

LATE ORDOVICIAN SOLITARY RUGOSE CORALS
OF THE BEAVERFOOT FORMATION, SOUTHERN ROCKY MOUNTAINS,
BRITISH COLUMBIA AND ALBERTA.

Caroline J. Knapp

A thesis
presented to the University of Manitoba
in partial fulfillment of the
requirements for the degree of
Master of Science
in
Department of Earth Sciences

Winnipeg, Manitoba 1985

LATE ORDOVICIAN SOLITARY RUGOSE CORALS OF THE BEAVERFOOT FORMATION,
SOUTHERN ROCKY MOUNTAINS, BRITISH COLUMBIA AND ALBERTA

BY

CAROLINE J. KNAPP

A thesis submitted to the Faculty of Graduate Studies of
the University of Manitoba in partial fulfillment of the requirements
of the degree of

MASTER OF SCIENCE

✓ © 1985

Permission has been granted to the LIBRARY OF THE UNIVER-
SITY OF MANITOBA to lend or sell copies of this thesis, to
the NATIONAL LIBRARY OF CANADA to microfilm this
thesis and to lend or sell copies of the film, and UNIVERSITY
MICROFILMS to publish an abstract of this thesis.

The author reserves other publication rights, and neither the
thesis nor extensive extracts from it may be printed or other-
wise reproduced without the author's written permission.

Contents

Abstract	1
Introduction	3
Abbreviations	3
Explanation of figures	4
General geology	7
History of stratigraphic nomenclature	7
Lithostratigraphy	9
Biostratigraphy	11
Depositional environments	13
Solitary rugose corals	14
Previous work	14
Present material	15
Preservation	15
Identification and relative abundance of taxa	22
Geographic and stratigraphic distribution	24
Taphonomy and paleoecology	26
Abrasion	26
Attachment structures	28
Orientation	30
Paleoecologic associations	34
Paleoenvironments and paleobathymetry	36
Close biotic associates	38
Objects within coralla	38
Epizoans and borings	40
Distribution and evolution	42

<u>Salvadorea</u>	42
<u>Bighornia</u>	44
<u>Grewingkia</u>	46
<u>Deiracorallium</u>	48
Paleobiogeography	49
Biostratigraphy	51
Systematic paleontology	54
Genus <u>Salvadorea</u> Nelson, 1981	54
<u>S. distincta distincta</u> (Wilson, 1926)	55
<u>Salvadorea</u> sp. 2 of Nelson, 1981	68
Genus <u>Bighornia</u> Duncan, 1957	70
<u>B. patella</u> (Wilson, 1926)	75
<u>B. wilsonae</u> Knapp and Elias, n. sp.	89
<u>B. sp. cf. B. bottei</u> Nelson, 1963	92
Genus <u>Grewingkia</u> Dybowski, 1873	95
<u>G. haysii haysii</u> (Meek, 1865)	95
Genus <u>Deiracorallium</u> Nelson, 1963	109
<u>D. prolongatum</u> (Wilson, 1926)	109
Acknowledgments	119
References cited	120
Appendix 1. Distribution and frequency of corals	129
Appendix 2. Identification of specimens	136
Appendix 3. Biometric data	152
Appendix 4. Additional data on <u>S. distincta distincta</u>	167
Appendix 5. Length of cardinal septum	169

Table

1. Features of solitary corals	27
--------------------------------------	----

Figures

1. Geologic map of southern Rocky Mountains	5
2. Topographic map showing localities <u>N12</u> , <u>K12A</u> , <u>K12B</u>	16
3. Photograph of localities <u>K12A</u> , <u>K12B</u>	18
4. Stratigraphic section, localities <u>K12A</u> , <u>K12B</u>	20
5. <u>G. haysii haysii</u> and <u>S. distincta distincta</u>	32
6. <u>S. distincta distincta</u> and <u>Salvadorea</u> sp. 2	64
7. Number of major septa in <u>S. distincta distincta</u> and <u>Salvadorea</u> sp. 2	66
8. Coral height and cross-sectional dimension in <u>Bighornia</u> ...	73
9. <u>B. patella</u> , <u>B. wilsonae</u> , and <u>B. sp. cf. B. bottei</u>	83
10. Cross-sectional dimensions in <u>Bighornia</u>	85
11. Number of major septa in <u>Bighornia</u>	87
12. <u>G. haysii haysii</u>	103
13. Cross-sectional dimensions in <u>Grewingkia</u> and <u>Deiracorallium</u>	105
14. Number of major septa in <u>G. haysii haysii</u>	107
15. <u>D. prolongatum</u>	115
16. Number of major septa in <u>D. prolongatum</u>	117

Late Ordovician solitary rugose corals
of the Beaverfoot Formation, southern Rocky Mountains,
British Columbia and Alberta

Caroline J. Knapp

Department of Earth Sciences, University of Manitoba,
Winnipeg, Man., Canada R3T 2N2

The following Late Ordovician solitary Rugosa are present within the Beaverfoot Formation (Upper Ordovician-Lower Silurian) in the southern Rocky Mountains of British Columbia and Alberta: Salvadorea distincta distincta (Wilson, 1926), Bighornia patella (Wilson, 1926), B. sp. cf. B. bottei Nelson, 1963, Grewingkia haysii haysii (Meek, 1865), Deiracorallium prolongatum (Wilson, 1926), and Salvadorea sp. 2 of Nelson, 1981. Corals of this Salvadorea-dominated assemblage are most common and widespread in the lower part of the Beaverfoot above the basal Whiskey Trail Member.

Analyses of coral abrasion, curvature, and life orientation suggest that G. haysii haysii inhabited higher energy environments than S. distincta distincta and B. patella. All taxa probably lived in close proximity, and the coralla were transported during severe storms. The presence of solitary corals in particular intervals within the Beaverfoot Formation could indicate shallow water maxima and/or relatively open, normal marine conditions.

The area of Beaverfoot sedimentation was situated within the Red River-Stony Mountain Solitary Coral Province, which occupied most of North America during Late Ordovician time. The six species in this

formation comprise an "epicontinental" assemblage, and all occur in the Hudson Bay Basin. The absence of "continental margin" taxa could reflect environmental factors or geographic barriers, or could indicate that the Beaverfoot Formation was deposited some distance from the edge of the continent.

The base of the Bighornia-Thaerodonta zone in the Beaverfoot Formation is herein placed at the lowest occurrence of solitary corals within the Whiskey Trail Member. Elsewhere, this Salvadorea-dominated assemblage first appears in Maysvillian to middle Richmondian strata. The Bighornia-Thaerodonta zone is extended upward to include coral-bearing beds thought to be near the Ordovician-Silurian boundary. The uppermost portion may be Gamachian.

No evolutionary changes are recognized in solitary rugosan species within the Beaverfoot Formation. B. wilsonae Knapp and Elias, n. sp., the ancestor of B. patella, is known from the Second Value Dolomite of the Montoya Group in New Mexico and Texas, and the Selkirk Member of the Red River Formation in southern Manitoba.

Introduction

The Beaverfoot Formation of Late Ordovician to Early Silurian age is exposed in the southern Rocky Mountains of British Columbia and Alberta (Fig. 1). Within this area, the original depositional strike as well as trends of thrust sheets, mountain ranges, and outcrops are all approximately parallel in a northwest-southeast direction. The formation represents predominantly carbonate deposition on a broad platform along the early Paleozoic continental margin of western North America. Various faunal zones have been recognized within the Beaverfoot, but the only descriptive paleontological work was by Wilson (1926).

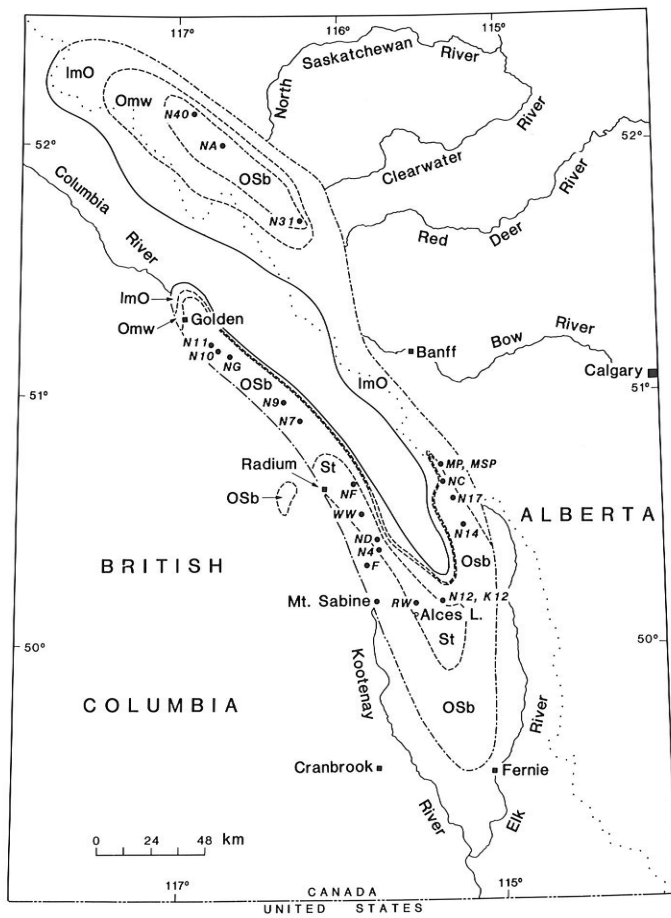
The purposes of this study are to describe, using modern techniques, the Late Ordovician solitary Rugosa of the Beaverfoot Formation, to document their stratigraphic and geographic distributions, and provide paleoecologic interpretations. The evolutionary, paleobiogeographic, and biostratigraphic significance of these fossils is considered using comparisons with corals described from elsewhere in North America (Nelson, 1963, 1981; Elias, 1981, 1982a, 1983a, 1983b, 1985; Elias and Potter, 1984), and a chronostratigraphic framework based primarily on conodont data (Sweet, 1979; McCracken and Barnes, 1981; Elias, 1985).

Abbreviations—GSC (Geological Survey of Canada, Ottawa, Ontario), MMH (Museum mineralogicum hafniensis, Geologisk Museum, Copenhagen, Denmark), PMO (Paleontologisk Museum, Oslo, Norway), USNM (National Museum of Natural History, Smithsonian Institution, Washington, D.C.).

Explanation of figures—For photographs of coral exteriors, specimens were coated with ammonium chloride. All transverse and longitudinal sections were prepared using thin sections as negatives in a photographic enlarger. Transverse sections are oriented as they appear looking down from the calice toward the tip of the coral, with the cardinal side facing the bottom of the page. All longitudinal sections are oriented with the calice facing the top of the page.

Figure 1. Geologic map of part of the southern Rocky Mountains (from Norford, 1969, fig. 6). Late Ordovician solitary rugose corals from the Beaverfoot Formation were collected at the localities named below.

Dashed line	geologic boundary
Short dash-dot line	feather edge of stratigraphic interval beneath sub-Devonian unconformity
Long dash-dot line	structural discontinuity along Rocky Mountain Trench
Solid line	truncation due to recent erosion
St	Tegart Formation (Silurian)
OSb	Beaverfoot Formation (Upper Ordovician to Lower Silurian)
Omw	Mount Wilson Quartzite (Middle to Upper Ordovician)
lmO	upper Lower to Middle Ordovician (Owen Creek Formation, Skoki Formation, Tipperary Quartzite, Glenogle Shales, upper part of Outram Formation)
<u>MP</u>	Palliser Pass
<u>WW</u>	Windermere Creek
<u>MSP</u>	between Spray River and Palliser Pass
<u>F</u>	Fairmont Springs
<u>RW</u>	White Knight Mountain
<u>NA</u>	Mount Wilson
<u>NC</u>	Tipperary Pass
<u>ND</u>	Pedley Pass
<u>NE</u>	Mount Sinclair
<u>NG</u>	Carbonate Creek
<u>N⁴</u>	Indianhead Mountain
<u>N7</u>	Pinnacle Creek
<u>N9</u>	Hatch Creek
<u>N10</u>	Pagliari Creek
<u>N11</u>	Horse Creek
<u>N12</u>	Blackfoot Creek
<u>N14</u>	Shatch Mountain
<u>N17</u>	Mount Onslow
<u>N31</u>	Pipestone River
<u>N40</u>	Cirrus Mountain
<u>K12</u>	Akutlak Creek



General geology

History of stratigraphic nomenclature—Strata in the Beaverfoot Range of southwestern British Columbia were first studied by McConnell (1887). He identified a sequence of quartzites succeeded by dolomites as the "Halysites beds," and assigned it to the Silurian. Burling (1922, p. 452) proposed the name Beaverfoot Formation for the "Halysites beds," and considered it to be Late Ordovician (Richmondian) in age. The type section is at Carbonate Creek. The quartzite interval was separated from the Beaverfoot and named Wonah Quartzite by Walcott (1924, p. 48-50). He also proposed the term Brisco Formation for a Silurian dolomitic and argillaceous unit above the Beaverfoot (Walcott, 1924, p. 47, 48). The type sections of his units are at Mount Sinclair in the Brisco Range. Later workers could not differentiate the Beaverfoot and Brisco on lithologic grounds, and used the term Beaverfoot-Brisco Formation (references cited in Norford, 1969, p. 5).

Based on work in the southern Rocky Mountains of Alberta, Walcott (1923, p. 464, 465; 1928, p. 208-210) proposed the term Mount Wilson Quartzite for a unit that he tentatively assigned to the Devonian. The type section is at Mount Wilson. Severson (1950, p. 1838, 1839) recognized the "Halysites beds" above the Mount Wilson Quartzite. These units were considered Silurian and Ordovician, respectively. The "Halysites beds" were demonstrated to be Late Ordovician by Harker, Hutchinson, and McLaren (1954, p. 52) and, specifically, Richmondian by Bolton (in Leech, 1954, p. 24). They were assigned to the Beaverfoot-Brisco Formation by Norford (1961).

Norford (1969, p. 28) confirmed the suggestion of North and Henderson (1954, p. 68) that the term Wonah Quartzite is a junior synonym of Mount Wilson Quartzite, and the former name is now obsolete.

Norford (1962a, p. 446) subdivided the Beaverfoot-Brisco Formation of British Columbia into lower and upper members. The lower member comprised the main mass of resistant dolostone and limestone, including the Beaverfoot and Brisco of Walcott plus younger strata that are absent at Mount Sinclair. The recessive upper member included argillaceous limestones and shales. In a later overall synthesis, Norford (1969, p. 28) considered strata of the type Brisco to be part of the Beaverfoot Formation, and proposed Pedley Pass as a standard section for the formation. Norford (1969, p. 32) erected the Tegart Formation for a Silurian unit previously distinguished as the upper member of the Beaverfoot-Brisco Formation. The latter term was abandoned. The name Whiskey Trail Member was proposed by Norford (1969, p. 29) for a recessive, arenaceous and dolomitic interval at the base of the Beaverfoot Formation. The type section of this member is at Carbonate Creek.

Lithostratigraphy—The thickness of the Beaverfoot Formation at Pedley Pass, where it is overlain by the Tegart Formation, is 506.3 m (1661 ft.). The thickness is 17.1 m (56 ft.) at Tipperary Lake, where it is overlain by Devonian rocks. The Beaverfoot thins from west to east in the southern Rocky Mountains (Norford, 1969, figs. 13, 14).

At the type section (Carbonate Creek), the contact of the Beaverfoot Formation with the underlying Middle to Upper Ordovician Mount Wilson Quartzite is not visible, but is apparently concordant (Norford, 1969, p. 28). The contact at Pedley Pass is irregular but concordant, as it is throughout most of the southern Rockies. At Pinnacle Creek, shallow erosional surfaces are present between the Beaverfoot and Mount Wilson. In the south and southeast, the Beaverfoot overlaps the Mount Wilson to rest on older Ordovician and Cambrian rocks.

The Whiskey Trail Member at the base of the Beaverfoot Formation is of variable thickness. It is 28.3 m (93 ft.) thick at Carbonate Creek, but only 2.1 m (7 ft.) thick at Tipperary Lake. The Whiskey Trail is not present where the main part of the Beaverfoot overlaps the Mount Wilson Quartzite. Its distribution pattern more closely resembles that of the Mount Wilson than that of the main Beaverfoot (Norford, 1969, p. 32). The Whiskey Trail Member is composed of dolomitic quartz sandstones with minor and typically thin bedded quartzite layers, arenaceous and argillaceous dolomites, dolomites with echinoderm debris, and olive-grey mudstones (Norford, 1969, p. 30). The contact with the main part of the Beaverfoot Formation is regionally disconformable.

The main part of the Beaverfoot is composed of medium and thickly bedded, resistant dolomites that weather in colours ranging from pale yellowish brown to light grey and olive (Norford, 1969, p. 29). The dolomites are composed of silt-sized grains to finely crystalline mosaics. Some beds contain siliceous material and rarely quartz silt. At Pedley Pass and near Blackfoot Creek, limestones and dolomitic limestones are preserved. The limestones are aphanitic and weather light grey. The Silurian Tegart Formation conformably overlies the Beaverfoot Formation in the southwestern part of the southern Rocky Mountains (Norford, 1969, p. 32, 33). Elsewhere it is absent, and Devonian rocks rest disconformably or paraconformably on the Beaverfoot.

Biostratigraphy—Norford (1969, p. 38) identified a "conodont zone" comprising the uppermost bed of the Mount Wilson Quartzite and the overlying Whiskey Trail Member of the Beaverfoot Formation. He stated that the megafauna in this zone seemed to be distinct from that in strata immediately above (Norford, 1969, p. 30, 31).

In the main part of the Beaverfoot Formation, Norford (1962a, p. 449, fig. 2) recognized the following four shelly assemblage zones, listed in ascending stratigraphic order:

Bighornia-Thaerodonta zone, Eostropheodonta zone, Pentamerus zone, and Eophacops-Cheirurus zone. The first two are separated by a "poorly fossiliferous interval." The Bighornia-Thaerodonta zone at Mount Sinclair comprises 55 m (180 ft.) of the Beaverfoot Formation immediately above the Whiskey Trail Member (Norford, 1969, p. 38). The characteristic taxa are Bighornia patella and Thaerodonta aff. T. saxea. The associated fauna was listed by Norford (1969, p. 38, 39), who considered the age to be Late Ordovician. Barnes, Jackson, and Norford (1976, fig. 5) have integrated the Bighornia-Thaerodonta zone with others based on graptolites and conodonts.

Norford (1969, p. 39) recognized a thick, "poorly fossiliferous interval" of the Beaverfoot Formation that separates the Bighornia-Thaerodonta zone from the Eostropheodonta zone. It is 304.8 m (1000 ft.) thick at Pedley Pass and 243.8 m (800 ft.) thick at Mount Sinclair. Uyeno (in Norford, 1969, p. 39) identified two conodont faunules from this interval at Mount Sinclair. Faunule A is from a horizon 38.7 m (127 ft.) above the upper limit of the Bighornia-Thaerodonta zone. Uyeno considered it to be of Ordovician

age. Faunule B, from an interval 136.2-163.6 m (447-537 ft.) above the Bighornia-Thaerodonta zone, could be Ordovician or Silurian, with two genera more typical of the latter.

Macrofossils in the Eostropheodonta zone suggest an early to middle Llandovery age (Norford, 1969, p. 39). This assemblage occurs 335.3-419.1 m (1100-1375 ft.) above the base of the formation at Pedley Pass, and from 304.8 m (1000 ft.) above the base at Mount Sinclair to the faulted top at 395.6 m (1298 ft.) (Norford, 1962a, p. 450).

The Pentamerus zone is found in sections of the Beaverfoot located 32 km (20 mi.) southeast and 19 km (12 mi.) northwest of Alces Lake (Norford, 1962a, p. 451). A late Llandovery age is indicated by the presence of Pentamerus and Cystihalysites (Norford, 1969, p. 40).

The Eophacops-Cheirurus zone includes the uppermost beds of the Beaverfoot Formation and most if not all of the Tegart Formation. An incursion of graptolites representing the Monograptus spiralis zone indicates a late Llandovery age (Norford, 1969, p. 40).

Depositional environments—Early Paleozoic sediments preserved in the southern Rocky Mountains of British Columbia and Alberta accumulated along a passive continental margin. The Whiskey Trail Member of the Beaverfoot Formation was probably deposited during a marine transgression across a surface that was mantled by detritus of the Mount Wilson Quartzite (Norford, pers. commun., 1984). The variable thickness could reflect the presence of local pockets of debris, or topographic irregularities. An alternative hypothesis is that the Whiskey Trail represents a continuation of the Mount Wilson transgressive phase, with deposition in deeper water conditions.

Little is known about environments in which the main part of the Beaverfoot Formation was deposited. During Late Ordovician and most of Early Silurian time, a broad belt of shelf-type carbonate sediments extended beyond the limits of the Mount Wilson Quartzite and probably covered the entire area now preserved in the southern Rocky Mountains (Norford, 1969, p. 42).

The early Paleozoic continental margin of western North America underwent extensive tectonic compression during the formation of the Rocky Mountains. North and Henderson (1954, p. 78) estimated crustal shortening of about 161 km (100 mi.), including the Rocky Mountain Trench and foothills, at the approximate latitude of Banff, Alberta.

Solitary rugose corals

Previous work—Kirk (in Walcott, 1924, p. 13) identified the solitary rugose coral Streptelasma rusticum in a faunal collection from the Beaverfoot Formation, obtained 1.6 km (1 mi.) west of Mount Sinclair. Streptelasma trilobatum was also listed, apparently from the Beaverfoot. Walcott (1924, p. 26) recorded a similar fauna at Mount Sabine.

Solitary corals of the Beaverfoot Formation were described in detail by Wilson (1926, p. 11-13) on the basis of collections made by J.R. Marshall, E.M. Kindle, J.F. Walker, and L.D. Burling for the Geological Survey of Canada. Wilson assigned these corals to four new species, as follows: Streptelasma fragile, S. prolongatum, S. distinctum, and S. patellum. They were considered to be of Richmondian age (Wilson, 1926, p. 2). Kirk (1927, p. 287), in a review of Wilson's paper, stated that S. fragile was from Silurian strata.

Bolton (in Leech, 1954, p. 20-23) identified Streptelasma sp., S. prolongatum, S. distinctum, and S. trilobatum from beds in the lower part of the Beaverfoot Formation at White Knight Peak (refer to Fig. 1) and other localities in that vicinity.

Norford (1969, p. 30, 31) reported solitary corals from the Whiskey Trail Member of the Beaverfoot Formation. These occur in the upper part of his "conodont zone." Corals are not known from the underlying Mount Wilson Quartzite (Norford, 1969, p. 26). Norford (1962a, p. 449) noted that most of Wilson's specimens were from the Bighornia-Thaerodonta zone. He recognized Bighornia cf. B. parva, Grewingkia sp., Lobocorallium prolongatum, and Streptelasma sp. (Norford, 1969, p. 38). Norford (1962a, p. 449; 1969, p. 39) found solitary corals, identified as Streptelasma sp., in the "poorly fossiliferous" interval above this zone. S. fragile and

Streptelasma sp. were listed from the Eostropheodonta zone, and solitary corals referred to as Streptelasma sp. were reported in the Pentamerus zone (Norford, 1962a, p. 450, 451; 1969, p. 39).

