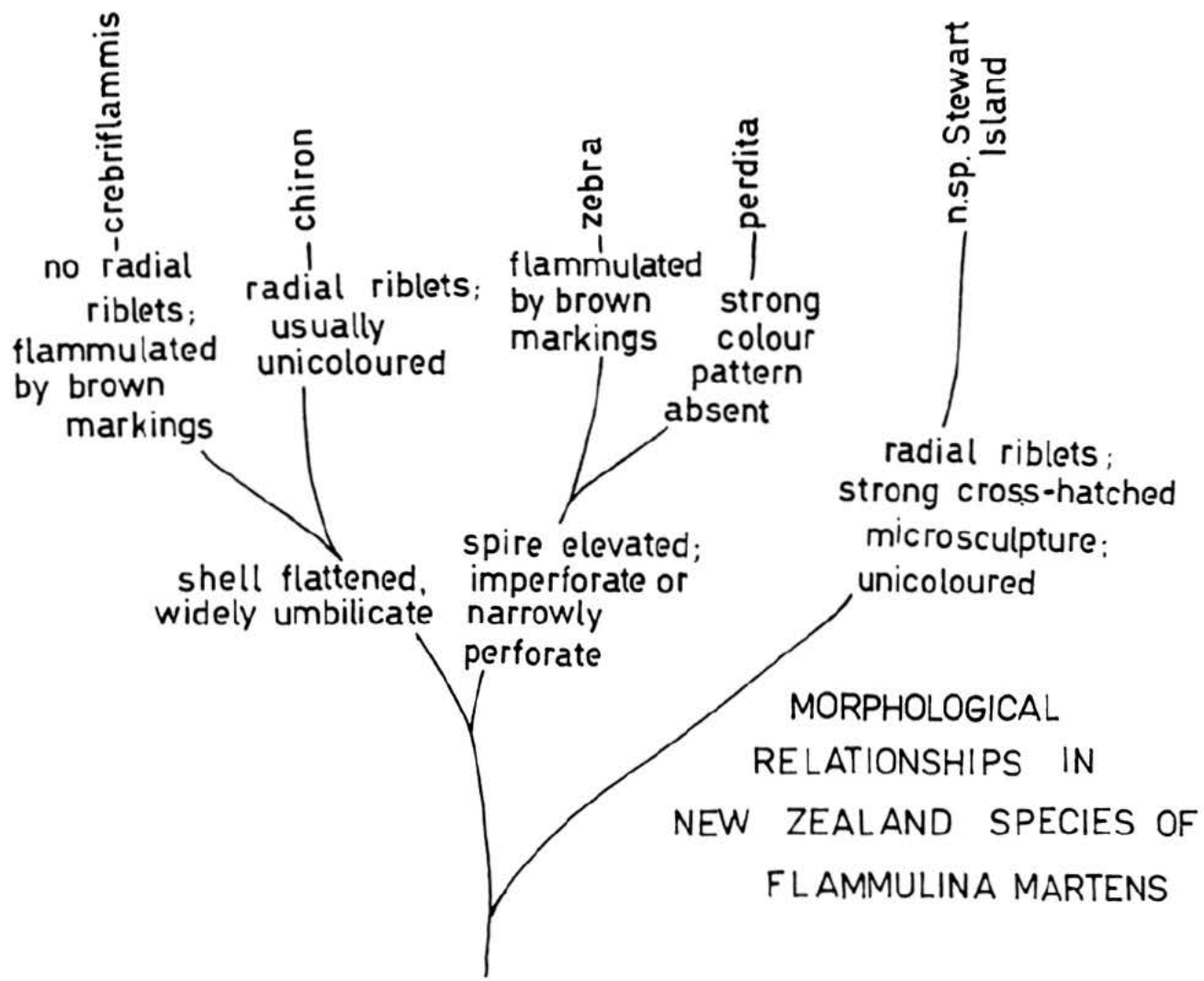
striate protoconch, different radular structure and stronger development of radial riblets. This flammulinid snail displays the same strong diagonal reticulating striae shown by Flammoconcha s. str. (Endodontinae Suter).

Material examined: Ferny Gully, Halfmoon Bay, Stewart Island (Cresswell 21/I/68. One specimen).

Key to New Zealand species of Flammulina Martens, 1873

1. Shell strongly flammulated by reddish-brown markings 2
 Shell not strongly flammulated by reddish-brown markings 3
2. Shell minutely perforate or imperforate zebra
 Shell umbilicate crebriflammis
3. Shell with membranous radial riblets 4
 Shell lacking radial riblets 5
4. Shell with sparse radial riblets; protoconch smooth; umbilicate chiron
 Shell with numerous radial riblets; protoconch strongly spirally striate; imperforate n. sp. (Stewart Id)
5. Shell smooth, apart from inequidistant arcuate, radial growth ridges; colour pale olive-horny, occasionally with weak reddish radial streaks; protoconch smooth; narrowly umbilicate perdita

Fig. 6 New Zealand species of Flammulina Martens.



INCERTAE SEDIS

? Flammulina alpina Suter, 1904

Figs. 9, H-I; 12, F.

- 1891 Amphidoxa corneo-fulva (Pfr.): Suter, Trans. N.Z. Inst., 24,
p. 287; not of Pfeiffer.
- 1893 Flammulina corneo-fulva (Pfr.): Hedley & Suter, Proc. Linn.
Soc. N.S.W., (2), 7, p. 644; not
of Pfeiffer.
- 1904 Flammulina alpina Suter, Index Faunae Novae-Zealandiae, p. 62.

Shell relatively large (diameter 8.0 mm), suborbicular, umbilicate, smooth, shining, pellucid, of $4\frac{1}{2}$ whorls. Radula with the formula $140 \times 17 + 16 + 1 + 16 + 17$; marginal teeth tricuspid, the central cusp the strongest.

Type material: Holotype in Dominion Museum, Wellington.

Type locality: Head of Staircase Creek, 5, 300 feet altitude, on Nenger Range, Canterbury, in slush of snow, hundreds together (G. F. Roberts); March, 1884. ("Staircase Creek" should read Staircase Gully; "Nenger Range", Torlesse Range).

Remarks: Suter's label with the unique holotype indicates that the Nenger Range is inland from Springfield, Canterbury; G. F. Roberts's label without doubt referred to the Torlesse Range. Suter (1892, p. 287)

further confirms this view when he states that the two specimens he received came from a person living in Christchurch. "Staircase Creek" (of Roberts) must refer to Staircase Gully which drains north (the stream has no official name) along the eastern flank of the Torlesse Range into the Waimakariri River.

Suter (1892) mentioned that ?F. alpina was identical in shell characteristics with Oxychilus cellarius (Mueller) (=corneo-fulva Pfeiffer), an introduced snail. In view of these striking similarities one tends to the opinion that the broken specimen of alpina from which Suter mounted the radula was a different species from that of the holotype. It seems likely that alpina, like corneo-fulva, is also a synonym of O. cellarius.

If the altitude of the type locality is correct, then alpina must be living in scree barrens, all continuous vegetation ceasing above 5,000 on the Torlesse Range.

?Flammulina cornea (Hutton, 1883)

Figs. 2, B; 11, F-G.

1883 Amphidoxa cornea Hutton, Trans. N.Z. Inst., 15, p.136.

1893 Gerontia (Calymna) cornea (Hutt.): Pilsbry, Man. Conch.,
(2), 8, p. 75.

1893 Flammulina cornea (Hutt.): Hedley & Suter, Proc. Linn. Soc. N.S.W., (2), 7, p.643.

Suter (1913, p.675) stated that the species is very closely allied to F. compressivoluta (Reeve) "... but the whorls are more convex, the suture is not false-margined and crenulated, and the shell is smaller; there is also no trace of spiral striation".

