shallower water, with the subsequent disappearance, may be due to pursuit of food, or perchance a new danger that assailed them. Whatever the cause, the shell is probably very rare in New Zealand, though the writer has seen a specimen from the collection of Mr. A. W. B. Powell, of Auckland, dredged in 25–30 fathoms in the Bay of Plenty, where the shell may perhaps be less rare. The species is easily distinguished from *C. labiata* (Perry), which it resembles in smoothness, by its widely open umbilicus; much larger, more inflated, and thinner test; total absence of keels and nodules, and presence of deep infrasutural spiral grooves; and total absence of denticles on the outer lip. From *C. pyra* (Lamk.), to which it is more nearly allied, it differs in its rather greater size and thinner shell; its regularly convex whorls, without nodules, its simpler spiral sculpture and total absence of basal grooves and crenulations of the outer lip; the higher spire (ratio height of spire to height of aperture in the four shells measured is ·31, ·37, ·39, ·42, while the maximum ratio observed in *C. pyra* is under $\frac{1}{3}$); characteristic colour, and the disposition of the canal, which is not cut back nearly so far nor so much recurved, is wider, and has its termination squarish instead of rounded.

The Family Liotiidae, Iredale, in the New Zealand Tertiary: Part 1, the Genus Brookula.

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Plate 53.

The shell recorded by Suter as *Lissospira corulum* (Hutt.) is a rather common fossil in the Castlecliff beds, and was originally described by Hutton (1884) as a Pliocene fossil from that locality under the name of *Scalaria corulum* (Hutt.). Subsequently it was discovered to be a still-living form, and was placed, together with another Recent minute shell, in the genus *Lissospira* (Suter, 1913), after a temporary classification in *Cyclostrema* (Suter, 1910). Iredale (1915) rejected these genera as inapplicable to Neozelanic shells, and placed Hutton's species in his genus *Brookula*, with genotype *B. stibarochila* Iredale from the Kermedec Islands (Iredale, 1912). *B. corulum* (Hutt.) is, however, not a typical member of this genus: the elevated spire and somewhat smooth base are abnormal. Iredale (1915) has also proposed the genus *Liotella* to contain such forms as Suter's *Liotia polypleura* Hedley, *L. rotula* Suter, and (?) *Cyclostremella neozelanica* Suter, and the exact difference between *Liotella* and *Brookula* is not very clear. The author at first hesitated to refer all the following species to *Brookula*, but after a discussion of the question with Mr. W. R. B. Oliver, of the Dominion Museum, that course was adopted, it being assumed that *Liotella* should be restricted to subdiscoidal forms.

Apart from *B. corulum* (Hutt.) no others of the genus have up till now been recorded from our Tertiary beds; six new species are here proposed. Specimens are often by no means uncommon in washings and sievings;

the most prolific localities found were Castlecliff, and especially Pukeuri, where four species occur.

Brookula fossilis n. sp. (Plate 53, figs. 4*a*, 4*b*, 4*c*.)

Description of Holotype.—Shell very small, turbinate, perforate, translucent, shining. Whorls 3¼, convex, periphery regularly rounded, ornamented with rather prominent and blunt axial ribs, a little unevenly spread and numbering 25 on body-whorl; they remain of same width over the whole whorl, but about half-way across rounded base begin to taper and gradually thin out into umbilicus, which they enter with uniform curve. Interstices only slightly wider than ribs, and show faint traces of spiral striation. Spire very slightly higher than aperture, outlines faintly convex, angle approximately 90°. Protoconch of 1 small globose whorl, distinctly separated from sculptured whorls. Suture deep. Aperture subcircular, very faintly angled above, peristome continuous, columella arcuate. Umbilicus not deep, about one-third width of aperture, only slightly encroached on by columella.

Height, 1 mm.; diameter, 1 mm.

Holotype and five paratypes, from Castlecliff, in author's collection.

Examples seen are very constant, but axials vary from 22 to 25, generally about 24, and interstices are sometimes wider than on holotype, exceptionally reaching 2½ times width of ribs. As far as can be seen from figure, the shell found in a dredging from 15′ S. of Big King Island, in 98 fathoms, and listed by Miss Mestayer (1916) as "*Brookula* sp.," is very close to, if not identical with, this species. This is not surprising, as so many of the Castlecliff shells also occur Recent. More and better specimens of the Recent shell may turn up some day and allow of actual comparison; till then it seems better to regard this species as also of Recent occurrence.