Present material—A total of 417 solitary rugose corals from 21 localities in the southern Rocky Mountains of British Columbia and Alberta were examined during this study (Appendix 1, Fig. 1). All are from the Late Ordovician portion of the Beaverfoot Formation. Material was obtained from the following sources: (1) 14 specimens from the early collections described by Wilson (1926), (2) 5 specimens from the collection of Root (1955), (3) 230 specimens collected by Norford, and (4) the present collection. The latter consists of 168 specimens recovered from the basal 128 m (420 ft.) of the Beaverfoot Formation above Akutlak Creek, British Columbia, in August of 1984 (Fig. 2). This locality was selected for detailed study because the Beaverfoot is not dolomitized, is relatively fossiliferous, and the fossils are comparatively well preserved. The strata are nearly vertical (Fig. 3). The lower 35 m (114.8 ft.) of section were measured along the ridge crest, and an additional 93 m (305.1 ft.) were measured along the base of the ridge. The continuous exposure was carefully examined for solitary corals, and all specimens seen were collected. Therefore, the data in Fig. 4 provide an indication of relative abundance.

Preservation—Specimens from most localities are silicified and in poor condition. The best material is from sections in the vicinity of Akutlak Creek, where some of the original calcite and fibrous microstructure are preserved in many coralla.

Figure 2. Topographic map (from National Topographic System, 1:50,000 series, map 82J/3, edition 2, Mount Peck, British Columbia), showing localities N12, K12A, and K12B. Contour interval 1000 ft. (305 m). Location of Mount Wilson Quartzite (Omw) from Norford (pers. commun., 1984).

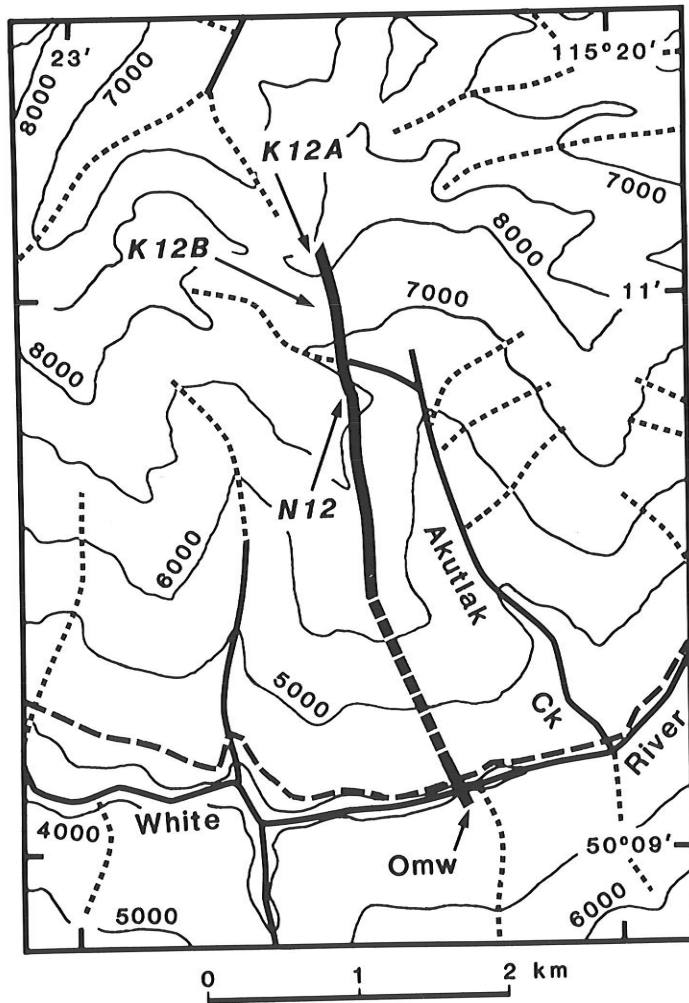


Figure 3. Akutlak Creek locality viewed from south showing lines of section K12A and K12B (dotted). Omw = Mount Wilson Quartzite, OSb = Beaverfoot Formation, w = Whiskey Trail Member of Beaverfoot. Refer to Figs. 1 and 2 for location.

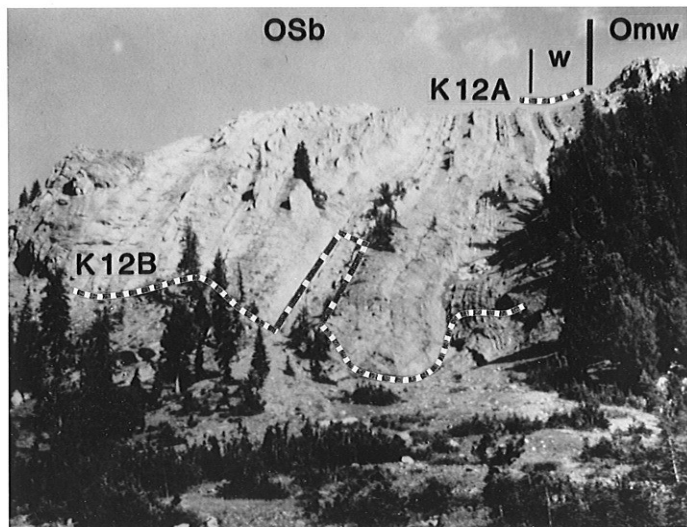
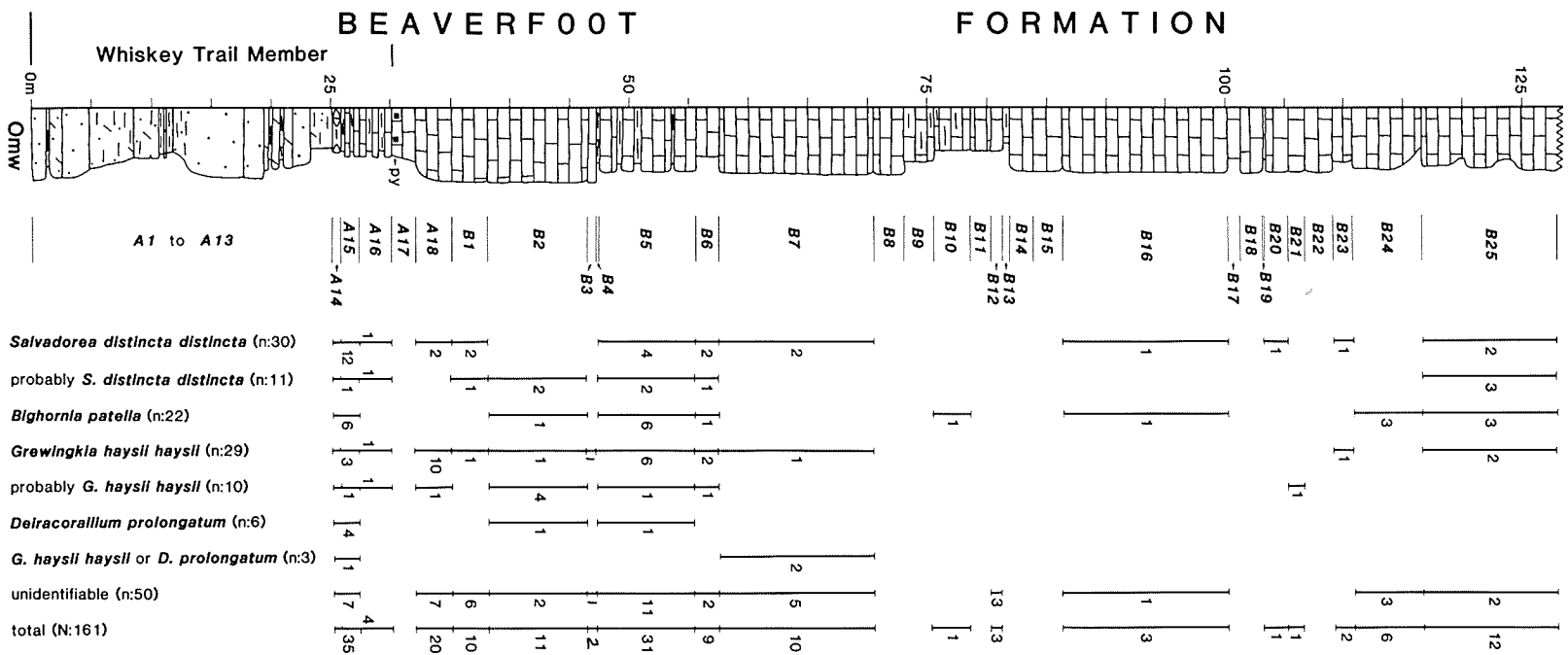


Figure 4. Stratigraphic section at Akutlak Creek locality (K12A, B), showing intervals bearing solitary rugose corals plus distribution and frequency of taxa. Lithologies are indicated by standard symbols, py = pyrite. Refer to Figs. 1-3 for location.



Identification and relative abundance of taxa—Late Ordovician

solitary rugose corals of the Beaverfoot Formation can be divided into the following three groups on the basis of external form: (1) typically trochoid, (2) subcalceoloid, and (3) triangulate to trilobate. On the basis of ontogeny and internal structures, virtually all of the typically trochoid specimens having approximately circular cross sections are assigned to Salvadorea distincta distincta (Wilson, 1926) (Fig. 6A-Q). One corallum with unusually thin septa is identified as Salvadorea sp. 2 of Nelson, 1981 (Fig. 6R-U). The subcalceoloid, depressed corals have a concave cardinal side. Small to medium-sized individuals are Bighornia patella (Wilson, 1926) (Fig. 9A-R). Two large coralla are identified as B. sp. cf. B. bottei Nelson, 1963 (Fig. 9W-BB). Two subgroups of specimens having triangulate to trilobate cross sections can be recognized. The markedly trilobate, usually depressed individuals are Grewingkia haysii haysii (Meek, 1865) (Fig. 12A-M). Small, triangulate to very slightly trilobate, greatly compressed coralla are Deiracorallium prolongatum (Wilson, 1926) (Fig. 15A-N). However, because of the external variability within these species, an examination of internal structures is sometimes necessary to identify them. The axial structure of G. haysii haysii is large, whereas that of D. prolongatum is small or undeveloped. It is often impossible to distinguish S. distincta distincta, G. haysii haysii, and D. prolongatum when dealing with very small coralla representing the earliest ontogenetic stages, particularly because preservation is usually poor.

Of the 417 solitary corals studied, 181 (43%) could be identified

conclusively to the species level, 75 (18%) were assigned with less certainty, and 161 (39%) are unidentifiable (Appendix 2). Relative abundances of taxa are indicated by the totals in Appendix 1 and Fig.

4. S. distincta distincta is most common, B. patella and G. haysii haysii are common, D. prolongatum is rare, B. sp. cf. B. bottei is represented by two specimens, and Salvadorea sp. 2 is known from one individual.

Geographic and stratigraphic distribution—Solitary rugose corals occur throughout the outcrop belt of the Beaverfoot Formation (Fig. 1). Specimens identified with various degrees of certainty as Salvadorea distincta distincta are known from 19 of the 21 localities for which data are available (Appendix 1). Corresponding figures for the other taxa are: Bighornia patella and Grewingkia haysii haysii from 14 localities, Deiracorallium prolongatum from six, B. sp. cf. B. bottei from two, and Salvadorea sp. 2 from one. These differences are to be expected, given the differing relative abundances of taxa and the comparatively small sample sizes from all localities except Akutlak Creek. It seems likely that all species were distributed throughout the area of Beaverfoot deposition.

In the Akutlak Creek section, S. distincta distincta, B. patella, G. haysii haysii, and D. prolongatum first appear 25.1 m (82.3 ft.) above the base of the Beaverfoot, within the 30.1 m (98.8 ft.) thick Whiskey Trail Member (Fig. 4). At Carbonate Creek, where this member is 28.3 m (93 ft.) thick, specimens occur at 25–25.2 m (82–83 ft.) (Appendix 1). In general, solitary corals are most common within the lower 50 m (164 ft.) of the Beaverfoot Formation, but above the Whiskey Trail Member where it is present. Beyond 70 m (230 ft.) in the Akutlak Creek section, they are uncommon, and barren intervals are thicker and more frequent. S. distincta distincta, B. patella, and G. haysii haysii are known from the uppermost interval of this 128 m (420 ft.) thick section. The stratigraphically highest solitary Rugosa known from the Ordovician portion of the Beaverfoot occur at heights of 155.8–156.1 m (511–512 ft.) above the base of the formation at Pinnacle

Creek, 173.4-174.7 m (569-573 ft.) at Pedley Pass, and 181-189.3 m (594-621 ft.) at Horse Creek. Specimens in these collections are relatively small, and S. distincta distincta is the only species recognized.

Solitary corals that could be identified with various degrees of certainty number 20 or more in only two stratigraphic intervals, both at Akutlak Creek (Fig. 4, intervals A14/15, B5). In each case, S. distincta distincta, B. patella, G. haysii haysii, and D. prolongatum are present. The only other intervals from which all four taxa are known are B2 at Akutlak Creek and the lower 9.4 m (31 ft.) of the Beaverfoot at Shatch Mountain (Appendix 1). The absence of one or more species in other collections may reflect the small sample sizes and the low relative abundances of some taxa.

Taphonomy and paleoecology

Abrasion—For a total of 44 solitary corals from the Beaverfoot Formation, it was possible to determine whether the epitheca and stereozone are present or absent (Appendix 3). The information presented in Table 1 was based on an examination of 68 transverse thin sections. The absence of part or all of the coral wall is considered to result from abrasion. In Bighornia patella and Salvadorea distincta distincta, the epitheca is present on most coralla. It is not preserved on any specimens of Grewingkia haysii haysii, which commonly lack part or all of the stereozone. There are too few data from Deiracorallium prolongatum for comparison.

The degree of abrasion of coral exteriors could reflect the duration and/or intensity of the process. Elias (1982b, p. 1590) found that large corals tend to be more highly abraded than small individuals in the Stony Mountain Formation of southern Manitoba. This was related to the duration of exposure before burial, and therefore to sedimentation rate. In the Beaverfoot Formation, corals of the smallest species, B. patella, are least abraded, whereas those belonging to G. haysii haysii, the largest, are most abraded. However, these differences could be related, at least in part, to energy of the environment. If G. haysii haysii was subjected to higher energy conditions than B. patella and S. distincta distincta, a greater degree of abrasion would be expected.

TABLE 1. Features of solitary rugose corals in the Beaverfoot Formation, British Columbia and Alberta

Taxa	Size ^d	Curvature ^b	Nature of exterior			Epizoans						Borings		
			With epitheca	Without epitheca	Without part or all of stereozone	Bryozoans			Colonial corals			Trypanites		
						- ^c	+ ^d	Location ^e	-	+	Location	-	+	Location
<u>Salvadorea distincta distincta</u>	M	A	10 (62.5%)	4 (25%)	2 (12.5%)	41 (91%)	4 (9%)	1C (33%) 1A (33%) 1C-A (33%)	45 (100%)	0	-	44 (98%)	1 (2%)	2A (67%) 1K (33%)
<u>Bighornia patella</u>	S	B	10 (91%)	1 (9%)	-	30 (97%)	1 (3%)	1C-A (100%)	31 (100%)	0	-	27 (87%)	4 (13%)	3C (50%) 3A (50%)
<u>Grewingkia haysii haysii</u>	L	C	-	6 (43%)	8 (57%)	30 (97%)	1 (3%)	1K (100%)	25 (81%)	6 (19%)	1C (17%) 1C-A (17%) 1A (17%) 1K-A (17%) 2K (32%)	15 (48%)	16 (52%)	13C (22%) 22A (39%) 22K (39%)
<u>Deiracorallium prolongatum</u>	M	-	2 (67%)	-	1 (33%)	9 (90%)	1 (10%)	1K (100%)	10 (100%)	0	-	6 (60%)	4 (40%)	3C (20%) 5A (33%) 7K (47%)

^a S = small, M = medium, L = large

^b A = very slightly curved, B = slightly curved, C = moderately to greatly curved

^c Number of specimens without epizoans or borings

^d Number of specimens with epizoans or borings

^e Location of all epizoans and borings on coral (C = cardinal side, A = alar side, K = counter side)

Attachment structures—Attachment structures were not observed on Salvadorea distincta distincta, Grewingkia haysii haysii, or Deiracorallium prolongatum. Five (14%) of 36 coralla representing Bighornia patella, and the two individuals of B. sp. cf. B. bottei, have a spoon-shaped depression rising from the apex on the concave cardinal side (Fig. 9K-Q, W-BB). Similar structures in B. patella have been observed on six (8.5%) of 70 specimens from the Stony Mountain Formation in southern Manitoba (Elias, 1982b, p. 1588; 1983a, fig. 16a, b, h), two of three from the Fort Atkinson Formation in Iowa, and all three known from the Vauréal Formation on Anticosti Island, Québec (Elias, 1982a, p. 80, pl. 14, figs. 19, 23, pl. 15, fig. 7). Nelson (1963, p. 42, pl. 9, figs. 5, 6, pl. 11, figs. 5, 6, pl. 12, figs. 2-4) reported this type of structure on most representatives of B. bottei from the Chasm Creek Formation in northern Manitoba. In B. wilsonae, a species closely related to B. patella, this feature has been noted on three of nine corals from the Red River Formation in southern Manitoba (Elias, 1981, p. 5, pl. 10, figs. 1, 2; Fig. 9U,V) but does not occur on specimens from the Second Value Dolomite of the Montoya Group in New Mexico and Texas (Elias, 1985, p.14, 43). On nonabraded individuals from the Red River Formation, and on one from the Cape Calhoun Formation of Greenland that was examined in this study (MMH 2995), growth lines do not extend into the spoon-shaped depression. Elias (1981, p. 5) interpreted these structures as sites where the corals were fixed to smooth, curved surfaces such as cephalopod shells. However, attached specimens have not been found. Selective dissolution of aragonitic substrates is a possible reason,

and is suggested by the preservational state of molluscs in the Beaverfoot, Stony Mountain, and Red River formations (e.g., Kendall, 1977, p. 493, 494). The variable proportions of Bighornia corals having attachment sites in different stratigraphic units may reflect the availability of suitable objects.

The overall rarity of attachment sites on solitary rugose corals of the Beaverfoot Formation indicates that the vast majority behaved as unattached objects on soft substrates. Where present, the location of attachment structures is consistent with the hypothesis that larvae became fixed to substrates with their cardinal sides (Elias, 1984b, p. 534). Larvae of corals with convex cardinal sides, such as S. distincta distincta, G. haysii haysii, and D. prolongatum, would have settled on upper sides of grains of sediment. Larvae of B. patella and B. sp. cf. B. bottei, in which the cardinal side is concave, apparently fixed themselves to undersides of grains of sediment or, less commonly, large shells (Elias, 1984b, fig. 2).

Orientation—Prior to the removal of 161 solitary corals found at the Akutlak Creek section (Fig. 4), their orientations with respect to bedding were noted. Virtually all were lying sideways in what would have been stable depositional positions following transport. The absence of high angle bends in these corals suggests that the polyps could not redirect their growth axes after being overturned, and such events may have killed them. This is typical of Late Ordovician solitary Rugosa in the Red River-Stony Mountain and Richmond Provinces of North America (Elias, 1984b, p. 534).

There have been no previous reports of Late Ordovician nonattached solitary corals incontrovertibly preserved in growth position. Elias (1982b, p. 1592) provided evidence suggesting that small proportions of transported coralla could be deposited with calices facing upward, as they must have during life. The growth orientations of various types of solitary corals have been reconstructed using the distribution and abundance of borings, epizoans, and bioclastic material that was incorporated into their outer walls (Elias, 1984b, p. 534, and references therein). Two specimens collected from interval B5 at Akutlak Creek (Fig. 4) were oriented in the hypothesized life positions. The unique way in which these individuals were preserved indicates almost certainly that they are in situ.

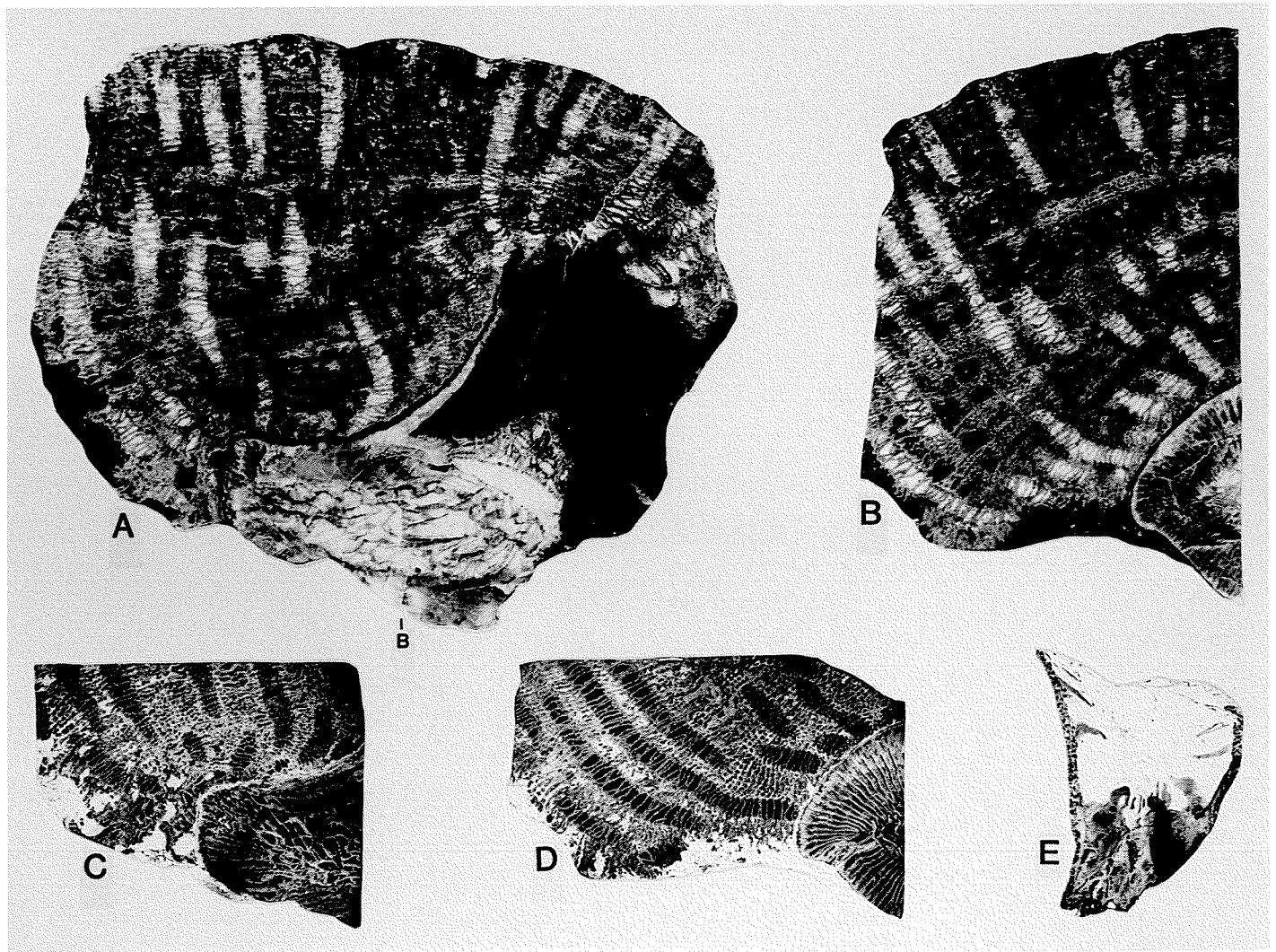
One of the specimens represents Grewingkia haysii haysii. It was oriented with the plane of bilateral symmetry vertical, the convex cardinal side down, concave counter side up, and calice opening upward with respect to bedding (Fig. 5A-D). The entire upper half is covered by Calapoecia, a tabulate coral. Corallites comprising this

epizoan rise from the host at various angles, but then curve upward and terminate along a nearly horizontal surface. This large colony was undoubtedly preserved in growth position. Unfortunately, it cannot be determined from thin sections if the surface of G. haysii haysii is nonabraded or abraded, because preservation of the exterior surface is poor. However, the delicate calice rim is unbroken, suggesting that the corallum was not transported before being covered. When the colony overgrew the solitary coral, it spread laterally from the apex and sides, thereby recording the position of the substrate. It covered over the host's calice, undoubtedly after death of the rugosan and likely after the empty corallum was filled with sediment. The orientation of this solitary coral and the inferred location of the sediment-water interface is exactly as hypothesized for the life position of a greatly curved, slightly trilobate individual (Elias, 1980, fig. 5; 1981, fig. 4d).