Type material: Canterbury Museum, Christchurch.

Type locality: Auckland

Remarks: There seems little doubt that cornea is an endodontinid snail closely related to compressivoluta but having examined only the type material and having no knowledge of the soft-part anatomy of the species, it is included in this incertae sedis section of the paper.

? Flammulina lateaperta Dell, 1955

Fig. 4, A; Plate 1, D.

1955 Flammulina lateaperta Dell, Trans. R. Soc. N. Z., 82, (5),
p.1140.

Shell small (diameter 4.1 mm), thin, yellowish-gold, delicately radially costate, imperforate. Radula with the formula 18 + 8 + 1 + 8 + 18 (see Dell, 1955 for complete diagnosis).

Distribution and remarks: The species is restricted to the south-west of the South Island. I have examined the holotype (Caswell Sound Dell 13/III/49) and the Puysegur Point specimen (O'Connor -/VII/40). The Puysegur Point specimen has a more distinctive sculpture than

"growth wrinkles" (Dell, 1955), being ornamented by sharp, arcuate radial riblets. The riblets, however, have been worn off in places on this specimen and in such places appear to be growth wrinkles. The relatively large protoconch of the Puysegur Point specimen indicates that it is a juvenile. This juvenile specimen of ?F. lateaperta is very similar in shell form to adults of Flammoconcha feredayi (Suter), the two being distinguished by the greater number of whorls and relatively smaller protoconch in feredayi.

The holotype of lateaperta has no arcuate riblets but it does show regular, arcuate growth wrinkles. It seems likely that originally there were very thin, membranous riblets projecting from these wrinkles in the holotype. In the field, during collecting or in storage, these fragile riblets have been subsequently lost. The only specimen of Flammoconcha olivacea (Suter) which I could locate in the Dominion Museum (Kaimai Range, Auckland. O'Connor Coll.) had the riblets completely worn off; there being only the basal growth wrinkle portions of them remaining. The live specimen of F. cumberi (Powell) examined in this study also had nearly all of the raised riblets worn off.

DISCUSSION. The distinction between Flammulina Martens and Flammoconcha Dell, strongly evident in reproductive morphology, can be supported by small differences in the structure of the marginal teeth of the radula between both genera. In Flammulina, the marginal teeth are essentially tricuspid and towards the end of the marginal

series the fused cusps present a fairly symmetrical outline, the two lateral cusps nearly equally developed. Fusion of the cusps is not evident to the same extent in the new species informally introduced from Stewart Island; the marginal teeth, however, are tricuspid. Flammoconcha, on the other hand, has asymmetrical marginal teeth, the two inner cusps always distinctly larger than the outer cusp/s (when present). There is also a tendency for the marginal teeth of Flammoconcha to become multicuspid, at least four cusps usually evident. The radula of F. laingi has been strongly modified but on shell and reproductive morphology the species shows strong affinities with the other large species of Flammoconcha (more so than with Thalassohelix Pilsbry, 1892). Rather than create a new taxon for this anomalous species it is classified within Flammoconcha Dell. F. compressivoluta has marginal teeth which can be interpreted as intermediate between the conditions shown by laingi and the other species of Flammoconcha.

The generic shell features of Gerontia Hutton, 1883, Suteria Pilsbry, 1892 and Therasiella Powell, 1948 are so distinct from other New Zealand endodontinids that I have had to use minor shell characters for purposes of showing interrelationships between these and other endodontinid genera. Both Gerontia and Therasiella have membranous riblets and no reticulating lirae in the interrational spaces, showing possible affinities with Flammoconcha Dell. Suteria, on the

other hand, has heavy, calcareous-based riblets and weak development of reticulating spiral lirae in the interradial spaces, showing possible affinities with the charopid complex.

Although Charopa (Egestula) and an occasional species in other charopid subgenera have no reticulating lirae, in view of their other charopid features (as opposed to the characteristic shell forms of Therasiella and Gerontia) they are retained in the charopid arm of the basic endodontinid dichotomy. The absence of a reticulating microsculpture in the above species is interpreted as a secondary development, whereas the sculptures of Gerontia and Therasiella display the ancestral features of the Flammoconcha complex.

Illustrations of morphological relationships are vulnerable, in that other workers, using the same groups of characters, may construct "trees" differing markedly in their basic dichotomies. However tentative, it is thought to be more informative to illustrate my interpretation of generic relationships within New Zealand members of the Endodontinae Suter, than to list genera and subgenera in monograph form only. Such diagrams are useful summaries of information. They are, however, not necessarily phyletic, although as near phylogenies as lack of comprehensive fossil material will allow.

Gerontia Hutton, Suteria Pilsbry and Therasiella Powell will be reviewed in the following paper in this series.

ABBREVIATIONS USED IN FIGS. 9-13

a., atrium; a.g., albumen gland; ep., epiphallus;
g., gonad; h.d., hermaphroditic duct; ov., oviduct;
p., penis; p.g., prostatic gland; p.o., pulmonary opening;
p.r.m., penis retractor muscle; sp., spermatheca;
sp.d., spermathecal duct; t., talon; u., uterus;
v., vagina; v.d., vas deferens.

Table 1. Shell Variation Data. For species indicated
~~in table.~~ IMP, imperforate.

Table 1 Shell Variation Data

| Locality | N | RI | HI | UI | P.Wh. | B.Wh. | PNW |
|--|---|---------------|---------------|-----|-------|-------|-----------------|
| <u>Flammoconcha feredayi</u> | | | | | | | |
| Chateau Tongariro, North Island | 1 | 15.5 | 1.42 | IMP | 1½ | 3¼ | 43.0 |
| Kowai Bush, Canterbury | 4 | 17.9- 21.8 | 1.56- 1.58 | IMP | 1½ | 3 | 42.0- 50.0 |
| Cass, Canterbury | 3 | 16.9- 20.0 | 1.40- 1.60 | IMP | 1½ | 3 | 37.0- 50.0 |
| <u>Flammoconcha viridula n.sp.</u> | | | | | | | |
| Ashley Gorge, Canterbury | 1 | 14.6 | 1.53 | IMP | 1½ | 3 | 38.0 |
| Arthur's Pass, Canterbury | 1 | 11.5 | 1.50 | IMP | 1½ | 3¼ | 28.0 |
| Karamea, Nelson | 1 | 13.7 | 1.60 | IMP | 1½ | 3¼ | 29.0 |
| <u>Flammoconcha albina n.sp.</u> | | | | | | | |
| Cass, Canterbury | 1 | 8.5 | 1.64 | IMP | 1½ | 3¼ | 18.0 |
| <u>Flammoconcha glacialis</u> | | | | | | | |
| Lake Wakatipu, Otago | 1 | 56.3 | 1.77 | IMP | 1½ | 2 | 90.0 |
| Hooker Valley, Canterbury | 4 | 46.9- 55.3 | 1.50- 1.74 | IMP | 1½-1¾ | 3¼ | 114.0- 133.0 |
| <u>Flammulina sp. (n.sp. Stewart Island)</u> | | | | | | | |
| Ferny Gully, Halfmoon Bay | 1 | 15.1 | 1.90 | IMP | 1½ | 3 | 50.0 |

Fig. 7. Radula morphology of: A, Flammulina perdita (Hutton), Pukeokaoka Island, Stewart Island; B, F. chiron (Gray), Jackson Head, S. Westland; C, F. crebriflammis (Pfeiffer), Wairoa Gorge, Nelson; D, F. zebra (Le Guillou) Middle Waipara Gorge, Canterbury; E, Flammoconcha olivacea (Suter), Mangamuka Gorge, Northland; F, F. cumberi (Powell), Gouland Downs, Nelson; G, F. stewartensis Dell, Ferny Gully, Halfmoon Bay, Stewart Island.