The only Castlecliff form with which this shell can be confused is a shell described later in this paper as *Brookula funiculata* n. sp. At first sight they are much alike, but careful scrutiny shows that *B. fossilis* has a higher spire with lower and more numerous ribs, which are not so evanescent on apical whorls, which in turn are not so discoidal and have a more globose protoconch. The faint circumumbilical keel and sudden change in ribs at this point, characteristic of *B. funiculata*, is wanting in *B. fossilis*.

B. fossilis is readily distinguished from the new species of *Brookula* from Pukeuri (described later) in being much smaller, and possessing much blunter less-prominent axials, and only faint traces of spirals.

Of Recent Neozelanic shells the nearest species is *B. corulum* (Hutt.), which differs in its more turbinate form, its spire being 1½ or more times height of aperture, angle about 50°; in its aperture being more oval, with inner lip encroaching much more on small chink-like umbilicus; and in its more inconspicuous sculpture, axials being much fainter and flatter, prominent only above periphery, after which they suddenly diminish and are so little prominent on base that it seems at first quite smooth; interstices vary from about half to a little more than width of ribs, and are crossed by fairly fine spirals, which, however, are much more prominent than in *B. fossilis*, and hence easily seen.

Brookula iredalei n. sp. (Plate 53, figs. 2*a*, 2*b*, 2*c*.)

Description of Holotype.—Shell minute, but fairly large for the genus, elevated turbinate, perforate, translucent, shining. Whorls 4, convex, periphery regularly rounded, ornamented with fine sharp and prominent

axial ribs, slightly sinuated, generally in three places, and retrocurrent towards umbilicus; there are 24 per whorl on holotype, 27, 25, 26 on others, interstices 2–3 times their width, delicately spirally striate, threads linear, with wide interstices; neither spirals nor axials decrease in prominence on base (as in *B. corulum* Hutt.), but fade gradually into umbilicus. Spire about same height as aperture, outline straight (angle about 70°), whorls 4 (1⅛ of which form the smooth, globose protoconch), convex, periphery and base regularly rounded. Suture deep. Aperture roundly ovate, bluntly angled above. Peristome and columella as in *B. corulum* (Hutt.). Umbilicus distinct, about one-sixth of minor diameter, chink-like, partly hidden by inner lip.

Height, 1·6 mm.; width, 1·5 mm.

Holotype and six paratypes, from Pukeuri, in the author's collection.

In spiral and axial sculpture no difference can be seen between this shell and *B. pukeuriensis* n. sp. (described below), but it is readily separated from it by its non-subdiscoidal upper whorls (*i.e.*, its spire-angle is constant and whorl-increase regular) and by its umbilicus, which is not round and open but more like that of *B. corulum* (Hutt.). The only other species *B. iredalei* resembles is *B. corulum* (Hutt.); but that shell is smaller, with lightly convex spire (angle about 45°), has much lower blunter and more inconspicuous axials, very much less prominent on base, interstices hardly wider than ribs; its spirals are much coarser and flatter, about half width of axials, separated by linear interstices; and its umbilicus is considerably narrower and less prominent.