The second specimen is identified as Salvadorea distincta distincta. It was oriented with the calice opening upward and apex pointing down (Fig. 5E). Situated directly above this individual was a large colonial coral in growth position. The observed upright orientation of S. distincta distincta is the same as that hypothesized for slightly curved solitary corals (Elias, 1982b, fig. 5d).

Both specimens that were almost certainly preserved in situ occur beneath large colonial corals. It seems likely that they were thereby shielded from high energy events such as storms, which could have overturned and transported other solitary corals.

Figure 5. Grewingkia haysii haysii (Meek, 1865) (A-D) and Salvadorea distincta distincta (Wilson, 1926) (E), as oriented with respect to bedding in the Beaverfoot Formation. A-D, GSC K12B-5-30: A, longitudinal polished section (cardinal side down), X1; B, transverse polished section, X1; C, longitudinal thin section, X1; D, transverse thin section, X1. E, GSC K12B-5-2: longitudinal thin section (cardinal side right), X1.



Paleoecologic associations—Based on the degree of abrasion, it is possible that corals of Grewingkia haysii haysii were subjected to higher energy conditions than Salvadorea distincta distincta and Bighornia patella. Individuals of G. haysii haysii are moderately to greatly curved, whereas S. distincta distincta and B. patella are very slightly to slightly curved (Table 1). Curvature of D. prolongatum could not be determined from available specimens. Paleoecologic studies suggest that there is a positive correlation between an increase in the degree of curvature and current energy (Elias, 1981, p. 5, 6; 1984b, p. 534; 1985, p.14). The in situ specimen of G. haysii haysii is lying on its convex side, whereas that of S. distincta distincta is upright. These orientations are thought to result from exposure of polyps to relatively strong and weak currents, respectively (Elias, 1984b, fig. 2b, d). The above lines of evidence suggest that Grewingkia inhabited relatively high energy environments, while Salvadorea and Bighornia favoured low energy niches. The latter group was dominant. The ecologic position of Deiracorallium is uncertain. Corals representing all taxa are found together in the Beaverfoot. They probably lived in close proximity, and were mixed during unusually high energy events such as storms.

Relationships similar to those noted above have been observed elsewhere. In the Stony Mountain Formation of southern Manitoba, Elias (1982b, p. 1586, 1587) recognized close ecologic ties between Helicelasma (the species was assigned to Salvadorea in Elias, 1985, p.45) and Bighornia, and between Lobocorallium (a species similar to G. haysii haysii) and Deiracorallium. This was based on an analysis of

the relative frequencies of taxa (Elias, 1982b, fig. 3). The Salvadorea-Bighornia group is dominant. On the basis of growth forms and abrasion of corals within the Aleman Formation of the Montoya Group in New Mexico and Texas, Elias (1985, p. 14) inferred that S. distincta distincta, the dominant taxon, lived in lower energy environments than species of Grewingkia that are similar to G. haysii haysii.

Paleoenvironments and paleobathymetry—Solitary *Rugosa* are not known to occur in sandstones or sandy carbonate beds within the Whiskey Trail Member of the Beaverfoot Formation. All specimens from that member are in silty or argillaceous carbonates (Fig. 4). These fossils become common and widespread in clean carbonates of the main Beaverfoot above the Whiskey Trail. Similarly, solitary corals are uncommon within the Cable Canyon Sandstone Member at the base of the Second Value Dolomite, Montoya Group, in New Mexico and Texas, but are common in overlying beds of the Upham Dolomite Member (Elias, 1985, fig. 2). These organisms did not care for environments in which coarse clastic sediments were deposited.

Above the lower part of the main portion of the Beaverfoot Formation, solitary corals become uncommon, and barren intervals are thicker and more frequent. Elias (1982b, p. 1586, fig. 2) noted a general upward decrease in abundance of these fossils within the Stony Mountain Formation of southern Manitoba. Corresponding changes in lithologies and sedimentary structures suggest a transition from open, normal marine environments to restricted, hypersaline conditions. In the Aleman Formation and Cutter Dolomite of the Montoya Group, occurrences of solitary corals coincide with relative abundance peaks of conodonts inferred to be "shallow water" forms (Elias, 1985, p.14-16, fig. 2). "Deeper water" conodonts are more common in intervals lacking corals. However, sedimentologic evidence suggests that the principal limiting variable was not water depth, but the degree of environmental restriction (factors such as limited circulation, greater salinity, and possibly less oxygen and higher temperature). Occurrences of

solitary Rugosa in the Beaverfoot Formation could indicate shallow water maxima and/or open, normal marine conditions.

Close biotic associates

Objects within coralla—A total of 175 transverse thin sections of 117 solitary Rugosa from the Beaverfoot Formation, plus 14 longitudinal thin sections from 11 of these specimens were examined for the presence of foreign objects of the type described by Elias (1984a, p. 105, 107, fig. 3). Four corals and possibly a fifth were found to contain ostracodes. In one section of Salvadorea distincta distincta (GSC N4-1-2), an ostracode is located in the cardinal fossula, another is in the first interseptal chamber on one side of the cardinal fossula, and a third is in an interseptal chamber on one alar side of the coral. The exact position of the alar fossula cannot be established in this coral. A different specimen of S. distincta distincta has an ostracode situated in the cardinal fossula (Fig. 6P). One individual of Deiracorallium prolongatum contains an ostracode near the axis in the elongate cardinal fossula (Fig. 15F). A section through one specimen of Grewingkia haysii haysii (GSC K12A-18-22) has an ostracode situated about midway between the cardinal septum and one alar septum, and possibly a second at the axial end of the cardinal fossula. Another coral of G. haysii haysii has an indistinct oval outline in one alar fossula that may represent a recrystallized ostracode (Fig. 12F). Septa and/or tabulae are diverted around the objects in all these corals.

Two hypotheses have been proposed to account for the inclusion of an ostracode within a coral (Elias, 1984a, p. 105, 107, fig. 4). In the first, it entered the calice when a portion of the polyp temporarily detached from the corallum and contracted radially. The

object became trapped when the polyp expanded and reattached, and was covered over when skeletal secretion resumed. The second, less likely hypothesis is that an ostracode entered the polyp's central cavity through the mouth and came to rest on its floor. When the polyp moved upward in the corallum by atrophy of its aboral surface and formation of a new base at a higher level, the object became incorporated within the corallum. It was suggested that ostracodes may have been captured for food (Elias, 1984a, p. 107). Another possibility is that these crustaceans lived in the gastric cavities of polyps. Stasek (1958, p. 119, 124, 125) reported on modern amphipod crustaceans that dwell within anemones. In either of the above hypotheses, a close association between solitary Rugosa and Ostracoda is implied.

Elias (1984a, p. 105, table 4) found that ostracodes and other less common foreign objects are generally situated within or near the cardinal and alar fossulae, as observed in corals from the Beaverfoot Formation. This and several other lines of paleobiologic evidence indicate that portions of a polyp in the fossula could contract and expand, and probably functioned for water circulation in the central cavity, and for the intake of food and/or ejection of undigested material through the mouth (Elias, 1984a).

It has been noted that foreign objects are more common in species of Edenian-Maysvillian age than in their Richmondian descendants within the Red River-Stony Mountain Province (Elias, 1984a, p. 110, 111). The rarity of ostracodes in Beaverfoot specimens is consistent with that observation.

Epizoans and borings—A total of 117 solitary corals were examined for the presence of epizoans and borings. The observations recorded in Table 1 are based on 175 transverse thin sections (Appendix 3).

Epizoans are rare. Bryozoans occur on Salvadorea distincta distincta (Fig. 6Q), Bighornia patella, Grewingkia haysii haysii, and Deiracorallium prolongatum. Colonial corals have been found only on G. haysii haysii, the largest species (Figs. 5A-D, 12L).

Trypanites borings, produced as dwelling structures by polychaete annelids (see Elias, 1980, p. 275), occur in S. distincta distincta, B. patella, G. haysii haysii, and Deiracorallium prolongatum (Table 1). They are predominantly in the counter plus alar sides of Salvadorea, Grewingkia (Fig. 12L), and Deiracorallium (Fig. 15J, K, N,), and only in the cardinal plus alar sides of Bighornia. Those surfaces were exposed above the substrate while the corals were in growth positions (see Elias, 1980, p. 275, 276, fig. 5; 1982b, p. 1587, 1588, fig. 5a-d). The observed distributions of Trypanites would be expected if the annelids usually become associated with live hosts. These borings are most common in G. haysii haysii, the largest species. Using data from the Stony Mountain Formation in southern Manitoba, Elias (1982b, p. 1594) found that the frequency of borings increased with coral size, which determined the surface area exposed for settlement as well as the duration of exposure before burial. The distribution of Trypanites in solitary Rugosa of the Beaverfoot Formation could also reflect environmental preferences of the annelids. These borings are least common in Salvadorea and Bighornia, the two taxa that lived in relatively quiet water, and more common in Grewingkia (and perhaps

Deiracorallium), which inhabited higher energy environments (see Paleoecologic associations under "Taphonomy and paleoecology").

Distribution and evolution

Salvadorea—Salvadorea distincta distincta occurs within the lower portion of the Beaverfoot Formation in southern British Columbia and Alberta. It is possibly present in early to middle Maysvillian and definitely in late Maysvillian to early Richmondian strata within the Aleman Formation of the Montoya Group in New Mexico and Texas. This species is also known from the middle to late Richmondian Caution Creek and Chasm Creek formations of the Churchill River Group in northern Manitoba.

S. distincta distincta does not undergo recognizable evolutionary changes in the Beaverfoot Formation. Cross-sectional shape, degree of septal dilation, number of septa, length of minor septa, and complexity of the axial structure remain unchanged within the Akutlak Creek section (Appendix 4). Nelson (1981, p. 17, 46) found no evolutionary trends in the Churchill River Group. Within the Montoya Group, S. distincta distincta extends to the top of the Aleman Formation. It is succeeded by S. distincta cutterensis at the base of the Cutter Dolomite. The transition was apparently rapid, and involved a decrease in number of septa, increase in length of minor septa, disappearance of complex axial structures, and development of slightly triangulate external form in some individuals (Elias, 1985, p. 19).

The appearance of S. distincta cutterensis in New Mexico and Texas coincided with the beginning of widespread early Richmondian clastic deposition in the basal Cutter Dolomite (Elias, 1985, p. 19). In southern Manitoba, the change from S. randi of the Red River Formation to S. selecta of the Stony Mountain Formation involved an increase in

the degree of septal dilation (Elias, 1983a, p. 932). The latter species appeared during the middle Richmondian, when fine clastic sediment was being deposited. Clastic units are not present within the Churchill River Group in northern Manitoba, where S. distincta distincta remained unchanged. Similarly, there are no significant, widespread clastic intervals in the Beaverfoot Formation above the basal Whiskey Trail Member.

A single individual identified as Salvadorea sp. 2 was found near the base of the Beaverfoot Formation. This taxon is known from two specimens in middle to late Richmondian strata within the Chasm Creek Formation of the Churchill River Group in northern Manitoba. The relationship of these corals to S. distincta distincta is not understood.

Bighornia—Bighornia patella is the most widely distributed North American Late Ordovician solitary rugose coral presently known. Definite occurrences are in the following units: lower portion of the Beaverfoot Formation in southern British Columbia and Alberta, Cutter Dolomite (middle Richmondian strata) of the Montoya Group in Texas, Fort Atkinson Formation (Richmondian) of Iowa, shaly beds at the top of the Bighorn Dolomite (middle to late Richmondian) in Wyoming, Gunn and Penitentiary members (middle to late Richmondian) of the Stony Mountain Formation in southern Manitoba, Caution Creek and Chasm Creek formations (middle Richmondian strata) of the Churchill River Group in northern Manitoba, lower member of the Vauréal Formation (Richmondian) on Anticosti Island in Québec, and unknown units on Norman Lockyer and Ellesmere Islands in the District of Franklin.

B. wilsonae, a new species described herein, was ancestral to B. patella. The transition involved shortening of the cardinal septum in earlier ontogenetic stages, and a change in orientation of septal fibres (as viewed in transverse sections) from those that curve outward in the direction of the coral axis to those that are perpendicular to the sides of septa. Definite occurrences of B. wilsonae are in the Upham Dolomite Member of the Second Value Dolomite (middle Edenian to earliest Maysvillian), Montoya Group, in New Mexico and Texas, and in the Selkirk Member (middle Maysvillian strata) of the Red River Formation in southern Manitoba. There are presently insufficient data to determine whether specimens from the following Late Ordovician units are B. wilsonae or B. patella: basal and middle members of the Mount Kindle Formation in the District of

Mackenzie, Cape Calhoun Formation in northwestern Greenland, and an unnamed unit in east-central Alaska.

There is another group of North American Late Ordovician solitary Rugosa that belongs to Bighornia. These corals expand more rapidly above the apex and attain greater heights than B. wilsonae and B. patella. Within this large size category, only B. bottei from the Chasm Creek Formation (middle to late Richmondian) of the Churchill River Group in northern Manitoba is well known. Other occurrences of specimens apparently similar to B. bottei are as follows: Stonewall Formation (latest Richmondian to Gamachian) in southern Manitoba, unknown units on Melville Peninsula and Ellesmere and Baffin Islands in the District of Franklin, and Cape Calhoun Formation in northwestern Greenland. Two poorly preserved corals from the Beaverfoot Formation are identified as B. sp. cf. B. bottei. In Manitoba, and perhaps elsewhere as well, these corals range into younger strata than B. patella. Their relationship to the B. wilsonae-B. patella group is unknown.

Grewingkia—Grewingkia haysii haysii is known from the following locations: lower portion of the Beaverfoot Formation in southern British Columbia and Alberta, Caution Creek and Chasm Creek formations (middle to late Richmondian) of the Churchill River Group in northern Manitoba, a Richmondian outlier north of Aberdeen Lake in the District of Keewatin, unknown units on Baffin and Ellesmere Islands in the District of Franklin, and Cape Calhoun Formation in northwestern Greenland. This subspecies is possibly present within the basal member of the Mount Kindle Formation in the District of Mackenzie.

Internal structures of G. haysii haysii and G. haysii selkirkensis are similar. However, the former is generally depressed to equidimensional in cross-sectional shape, whereas the latter is compressed. G. haysii selkirkensis is known from the Selkirk Member (middle to late Maysvillian) of the Red River Formation in southern Manitoba. It is similar in form to G. franklinensis and G. sp. cf. G. franklinensis, which are present in the Aleman Formation (early Maysvillian to early Richmondian) and Cutter Dolomite (middle Richmondian), respectively, of the Montoya Group in New Mexico and Texas. These corals differ from G. haysii in having a median septal lamella within the axial structure.

All the above taxa are thought to have arisen from G. robusta (Elias, 1985, p.17, 18). This species has been positively identified in the Second Value Dolomite (middle Edenian to earliest Maysvillian) of the Montoya Group in New Mexico and Texas, the Selkirk Member (middle Maysvillian strata) of the Red River Formation in southern Manitoba, the Portage Chute and Surprise Creek formations (?Edenian to early

Richmondian) of the Bad Cache Rapids Group in northern Manitoba, and the Bad Cache Rapids Formation on Melville Peninsula in the District of Franklin. G. haysii selkirkensis probably gave rise to Lobocorallium trilobatum vaurealense, which is known from middle to late Richmondian strata in the upper member of the Vauréal Formation on Anticosti Island, and in the White Head Formation at Percé, Québec. L. trilobatum trilobatum in the Gunn and Penitentiary members (middle to late Richmondian) of the Stony Mountain Formation in southern Manitoba and equivalent strata within the upper part of the Bighorn Dolomite in Wyoming probably evolved from G. haysii haysii. The development of Lobocorallium primarily involved an increase in the degree of septal dilation throughout ontogeny.

~~Deiracorallium~~ Deiracorallium prolongatum is present in the lower portion of the Beaverfoot Formation in southern British Columbia and Alberta, and in middle to late Richmondian strata within the Chasm Creek Formation of the Churchill River Group in northern Manitoba. At least one other species of Deiracorallium, distinguished by its small size and short cardinal septum, occurs in the following units:

Caution Creek and Chasm Creek formations (middle Richmondian strata) of the Churchill River Group in northern Manitoba, Gunn and Penitentiary members (middle to late Richmondian) of the Stony Mountain Formation in southern Manitoba, and upper member of the Vauréal Formation (middle to late Richmondian) on Anticosti Island in Québec. Specimens from these three regions have been assigned to D. manitobense (plus D. manitobense churchillense), D. angulatum gunni, and D. angulatum angulatum, respectively. D. manitobense may prove to be a synonym of D. angulatum (Elias, 1983a, p. 941). The relationship of these corals to D. prolongatum is not known.

In Manitoba, species of Deiracorallium comparable in size to D. prolongatum occur in older units. D. harveyi is known from the Portage Chute and Surprise Creek formations (?Edenian to early Richmondian) of the Bad Cache Rapids Group in northern Manitoba, and D. delicatum is present in the Selkirk Member (middle Maysvillian strata) of the Red River Formation in southern Manitoba. These earlier taxa differ from D. prolongatum and D. angulatum in having comparatively large, complex axial structures. They may be ancestors of the Richmondian species (Elias, 1983a, p. 932).

Paleobiogeography

The paleobiogeography of North American Late Ordovician solitary rugose corals has been discussed by Elias (1981, p. 2, 8, 10; 1982a, p. 47-52, fig. 24, table 3; 1983a, p. 927-931, fig. 1; 1983b, p. 6; 1984b, fig. 1; 1985, p. 16-20, fig. 3) and Elias and Potter (1984, p. 1205, 1206). The Red River-Stony Mountain Solitary Coral Province of Edenian to Gamachian age occupied most of North America.

Characteristic taxa are Grewingkia (species in which at least some coralla have triangulate to trilobate form), Lobocorallium, Deiracorallium, Bighornia, and Salvadorea. The presence of G. haysii, D. prolongatum, B. patella, B. sp. cf. B. bottei, S. distincta, and S. sp. 2 within the Beaverfoot Formation indicates that the area preserved in the southern Rocky Mountains of British Columbia and Alberta was situated within the Red River-Stony Mountain Province.

Elias (1985, p. 16) recognized two types of solitary coral assemblages in the Red River-Stony Mountain Province. One is associated with epicontinental seas thought to have had slightly elevated temperatures and salinities, and the other with normal, open marine environments along the continental margin. "Epicontinental" assemblages are dominated by or composed exclusively of characteristic taxa listed in the preceding paragraph. These may be present or absent in "continental margin" assemblages, which include genera such as Bodophyllum and Streptelasma, and species of Grewingkia and Streptelasma that are similar to forms in northwestern Europe. Solitary Rugosa of the Beaverfoot Formation represent an exclusively

"epicontinental" assemblage. All six species occur in northern Manitoba. This further substantiates the statement by Elias (1983a, p. 953) that solitary corals in western Canada and northern North America appear to be most closely related to those of the Hudson Bay Basin. Two of the Beaverfoot species, Bighornia patella and Salvadorea distincta distincta, are present in New Mexico and Texas. Only B. patella, known from southern Manitoba and northern Wyoming, has been found in the Williston Basin. None of the Beaverfoot species occur in the eastern Klamath Mountains of northern California, where "continental margin" corals that apparently lived in an island arc setting relatively near North America are found in an allochthonous terrane (Elias and Potter, 1984).

The Beaverfoot Formation was probably deposited near the margin of North America, although its exact paleoposition is uncertain because Upper Ordovician rocks representing basinal facies are unknown in southeastern British Columbia (Norford, pers. commun., 1985). The absence of "continental margin" taxa in the Beaverfoot Formation is somewhat surprising. Budge (1977) listed Bodophyllum and Streptelasma, as well as cf. Grewingkia, Lobocorallium, Deiracorallium, and Bighornia, from late Late Ordovician strata in Nevada and Utah, which were presumably deposited in a similar setting. One "continental margin" taxon, Neotryplasma, is known from early Late Ordovician strata in the Montoya Group of westernmost Texas, but all species in the late Late Ordovician portion are "epicontinental" (Elias, 1985, p. 16, 20). They lived several hundred kilometres from the Ouachita Geocline. It is probable that the Beaverfoot Formation was deposited at some distance from the edge of the continent. Alternatively, "continental margin" taxa could have been excluded by environmental factors or geographic barriers.

Biostratigraphy

Salvadorea distincta distincta, Bighornia patella, Deiracorallium prolongatum, and Grewingkia haysii haysii occur in the upper part of the Whiskey Trail Member and in overlying strata of the Beaverfoot Formation, where Salvadorea sp. 2 and B. sp. cf. B. bottei are also known. The base of the Bighornia-Thaerodonta zone, previously located at the bottom of the main portion of the Beaverfoot (Norford, 1969, p. 38), is herein placed at the first appearance of this solitary coral assemblage within the Whiskey Trail. A close historical relationship between deposition of clastic sediments comprising the Whiskey Trail Member and carbonates of the main Beaverfoot Formation is inferred.

Norford (1962a, fig. 2) traced the Bighornia-Thaerodonta zone to a height of 61 m (200 ft.) above the base of the Beaverfoot at Pedley Pass, and 64.6 m (212 ft.) at Mount Sinclair. In this study, the diagnostic species B. patella is documented from the uppermost interval of the 128 m (420 ft.) thick Akutlak Creek section (Fig. 4). S. distincta distincta, the dominant taxon in the solitary coral assemblage of the Bighornia-Thaerodonta zone, occurs at heights of 155.8-156.1 m (511-512 ft.), 173.4-174.7 m (569-573 ft.), and 181-189.3 m (594-621 ft.) above the base of the Beaverfoot at Pinnacle Creek, Pedley Pass, and Horse Creek, respectively. These collections, situated within the "poorly fossiliferous interval" of Norford (1969, p. 39), are herein considered to represent the Bighornia-Thaerodonta zone. Conodonts from a slightly higher interval 200.9-228.3 m (659-749 ft.) above the base of the formation at Mount Sinclair are possibly Silurian in age (Norford, 1969, p. 39). It seems likely that the

Bighornia-Thaerodonta zone spans the entire Ordovician portion of the Beaverfoot Formation.