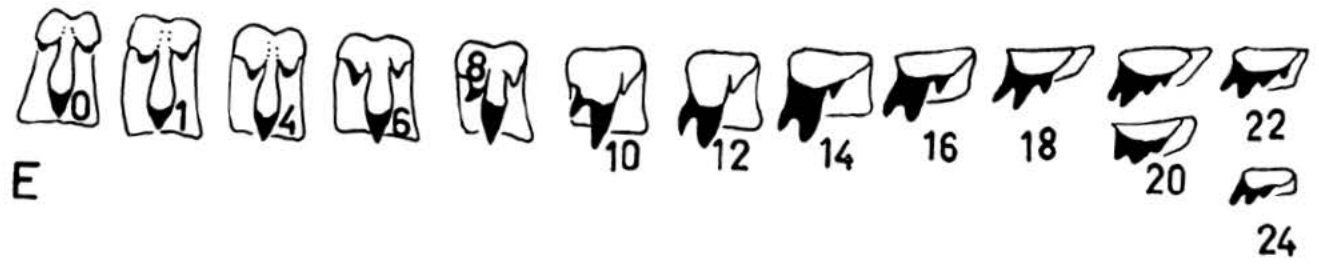
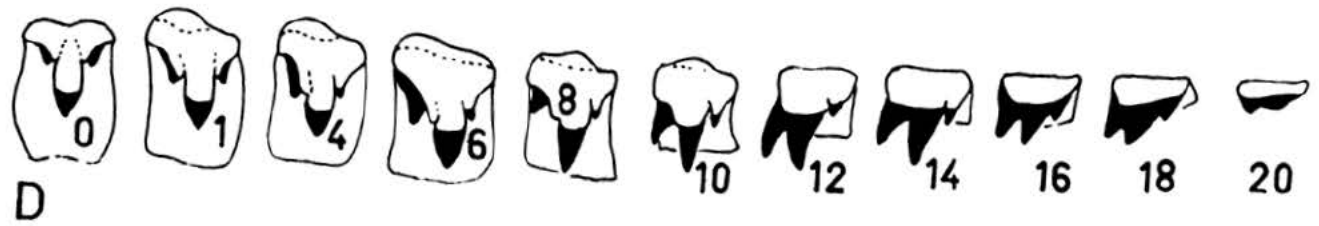
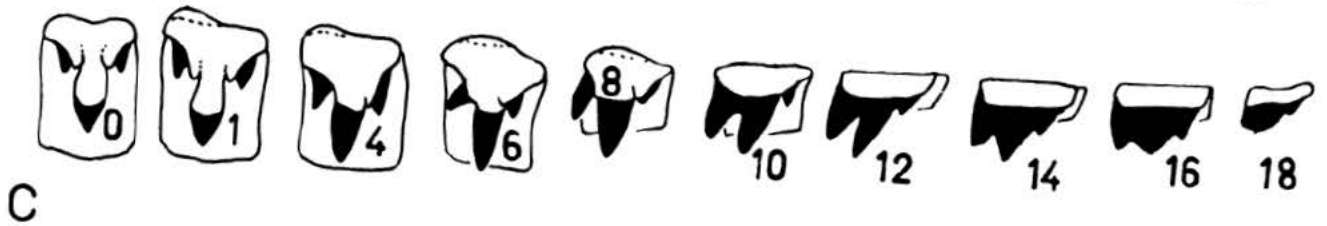
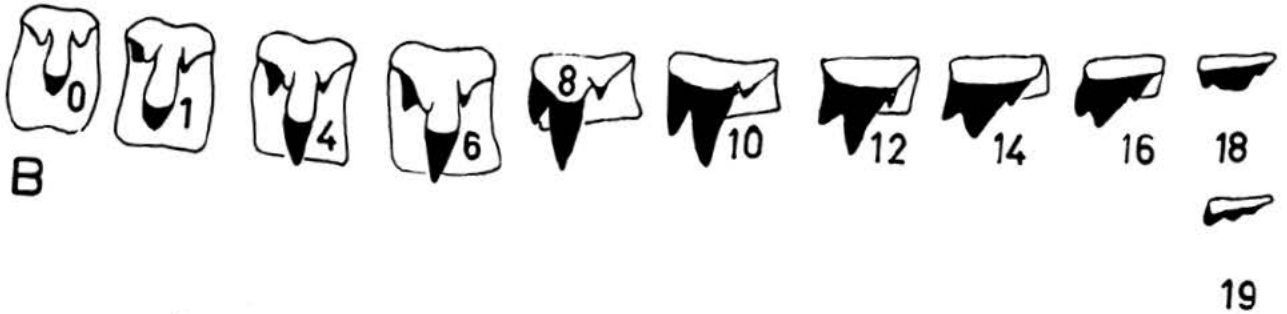
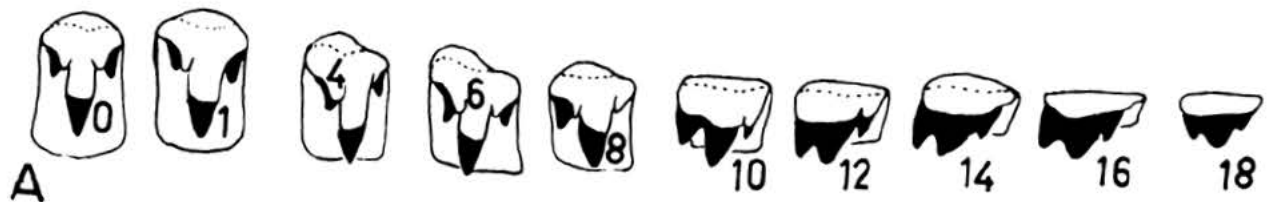


Fig. 8. Radula morphology of: A, Flammoconcha albina n. sp., Cass River, Canterbury; B, F. glacialis (Suter), Hooker Valley, Canterbury; C, F. feredayi (Suter), Kowai Bush, Canterbury; D, F. viridula n. sp., Ashley Gorge, Canterbury; E, Flammulina n. sp., Ferny Gully, Halfmoon Bay, Stewart Island; F, Flammoconcha laingi (Suter), Bluecliffs, Southland; G, Protoflammulina johnsi n. gen. & n. sp., Snares Islands.