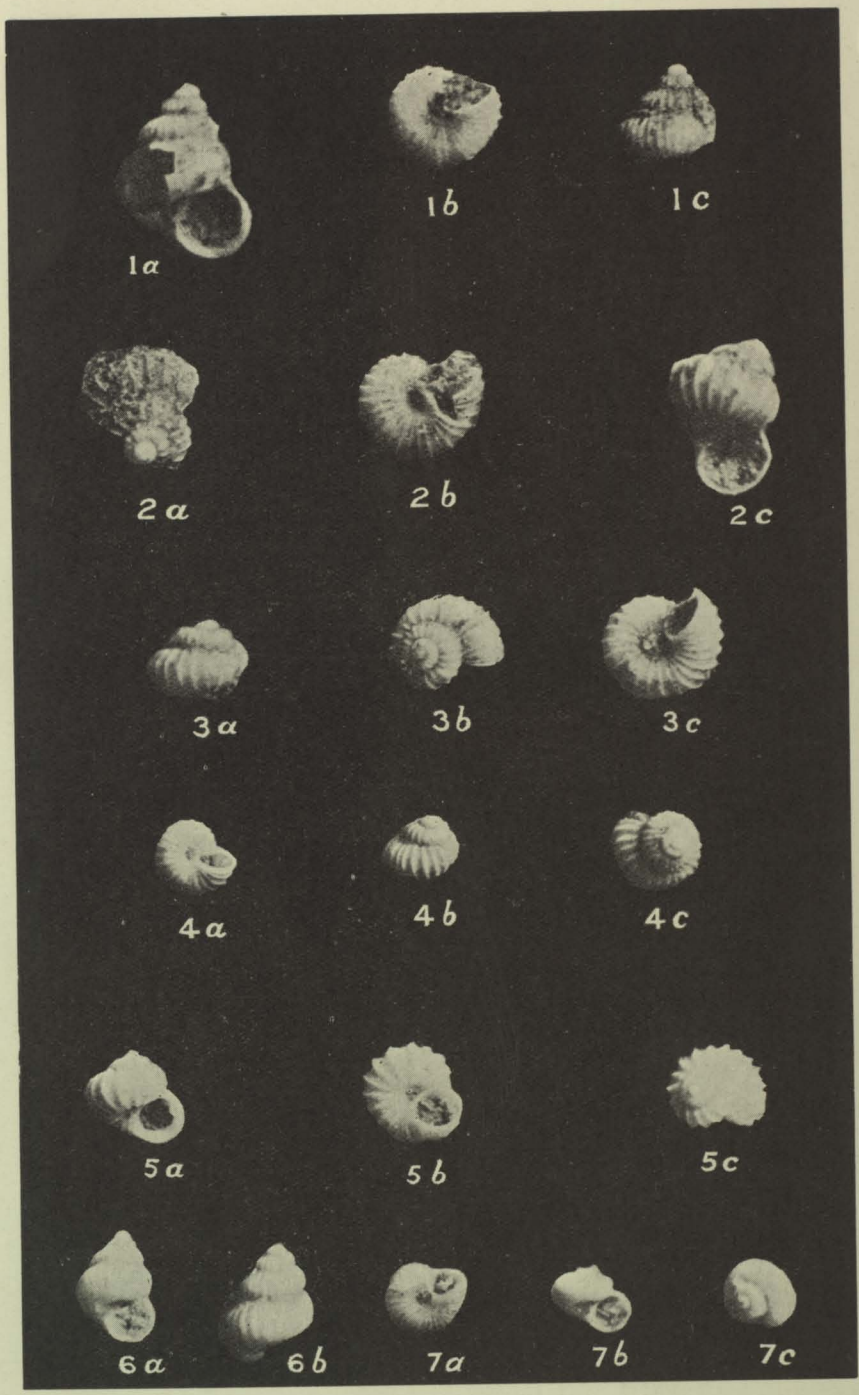
Brookula tenuilirata n. sp. (Plate 53, figs. 1*a*, 1*b*, 1*c*.)

Shell minute but rather large for the genus, elevated-turbinate, thin, perforate, translucent, shining. Axials 42 on the last whorl, the last 12 getting more and more crowded. Two other adult examples have respectively 43, with the last 15 crowded, and 41, with the last 12 crowded. Axials thin and sharp, very similar to those in *B. iredalei* n. sp. (v.s.), but lower, more crowded together, and generally less conspicuous. Exceedingly fine sharp linear spirals, with wide interstices crossing gaps between axials, which are considerably less prominent on base and taper off gradually to vanish in umbilicus; spire conical, almost twice height of aperture, outlines almost straight, angle about 50°. Protoconch of a little over 1 whorl—its nuclear volutions, however, are very obscure—smooth, globose, and fairly prominent, moderately well marked off from embryonic whorls. Whorls lowly convex, periphery and base rounded. Suture moderately impressed. Aperture almost circular, faintly angled above, peristome continuous, columella arcuate, very little expanded. Perforation a moderately deep chink, less than half the size of that in *B. iredalei* n. sp., considerably encroached on and hidden by the columella.

Height, 2 mm.; diameter, 1·5 mm.

Holotype and four paratypes, from Pukeuri, in the author's collection.

This shell differs from *B. iredalei* mainly in its taller spire, less convex outline of whorls, and greater number of axials. In some respects—*e.g.*, shape, convexity of whorls, prominence of sculpture, and size and shape of umbilicus—it stands between *B. iredalei* and *B. corulum* (Hutt.); especially reminiscent of the latter is the obsolescence of the axial sculpture on base. The spiral threads are rather more prominent than in *B. iredalei*, especially on base; they are also closer together on whorls, but wider apart on base than in *B. iredalei*.



FIGS 1*a*, 1*b*, 1*c*.—*Brookula tenuilirata* n. sp.
FIGS 2*a*, 2*b*, 2*c*.—*Brookula iredalei* n. sp.
FIGS. 3*a*, 3*b*, 3*c*.—*Brookula pukeuriensis* n. sp.
FIGS. 4*a*, 4*b*, 4*c*.—*Brookula fossilis* n. sp.
FIGS. 5*a*, 5*b*, 5*c*.—*Brookula funiculata* n. sp.
FIGS. 6*a*, 6*b*.—*Brookula corulum* Hutt.
FIGS. 7*a*, 7*b*, 7*c*.—*Brookula endodonta* n. sp.