Within the Late Ordovician Red River-Stony Mountain Province, Elias (1985, p. 20, 21) recognized a Grewingkia-dominated assemblage that was succeeded by a Salvadorea-dominated assemblage. This change is not synchronous throughout the province, when analyzed in a framework of correlations based primarily on conodont biostratigraphy (Sweet, 1979, fig 4; Elias, 1985, p. 7, 10). Solitary corals of the Beaverfoot Formation represent the Salvadorea-dominated assemblage, which definitely appeared by late Maysvillian time, and possibly during the early to middle Maysvillian, in New Mexico and Texas. Within the Williston Basin, this assemblage is first found in early to middle Richmondian strata (Fort Garry Member of the Red River Formation in southern Manitoba; Elias, unpubl. data). Its earliest known occurrence in the Hudson Bay Basin is middle Richmondian. Thus, deposition of the Beaverfoot probably began some time in the Maysvillian to middle Richmondian. If the Salvadorea-dominated assemblage originated earlier along the continental margin than in epicontinental areas, a relatively early age for the onset of Beaverfoot sedimentation is possible. All six solitary rugosan species present in the Bighornia-Thaerodonta zone of the Beaverfoot Formation also occur in middle to late Richmondian strata comprising the Churchill River Group in the Hudson Bay Basin.

The uppermost portion of the Bighornia-Thaerodonta zone could be as young as Gamachian. Bighornia is probably present in the Stonewall Formation of southern Manitoba, and Salvadorea occurs within

the Ellis Bay Formation on Anticosti Island in Québec. According to conodont biostratigraphy, these strata are latest Richmondian to Gamachian, and Gamachian in age, respectively (Sweet, 1979, p. 54, fig. 4; McCracken and Barnes, 1981, p. 64, fig. 12).

Systematic paleontology

Subclass Rugosa Milne-Edwards & Haime, 1850

Order Stauriida Verrill, 1865

Suborder Streptelasmatina Wedekind, 1927

Family Streptelasmatidae Nicholson in Nicholson & Lydekker, 1889Subfamily Streptelasmatinae Nicholson in Nicholson & Lydekker, 1889Genus Salvadorea Nelson, 1981Salvadorea Nelson, 1981, p. 45; Elias, 1985, p. 43, 45.Helicelasma Neuman, 1969. Elias, 1981, p. 19, 20 [partim]; Elias, 1982a, p. 60, 61 [partim]; Elias, 1983a, p. 934 [partim].

Type species—Salvadorea kingae kingae Nelson, 1981. The originally designated type species is herein considered a junior synonym of S. distincta distincta (Wilson, 1926).

Salvadorea distincta distincta (Wilson, 1926)

Figs. 5E, 6A-Q

Streptelasma distinctum Wilson, 1926, p. 12, 13 [partim], pl. 1,

fig. 7, [non] pl. 1, fig. 6.

Streptelasma prolongatum Wilson, 1926, p. 11, 12 [partim], pl. 1,

fig. 5, [?] pl. 2, fig. 2, [non] pl. 1, figs. 3, 4.

[?] Streptelasma sp. cf. S. distinctum Wilson, 1926. Pestana, 1960,

p. 866, pl. 109, fig. 6.

[?] Streptelasma distinctum Wilson, 1926. Kaljo and Klaamann, 1965,

p. 418, 419, pl. 1, figs. 8, 9.

[non] Streptelasma cf. distinctum Wilson, 1926. Ho, 1978, p. 10, 11,

pl. 1, fig. 3a-d.

Salvadorea kingae Nelson, 1981, p. 45-47, fig. 12, pl. 3, figs.

1-10, pl. 4, figs. 1-14, pl. 5, figs. 1-7.

Salvadorea? sp. 1. Nelson, 1981, p. 47, 48, pl. 5, figs. 8-12.

Salvadorea kingae kingae Nelson, 1981. Elias, 1985, p. 45-48, figs. 19.1-19.24.

Lectotype—Designated herein: GSC 6731a (Wilson, 1926, pl. 1, fig. 7),

76 m (250 ft.) below "Halysites beds," Beaverfoot Formation, GSC loc.

7561, 0.8 km (0.5 mi.) east of trail over Palliser Pass, British

Columbia, J.R. Marshall collection (for location, refer to Fig. 1).

Additional specimens described herein—All from Beaverfoot Formation.

Early collections (for location, refer to Fig. 1): GSC 6729a

(Wilson, 1926, pl. 1, fig. 5), W1-2-2, below Halysites beds, GSC loc.

7563, 1.2 km (0.75 mi.) east of trail over Palliser Pass, British

Columbia, J.R. Marshall collection; GSC W2-1-1, GSC loc. 7969, between

Spray and Palliser Rivers, from the western slope of a knoll between

Mount Sir Douglas and Mount Munro, at an elevation of about 2377 m (7800 ft.), British Columbia, J.R. Marshall collection.

Root collection (for location, refer to Fig. 1): GSC R211iv, R211v, White Knight Peak, British Columbia.

Norford collection (for locations, refer to Fig. 1; for stratigraphic positions, refer to Appendix 1): GSC NA-1-7, GSC loc. 56107, Mount Wilson, Alberta; GSC NC-1-1, NC-1-4, NC-1-5, GSC loc. 57209, Tipperary Lake, British Columbia; GSC ND-2-9 (Fig. 6F), GSC loc. 47404, Pedley Pass, British Columbia; GSC NG-2-1a, NG-2-2, GSC loc. 5063, Carbonate Creek, British Columbia; GSC N4-1-2, GSC loc. 64584, 6.4 km (4 mi.) south-southeast of Indianhead Mountain, British Columbia; GSC N7-3-2, N7-3-6, N7-3-8, GSC loc. 56076, GSC N7-6-1a, GSC loc. 56080, Pinnacle Creek, British Columbia; GSC N9-3-1, N9-3-2, GSC loc. 45606, GSC N9-1-1 (Fig. 6B), GSC loc. 45604, Hatch Creek, British Columbia; GSC N10-1-9 (Fig. 6E), GSC loc. 52183, Pagliaro Creek, British Columbia; GSC N11-3-1, GSC loc. 69837, Horse Creek, British Columbia; GSC N12-8-1 (Fig. 6H), GSC loc. 45582, GSC N12-7-2, GSC loc. 52160, Blackfoot Creek, British Columbia; GSC N14-1-8, N14-1-10, GSC loc. 58188, Shatch Mountain, British Columbia; GSC N31-2-5 (Fig. 6A), GSC loc. 52186, Pipestone River, Alberta; GSC N40-2-2 (Fig. 6G), GSC loc. 42026, Cirrus Mountain, Alberta.

Present collection (all from Akutlak Creek, British Columbia; for location, refer to Figs. 1, 2; for stratigraphic positions, refer to Fig. 4): GSC K12A-14/15-2, K12A-14/15-3, K12A-14/15-4a, K12A-14/15-11 (Fig. 6J-O), K12A-14/15-14 (Fig. 6I), K12A-14/15-18, K12A-14/15-21, K12A-14/15-22, K12A-14/15-23, K12A-14/15-25 (Fig. 6C,D), K12A-14/15-27,

K12A-14/15-33, interval A14 + A15; GSC K12A-15/16-1, interval A15 + A16; GSC K12A-18-4, K12A-18-21, interval A18; GSC K12A-BR-1, K12A-BR-2, K12A-BR-6, rubble near interval A18; GSC K12B-1-13, interval B1; GSC K12B-5-2 (Fig. 5E), K12B-5-5, K12B-5-13, K12B-5-16, interval B5; GSC K12B-6-2, K12B-6-4, interval B6; GSC K12B-7-2, K12B-7-3, interval B7; GSC K12B-16-1, interval B16; GSC K12B-20-1, interval B20; GSC K12B-23-1, interval B23; GSC K12B-24-4, interval B24; GSC K12B-25-4, K12B-25-11, interval B25; GSC K12B-T-1 (Fig. 6P, Q), talus.

Occurrences—Upper Ordovician: Beaverfoot Formation including Whiskey Trail Member (Richmondian, possibly Maysvillian and Gamachian strata), southern Rocky Mountains, British Columbia and Alberta, Canada; Caution Creek and Chasm Creek formations (middle to upper Richmondian), Churchill River Group, Hudson Bay Lowland, Manitoba, Canada; Aleman Formation (upper Maysvillian to lower Richmondian strata, possibly lower to middle Maysvillian strata), Montoya Group, southern New Mexico and westernmost Texas, U.S.A.

Diagnosis—Corallum trochoid, circular or rarely triangulate in cross section. Septa moderately to completely dilated in early stages, degree of dilation decreasing during ontogeny to nondilated in late stages. Major septa converge axially in groups, generally forming a slight counterclockwise whorl. Axial structure highly variable in late stages, from small comprising a few septal lobes to large with numerous long, contorted septal lobes and lamellae; commonly of intermediate size with septal lobes and a few lamellae. Cardinal fossula broad with enlarged axial end, cardinal septum typically short

in late stages. Minor septa confined to, or extend a short distance beyond, moderated broad stereozone. Tabulae greatly convex upward, greatly depressed in cardinal fossula.

Description of corals—The largest specimen is 56 mm long and has a maximum diameter of 29 mm, but the base and top are missing (GSC K12B-T-1). The corals are slightly curved with a convex cardinal side, and are trochoid (Fig. 6J, K) to rarely ceratoid (Fig. 6P). The majority have circular cross sections, but 3 of 17 individuals are slightly triangulate in late ontogenetic stages (Fig. 6G). Septal grooves and interseptal ridges are preserved on a few specimens. Depth of the calice is 40% of the coral length in one individual (GSC K12B-5-2, length = 42 mm; Fig. 5E), and 49% in another (GSC K12A-15/16-1, length = 45 mm).

Ontogeny and internal structures—The relationship between number of septa and coral diameter is shown in Fig. 7. In early ontogenetic stages (Fig. 6A, C), major septa are moderately to completely dilated. Dilation gradually decreases during intermediate stages (Fig. 6B, D-F, N), and septa are nondilated by late stages (Fig. 6G-I, O, Q). In early stages, major septa meet at the axis. During intermediate stages, groups of adjacent septa join a short distance from the axis, and septal lobes arising from these groups extend to the axis. In late stages, major septa continue to converge into groups, and commonly form a slight counterclockwise whorl (Fig. 6H). The radius of the axial region ranges from 23% (GSC Ng-2-1a) to 41% of the coral radius (GSC K12B-T-1). The axial structure varies from a few septal lobes

extending from the groups of septa in corals with a small axial region (Fig. 6G, H), to a complex structure of numerous long, contorted septal lobes and lamellae in those with a large axial structure (Fig. 6Q). There is a complete gradation between these end members; axial structures of intermediate size with septal lobes and a few lamellae are most common (Fig. 6I, O).

The cardinal septum is long in early to intermediate stages, when it becomes thinner than the other major septa (Fig. 6D, N). In cross sections through late stages, the middle portion of this septum is generally absent, leaving a short septum and a projection from the axis (Fig. 6G, H, Q). At the base of the calice, this axial projection disappears (Fig. 6I). The cardinal septum becomes short in 11 of 17 specimens (65%). The greatest diameter at which a long cardinal septum is present is 21 mm (GSC K12A-18-4), and the smallest diameter with a short cardinal septum is 11 mm (GSC K12B-25-11). The cardinal fossula is broad in late stages and expands at the axial end.

The length of minor septa in late stages varies from 20% (GSC K12B-T-1) to 30% of the coral radius (GSC K12A-14/15-14). Minor septa are confined to the stereozone during late stages in eight of 16 specimens. In the remainder, up to 50% of the length of the minor septa extends beyond the stereozone (GSC K12B-T-1). Thickness of the stereozone ranges from 14% (GSC K12B-T-1) to 33% of the coral radius (GSC K12B-25-4).

The complete and incomplete tabulae are greatly convex upward and greatly depressed in the cardinal fossula, where they decline from the axis at an angle of approximately 60° (Fig. 6L, M, P). Spacing of

tabulae varies from 0.4 mm (GSC K12A-14/15-11) to 2.4 mm (GSC K12B-T-1).

Microstructure—In transverse thin sections, the major septa are fibrous. From a medial position in the septum, fibres typically curve outward in the direction of the coral axis (e.g., Elias, 1981, fig. 5a; 1983a, fig. 7a). In one individual (GSC N12-8-1), the fibres appear to be perpendicular to the medial line. In the stereozone during intermediate to late stages, U-shaped lamellae with concave sides facing the coral axis are present between the major and minor septa. A contorted suture extends through the lamellae in a medial position between the septa. The epitheca consists of short, indistinct fibres that are approximately perpendicular to the surface of the corallum. In longitudinal thin sections, septal fibres are slightly inclined from the coral wall toward the axis.

Discussion—Streptelasma distinctum was originally described from the Beaverfoot Formation in British Columbia by Wilson (1926). She did not identify type specimens, but illustrated two corals. One of them is herein designated as the lectotype of Salvadorea distincta distincta (Wilson, 1926) (GSC 6731a; Wilson, 1926, pl. 1, fig. 7). The other is reassigned to Bighornia patella (Wilson, 1926). Another coral illustrated by Wilson (1926, pl. 1, fig. 5; GSC 6729a) is circular to slightly triangulate in cross section. The dashed line added to the published figure incorrectly implies that the cardinal side of the specimen is incomplete, and that the corallum is greatly compressed. This individual was originally identified as Streptelasma prolongatum Wilson, 1926, but is herein reassigned to Salvadorea distincta distincta. The specimen with an oblique polished surface that was

illustrated as Streptelasma prolongatum may be Salvadorea distincta distincta (GSC 6730; Wilson, 1926, pl. 2, fig. 2).

The corals described herein cannot be distinguished morphologically from those previously assigned to Salvadorea kingae kingae Nelson, 1981 (which includes S.? sp. 1 of Nelson, 1981; refer to Elias, 1985, p. 48). The latter taxon has been documented from the Caution Creek and Chasm Creek formations of the Churchill River Group in Manitoba (Nelson, 1981), and the Aleman Formation of the Montoya Group in New Mexico and Texas (Elias, 1985). Ranges of variability involving the degree of septal dilation, size and nature of the axial structure, size and shape of the cardinal fossula, length of the minor septa, and thickness of the stereozone are similar. Variability in the number of septa is essentially the same for specimens from the Beaverfoot Formation and Churchill River Group, but the number of septa in corals from the Aleman Formation tends to be in the higher half of the range (compare Fig. 7 with Elias, 1985, fig. 20). The proportion of coralla in which the cardinal septum becomes short below the calice does not differ significantly among specimens from the Beaverfoot Formation, the Caution Creek and Chasm Creek formations, and the Aleman Formation (using chi-square test for proportions, with $\alpha = 0.05$; refer to Elias, 1985, table 3).

The only distinguishing characteristic of the collection from the Beaverfoot is that a small proportion of specimens are slightly triangulate in late stages, whereas the corals known from elsewhere are circular in cross section. However, some slightly triangulate individuals have also been reported in Salvadorea distincta

cutterensis Elias, 1985 of the Cutter Dolomite in New Mexico and Texas (Elias, 1985, p.50, figs. 21.13, 21.17-21.19). This feature alone is considered insufficient to recognize S. distincta distincta and S. kingae kingae as separate taxa, and the latter is herein regarded as a junior synonym. Most specimens of S. distincta cutterensis lie within the range of variability in S. distincta distincta. However, the axial structure is always very small and comprise a few septal lobes only, and the minor septa are generally longer.

S. randi (Elias, 1981) is similar to S. distincta distincta, but details of septal dilation, number of septa, nature of the cardinal fossula and cardinal septum, and the axial structure are different (Elias, 1981, p. 21; 1983a, p. 938, 1985, table 3). It occurs within the Selkirk Member (middle Maysvillian strata) of the Red River Formation in southern Manitoba, and the Scales and Brainard formations (Richmondian) of the Maquoketa Group in Iowa and Illinois. S. selecta (Billings, 1865) closely resembles S. randi, but has septa that are completely dilated until immediately below the calice in late stages (Elias, 1982a, p. 62, 63; 1983a, p. 938; 1985, table 3). It is known from the Gunn, Penitentiary, and possibly Gunton members (middle to upper Richmondian) of the Stony Mountain Formation in southern Manitoba, the upper member (middle to upper Richmondian) of the Vauréal Formation and the Ellis Bay Formation (Gamachian strata) on Anticosti Island in Québec, and the White Head Formation (Richmondian strata) at Percé, Québec.

Pestana (1960) identified a single, small specimen from the Johnson Spring Formation (Middle Ordovician; Rocklandian-Kirkfieldian)

of California as Streptelasma sp. cf. S. distinctum. He noted that "it is probably a distinct species but available material is not adequate for a specific description."

Kaljo and Klaamann (1965) identified Streptelasma distinctum from the Portrane Limestone (Upper Ordovician; Ashgill) of Ireland. Their description and illustrations of poorly preserved, silicified material do not provide enough information to confirm the taxonomic assignment. They considered Streptelasma bystrowi Reiman, 1958, from the Vormsi Horizon (Upper Ordovician; upper Caradoc) of the Estonian SSR to be a junior synonym of S. distinctum. However, that species is insufficiently known to verify such a conclusion (Reiman, 1958, p. 33, 34, pl. 1, figs. 4-6).

Ho (1978) reported Streptelasma cf. distinctum from the Guanyinqiao bed (Upper Ordovician; Ashgill, Hirnantian) within the Wufeng Formation in the Guizhou Province of China. Unlike Salvadorea distincta, a large, open axial region appears to develop in late stages (Ho, 1978, pl. 1, fig. 3c).

One specimen from the Beaverfoot Formation resembles S. distincta distincta, but has nondilated and more numerous major septa, and a narrow stereozone. It is identified as Salvadorea sp. 2 of Nelson, 1981.

Figure 6. Salvadorea distincta distincta (Wilson, 1926) and Salvadorea sp. 2 of Nelson, 1981 from the Beaverfoot Formation. A-Q, S. distincta distincta. A, GSC N31-2-5: view of calice (stereopair), X2.5. B, GSC N9-1-1: view of calice (stereopair), X2.25. C, D, GSC K12A-14/15-25: transverse sections, X4, X2. E, GSC N10-1-9: transverse section, X4. F, GSC ND-2-9: transverse section, X4. G, GSC N40-2-2: transverse section, X2. H, GSC N12-8-1: transverse section, X1.5. I, GSC K12A-14/15-14: transverse section, X1.5. J-O, GSC K12A-14/15-11: J, cardinal view, X1; K, alar view (cardinal side left), X1; L, M, longitudinal sections (cardinal side left), X1.5; N, O, transverse sections, X2. P, Q, GSC K12B-T-1: P, longitudinal section (cardinal side right), X1.5; Q, transverse section, X1.5. R-U, Salvadorea sp. 2, GSC NA-1-5: R, longitudinal section (cardinal side right), X2.5; S-U, transverse sections, X5, X2.5, X2.5. Position of ostracode (P) and epizoic bryozoan (Q) indicated by arrows.

Note: Photograph E should be rotated 90° clockwise.

Photograph Q is located at the top of P.

Photograph U is located at the bottom of R.

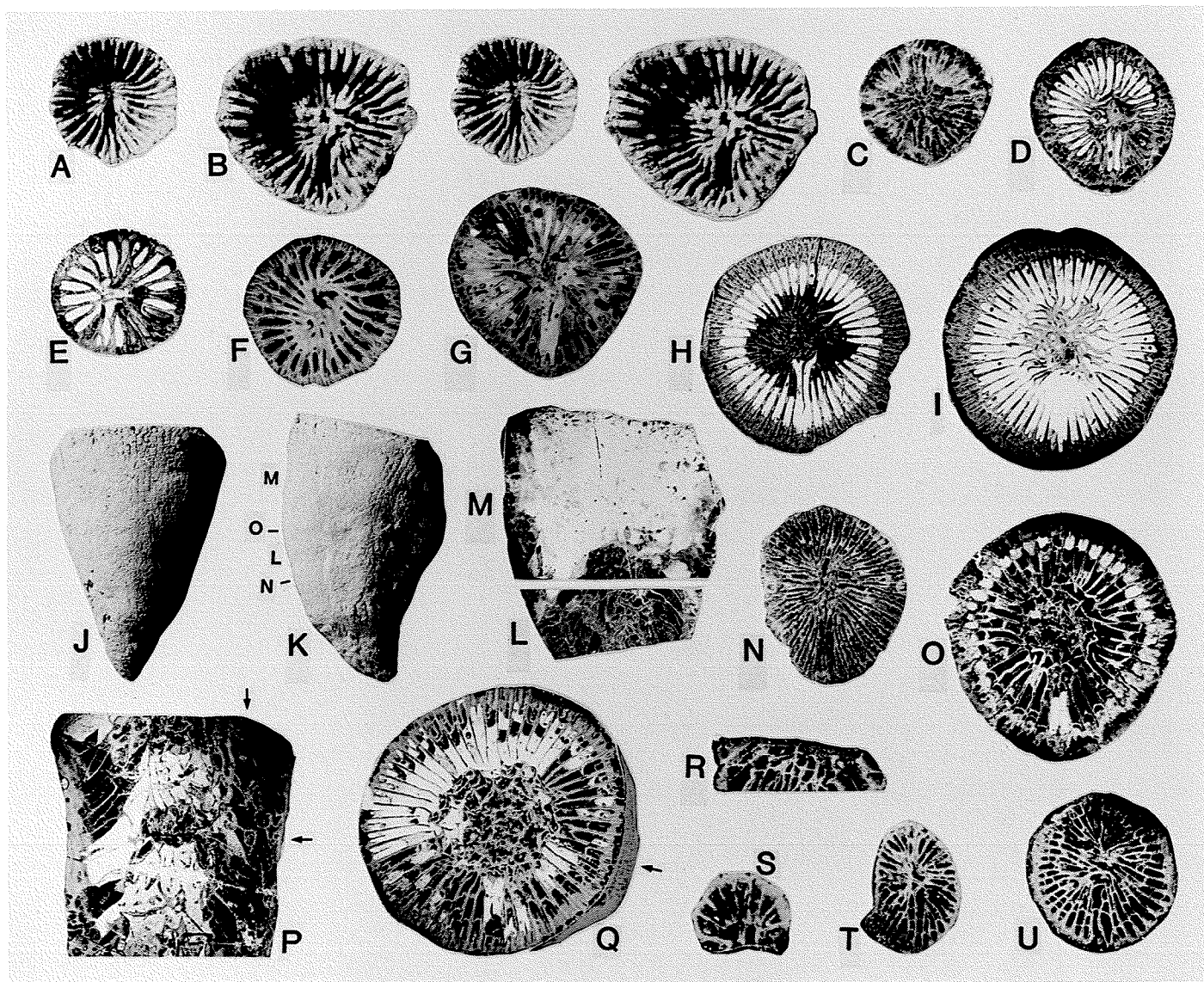
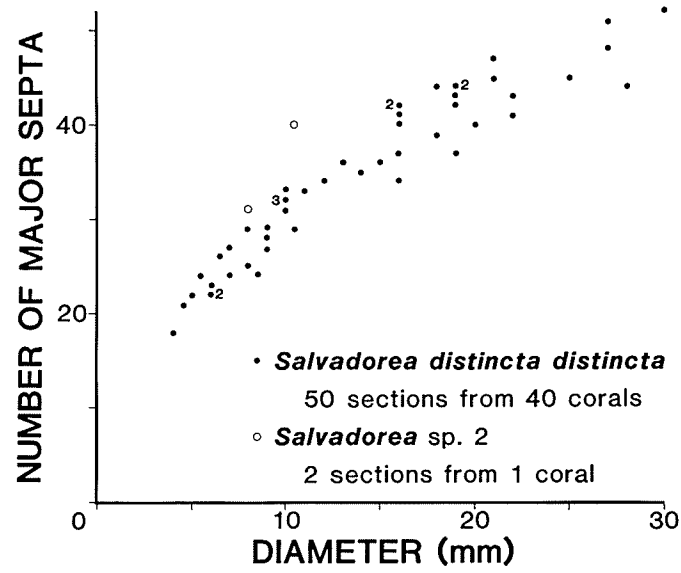


Figure 7. Relationship between number of major septa and coral diameter in Salvadorea distincta distincta and Salvadorea sp. 2: Beaverfoot Formation, British Columbia and Alberta, and Alberta, respectively.