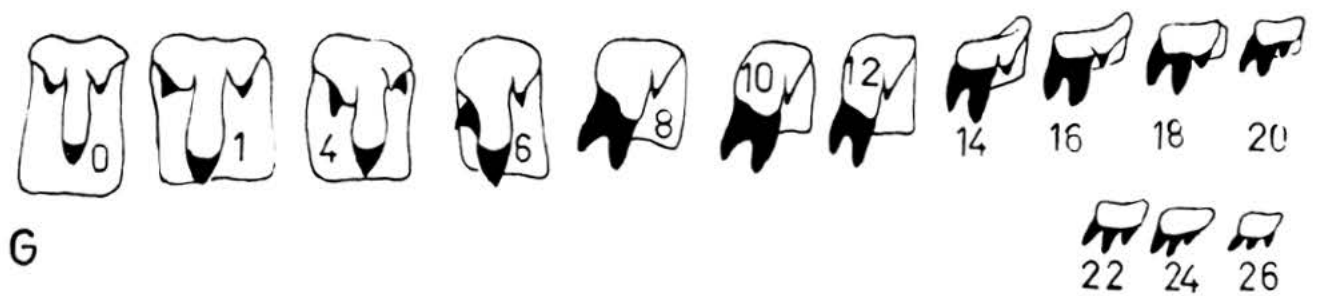
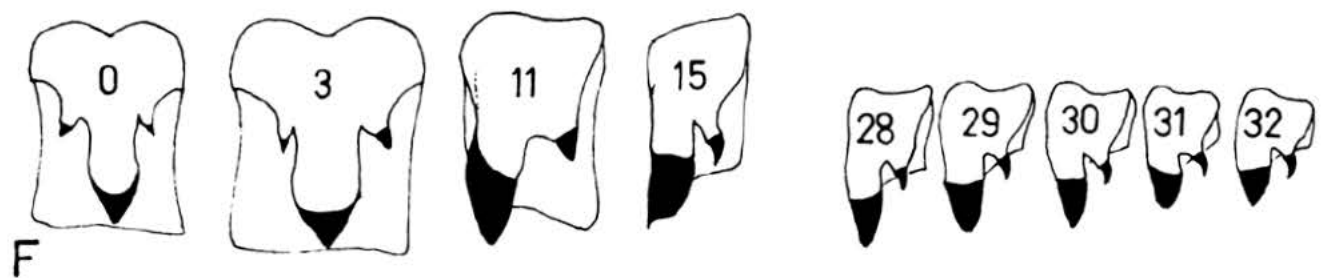
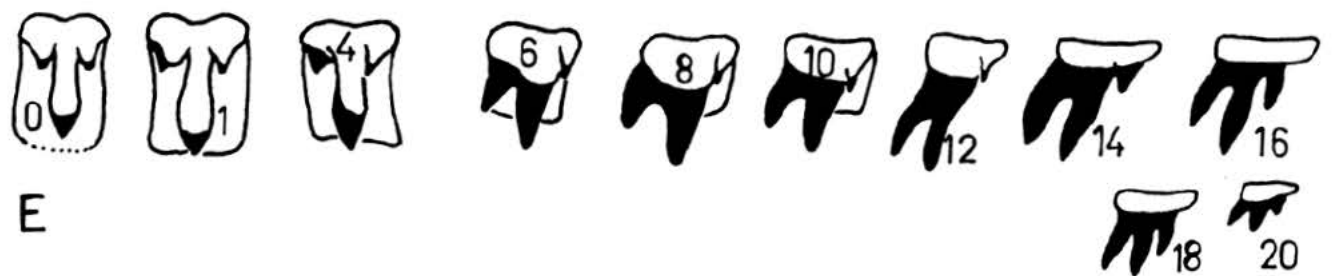
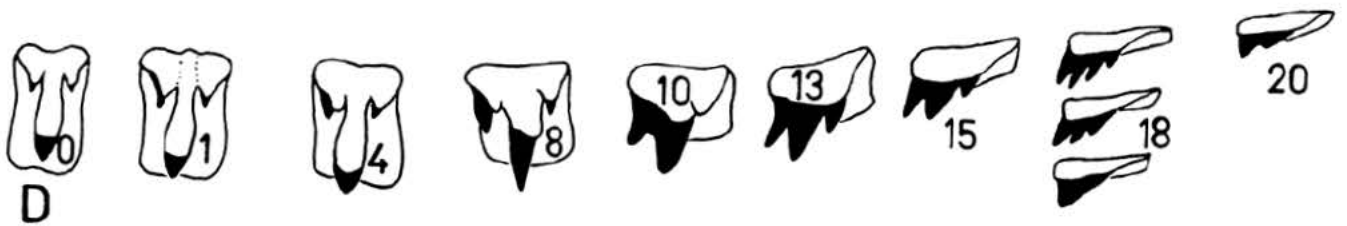
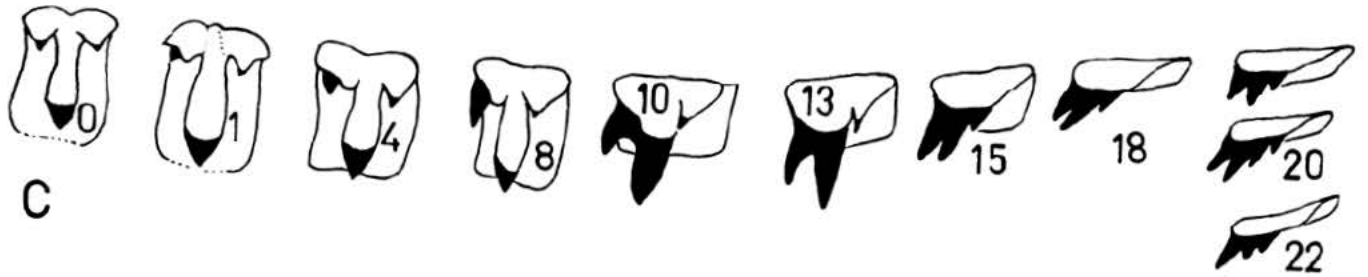
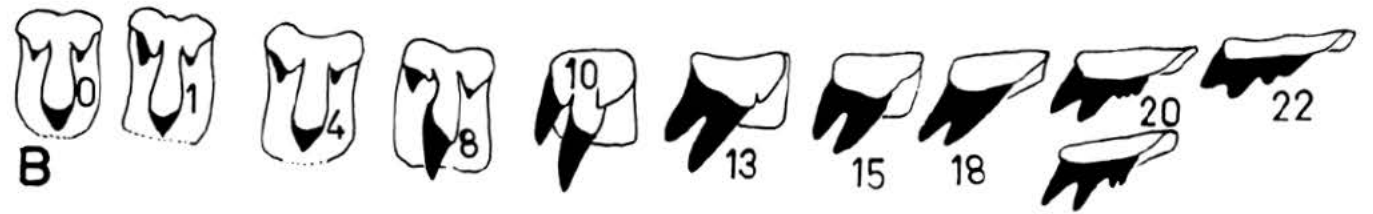
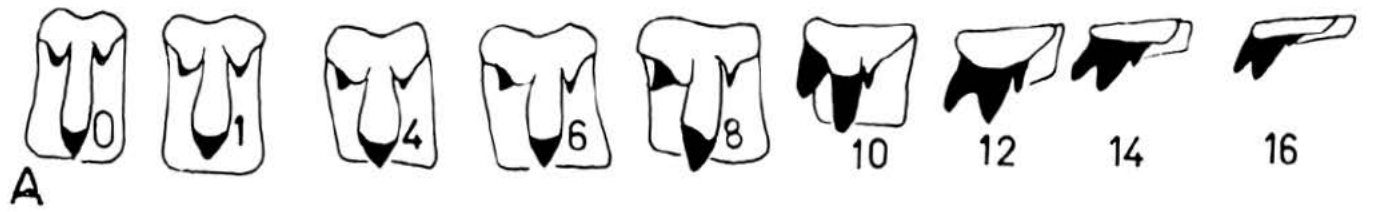
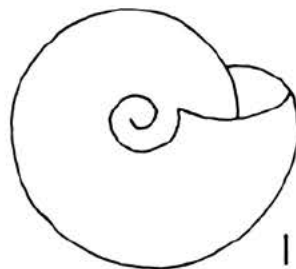
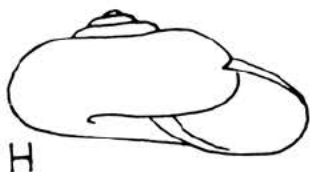