All figs. × about 12.

Face p. 528.]

Brookula funiculata n. sp. (Plate 53, figs. 5*a*, 5*b*, 5*c*.)

Shell minute, thin but not very fragile, depressed-turbinate (same general outlines as *Liotella polypleura* (Hedley)), perforate, 20 axials on last whorl, the last five being much more crowded; they are thick and prominent, almost straight but sloping slightly backwards, a little sinuated on base; interstices of variable width, usually 1½–2 times width of ribs. They contain exceedingly fine and generally very faint spirals, low and rounded, only a small fraction of axials in width, interstices linear. The axials continue very prominent on base till about two-thirds across, when they suddenly diminish in width and height and turn in towards umbilicus, thus marking off the edge of a funicle surrounding umbilicus, and this edge, though often very indistinct, is never wholly wanting; it is most prominent on juvenile shells. The funicle is about one-third the major diameter, and at its bottom lies umbilical perforation, which is moderately deep and rather irregular in outline, markedly encroached on by inner lip; it is about one-quarter the width of funicle, and is distinctly lateral, there being a much longer funicular slope towards aperture than elsewhere. After about 1½ whorls from aperture axials very rapidly become obsolete, so that protoconch (1¼ smooth globular whorls) is only indistinctly marked off from following whorl. Spire approximately the same height as aperture, lightly convex, angle about 90° or more. Whorls 3¼, regularly increasing, not tightly wound, but not so loose as in *Liotella polypleura* (Hedley), body-whorl and base narrowly convex; upper whorls being raised, a view from above showing a strongly turbinate shape. Suture deep. Aperture almost free, subcircular, with faint rounded angulation above, peristome continuous, columella arcuate, not reflexed.

Holotype: Height, 0·8 mm.; length, 1 mm. Largest specimen: Height, 0·95 mm.; length, 1·2 mm.

Holotype and about forty paratypes, from Castlecliff, in the author's collection.

Axial ribs generally number 20, but sometimes fall to 17 or 18, due to non-development of crowded anterior ribs. Sometimes axials are thinner, so that interstices may be up to three times their width. This shell has much resemblance to some species of *Liotella;* it differs from *L. polypleura* (Hedley) in details of aperture, axial ribs, interstices, and umbilicus, and from *L. rotula* (Suter) in turbinate shape and different umbilicus. Also related to shell next described. The record of *L. polypleura* (Hedley) from Castlecliff beds possibly refers to this species. The author has examined a considerable number of Wanganui minutiae, and, though this *Brookula* is common (though only in occasional patches, especially in the matrix round corals), no specimens of true *Liotella* or *Liotina* have yet been found.

Brookula pukeuriensis n. sp. (Plate 53, figs. 3*a*, 3*b*, 3*c*.)

Shell minute, very thin and fragile, turbinate, perforate, 23 axials on last whorl in each of the three shells examined, prominent but thin and sharp, curved forward on periphery, slightly sinuate on base; interstices 3–4 times their width, with very fine and linear spirals, interstices again about 3–4 times their width. The spiral sculpture is much more conspicuous than in *B. funiculata*. Axials not obsolete on upper whorls but distinct and sharp directly after protoconch; they pass over base and thin out quite regularly on nearing umbilicus. Perforation semi-perspective, without surrounding funicle; its circular outline hardly interrupted by inner lip, central, and about one-quarter of major diameter. Spire about the same height as aperture, its angle a little less than 90°. Whorls 4,

(protoconch 1½, distinctly marked off); upper whorls rather discoidal, the shell appearing wheel-like from above. Suture deep. Aperture almost free, subcircular, peristome continuous, columella arcuate, not reflexed.

Height, 1·1 mm.; length, 1·35 mm.

Holotype and about thirty paratypes, from Pukeuri, in the author's collection. Also found at Ardgowan and Target Gully, but not nearly so plentiful.

In its depressed form this shell resembles *B. funiculata*, but is amply distinguished by its altogether more delicate appearance, absence of umbilical keel, and several other details. It may be noted that its whorls descend much more rapidly than in the Pliocene shell, so that although its protoconch is less raised above the encircling whorl the penultimate whorl is much more prominent than in *B. funiculata*. In this it closely accords with the type of the genus, *B. stibarochila* Iredale, and except for its much more delicate facies and more depressed form it is extremely like this species.

Brookula endodonta n. sp. (Plate 53, figs. *7a*, *7b*, *7c*.)