Salvadorea sp. 2 of Nelson, 1981

Fig. 6R-U

Salvadorea sp. 2. Nelson, 1981, p. 48, pl. 5, figs. 13-17.

Specimen described herein—GSC NA-1-5, GSC loc. 56107, Mount Wilson, Alberta (for location, refer to Fig. 1; for stratigraphic position, refer to Appendix 1).

Occurrences—Upper Ordovician: Beaverfoot Formation (Richmondian, possibly Maysvillian strata), southern Rocky Mountains, Alberta, Canada; member 2, Chasm Creek Formation (middle to upper Richmondian), Hudson Bay Lowland, Manitoba, Canada.

Description—The small, silicified specimen has a maximum diameter of 10.5 mm. It is trochoid, and circular in cross section. The relationship between number of septa and coral diameter is shown in Fig. 7. The major septa are nondilated in the early stage, and appear to meet at the axis (Fig. 6S). In intermediate and late stages (Fig. 6T, U), adjacent septa join a short distance from the axis. Lobes arising from these groups extend to the axis, forming a small, simple axial structure. Its radius is 33% of the coral radius in the late stage. The cardinal septum is long, and the cardinal fossula is moderately broad. Minor septa cannot be recognized. If present, they are confined to the relatively narrow stereozone. Tabulae are moderately convex upward, and slightly depressed in the cardinal fossula (Fig. 6R).

Discussion—Except for its smaller size, the specimen described herein

cannot be distinguished from two individuals found in Manitoba and identified as Salvadorea sp. 2 by Nelson (1981). These corals differ from S. distincta distincta (Wilson, 1926) in having nondilated and more numerous major septa (refer to Fig. 7), and a narrow stereozone. Nelson (1981, p. 48) considered them to be either aberrant representatives of S. distincta distincta, or a new species. Because of this uncertainty, and the small amount of material, a specific name has not been assigned.

Genus Bighornia Duncan, 1957

Bighornia Duncan, 1957, p. 608-611; Nelson, 1963, p. 39, 40;
Neuman, 1977, p. 75; Elias, 1981, p. 24, 25; Elias, 1982a, p. 79,
80; Elias, 1983a, p. 948.

Type species—Bighornia patella (Wilson, 1926). The originally designated type species, B. parva Duncan, 1957, is herein considered a junior synonym.

Diagnosis—Corallum typically depressed and subcalceoloid, with concave cardinal side. Cross-sectional shape in early stages depressed and triangulate, or oval with flattened counter side, or crescentic with concave cardinal side; in later stages slightly depressed and triangulate, or oval, or round. Axial structure includes solid columella elongate in cardinal-counter direction and contiguous with counter septum, plus a few septal lobes and rarely lamellae. Cardinal fossula moderately broad to broad in late stages.

Discussion—The relationship between coral height and average cross-sectional dimension for Bighornia is shown in Fig. 8. Two groups of specimens can be identified. One consists of small to medium-sized individuals, and the other comprises corals that expand rapidly above the apex and attain large sizes. Duncan (1957, p. 613) and Nelson (1963, p. 39-41) distinguished species within the small to medium size category on the basis of external form, number of septa, and length of minor septa. Subsequent studies (Elias, 1981, 1982a, 1983a, 1985; present study) have documented the ranges of variability involving external form and its relation to internal morphology, including

arrangement plus number of septa. Elias (1981, p. 25, 26; 1982a, p. 81, 82; 1983a, p. 952; 1985, p. 41, 43) recognized a close similarity of all corals in the small to medium size group, and tentatively referred to them as Bighornia sp. cf. B. patella (Wilson, 1926) because B. patella from the type area was poorly known. However, consistent differences involving length of the cardinal septum and orientation of septal fibres were noted between Edenian-Maysvillian and Richmondian collections (Elias, 1985, p. 18). Material described herein from the Beaverfoot Formation provides sufficient data for a taxonomic revision. The small to medium-sized late Late Ordovician corals, including those described as B. parva by Duncan (1957), are assigned to B. patella (Wilson, 1926). B. wilsonae Knapp and Elias, n. sp. is proposed for the early Late Ordovician forms.

With the exception of Bighornia bottei Nelson, 1963, taxa included definitely or tentatively in the large size category of the genus are poorly known. They are listed below.

Streptelasma integriseptatum Parks, 1915, p. 13-15, pl. 5, figs. 1-3;

Churchill River Group (middle to upper Richmondian), lower rapids, Shamattawa (Gods) River, Hudson Bay Lowland, Manitoba.

Streptelasma haysii (Meek, 1865). Cox, 1937, p. 8, 9 [partim], pl. 2,

fig. 4a, b; Cape Frazier, Ellesmere Island, District of Franklin, Northwest Territories.

[?] Streptelasma? oppletum Teichert, 1937, p. 51, 52, pl. 2, figs.

5-8, pl. 3, figs. 1-4; Ungerlarsuk, Ungerlodjan, and Iglulik Island, east coast, Melville Peninsula, District of Franklin, and Cape Calhoun Formation (Upper Ordovician), Cape Calhoun,

northwestern Greenland.

[?] Streptelasma? latum Teichert, 1937, p. 52, 53, pl. 2, figs.

3, 4, 9; drift, Cape Griffith, Baffin Island, District of Franklin, Northwest Territories.

[?] Streptelasma cf. integriseptatum Parks, 1915. Stearn, 1956, p. 88,

89; Stonewall Formation (uppermost Richmondian to Gamachian), near The Pas, Manitoba.

Bighornia sp. Nelson, 1959, pl. 4, figs. 3a-d, and Nelson, 1975, pl. 8, figs.

4-7; Chasm Creek Formation (middle to upper Richmondian), Hudson Bay Lowland, Manitoba.

Bighornia bottei Nelson, 1963, p. 41-43, pl. 5, fig. 6, pl. 9, figs.

5, 6a-d, pl. 11, figs. 5a, b, 6a-c, 7, 8, pl. 12, figs. 1, 2a-g, 3a, b, 4a-c; Chasm Creek Formation (middle to upper Richmondian), Churchill River Group, Hudson Bay Lowland, Manitoba.

Bighornia sp. cf. B. bottei Nelson, 1963. Described herein; Beaverfoot

Formation (Richmondian, possibly Maysvillian strata), southern Rocky Mountains, British Columbia.

Figure 8. Relationship between coral height and average cross-sectional dimension (average of cardinal-counter and alar-alar dimensions) in Bighornia. B. patella: Beaverfoot Formation, British Columbia and Alberta; Fort Atkinson Formation, Maquoketa Group, Iowa; Ellesmere Island, District of Franklin (Cox, 1937, p. 16); Gunn and Penitentiary members, Stony Mountain Formation, Manitoba; upper Bighorn Dolomite, Wyoming (Duncan, 1957, p. 611, 612, pl. 70, figs. 8, 14); Caution Creek and Chasm Creek formations, Churchill River Group, Manitoba (Nelson, 1963, pl. 11, figs. 1b, c, 3b, c, 4b, c); lower member, Vauréal Formation, Québec. B. wilsonae: Upham Dolomite Member, Second Value Dolomite, Montoya Group, New Mexico and Texas; Selkirk Member, Red River Formation, Manitoba. B. sp. cf. B. bottei: Beaverfoot Formation, British Columbia. B. bottei: Chasm Creek Formation, Churchill River Group, Manitoba (Nelson, 1963, p. 42, 43). Streptelasma integriseptatum: Churchill River Group, lower rapids, Shamattawa (Gods) River, Manitoba. Streptelasma? latum: drift, Baffin Island, District of Franklin (Teichert, 1937, pl. 2, figs. 3, 4). Streptelasma? oppletum: Melville Peninsula, District of Franklin (Teichert, 1937, pl. 2, figs. 6, 8).

Bighornia patella (Wilson, 1926)

Fig. 9A-R

Streptelasma patellum Wilson, 1926, p. 13, pl. 2, fig. 1.Streptelasma distinctum Wilson 1926, p. 12, 13 [partim], pl. 1, fig. 6, [non] pl. 1, fig. 7.[?] Streptelasma aff. breve Ulrich in Winchell and Schuchert, 1895.

Troedsson, 1928, p. 109, pl. 26, figs. 6, 7.

Lindströmia solearis Ladd, 1929, p. 397-399, pl. 4, figs. 6-12.? Holophragma scheii Cox, 1937, p. 15-17, pl. 2, figs. 14-16.Holophragma anticonvexa Okulitch, 1943, p. 68, 69, pl. 1, figs. 11, 12."Holophragma" sp. Ross, 1957, pl. 37, figs. 3, 5-7.Bighornia parva Duncan, 1957, p. 611-614, pl. 70, figs. 1-18; Norford,1962b, pl. 6, figs. 12, 16; Norford et al. in Douglas, 1970, pl.

5, figs. 3, 11.

Bighornia patella (Wilson, 1926). Nelson, 1963, p. 40, 41, pl. 11,

figs. 1a-c, 2, 3a-d.

Bighornia solearis (Ladd, 1929). Nelson, 1963, p. 41, pl. 11, fig. 4a-d.[?] Bighornia sp. Norford and Macqueen, 1975, pl. 9, figs. 9, 10;Oliver in Oliver, Merriam, and Churkin, 1975, pl. 5, fig. 6.Bighornia cf. B. patella (Wilson, 1926). Elias, 1981, p. 25, 26[partim], [non] pl. 10, figs. 1-21; Elias, 1982a, p. 80-82[partim], pl. 14, figs. 17-24, pl. 15, figs. 1-11; Elias, 1983a,p. 948, 950-952 [partim], figs. 7d, 14e-t, 16a-o.Bighornia sp. cf. B. patella (Wilson, 1926). Elias, 1985, p. 40, 41, 43[partim], figs. 16.14-16.16, [non] figs. 16.1-16.13, 17.Lectotype—Designated herein: GSC 6732 (Wilson, 1926, pl. 2, fig. 1;

Fig. 9A), 15 m (50 ft.) above base, Beaverfoot Formation, GSC loc.

7935, near head of Windermere Creek, Stanford Range, British Columbia, J.F. Walker collection (for location, refer to Fig. 1).

Additional specimens described herein—All from Beaverfoot Formation.

Early collections (for location, refer to Fig. 1): GSC 6731 (Wilson, 1926, pl. 1, fig. 6), below "Halysites beds," GSC loc. 7561, 0.8 km (0.5 mi.) east of the trail over Palliser Pass, British Columbia, J.R. Marshall collection.

Root collection (for location, refer to Fig. 1): GSC R211-ii, R211-vi, White Knight Peak, British Columbia.

Norford collection (for locations, refer to Fig. 1; for stratigraphic positions, refer to Appendix 1): GSC NG-1-3, GSC loc. 5064, GSC NG-2-3, GSC loc. 5063, GSC NG-3-7, NG-3-8, NG-3-12, GSC loc. 5062, Carbonate Creek, British Columbia; GSC N10-1-3, N10-1-7, N10-1-17, GSC loc. 52183, Pagliaro Creek, British Columbia; GSC N11-2-3 (Fig. 9B-E), N11-2-7, N11-2-9, N11-2-11, GSC loc. 69839, Horse Creek, British Columbia; GSC N12-4-1 (Fig. 9K-N), GSC loc. 45579, GSC N12-6-1, GSC loc. 45580, Blackfoot Creek, British Columbia; GSC N14-1-9, GSC loc. 58188, Shatch Mountain, British Columbia; GSC N40-2-5, GSC loc. 42026, Cirrus Mountain, Alberta.

Present collection (all from Akutlak Creek, British Columbia; for location, refer to Figs. 1, 2; for stratigraphic positions, refer to Fig. 4): GSC K12A-14/15-6 (Fig. 9I, J), K12A-14/15-18, K12A-14/15-19, K12A-14/15-28, K12A-14/15-31, K12A-14/15-34, interval A14 + A15; GSC K12B-2-10, interval B2; GSC K12B-5-10, K12B-5-12 (Fig. 9O-Q), K12B-5-26, interval B5; GSC K12B-6-5 (Fig. 9R), interval B6; GSC K12B-16-2, interval B16; GSC K12B-24-2, K12B-24-5 (Fig. 9F-H), interval

B24; GSC K12B-25-2, K12B-25-10, interval B25.

Occurrences—Upper Ordovician: Beaverfoot Formation including Whiskey Trail Member (Richmondian, possibly Maysvillian strata) southern Rocky Mountains, British Columbia and Alberta, Canada; Fort Atkinson Formation (Richmondian), Ossian, Iowa, U.S.A.; Strandpilaren, Norman Lockyer Island, Princess Marie Bay, Ellesmere Island, District of Franklin, Canada; Gunn and Penitentiary members (middle to upper Richmondian), Stony Mountain Formation, Stony Mountain, Manitoba, Canada; shaly beds at top of Bighorn Dolomite (middle to upper Richmondian), Johnson County, Wyoming, U.S.A.; Caution Creek and Chasm Creek formations (middle Richmondian strata), Churchill River Group, Hudson Bay Lowland, Manitoba, Canada; lower member, Vauréal Formation (Richmondian), Anticosti Island, Québec, Canada; Cutter Dolomite (middle Richmondian strata), Montoya Group, Texas, U.S.A..

Diagnosis—Corallum of small to medium size. Axial structure composed of prominent columella, plus septal lobes and rarely a few lamellae in late stages. Cardinal septum becomes thin and decreases in length during intermediate stages, and moderately broad cardinal fossula develops. In transverse section, septal fibres are oriented perpendicular to medial line within septum. Tabulae in incompletely dilated stages convex upward, greatly depressed in cardinal fossula.

Description of corals—Alar-alar and cardinal-counter dimensions across the calice rim of the largest individual are 22 mm and 19 mm, respectively (GSC R211-ii). The height of this specimen is about 20 mm, but the apex is missing. The relationship between coral height

and average cross-sectional dimension for the species is shown in Fig. 8. The coralla are subcalceoloid in form and slightly curved with concave cardinal sides. They are depressed throughout ontogeny (Fig. 10). Cross-sectional shapes are highly variable, but intergradational. Of 36 specimens, 50% are triangulate with flattened counter sides and angulate cardinal sides (Fig. 9B-H). The degree of triangulation decreases during ontogeny. In one of these corals, the counter side is slightly concave (GSC K12B-25-10). The shape of 36% of the specimens is suboval (Fig. 9I, J). One of these is subrectangular in early stages (GSC K12B-16-2). A concave, spoon-shaped indentation rises from the apex on the cardinal side in 14% of the corals. The shape of cross sections through these structures is generally crescentic (Fig. 9O-Q), but one individual is subrectangular (Fig. 9K-N). In all cases, a slight ridge is centred along the cardinal septum, and lateral projections extend the widths of two coralla (Fig. 9K, L, O-Q). These spoon-shaped structures have been interpreted as attachment sites (see Attachment structures under "Taphonomy and paleoecology"). The form of the coral returns to normal above such structures (Fig. 9M, N).

Within the calice, a prominent columella rises from a low boss formed by other elements of the axial structure (Fig. 9A, R)

Ontogeny and internal structures—The relationship between number of septa and coral average cross-sectional dimension is shown in Fig. 11. Individuals with the highest numbers of septa also have the most depressed cross-sectional shapes (GSC K12B-16-2, K12B-25-10). Of 18 specimens, 67% have very greatly to completely dilated septa until

just below the base of the calice (Fig. 9B-E, I, J). In 11%, dilation begins to decrease during intermediate stages (Fig. 9F-H). All of these corals are triangulate to suboval in form. In the remaining 22%, septa are nondilated to moderately dilated in all known ontogenetic stages (Fig. 9K-Q). Each of these individuals has a spoon-shaped indentation on the cardinal side.

In early ontogenetic stages, major septa meet at the axis of slightly depressed coralla (Fig. 9B), or along a zone that is elongate in the alar-alar direction of more depressed individuals (Fig. 9F, K, O). During intermediate stages (Fig. 9C, G, I, L, P), a columella develops at the axis. It is an extension of the counter septum, and is lenticular in cross section and elongate in the cardinal-counter direction. The columella is comparatively small in markedly depressed corals. The cardinal septum becomes thin, detaches from the columella, and remains very short thereafter. In 12 specimens, it was verified that the cardinal septum becomes short below the level at which sediment fills interseptal spaces (Appendix 5). The cardinal septum is long at higher levels in only two individuals. The cardinal fossula is moderately broad, with an expanded axial end. In intermediate to late stages (Fig. 9D, E, H, J, M, N, Q), the major septa join in groups axially, and septal lobes plus rarely a few lamellae appear on both alar sides of the columella. Minor septa are confined to the stereozone until the base of the calice, where some extend a very short distance beyond it in many corals. Thickness of the stereozone at the base of the calice ranges from 17% (GSC K12A-14/15-6) to 31% of the average cross-sectional radius (GSC N11-2-3).

Tabulae are not apparent in the majority of specimens, which have

completely dilated septa until near the base of the calice. In coralla having incompletely dilated septa in earlier stages, tabulae are greatly convex upward. They are greatly depressed in the cardinal fossula, and decline from the axis at an angle of approximately 80° (Fig. 9R).

Microstructure—In transverse thin sections, the major septa and axial structure are fibrous (e. g., Elias, 1983a, figs. 7d, 16g). The fibres extend perpendicularly from a medial line in the septum, and radiate from a medial position in the columella. A contorted suture extends between the major and minor septa where they are in lateral contact. The epitheca consists of short, indistinct fibres that are approximately perpendicular to the surface of the corallum. In a longitudinal thin section (GSC K12B-6-5), septal fibres are slightly inclined from the coral wall toward the axis, and fibres are inclined upward from a medial position in the columella.

Discussion—Streptelasma patellum was first described from the Beaverfoot Formation in British Columbia by Wilson (1926). She did not identify type specimens, but illustrated one coral which is herein designated as the lectotype of Bighornia patella (Wilson, 1926) (GSC 6732; Wilson, 1926, pl. 2, fig. 1; Fig. 9A). Another individual that was illustrated by Wilson (1926, pl. 1, fig. 6; GSC 6731) is depressed and the cardinal septum is located on the concave side. It was originally identified as Streptelasma distinctum Wilson, 1926, but is reassigned to Bighornia patella.

The material described herein cannot be distinguished from well

preserved specimens in an unknown unit on Ellesmere Island (Cox, 1937; PMO A 10585-10588 examined in this study), the Stony Mountain Formation (Okulitch, 1943; Elias, 1983a), the upper Bighorn Dolomite (Ross, 1957; Duncan, 1957; Norford, 1962b; Douglas, 1970), and the Vauréal Formation (Elias, 1982a). All these corals lie within the range of variability that has been documented for large collections from the Stony Mountain and Beaverfoot formations, involving size and shape of the corallum, number and arrangement of septa, degree of septal dilation, length of the cardinal septum and minor septa, type of septal microstructure, size and shape of the cardinal fossula, and size and nature of the axial structure. In this taxon, the length of the cardinal septum decreases during intermediate ontogenetic stages. It has been verified that the cardinal septum becomes short below the level at which sediment fills interseptal spaces in 25 specimens (12 from the Beaverfoot Formation, seven from the Stony Mountain Formation, three from Ellesmere Island, two from the Bighorn Dolomite, and one from the Vauréal Formation; Appendix 5). Only two corals, both from the Beaverfoot, are known to have a long cardinal septum at levels where sediment fills interseptal spaces. Septal fibres are oriented perpendicular to a medial line within the septum in transverse thin sections (Elias, 1983a, fig. 7d). The microstructure of silicified individuals from the Fort Atkinson Formation (Ladd, 1929; Elias, 1982a), Churchill River Group (Nelson, 1963), and Cutter Dolomite (Elias, 1985) is not known, but in other respects they cannot be distinguished from the specimens discussed above. Streptelasma patellum was the earliest name proposed, and all these corals are herein assigned to Bighornia

patella.

B. wilsonae Knapp and Elias, n. sp. is similar to B. patella (refer to Figs. 8-11), but the cardinal septum remains long until just below the base of the calice, and septal fibres curve outward in the direction of the coral axis from a medial position within the septum. Specimens of Bighornia from the following Upper Ordovician units probably belong to one of these species, but cannot be assigned with certainty because the microstructure and nature of the cardinal septum below the calice are unknown: Cape Calhoun Formation in northwestern Greenland (Troedsson, 1928; MMH 2994, 2995 examined in this study), basal and middle members of the Mount Kindle Formation in the District of Mackenzie (Norford and Macqueen, 1975), and an unnamed unit in east-central Alaska (Oliver, Merriam, and Churkin, 1975).

Two specimens from the Beaverfoot Formation that are representatives of Bighornia attain substantially larger sizes, expand more rapidly above the apex, and are more depressed than coralla assigned to B. patella (Figs. 8-10). They are identified as B. sp. cf. B. bottei Nelson, 1963.

Figure 9. Bighornia patella (Wilson, 1926) from the Beaverfoot Formation, B. wilsonae Knapp and Elias n. sp. from the Selkirk Member, Red River Formation, and B. sp. cf. B. bottei Nelson, 1981 from the Beaverfoot Formation. A-R, B. patella. A, GSC 6732 (lectotype): view of calice (stereopair), X2. B-E, GSC N11-2-3: transverse sections, X3.5. F-H, GSC K12B-24-5: transverse sections, X3.5. I, J, GSC K12A-14/15-6: transverse sections, X3.5. K-N, GSC N12-4-1: transverse sections, X3.5. O-Q, GSC K12B-5-12: transverse sections, X3.5. R, GSC K12B-6-5: longitudinal section (cardinal side right), X3.5. S-V, B. wilsonae. S, T, GSC UM 215: transverse sections, X3.5. U, V, GSC RJE 1-293: transverse sections, X3.5. W-BB, B. sp. cf. B. bottei. W-Y, GSC N11-2-2: transverse sections, X1.25. Z-BB, GSC N10-1-2: transverse sections, X1.25.