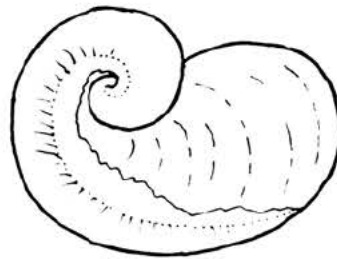
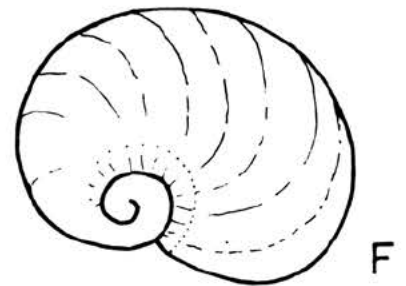
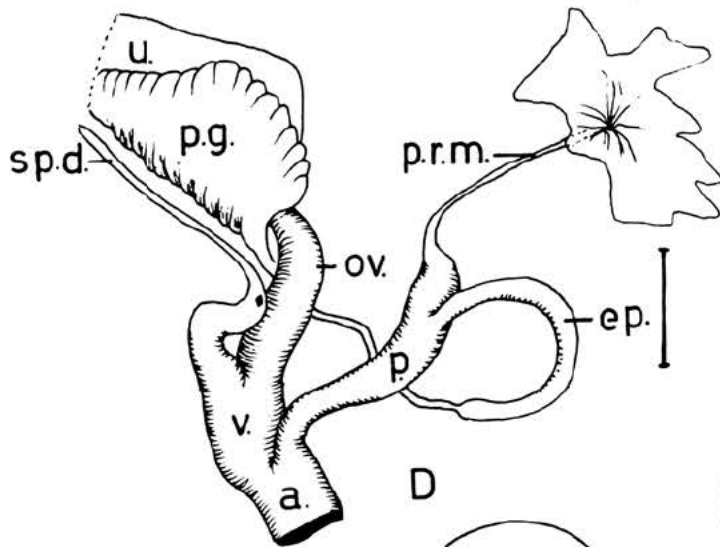
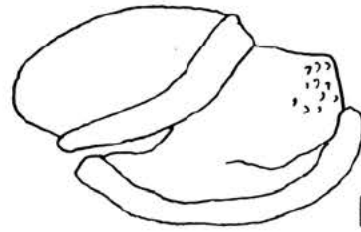
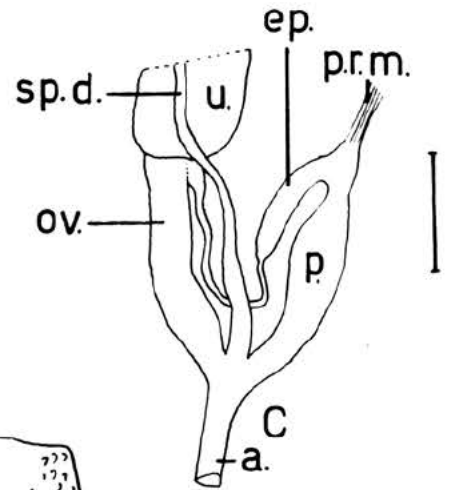
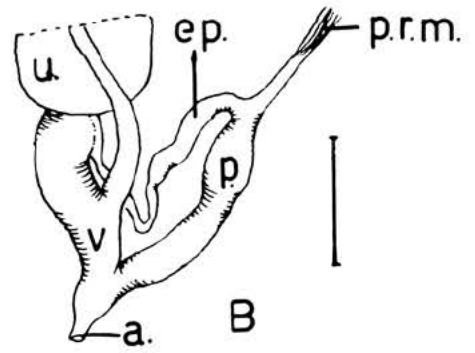
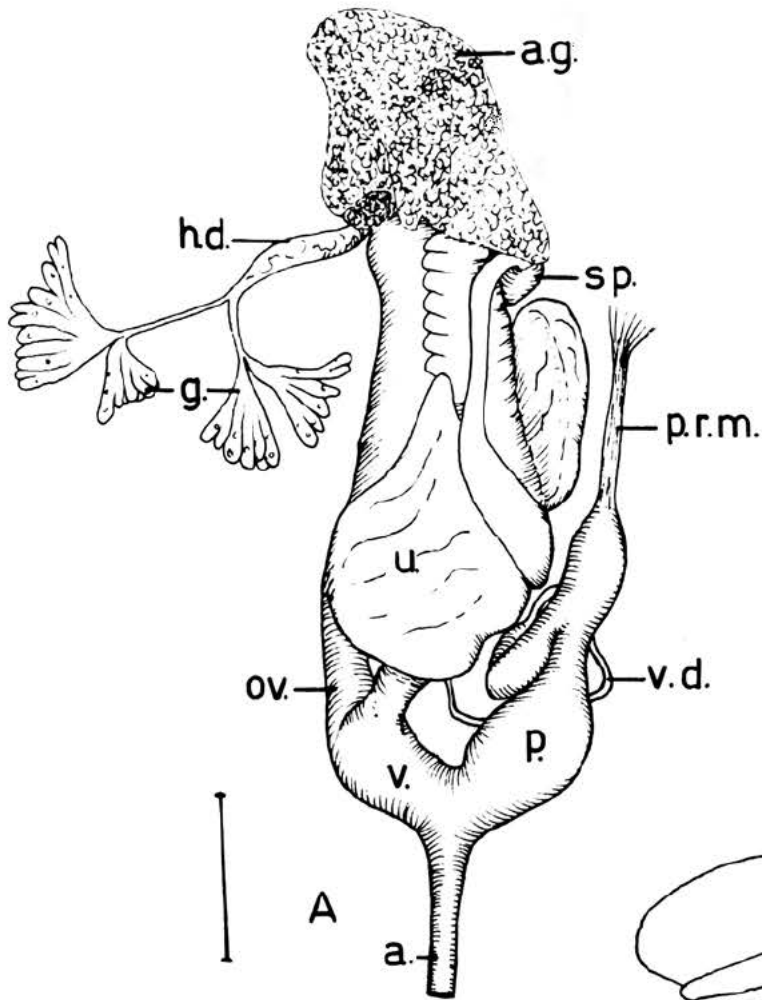
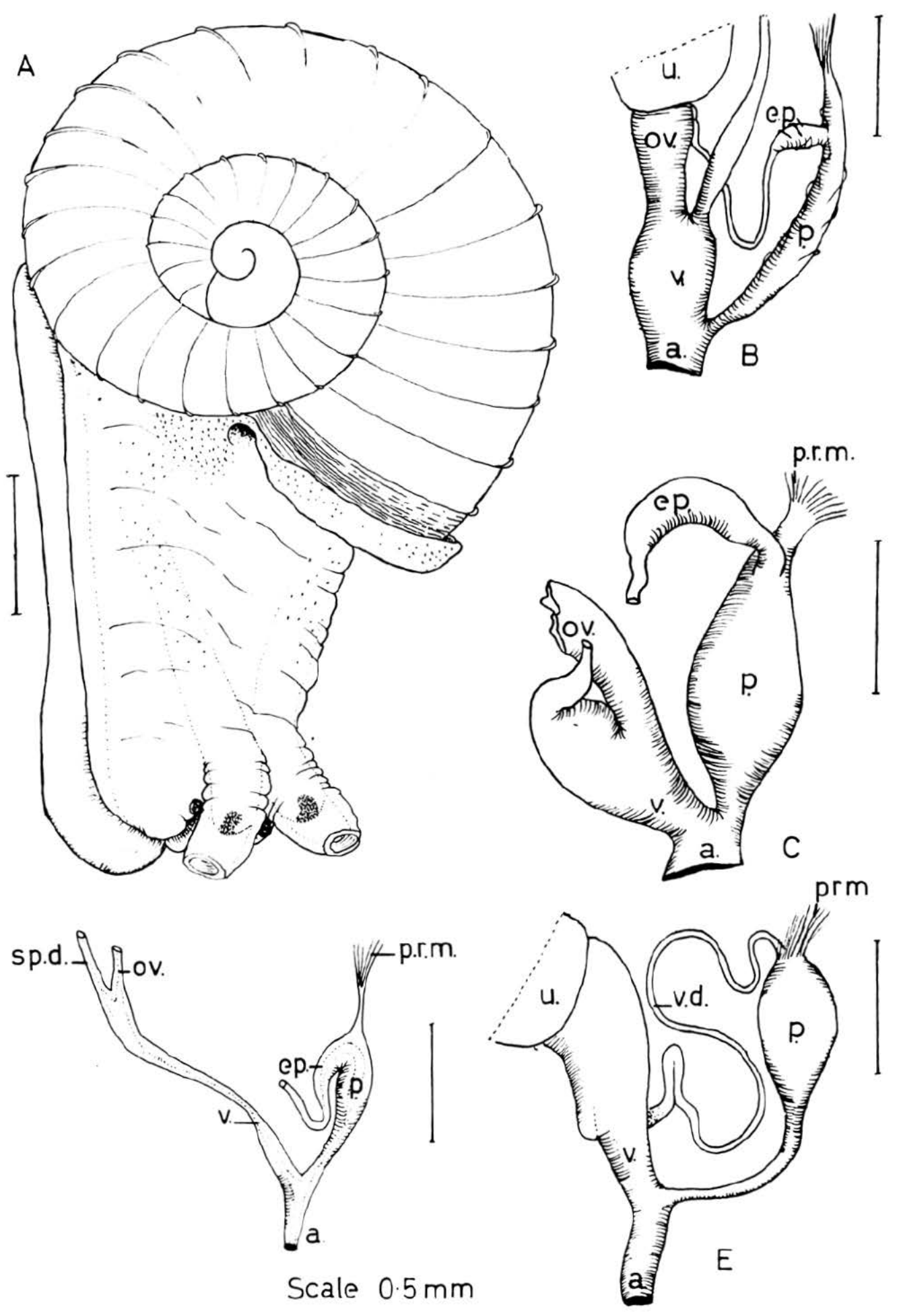