Shell minute, thin, depressed-turbinate, perforate. About 30 rounded axial ribs on last whorl, a little more crowded on earlier whorls, interstices equal to or slightly greater than ribs. Spirals exceedingly fine, subequal to interstices, more distinct than in *B. funiculata* but less so than in *B. pukeuriensis*. Axials ribs flattened down a little on base, and this, together with their greater number, gives base of this species a much smoother appearance than in *B. pukeuriensis;* but in other shell details—*e.g.*, umbilicus, aperture, suture—there is practically no difference between the two species. The spire is, however, rather lower, body-whorl more regularly rounded, and protoconch (1¼ whorls) slightly smaller.

Height, 0·7 mm.; length, 0·9 mm. Height, 0·9 mm.; length, 1·2 mm.

Types (two almost perfect juvenile shells) and six patatypes, from Target Gully, in the author's collection; also one specimen from Pukeuri. One fragment also from Clifden, Southland (horizon 6 of Park, 1921).

None of the adult shells are complete, but some of the juveniles are nearly perfect; practically all possess 30 axial ribs per whorl. The species is very close to *B. pukeuriensis*, differing mainly in its more depressed shape and greater number of axials, resulting in much closer and finer ribbing.

Of the species of *Brookula*, three (*B. fossilis*, *B. corulum*, and *B. funiculata*) seem to be restricted to the Pliocene, while of the four Miocene species only two have so far been found at more than one locality; the range of species seems therefore to be small, and they should prove of considerable use. The author regrets that he has had no opportunity of examining much shell-sand from horizons between the Awamoan and Castlecliffian; probably several more new forms would be found in such beds, as there is rather a wide evolutionary gap between the Pliocene and Miocene forms here described.

A rather curious point is that these Miocene species are more typical Brookulas than the three Pliocene forms. Although the name *Brookula* is used for all these species, they are easily divisible into two groups, one being typified by an elevated-turbinate shell with regular whorl-growth, constant spire-angle, and usually narrow umbilicus, and the other by a depressed-turbinate shell with subdiscoidal early whorls, leading to a continued decrease in spire-angle with growth, and a rather wide and prominent umbilicus.

The type of the genus, *B. stibarochila* Iredale, though rather elevated, evidently belongs to the second group. Mr. W. R. B. Oliver kindly presented the author with an authentic specimen of the type species, and an examination of this shows that, of the shells mentioned in this paper, the nearest to the type is *B. pukeuriensis*. This, however, is easily distinguished by its more fragile test, much more delicate and more numerous ribs, and more depressed shape. *B. stibarochila* Iredale has a variable number of coarse, prominent, rounded ribs (15 on the last whorl of the type, 19 in the author's specimen. Oliver (1914) remarks that "specimens vary considerably in the number of ribs; the type has them wide apart"), but its base is regularly convex, the ribs thinning down gradually into the deep, narrowly circular perforation. The author here proposes the new subgeneric name *Aequispirella* to cover the forms of the first group, naming as type *Scalaria corulum* Hutt.

Subgenus AEQUISPIRELLA n. subgen.

Shell minute, similar to *Brookula* s. str. except that early whorls are not depressed—*i.e.*, protoconch is prominent and raised instead of inconspicuous and discoidal. This imparts to spire the shape of a cone instead of a dome, and leads to much more regular whorl-growth than in *Brookula* s. str.; shell generally more elevated. Umbilicus generally much narrower and less prominent than in the strict forms, being often chink-like, and the axial sculpture sometimes becomes obsolete on base.

Type: *Scalaria corulum* Hutt. (Plate 53, figs. 6*a*, 6*b*.)

KEY TO SPECIES.

Shell depressed-turbinate (*Brookula* s. str.).
- Shell fairly strong, with a subobsolete umbilical keel, 20 axials per whorl .. .. *B. funiculata.*
- Shell fragile, with no umbilical keel.
  - About 23 thin and sharp axials on last whorl, interstices 3–4 times their width .. .. .. *B. pukeuriensis.*
  - About 30 rounded axials on last whorl, subequal to their interstices .. .. *B. endodonta.*

Shell elevated-turbinate (*Aequispirella*).
- Axial ribs considerably diminished in prominence on base.
  - Over 40 axials on last whorl .. .. .. *B. tenuilirata.*
  - Under 30 axials on last whorl .. .. .. *B. corulum.*
- Axial ribs not diminished in prominence on base.
  - Axials thin and sharp, spirals generally distinct .. *B. iredalei.*
  - Axials rather blunt; spirals very faint .. .. *B. fossilis.*

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