Note: Photograph Y should be rotated 180°.

Calice rim in lower left of photograph A faces inward as a result of damage to specimen.

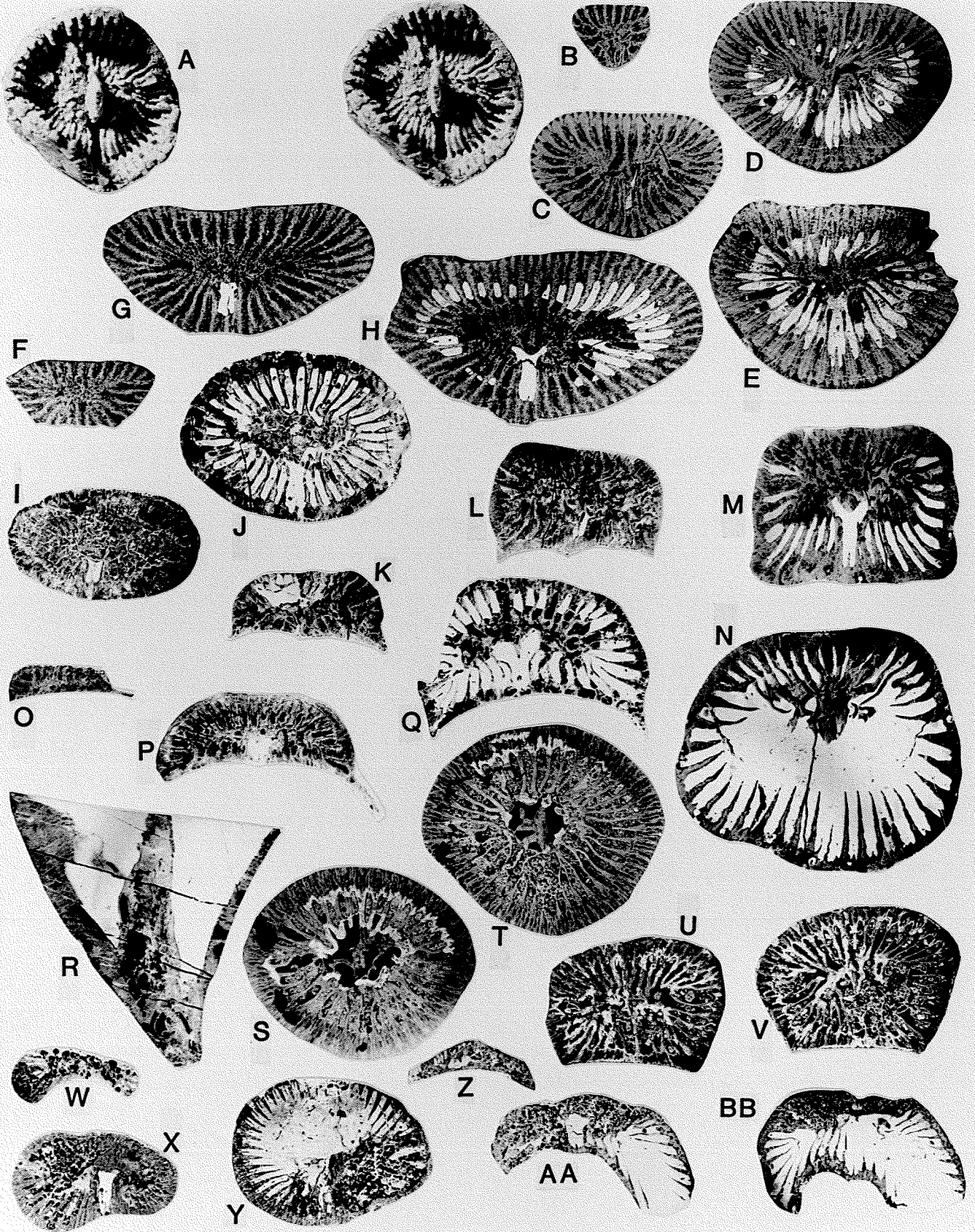


Figure 10. Relationship between cardinal-counter and alar-alar cross-sectional dimensions in Bighornia. B. patella: Beaverfoot Formation, British Columbia and Alberta; Fort Atkinson Formation, Maquoketa Group, Iowa; Ellesmere Island, District of Franklin; Gunn and Penitentiary members, Stony Mountain Formation, Manitoba; upper Bighorn Dolomite, Wyoming (Duncan, 1957, p. 611-613); Caution Creek and Chasm Creek formations, Churchill River Group, Manitoba (Nelson, 1963, pl. 11, figs. 1c, 2, 3c, 4c); lower member, Vauréal Formation, Québec. B. sp. cf. B. bottei: Beaverfoot Formation, British Columbia. B. wilsonae: Upham Dolomite Member, Second Value Dolomite, Montoya Group, New Mexico and Texas; Selkirk Member, Red River Formation, Manitoba. Equidimensional corals plot on the line, depressed corals plot below line.

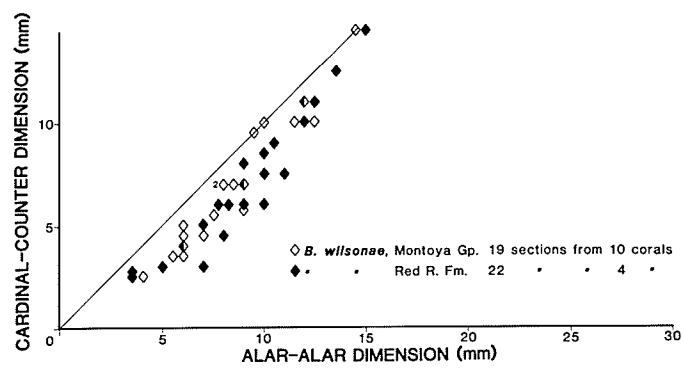
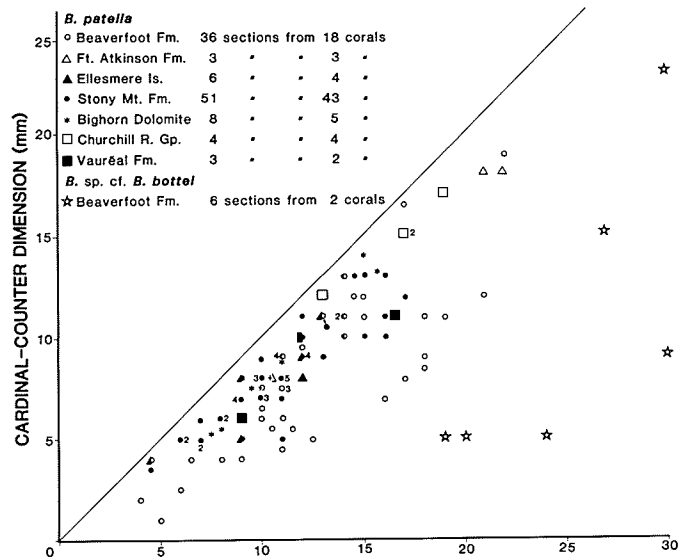
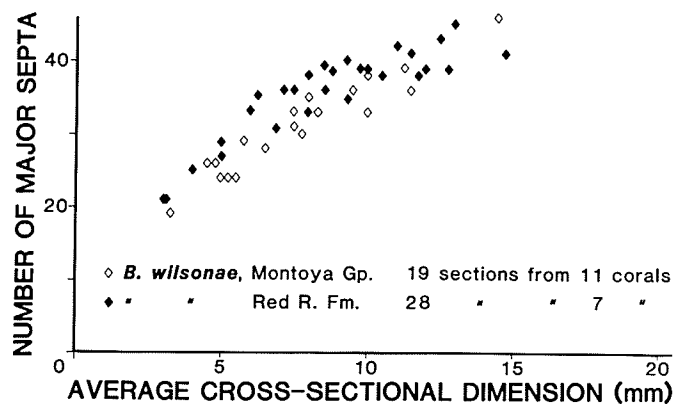
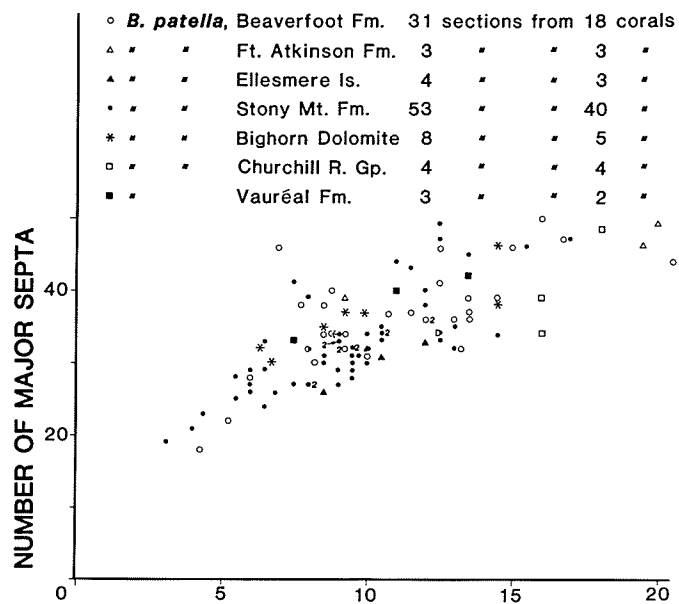


Figure 11. Relationship between number of major septa and coral average cross-sectional dimension (average of cardinal-counter and alar-alar cross-sectional dimensions) in Bighornia. B. patella: Beaverfoot Formation, British Columbia and Alberta; Fort Atkinson Formation, Maquoketa Group, Iowa; Ellesmere Island, District of Franklin; Gunn and Penitentiary members, Stony Mountain Formation, Manitoba; upper Bighorn Dolomite, Wyoming (Duncan, 1957, p. 611-613); Caution Creek and Chasm Creek formations, Churchill River Group, Manitoba (Nelson, 1963, pl. 11, figs. 1c, 2, 3c, 4c); lower member, Vauréal Formation, Québec. B. wilsonae: Upham Dolomite Member, Second Value Dolomite, Montoya Group, New Mexico and Texas; Selkirk Member, Red River Formation, Manitoba.



Bighornia wilsonae Knapp and Elias, n. sp.

Fig. 9S-V

[?] Streptelasma aff. breve Ulrich in Winchell and Schuchert, 1895.

Troedsson, 1926, p. 109, pl. 26, figs. 6, 7.

[?] Bighornia sp. Norford and Macqueen, 1975, pl. 9, figs. 9, 10;

Oliver in Oliver, Merriam, and Churkin, 1975, pl. 5, fig. 6.

Bighornia cf. B. patella (Wilson, 1926). Elias, 1981, p. 25, 26

[partim], pl. 10, figs. 1-21; Elias, 1982a, p. 80-82 [partim],

[non] pl. 14, figs. 17-24, pl. 15, figs. 1-11; Elias, 1983a,

p. 948, 950-952 [partim], [non] figs. 7d, 14e-t, 16a-o.

Bighornia sp. cf. B. patella (Wilson 1926). Elias, 1985, p. 40, 41, 43

[partim], figs. 16.1-16.13, 17, [non] 16.14-16.16.

Derivation of name—The species is named for Alice E. Wilson, who first described the fauna of the Beaverfoot Formation.

Holotype—Designated herein: USNM 381185 (Elias, 1985, figs. 16.1-16.7, 17), Upham Dolomite Member, Second Value Dolomite, Montoya Group, Cooks Range, Luna County, New Mexico (interval RHF-CR2, section 4 of Elias, 1985).

Paratypes—Designated herein: USNM 381190 (Elias, 1985, figs. 16.11-16.13), Upham Dolomite Member, Second Value Dolomite, Montoya Group, Alamo Canyon, Otero County, New Mexico (interval AC2, section 7 of Elias, 1985); USNM 381201 (Elias, 1985, fig. 16.10), 381202 (Elias, 1985, figs. 16.8, 16.9), Upham Dolomite Member, Second Value Dolomite, Montoya Group, Scenic Drive, El Paso County, Texas (interval SD1, section 11 of Elias, 1985).

Specimens examined herein—All from Selkirk Member, Red River Formation, Garson, Manitoba. GSC UM 215 (Fig. 9S, T), Rand collection; GSC RJE 1-271, Garson Limestone Co. Ltd. quarry, Elias collection; GSC RJE 1-293 (Fig. 9U, V), Gillis Quarries Ltd. quarry, Elias collection.

Occurrences—Upper Ordovician: Selkirk Member (middle Maysvillian strata), Red River Formation, Garson, Manitoba, Canada; Upham Dolomite Member (middle Edenian to lowermost Maysvillian), Second Value Dolomite, Montoya Group, New Mexico and Texas, U.S.A.

Diagnosis—Like Bighornia patella (Wilson, 1926), but cardinal septum remains long until immediately below base of calice in late stages. In transverse sections, septal fibres curve outward in direction of coral axis from a medial position in septum.

Discussion—The corals assigned herein to Bighornia wilsonae Knapp and Elias, n. sp. resemble B. patella (Wilson, 1926) in external form (refer to Figs. 8-10). Internal morphologies of these taxa are similar (refer to Figs. 9, 11), but in B. wilsonae the cardinal septum is long until just below the base of the calice. It has been verified that this septum remains long until above the level at which sediment begins to fill interseptal spaces in 12 specimens (eight from the Red River Formation, and four from the Second Value Dolomite; Appendix 5). In B. patella, the cardinal septum becomes short earlier during ontogeny (compare Fig. 9S, T with Fig. 9D, E, and Fig. 9U, V with Fig. 9P, Q). The microstructure in transverse sections of these species is also different. Septal fibres in B. wilsonae curve outward in the direction of the coral axis from a medial position within the septum (Elias, 1985, fig. 17). In B. patella, the fibres are perpendicular to the medial

line. Uncertainty concerning the specific identity of specimens from Greenland, District of Mackenzie, and Alaska was discussed under B. patella.

Bighornia sp. cf. B. bottei Nelson, 1963

Fig. 9W-BB

[cf.] Bighornia sp. Nelson, 1959, pl. 4, figs. 3a-d; Nelson, 1975, pl. 8, figs. 4-7.

[cf.] Bighornia bottei Nelson, 1963, p. 41-43, pl. 5, fig. 6, pl. 9, figs. 5, 6a-d, pl. 11, figs. 5a, b, 6a-c, 7, 8, pl. 12, figs. 1, 2a-g, 3a, b, 4a-c.

Specimens described herein—All from Beaverfoot Formation. Norford collection (for locations, refer to Fig. 1; for stratigraphic positions, refer to Appendix 1): GSC N10-1-2 (Fig. 9Z-BB), GSC loc. 52183, Pagliaro Creek, British Columbia; GSC N11-2-2 (Fig. 9W-Y), GSC loc. 69839, Horse Creek, British Columbia.

Occurrence—Upper Ordovician: Beaverfoot Formation (Richmondian, possibly Maysvillian strata), southern Rocky Mountains, British Columbia.

Description of corals—Both specimens are poorly preserved, and are affected by silicification and recrystallization. The height of one is estimated at about 25 mm (GSC N11-2-2), but the apical end is terminated along a stylolitic surface. The coralla expand rapidly above the apex (Fig. 8). Alar-alar dimensions across the calice rims are approximately 33 mm and 35 mm (GSC N11-2-2, N10-1-2, respectively). Both corals are depressed (Fig. 10; Appendix 3), with a spoon-shaped indentation rising from the apex on the cardinal side. A ridge along the cardinal septum is prominent on one individual (Fig. 9Z-BB). The other becomes suboval in cross section above the indentation

(Fig. 9W-Y).

Ontogeny and internal structures—One specimen is estimated to have 52 major septa at an alar-alar dimension of 27 mm (GSC N11-2-2). In early stages, the major septa are moderately to greatly dilated, and meet along a zone that is elongate in the alar-alar direction (Fig. 9W, Z). During intermediate stages, the thin cardinal septum becomes short, and a broad cardinal fossula with an expanded axial end develops (Fig. 9X, AA). A columellar structure that is apparently continuous with the counter septum can be detected in one coral (GSC N11-2-2). Septal lobes and lamellae are present in the axial region during late stages (Fig. 9Y, BB). A prominent, lenticular columella can be seen in one specimen (GSC N11-2-2). A few minor septa extend a short distance beyond the stereozone in both specimens.

Numerous tabulae are visible in transverse sections of one individual (Fig. 9W, X).

Microstructure—The original calcitic composition and microstructure are preserved in parts of one specimen (GSC N11-2-2). In transverse thin sections, septal fibres extend perpendicularly from a medial line in the septum. A contorted suture extends between the major and minor septa where they are in lateral contact.

Discussion—Compared with coralla assigned to B. patella (Wilson, 1926), the two specimens described above attain substantially larger sizes, expand more rapidly above the apex (Fig. 8), and are more depressed (Fig. 10). They are considered to represent the large size group of Bighornia (see Discussion under "Genus Bighornia Duncan,

1957"). The better preserved coral (GSC N11-2-2) is similar to B. bottei Nelson, 1963, which was described from the Chasm Creek Formation (middle to upper Richmondian) of the Churchill River Group in northern Manitoba. It resembles the latter species in external form, number plus dilation and arrangement of septa, nature of the cardinal fossula, type of axial structure, and development of tabulae. The other specimen (GSC N10-1-2) is more depressed than the types of B. bottei, which were measured by Nelson (1963, p. 42, 43). Because of the limited amount of data, and the poor understanding of other taxa included in the large size category of the genus, these corals from the Beaverfoot Formation are herein identified as B. sp. cf. B. bottei.

Genus Grewingkia Dybowski, 1873Grewingkia haysii haysii (Meek, 1865)

Figs. 5A-D, 12A-M

Zaphrentis haysii Meek, 1865, p. 32.Streptelasma haysii (Meek, 1865). Kirk, 1925, p. 445; Ladd, 1929, p. 396, 397, pl. 4, figs. 3-5, [?] 1, 2; Cox, 1937, p. 8, 9 [partim], [non] pl. 2, fig. 4a,b.Streptelasma prolongatum Wilson, 1926, p. 11, 12 [partim], pl. 1, fig. 3, [non] pl. 1, figs. 4, 5, pl. 2, fig. 2.Streptelasma foerstei Troedsson, 1928, p. 109, pl. 25, figs. 1, 3, pl. 26, fig. 5; Cox, 1937, p. 6-8, pl. 1, figs. 10, 11, [?] 12-16.Streptelasma goniophylloides Teichert, 1937, p. 49, 50, pl. 3, figs. 5-11.Streptelasma trilobatum (Whiteaves, 1895) var. Nelson, 1959, pl. 3, figs. 3a,b.Streptelasma prolongatum Wilson, 1926. Norford, 1962b, pl. 6, figs. 13, 14.Lobocorallium trilobatum var. major Nelson, 1963, p. 35-37, pl. 5, fig. 1, pl. 8, fig. 4, pl. 10, figs. 1, 2a-h.Lobocorallium trilobatum (Whiteaves, 1895). Nelson, 1975, pl. 8, figs. 2, 3.[?] Lobocorallium cf. L. trilobatum major Nelson, 1963. Norford and Macqueen, 1975, pl. 9, fig. 17.Lobocorallium major Nelson, 1963. Bolton and Nowlan, 1979, pl. 1, fig. 2.

Lobocorallium trilobatum major Nelson, 1963. Nelson, 1981, p. 51, 52, fig. 13, pl. 6, figs. 9-11, pl. 7, figs. 1-5.

Lobocorallium prolongatum (Wilson, 1926). Norford et al. in Douglas, 1970, pl. 5, fig. 1.

Grewingkia haysii (Meek, 1865). Elias, 1981, p. 17, 18 [partim], pl. 5, figs. 1-5, [non] pl. 5, figs. 6-15, pl. 6, figs. 1-12.

Grewingkia haysii haysii (Meek, 1865). Elias, 1985, p. 28, 29, 31.

Lectotype—Designated by Ladd (1929, p. 396, 397): USNM 25683 (Ladd, 1929, pl. 4, figs. 3-5; Elias, 1981, pl. 5, figs. 1-5), Cape Frazier, Ellesmere Island, District of Franklin, Northwest Territories.

Specimens described herein—All from Beaverfoot Formation.

Early collections (for location, refer to Fig. 1): GSC 6729, below "Halysites beds," GSC loc. 7563, 1.2 km (0.75 mi.) east of trail over Palliser Pass, British Columbia, J.R. Marshall collection.

Root collection (for location, refer to Fig. 1): GSC R211-i (Fig. 12M), White Knight Peak, British Columbia.

Norford collection (for locations, refer to Fig. 1; for stratigraphic positions, refer to Appendix 1): GSC N4-1-3, GSC loc. 64584, 6.4 km (4 mi.) south-southeast of Indianhead Mountain, British Columbia; GSC N7-3-10, GSC loc. 56076, Pinnacle Creek, British Columbia; GSC N12-1-1, GSC loc. 52159, GSC N12-2-1, N12-2-3, N12-2-5, N12-2-6, GSC loc. 45578, GSC N12-5-2 (Fig. 12J-L), GSC loc. 47414, Blackfoot Creek, British Columbia; GSC N17-1-1, GSC loc. 47426, Mount Onslow, British Columbia; GSC 16917 (Norford, 1962b, pl. 6, figs. 13, 14; Douglas, 1970, pl. 5, fig. 1; Fig. 12A), GSC loc. 42026, Cirrus

Mountain, Alberta.

Present collection (all from Akutlak Creek, British Columbia; for location, refer to Figs. 1, 2; for stratigraphic positions, refer to Fig. 4): GSC K12A-14/15-4b (Fig. 12B, C), K12A-14/15-10, K12A-14/15-12 (Fig. 12D), interval A14 + A15; GSC K12A-15/16-4, interval A15 + A16; GSC K12A-18-2, K12A-18-3, K12A-18-5 (Fig. 12G-I), K12A-18-9, K12A-18-14, K12A-18-15, K12A-18-22, interval A18; GSC K12A-BR-7, rubble near interval A18; GSC K12B-1-4, interval B1; GSC K12B-2-6, interval B2; GSC K12B-3-2, interval B3; GSC K12B-5-4, K12B-5-14, K12B-5-19, K12B-5-29, K12B-5-30 (Fig. 5A-D), interval B5; GSC K12B-6-3 (Fig. 12E, F), interval B6; GSC K12B-7-4, interval B7; GSC K12B-23-2, interval B23; GSC K12B-25-9, interval B25.

Occurrences—Upper Ordovician: Cape Frazier on Ellesmere Island and Mt. Nautilus on Baffin Island, District of Franklin, Northwest Territories, Canada; Cape Calhoun Formation (Upper Ordovician), Cape Calhoun, northwestern Greenland; Caution Creek and Chasm Creek formations (middle to upper Richmondian), Churchill River Group, Hudson Bay Lowland, Manitoba, Canada; Richmondian outlier north of Aberdeen Lake, District of Keewatin, Northwest Territories, Canada; Beaverfoot Formation including Whiskey Trail Member (Richmondian, possibly Maysvillian strata), southern Rocky Mountains, British Columbia and Alberta, Canada.