Fig. 9. A, reproductive system Flammoconcha feredayi (Suter), Kowai Bush, Canterbury; B - D, terminal reproductive structures of: B, F. feredayi, Chateau Tongariro; C, F. viridula n. sp., Ashley Gorge, Canterbury; D, F. glacialis (Suter), Hooker Valley, Canterbury; E, animal of F. stewartensis Dell (after Dell, 1952); F & G, shell of F. cumberi (Powell), juvenile specimen from Goulard Downs, Nelson (traced from photographs); H & I, shell ? F. alpina Suter



Scale 0.5mm

Fig. 10. A, habit diagram of Flammoconcha albina n. sp., Cass River, Canterbury; B - E, terminal reproductive structures of F. albina, F. stewartensis Dell, F. cumberi (Powell) and Laoma sorenseni (Powell), respectively.



Scale 0.5 mm

Fig. 11. A - B, Flammoconcha laingi (Suter), Bluecliffs, Southland. A, reproductive system; B, dissected penis; C - D, terminal reproductive structures of Flammulina perdita (Hutton), from Pukeokaoka Island, Stewart Island and Farewell Spit, respectively; E, reproductive system of Flammoconcha olivacea (Suter), Mangamuka Gorge, Northland; **F - G, shell ?F. cornea (Hutton) (after Suter, 1915)**

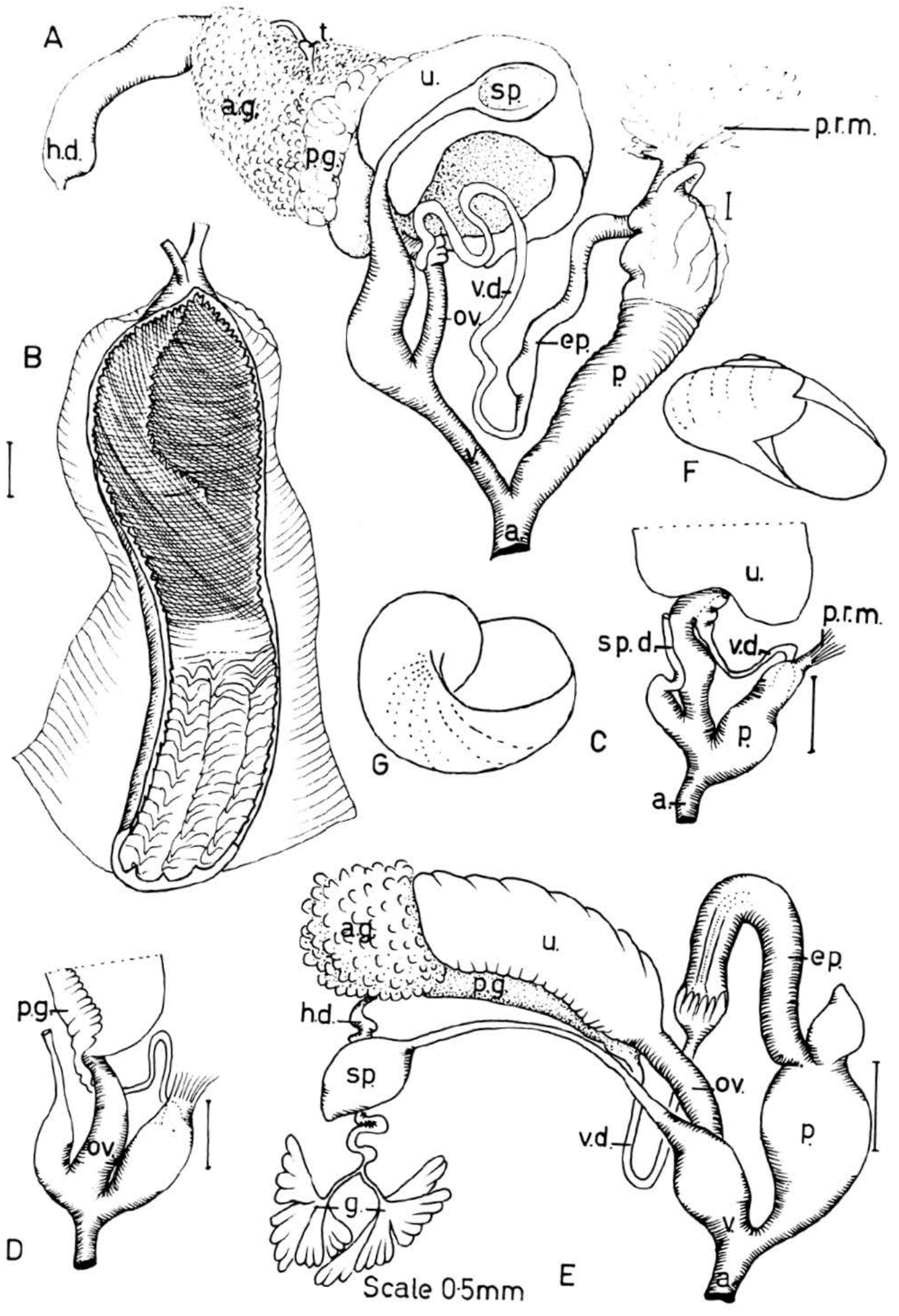


Fig. 12. A - B, showing the dimorphism in reproductive morphology in Protoflammulina johnsi n. gen. & n. sp., Snares Islands; C - E, Flammulina sp. n. sp., Ferny Gully, Halfmoon Bay, Stewart Island; C, microsculpture of shell; D, reproductive system; E, reconstructed diagram of shell from squashed specimen; **F, radula** ? F. alpina Suter (from Suter, 1891)