Diagnosis—Corallum slightly to markedly trilobate, trilobation most pronounced in intermediate stages. Cross section generally depressed to equidimensional. Major septa completely dilated in early stages,

degree of dilation decreases gradually during ontogeny. Axial structure large and complex, with septal lobes in periphery and contorted septal lamellae concentrated axially.

Description of corals—The longest coral has a length of 150 mm, but the base and part of the calice rim are missing (Fig. 12J). The upper portion is nearly cylindrical, with a maximum average cross-sectional dimension of 52 mm. Another individual has an average cross-sectional dimension of 64 mm just below the base of the calice (GSC K12A-18-22), and two incomplete specimens are even larger (GSC R211-i, N12-2-1). The corals are trochoid and moderately to greatly curved. They vary from depressed to compressed; most are depressed to equidimensional throughout ontogeny (Fig. 13). The cross-sectional shape is triangulate in early stages, and becomes trilobate early in intermediate stages. The maximum degree of trilobation, attained during intermediate stages, varies from slight to pronounced. It decreases during late stages, and the shape of some individuals returns to triangulate. A convex calicular boss corresponding to the axial structure begins to develop during intermediate stages (Fig. 12A), and is large in late stages. Depth of the calice is approximately 27% of the coral length (GSC K12B-5-30, length = 75 mm; Fig. 5A).

One specimen has an outer wall irregularity of the type described and interpreted by Elias (1984a, p. 103-105, fig. 1; Fig. 12L, alar position on left side).

Ontogeny and internal structures—The relationship between number of septa and coral average cross-sectional dimension is shown in Fig. 14.

In early ontogenetic stages, the major septa are greatly to usually completely dilated (Fig. 12B). The degree of dilation decreases gradually during intermediate (Fig. 12C, E, K) and late stages (Fig. 12D, F, I, L, M). By late stages, they vary from nondilated to moderately dilated, but remain completely dilated in the peripheral portion of the septal region in some corals. Major septa extend to the axis in early stages. During intermediate stages, a few septal lobes followed by lobes plus a few lamellae form the axial structure. They are moderately to generally greatly dilated. A median lamella is present in only two specimens (GSC K12A-14/15-4b, K12B-5-4). During late stages, the large, complex axial structure consists of septal lobes at the periphery plus numerous, nondilated to moderately dilated, generally long and contorted septal lamellae concentrated axially. The shapes of the axial region and coral exterior are similar in cross section. In late stages, the average radius of the axial region varies from 38% (GSC K12A-18-3) to 57% of the average coral radius (GSC N12-5-2).

The cardinal septum is long, and becomes thinner than other major septa toward the base of the calice. In one specimen, it becomes short at the base of the calice (GSC K12A-15/16-4). The relatively narrow cardinal fossula is conspicuous in intermediate to late stages. In some individuals it is slightly expanded at the axis. In corals having nondilated major septa in the latest stages, some minor septa extend beyond the relatively narrow stereozone. The maximum length of these septa is 19% of the average coral radius, in a specimen where the corresponding thickness of the stereozone is 8% of the radius

(GSC K12A-14/15-10).

The complete and incomplete tabulae are moderately to greatly convex upward in the axial region, and spaced 0.3 to 1.6 mm apart (Fig. 12G,H). Tabellae in the septal region are spaced up to 2.8 mm apart.

Microstructure—In transverse thin sections, the major septa, septal lobes, and lamellae are fibrous (e. g., Nelson, 1981, fig. 14; Elias, 1981, fig. 5a, b). From a medial position in the septum, fibres curve outward in the direction of the coral axis. A contorted suture extends between septa of both orders where they are in lateral contact in the stereozone. In incompletely dilated stages, U-shaped lamellae with concave sides facing the coral axis appear between septa in the stereozone. A contorted suture extends through the lamellae in a medial position between the septa.

Discussion—In her work on the Beaverfoot fauna, Wilson (1926) did not describe a taxon to include the type of corals documented above. However, one specimen that she illustrated as Streptelasma prolongatum Wilson, 1926 is trilobed and has an axial structure (GSC 6729; Wilson, 1926, pl. 1, fig. 3). The individual illustrated in Norford (1962b) and Douglas (1970) and identified as Streptelasma prolongatum and Lobocorallium prolongatum, respectively, is also trilobed and has an axial structure (Fig. 12A). These corals are herein assigned to Grewinkia haysii haysii (Meek, 1865).

These solitary rugosans from the Beaverfoot Formation cannot be distinguished from those included in the synonymy and assigned to G. haysii haysii by Elias (1985). Previously, the range of variability

in this taxon had been established primarily on the basis of a relatively large collection from the Churchill River Group (Nelson, 1963, 1981; Figs. 13, 14). The Beaverfoot material described herein provides additional information on variability involving external form and internal morphology. Norford and Macqueen (1975) illustrated a transverse section cut through the calice of a large coral from the basal member (Upper Ordovician) of the Mount Kindle Formation in the District of Mackenzie. It is triangulate in shape and has a Grewingkia-type axial structure. This specimen could represent G. haysii haysii, but a definite specific assignment is not possible until earlier ontogenetic stages are studied.

G. haysii selkirkensis Elias, 1985 is known from the Selkirk Member (middle Maysvillian to possibly lower Richmondian) of the Red River Formation in southern Manitoba (Elias, 1981, p. 17, 18, pl. 5, figs. 6-15, pl. 6, figs. 1-12; 1985, p. 31). The coralla are all compressed, whereas most individuals in collections of G. haysii haysii are depressed to equidimensional (Elias, 1985, fig. 10; Fig. 13). G. haysii selkirkensis is similar to G. franklinensis Elias, 1985 from the Aleman Formation (lower Maysvillian to lower Richmondian) of the Montoya Group in New Mexico and Texas, and G. sp. cf. G. franklinensis from the Cutter Dolomite (middle Richmondian) of the Montoya in Texas (Elias, 1985, p. 31-33, figs. 11.1-11.19). Corals of the latter species are distinct from G. haysii in having a median septal lamella in the axial structure during late stages.

Lobocorallium trilobatum trilobatum (Whiteaves, 1895) is present in the Gunn and Penitentiary members (middle to upper Richmondian) of

the Stony Mountain Formation in southern Manitoba, and equivalent red shaly beds within the upper part of the Bighorn Dolomite in Wyoming (Elias, 1983a, p. 944, 946-948, figs. 11u-cc, 13a-m, 14a-d). It is most similar to G. haysii haysii, but the degree of trilobation is more pronounced throughout ontogeny, the septa are generally completely dilated until the base of the calice, and the axial structure is usually smaller and simpler. L. trilobatum vaurealense (Twenhofel, 1928) is known from Richmondian strata within the upper member of the Vauréal Formation on Anticosti Island, and the White Head Formation at Percé, Québec. It most closely resembles G. haysii selkirkensis, but the coralla are all trilobate throughout ontogeny, and the degree of septal dilation does not decrease until later ontogenetic stages.

On the basis of external form, it can be difficult to distinguish relatively small, compressed specimens of G. haysii haysii from mature corals of Deiracorallium prolongatum (Wilson, 1926) in collections from the Beaverfoot Formation. However, individuals of the latter species are generally more compressed (Fig. 13), are triangulate to only very slightly trilobate, and rarely have an axial structure, which is comparatively small. Tiny corals representing early ontogenetic stages of these taxa are commonly poorly preserved, and can seldom be identified to the specific level. It appears that such specimens belonging to D. prolongatum are more compressed than G. haysii haysii.

Figure 12. Grewingkia haysii haysii (Meek, 1865) from the Beaverfoot Formation. A, GSC 16917: view of calice (stereopair), X1.5. B, C, GSC K12A-14/15-4b: transverse sections, X3, X2. D, GSC K12A-14/15-12: transverse section, X1.5. E, F, GSC K12B-6-3: transverse sections, X1.5. G-I, GSC K12A-18-5: G, H, longitudinal sections (cardinal side right), X1.5; I, transverse section, X1.5. J-L, GSC N12-5-2: J, alar view (cardinal side left), X1; K, L, transverse sections, X1.5. M, GSC R211-i: transverse section, X1. Position of possible ostracode (F) and Trypanites boring (L) indicated by arrows.

Note: "I-" should be positioned midway between G and H.

Trypanites boring present at the top of photograph L.

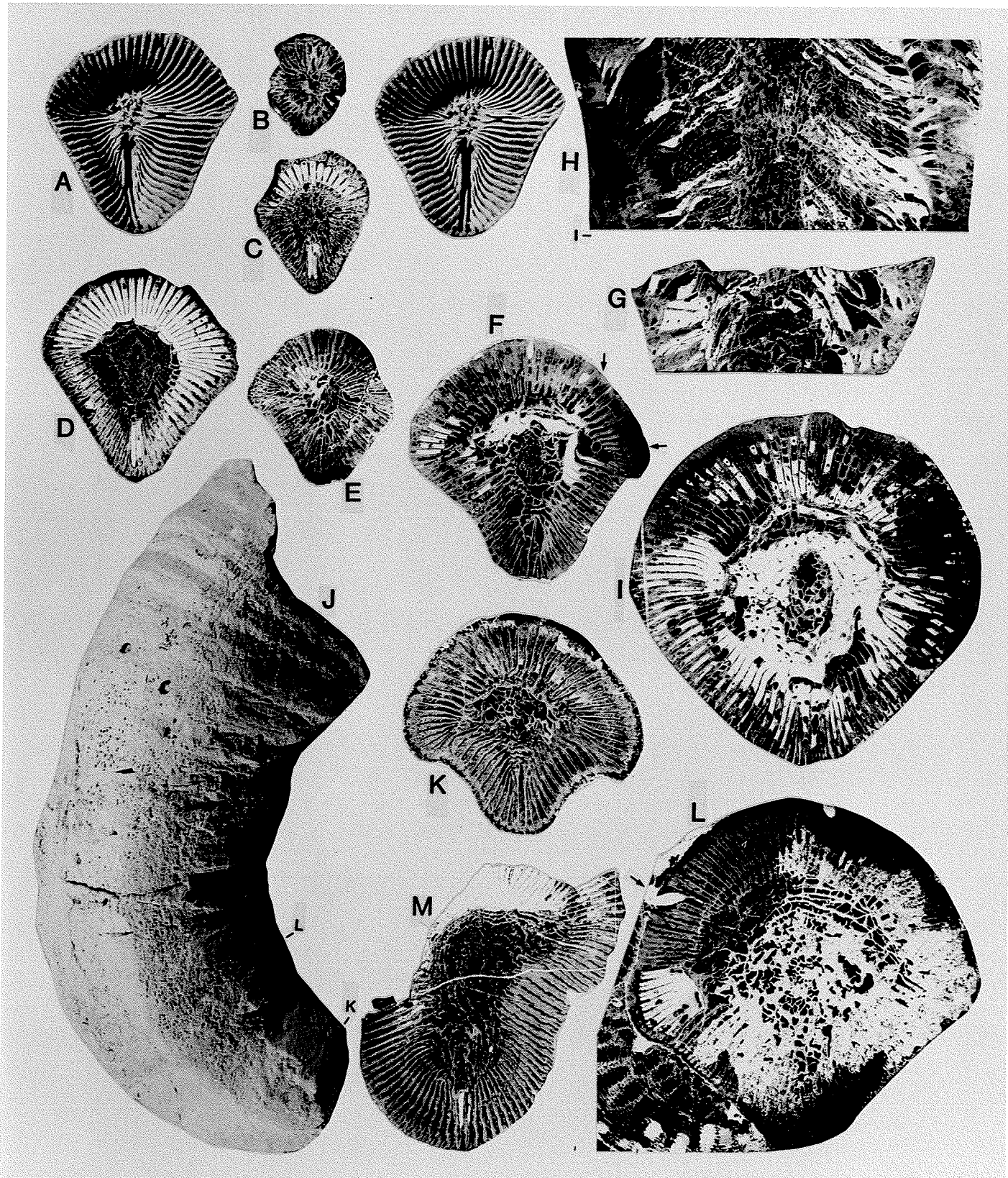


Figure 13. Relationship between cardinal-counter and alar-alar cross-sectional dimensions in Grewingkia and Deiracorallium. G. haysii haysii: Beaverfoot Formation, British Columbia and Alberta; Ellesmere Island, District of Franklin; Cape Calhoun Formation, northwestern Greenland; Caution Creek and Chasm Creek formations, Churchill River Group, Manitoba; outlier north of Aberdeen Lake, District of Keewatin (except for Beaverfoot Formation, sources of data cited in Elias, 1985, fig. 10). D. prolongatum: Beaverfoot Formation, British Columbia and Alberta; Chasm Creek Formation, Churchill River Group, Manitoba (Nelson, 1963, p. 39, pl. 13, figs. 6a-c; 1981, pl. 8, figs. 15-17).

◊	<i>G. haysii haysii</i> , Beaverfoot Fm.	15 section(s) from 12 coral(s)
◻	" " " " Ellesmere Is.	2 " " 1 "
◊	" " " " Cape Calhoun Fm.	8 " " 5 "
◻	" " " " Churchill R. Gp.	13 " " 4 "
◻	" " " " Aberdeen L.	1 " " 1 "
▲	<i>D. prolongatum</i> , Beaverfoot Fm.	14 " " 8 "
▲	" " " " Churchill R. Gp.	7 " " 2 "

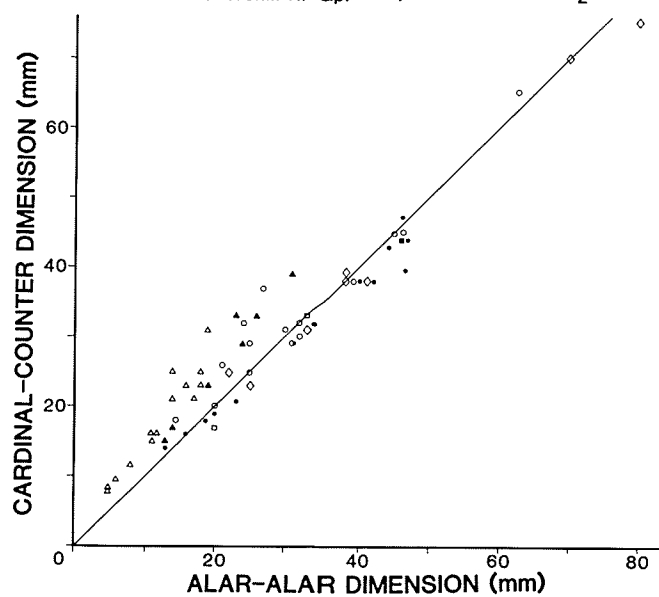
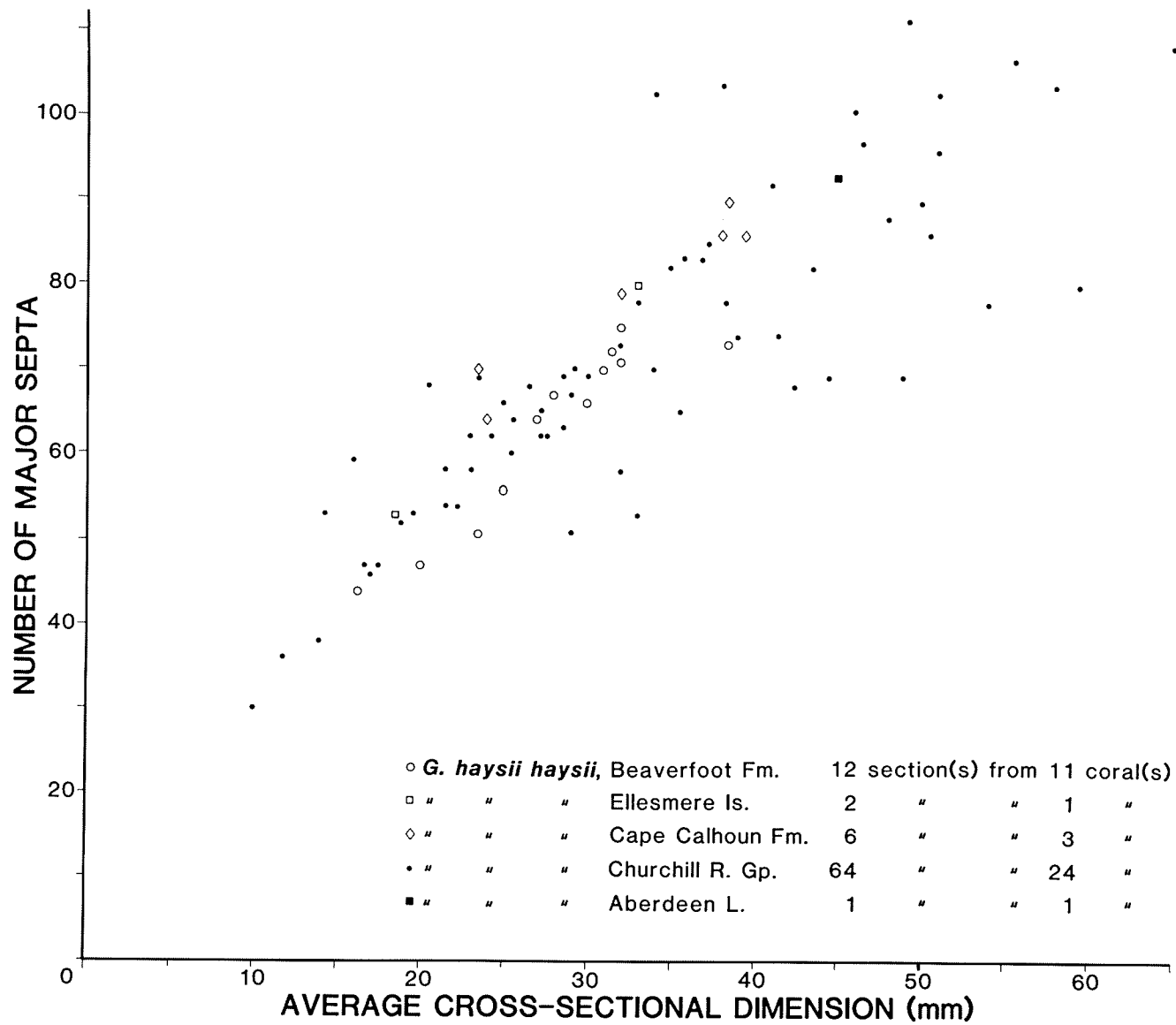


Figure 14. Relationship between number of major septa and coral average cross-sectional dimension (average of cardinal-counter and alar-alar dimensions) in Grewingkia haysii haysii: Beaverfoot Formation, British Columbia and Alberta; Ellesmere Island, District of Franklin; Cape Calhoun Formation, northwestern Greenland; Caution Creek and Chasm Creek formations, Churchill River Group, Manitoba; outlier north of Aberdeen Lake, District of Keewatin (except for Beaverfoot Formation, sources of data cited in Elias, 1985, fig. 9).



Genus Deiracorallium Nelson, 1963Deiracorallium prolongatum (Wilson, 1926)

Fig. 15A-N

Streptelasma prolongatum Wilson, 1926, p. 11-12, pl. 1, fig. 4,

[non] pl. 1, figs. 3, 5, [?] pl. 2, fig. 2.

[non] Streptelasma sp. cf. S. prolongatum Wilson, 1926. Pestana, 1960,

p. 866, 867, pl. 109, fig. 1.

[non] Streptelasma prolongatum Wilson, 1926. Norford, 1962b, pl. 6,

figs. 13, 14.

Deiracorallium giganteum Nelson, 1963, p. 38, 39, pl. 13, figs.

4a, b, 5, 6a-c; Nelson, 1981, p. 54-55, fig. 13, pl. 8, figs.

8-11, 15-17.

[non] Lobocorallium prolongatum (Wilson, 1926). Norford et al. in

Douglas, 1970, pl. 5, fig. 1.

Lectotype—Designated herein: GSC 6729b (Wilson, 1926, pl. 1, fig. 4),below "Halysites beds," Beaverfoot Formation, GSC loc. 7563, 1.2 km

(0.75 mi.) east of trail over Palliser Pass, British Columbia,

J.R. Marshall collection.

Additional specimens described herein—All from Beaverfoot Formation.Early collections (for location, refer to Fig. 1): GSC W1-1-1,76 m (250 ft.) below "Halysites beds," GSC loc. 7561, 0.8 km (0.5 mi.)

east of trail over Palliser Pass, British Columbia, J.R. Marshall

collection.

Norford collection (for locations, refer to Fig. 1; for

stratigraphic positions, refer to Appendix 1): GSC NC-1-2, GSC loc.

57209, Tipperary Lake, British Columbia; GSC N4-1-1, GSC loc. 64584, 6.4 km (4 mi.) south-southeast of Indianhead Mountain, British Columbia; GSC N14-1-3, N14-1-6, GSC loc. 58188, Shatch Mountain, British Columbia; GSC N40-3-6, N40-3-7, GSC loc. 70016, Cirrus Mountain, Alberta.

Present collection (all from Akutlak Creek, British Columbia; for location, refer to Figs. 1, 2; for stratigraphic positions, refer to Fig. 4): GSC K12A-14/15-1 (Fig. 15L-N), K12A-14/15-7, K12A-14/15-8 (Fig. 15A-F), K12A-14/15-20 (Fig. 15H-K), interval A14 + A15; GSC K12B-2-12, interval B2; GSC K12B-5-9 (Fig. 15G), interval B5.

Occurrences—Upper Ordovician: Beaverfoot Formation including Whiskey Trail Member (Richmondian, possibly Maysvillian strata), southern Rocky Mountains, British Columbia and Alberta, Canada; Chasm Creek Formation (middle to upper Richmondian), Churchill River Group, Hudson Bay Lowland, Manitoba, Canada.

Diagnosis—Corallum of medium size, greatly compressed, triangulate to very slightly trilobate. Septa greatly to generally completely dilated in early stages, degree of dilation decreases during intermediate or late stages. Major septa converge axially along zone elongate in cardinal-counter direction, or several septal lobes develop along axis, or rarely a small axial structure of short septal lobes and lamellae forms. Cardinal and counter septa long throughout ontogeny, cardinal fossula long and narrow.

Description of corals—Cardinal-counter and alar-alar dimensions at the top of the lectotype are 36 mm and 26.5 mm, respectively (Wilson, 1926, pl. 1, fig. 4). Corresponding dimensions across the calice rim

of another large individual are 37 mm and 23 mm (Fig. 15A,B). Coral lengths are unknown because both specimens are incomplete. The coralla are trochoid in alar view, and compressed throughout ontogeny (Fig. 13). They are triangulate, and in some cases very slightly trilobate in intermediate and/or late stages. The calice is comparatively shallow (Fig. 15D).

Ontogeny and internal structures—The relationship between number of septa and coral average cross-sectional dimension is shown in Fig. 16. In early stages (Fig. 15G,H,L), the major septa are greatly to generally completely dilated. In some individuals, septa become moderately dilated during intermediate stages (Fig. 15E,M) and slightly dilated to nondilated in late stages (Fig. 15F,N). In others, they remain completely dilated through intermediate stages (Fig. 15I), and dilation does not decrease until near the base of the calice in late stages (Fig. 15J,K). During early to intermediate stages, the major septa extend to the axis. Those on alar sides of the corallum meet along a zone that is elongate in the cardinal-counter direction. This septal arrangement continues through late stages in some specimens (Fig. 15F). In others, several septal lobes develop at the axis (Fig. 15J,K). In one individual, septal lobes plus a few lamellae form a small axial structure with an average radius that is 19% of the average coral radius (Fig. 15N).