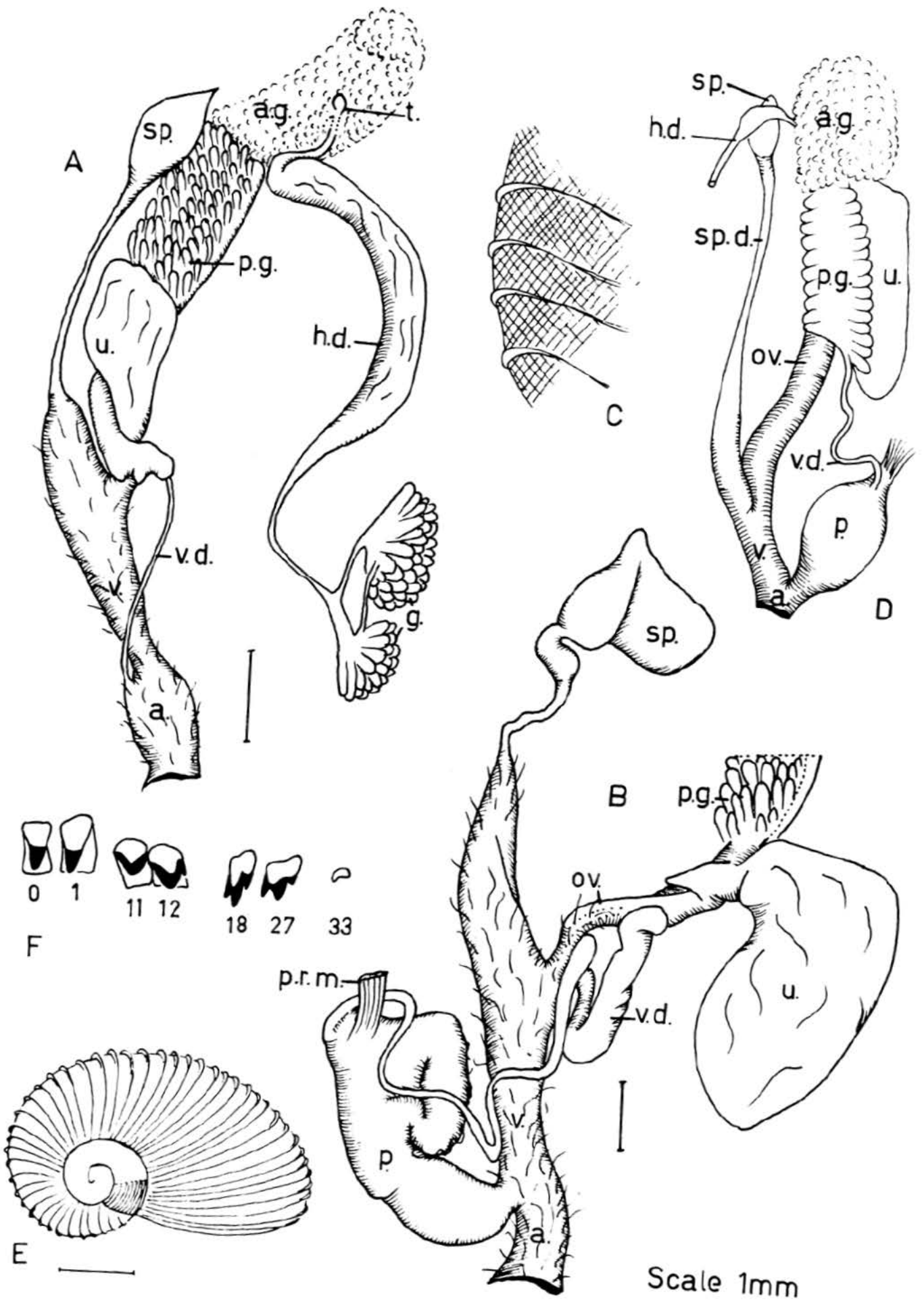
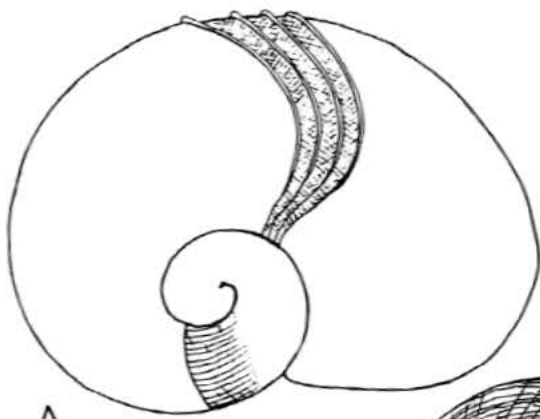
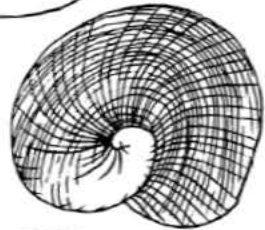


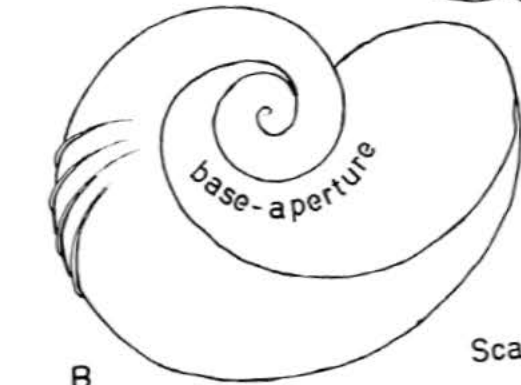
Fig. 13. A - B, shell of Flammoconcha marstoni n. sp.
Holotype, Mt Greenland, N. Westland;
C, protoconch of F. jacquenetta (Hutton);
D - E, terminal reproductive structures of
Flammulina crebriflammis (Pfeiffer) and
F. zebra (Le Guillou), respectively; F, habit
drawing of Flammoconcha cumberi (Powell),
Goulard Downs, Nelson.



A

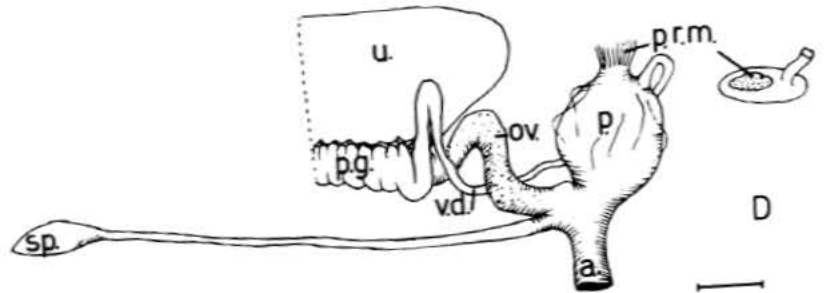


C

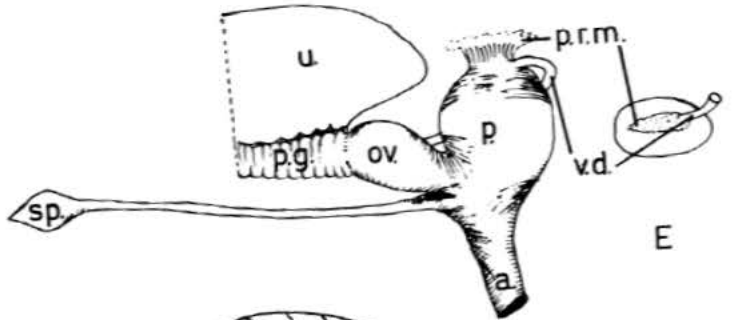


B

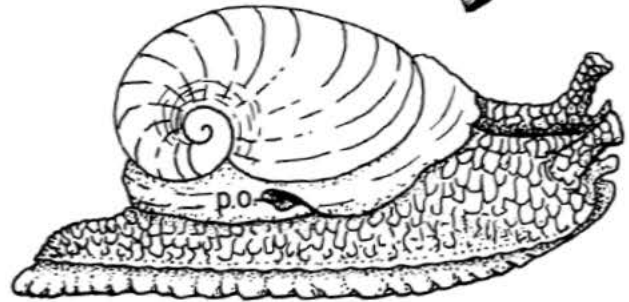
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D



E



F

Plate 1. A, Flammoconcha (Delloconcha) viridula n. sp.
Holotype. Arthur's Pass, Canterbury.
2.7 x 1.8 mm; B, F. (D.) feredayi (Suter),
Kowai Bush, Canterbury. 3.0 x 1.9 mm;
C, F. (D.) glacialis (Suter), Hooker Valley,
Canterbury. 3.3 x 1.9 mm; D, ?Flammulina
lateaperta Dell, Puysegur Point, Southland.
3.3 x 1.8 mm.



A



B



C



D

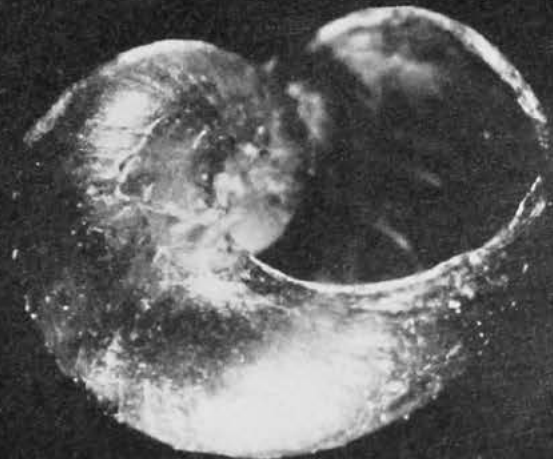


Plate 2. A, Flammoconcha (Delloconcha) jacquetta
(Hutton), Oparara, Nelson. 8.0 x 3.1 mm;
B, F. (D.) compressivoluta (Reeve),
Wainuiomata Hill, Wellington. 9.0 x 3.2 mm;
C, F. (D.) laingi (Suter), Bluecliffs,
Southland. 14.5 x 9.5 mm.



A



B



C



Plate 3. A, Flammulina perdita (Hutton), Farewell Spit, Nelson. 5.3 x 4.2 mm; B, Laoma sorenseni (Powell), Campbell Island. 2.7 x 1.2 mm; C, Flammoconcha (Delloconcha) olivacea (Suter), Kaima Range, Auckland. 4.8 x 3.2 mm.



A



B



C



Plate 4. Protoflammulina johnsi n. gen. & n. sp.

Paratype. Snares Islands. 9.3 x 4.2 mm.

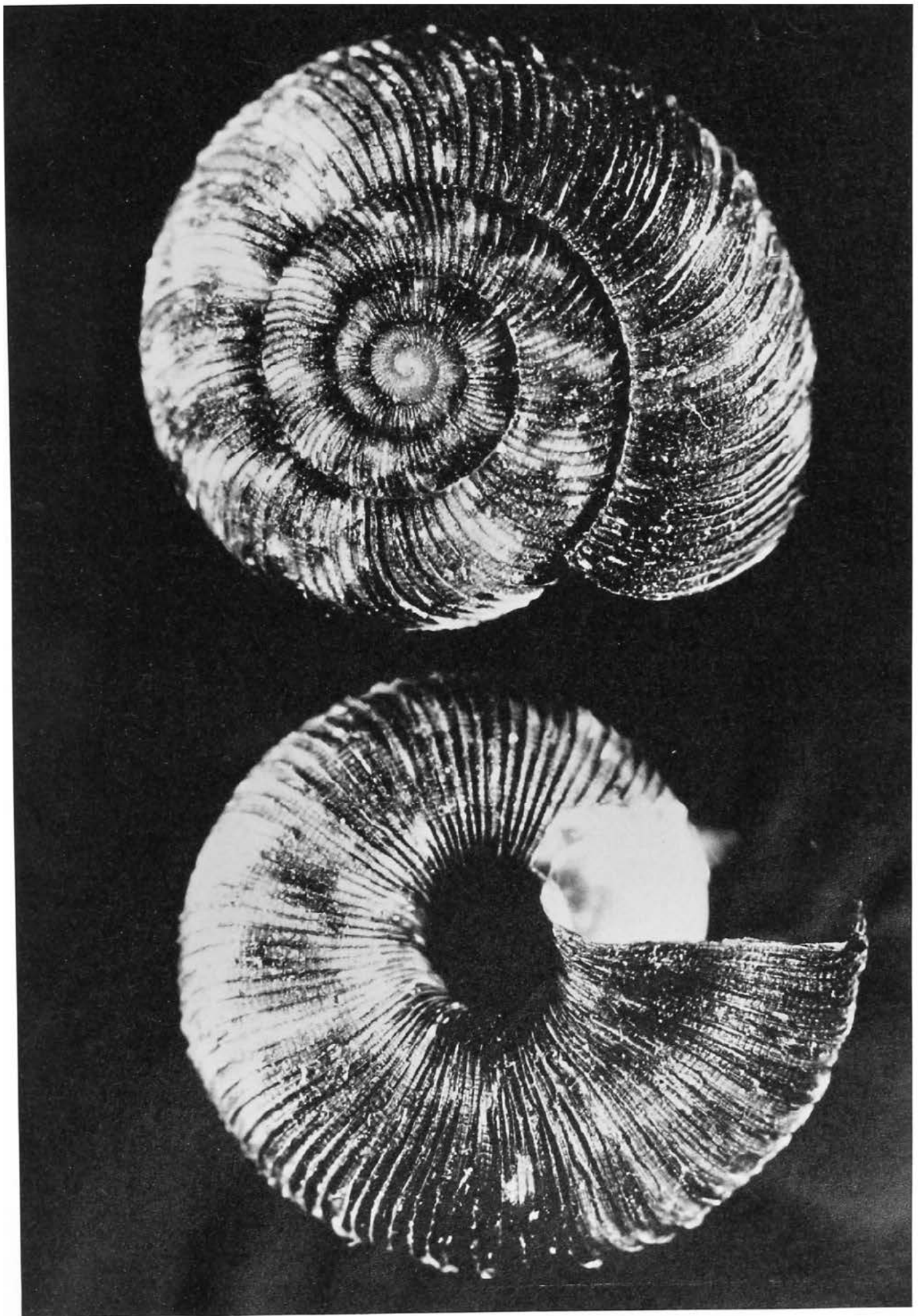


Plate 5. A, Flammulina chiron (Gray), Jackson Head,
S. Westland. 6.0 x 3.0 mm; B, F.
crebriflammis (Pfeiffer), Wairoa Gorge, Nelson.
5.5 x 3.5 mm; C, F. zebra (Le Guillou),
Dyer's Pass, Christchurch. 6.2 x 3.5 mm.



A



B



C