The cardinal and counter septa are longer than the other major septa throughout ontogeny. In six specimens, it was verified that the cardinal septum remains long above the level at which sediment fills

interseptal spaces (Appendix 5). The cardinal septum becomes relatively thin during intermediate stages, when a narrow but long and conspicuous cardinal fossula develops. Minor septa are confined to the stereozone until above the base of the calice. Their length is up to 28% of the average coral radius (GSC K12A-14/15-8). Thickness of the stereozone at the base of the calice is 11% of the average coral radius in one individual (GSC K12A-14/15-7), and 15% in another (GSC K12A-14/15-20).

Complete and incomplete tabulae are approximately horizontal in the axial part of the corallum (Fig. 15C,D). Their spacing varies from 0.2 to 0.6 mm. Tabellae in the peripheral portion are moderately to steeply inclined from the wall toward the axis, and are spaced 0.3 to 0.9 mm apart.

Microstructure—In transverse thin sections, the major septa are fibrous (e.g., Elias, 1983a, fig. 7c). From a medial position in the septum, the fibres curve outward in the direction of the coral axis.

Discussion—Streptelasma prolongatum Wilson, 1926, was proposed for solitary corals from the Beaverfoot Formation that have an elongate cardinal side with a long cardinal septum and fossula, but lack pronounced alar lobes. Wilson (1926) did not identify type specimens, but illustrated four individuals. One of these is markedly compressed with an elongate cardinal side (GSC 6729b; Wilson, 1926, pl. 1, fig. 4), and is herein designated as the lectotype of Deiracorallium prolongatum (Wilson, 1926). Of the other three specimens, one is Grewingkia haysii haysii (Meek, 1865), another is Salvadorea distincta distincta (Wilson, 1926), and the third may be S. distincta distincta

(see discussions under those taxa). The coral illustrated in Norford (1962b) and Douglas (1970) and identified as Streptelasma prolongatum and Lobocorallium prolongatum, respectively, is G. haysii haysii (Meek, 1865) (see discussion under that species).

Deiracorallium giganteum Nelson, 1963 was based on two specimens from the Chasm Creek Formation in northern Manitoba. They lie within the range of variability documented herein for D. prolongatum, involving shape (Fig. 13), arrangement and number of septa (Fig. 16), degree of septal dilation, size and shape of fossula, and thickness of stereozone. D. giganteum is considered to be a junior synonym of D. prolongatum.

Pestana (1960) identified a single specimen from the Johnson Spring Formation (Middle Ordovician; Rocklandian-Kirkfieldian) in California as Streptelasma sp. cf. S. prolongatum. It differs from D. prolongatum in having a larger axial structure, and minor septa that extend beyond the stereozone below the base of the calice.

D. prolongatum resembles D. angulatum angulatum (Billings, 1862) and D. angulatum gunni Elias, 1983a, known from the upper member (middle to upper Richmondian) of the Vauréal Formation on Anticosti Island in Québec, and the Gunn and Penitentiary members (middle to upper Richmondian) of the Stony Mountain Formation in southern Manitoba, respectively (Elias, 1982a, p. 64, 65, pl. 6, figs. 21-33; 1983a, p. 938, 939, 941, 942, figs. 11a-t). D. angulatum differs in being small, and having a short cardinal septum in late stages. It has been verified that the cardinal septum decreases in length below the level at which sediment fills interseptal spaces in ten specimens

(two from the Vauréal Formation, and eight from the Stony Mountain Formation; Appendix 5). D. manitobense manitobense Nelson, 1963, from the Caution Creek and Chasm Creek formations (middle to upper Richmondian) of the Churchill River Group in northern Manitoba, and D. manitobense churchillense from the Chasm Creek Formation, may belong to D. angulatum (Nelson, 1963, p. 37, 38, pl. 13, figs. 1, 2a,b, 3a,b; 1981, p. 53, 54, fig. 13, pl. 8, figs. 12-14; see Elias, 1982a, p. 65; 1983a, p. 941).

D. prolongatum is similar to D. harveyi Nelson, 1981 and D. delicatum Elias, 1981, which occur in the Portage Chute and Surprise Creek formations (?Edenian to lower Richmondian) of the Bad Cache Rapids Group in northern Manitoba, and the Selkirk Member (middle Maysvillian strata) of the Red River Formation in southern Manitoba, respectively (Nelson, 1981, p. 53, fig. 13, pl. 7, figs. 6-9, pl. 8, figs. 1-7; Elias, 1981, p. 22, 23, pl. 9, figs. 12-24). Corals belonging to these three taxa are medium-sized, but D. harveyi and D. delicatum differ from D. prolongatum in having comparatively large, complex axial structures. D. amplum (Troedsson, 1928), from the Cape Calhoun Formation (Upper Ordovician) of northwestern Greenland, is poorly known (Troedsson, 1928, pl. 26, fig. 4a,b; Elias, 1981, p. 22). It has a small axial structure, but attains greater cross-sectional dimensions with more septa than other species of the genus.

The difficulty in distinguishing some specimens of D. prolongatum and G. haysii haysii in Beaverfoot collections was discussed under the latter species.

Figure 15. Deiracorallium prolongatum (Wilson, 1926) from the Beaverfoot Formation. A-F, GSC K12A-14/15-8: A, cardinal view, X1; B, alar view (cardinal side left), X1; C, D, longitudinal sections (cardinal side left), X2; E, F, transverse sections, X2. G, GSC K12B-5-9: transverse section, X3. H-K, GSC K12A-14/15-20: transverse sections, X2.5. L-N, GSC K12A-14/15-1: transverse sections, X2.5. Position of ostracode (F) and Trypanites borings (J, K, N) indicated by arrows.

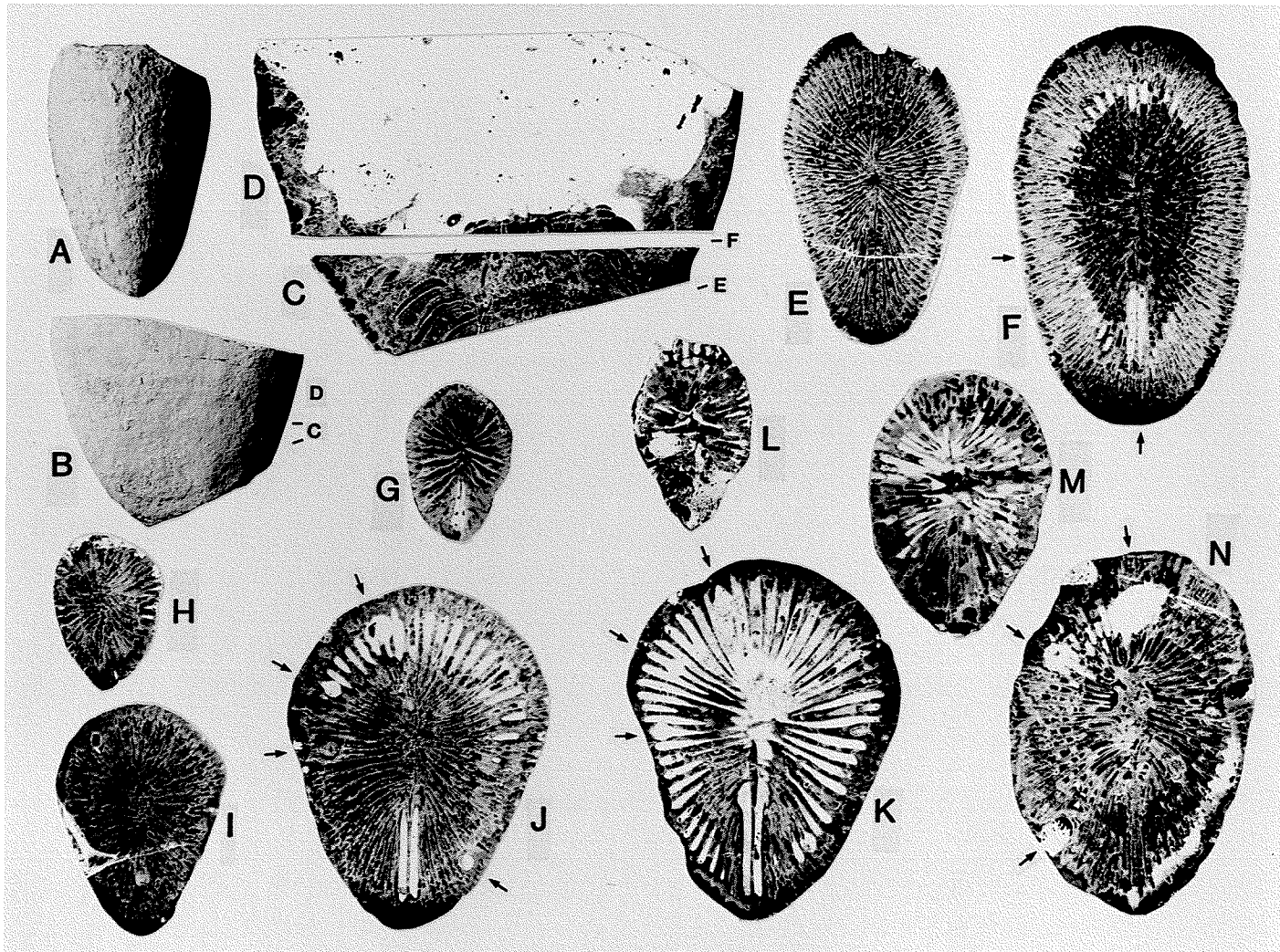
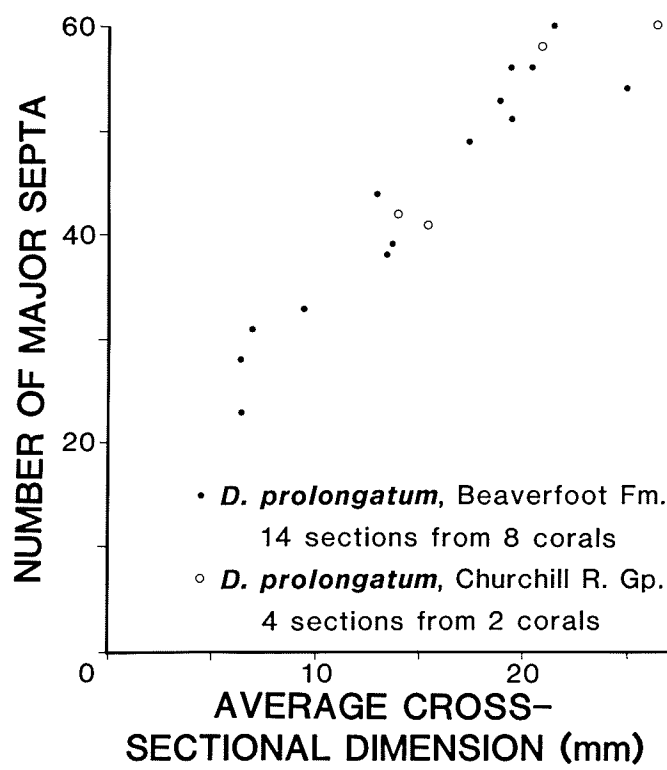


Figure 16. Relationship between number of major septa and coral average cross-sectional dimension (average of cardinal-counter and alar-alar dimensions) in Deiracorallium prolongatum: Beaverfoot Formation, British Columbia and Alberta; Chasm Creek Formation, Churchill River Group, Manitoba (Nelson, 1963, pl. 13, figs. 6a-c; 1981, pl. 8, figs. 15-17).



Acknowledgments

This research was funded by a Rotary Foundation (Graduate) Scholarship (1983-84) and by grants to Robert J. Elias (University of Manitoba) from the Natural Sciences and Engineering Research Council of Canada. Sincere thanks are extended to R. J. Elias for supervising the project. I am grateful to the following readers: Brian S. Norford (Geological Survey of Canada, Calgary), Thomas E. Bolton (Geological Survey of Canada, Ottawa), and William M. Last (University of Manitoba). Alan E. H. Pedder (Geological Survey of Canada, Calgary) reviewed the section on "Systematic paleontology." Field work was carried out in August, 1984, with the assistance of B. S. Norford, Robert J. McAuley and Ronald G. Zeilstra (University of Manitoba). I would like to thank the following for the loan of specimens: T. E. Bolton, David L. Bruton (Paleontologisk Museum, Oslo, Norway), Søren Floris (Geologisk Museum, Copenhagen, Denmark) and Russell D. White (Peabody Museum, Yale University, New Haven, Connecticut, U.S.A.). R. G. Zeilstra assisted with the preparation of specimens.

Finally many thanks to my parents and Simon for all their support during the last two years.

References cited

Barnes, C.R., Jackson, D.E. and Norford, B.S.

- 1976: Correlation between Canadian Ordovician zonation based on graptolites, conodonts and benthic macrofossils from key successions, in The Ordovician System: Proceedings of a Palaeontological Association Symposium, Birmingham, September 1974, M.G. Bassett, ed.; University of Wales Press and National Museum of Wales, Cardiff, p. 209-226.

Billings, E.

- 1862: New species of fossils from different parts of the Lower, Middle, and Upper Silurian rocks of Canada; Geological Survey of Canada, Palaeozoic Fossils, v. 1, no. 4, p. 96-185.
- 1865: Notice of some new genera and species of Palaeozoic fossils; Canadian Naturalist and Quarterly Journal of Science, new series, v. 2, p. 425-432.

Bolton, T.E. and Nowlan, G.S.

- 1979: A Late Ordovician fossil assemblage from an outlier north of Aberdeen Lake, District of Keewatin; Geological Survey of Canada, Bulletin 321, p. 1-26.

Budge, D.R.

- 1977: Biostratigraphy, biochronology, and some tectonic implications of Late Ordovician corals from the eastern Great Basin; Geological Society of America, Abstracts with Programs, v. 9, no. 6, p. 712.

Burling, L.D.

- 1922: A Cambro-Ordovician section in the Beaverfoot Range, near Golden, British Columbia; Geological Magazine, v. 59, no. 10, p. 452-461.

Cox, I.

1937: Arctic and some other species of Streptelasma; Geological Magazine, v. 74, no. 1, p. 1-19.

Douglas, R.J.W. (editor)

1970: Geology and economic minerals of Canada; Geological Survey of Canada, Economic Geology Report No. 1, 838 p.

Duncan, H.

1957: Bighornia, a new Ordovician coral genus; Journal of Paleontology, v. 31, no. 3, p. 607-615.

Elias, R.J.

1980: Borings in solitary rugose corals of the Selkirk Member, Red River Formation (late Middle or Upper Ordovician), southern Manitoba; Canadian Journal of Earth Sciences, v. 17, no. 2, p. 272-277.

1981: Solitary rugose corals of the Selkirk Member, Red River Formation (late Middle or Upper Ordovician), southern Manitoba; Geological Survey of Canada, Bulletin 344, 53 p.

1982a: Latest Ordovician solitary rugose corals of eastern North America; Bulletins of American Paleontology, v. 81, no. 314, 116 p.

1982b: Paleoecology and biostratigraphy of solitary rugose corals in the Stony Mountain Formation (Upper Ordovician), Stony Mountain, Manitoba; Canadian Journal of Earth Sciences, v. 19, no. 8, p. 1582-1598.

1983a: Late Ordovician solitary rugose corals of the Stony Mountain Formation, southern Manitoba, and its equivalents; Journal of Paleontology, v. 57, no. 5, p. 924-956.

- 1983b: Middle and Late Ordovician solitary rugose corals of the Cincinnati Arch region; United States Geological Survey, Professional Paper 1066-N, 13 p.
- 1984a: Paleobiologic significance of fossulae in North American Late Ordovician solitary rugose corals; *Paleobiology*, v. 10, no. 1, p. 102-114.
- 1984b: Paleobiology of solitary rugose corals, Late Ordovician of North America, in Recent Advances in the Paleobiology and Geology of the Cnidaria (Proceedings of the Fourth International Symposium on Fossil Cnidaria [and Archaeocyathids and Stromatoporoids] Held in Washington, D. C., U.S.A., August, 1983), W.A. Oliver, Jr., et al., eds.; *Palaeontographica Americana*, no. 54, p. 533-537.
- 1985: Solitary rugose corals of the Upper Ordovician Montoya Group, southern New Mexico and westernmost Texas; *Paleontological Society Memoir* 16, 58 p.

Elias, R.J. and Potter, A.W.

- 1984: Late Ordovician solitary rugose corals of the eastern Klamath Mountains, northern California; *Journal of Paleontology*, v. 58, no. 5, p. 1203-1214.

Harker, P., Hutchinson, R.D. and McLaren, D.J.

- 1954: The sub-Devonian unconformity in the eastern Rocky Mountains of Canada, in Western Canada Sedimentary Basin, L.M. Clark, ed.; American Association of Petroleum Geologists, Tulsa, p. 48-67.

Ho Xin-yi

- 1978: Tetracoral fauna of the Late Ordovician Guanyinqiao Formation, Bijie, Guizhou Province; Chinese Academy of

Geological Sciences, Professional Papers of Stratigraphy
and Palaeontology, no. 6, p. 1-45.

Kaljo, D. and Klaamann, E.

1965: The fauna of the Portrane Limestone, III: The corals;
Bulletin of the British Museum (Natural History),
Geology, v. 10, no. 11, p. 413-434.

Kendall, A.C.

1977: Origin of dolomite mottling in Ordovician limestones from
Saskatchewan and Manitoba; Bulletin of Canadian Petroleum
Geology, v. 25, no. 3, p. 480-504.

Kirk, E.

1927: Review of "An Upper Ordovician fauna from the Rocky Mountains,
British Columbia" by Alice E. Wilson; Journal of Geology,
v. 35, no. 3, p. 286-288.

Ladd, H.S.

1929: The stratigraphy and paleontology of the Maquoketa Shale of
Iowa, Part 1; Iowa Geological Survey, Annual Report (1928),
v. 34, p. 305-448.

Leech, G.B.

1954: Canal Flats, British Columbia; Geological Survey of Canada,
Paper 54-7, 32 p.

McConnell, R.G.

1887: Report on the geological structure of a portion of the Rocky
Mountains; Geological Survey of Canada, Annual Report, 1886,
v. 2, pt. D, p. 1-41.

McCracken, A.D. and Barnes, C.R.

1981: Conodont biostratigraphy and paleoecology of the Ellis Bay

Formation, Anticosti Island, Quebec, with special reference to Late Ordovician-Early Silurian chronostratigraphy and the systemic boundary; Geological Survey of Canada, Bulletin 329, p. 51-134.

Meek, F.B.

1865: Preliminary notice of a small collection of fossils found by Dr. Hays, on the west shore of Kennedy Channel, at the highest northern localities ever explored; American Journal of Science, series 2, v. 40, p. 31-34.

Milne-Edwards, H. and Haime, J.

1850: A monograph of the British fossil corals, Part 1: Introduction; Palaeontographical Society, London, v. 3, 71 p.

Nelson, S.J.

- 1959: Guide fossils of the Red River and Stony Mountain equivalents (Ordovician); Alberta Society of Petroleum Geologists, Journal, v. 7, no. 3, p. 51-61.
- 1963: Ordovician paleontology of the northern Hudson Bay Lowland; Geological Society of America, Memoir 90, 152 p.
- 1975: Paleontological field guides, northern Canada and Alaska; Bulletin of Canadian Petroleum Geology, v. 23, no. 3, p. 428-683.
- 1981: Solitary streptelasmatid corals, Ordovician of northern Hudson Bay Lowland, Manitoba, Canada; Palaeontographica, Abteilung A, v. 172, no. 1-3, p. 1-71.

Neuman, B.

- 1969: Upper Ordovician streptelasmatid corals from Scandinavia; University of Uppsala Geological Institutions, Bulletin, new series, v. 1, p. 1-73.
- 1977: On the taxonomy of Lower Palaeozoic solitary streptelasmatids;

France, Bureau de Recherches Géologiques et Minières, Mémoire 89, p. 69-77.

Nicholson, H.A. and Lydekker, R.

1889: A Manual of Palaeontology for the Use of Students, 3rd edition; William Blackwood and Sons, Edinburgh and London, v. 1, p. 1-885, v. 2, p. 886-1624.

Norford, B.S.

1961: The Beaverfoot-Brisco Formation at Cirrus Mountain, Alberta; Journal of the Alberta Society of Petroleum Geologists, v. 9, no. 8, p. 248-250.

1962a: Illustrations of Canadian fossils: Cambrian, Ordovician and Silurian of the western Cordillera; Geological Survey of Canada, Paper 62-14, 25 p.

1962b: The Beaverfoot-Brisco Formation in the Stanford Range, British Columbia; Journal of the Alberta Society of Petroleum Geologists, v. 10, no. 7, p. 443-453.

1969: Ordovician and Silurian stratigraphy of the southern Rocky Mountains; Geological Survey of Canada, Bulletin 176, 90 p.

Norford, B.S. and Macqueen, R.W.

1975: Lower Paleozoic Franklin Mountain and Mount Kindle formations, District of Mackenzie: Their type sections and regional development; Geological Survey of Canada, Paper 74-34, 37 p.

North, F.K. and Henderson, G.G.L.

1954: Summary of the geology of the southern Rocky Mountains of Canada; Alberta Society of Petroleum Geologists, Fourth Annual Field Conference, Guide Book, p. 15-81.

Okulitch, V.J.

1943: The Stony Mountain Formation of Manitoba; Royal Society of

Canada, Transactions, series 3, v. 37, no. 4, p. 59-74.

Oliver, W.A., Jr., Merriam, C.W. and Churkin, M., Jr.

1975: Ordovician, Silurian, and Devonian corals of Alaska;
United States Geological Survey, Professional Paper 823-B,
p. 13-44.

Parks, W.A.

1915: Palaeozoic fossils from a region southwest of Hudson Bay;
Royal Canadian Institute, Transactions, v. 11, no. 1, p. 3-95.

Pestana, H.R.

1960: Fossils from the Johnson Spring Formation, Middle Ordovician,
Independence Quadrangle, California; Journal of Paleontology,
v. 34, no. 5, p. 862-873.

Reiman, V.M.

1958: Novya ruzozy iz verchnyordovikskik i Llandoveriyskik
otlochenia pribaltiki; Eesti NSV Teaduste Akadeemia,
Geologia Instituudi Uurimused, Trudy Instituta Geologii,
v. 2, p. 33-47.

Root, S.

1955: The Paleozoic geology of the Canal Flats area, British
Columbia; Unpublished M.Sc. thesis, University of Manitoba,
132 p.

Ross, R.J., Jr.

1957: Ordovician fossils from wells in Williston Basin, eastern
Montana; United States Geological Survey, Bulletin 1021-M,
p. 439-510.

Severson, J.L.

1950: Devonian stratigraphy, Sunwapta Pass area, Alberta, Canada;
American Association of Petroleum Geologists, Bulletin,

v. 34, no. 9, p. 1826-1849.

Stasek, C.R.

1958: A new species of Allogaussia (Amphipoda, Lysianassidae) found living within the gastrovascular cavity of the sea-anenome Anthopleura elegantissima; Journal of the Washington Academy of Sciences, v. 48, no. 4, p. 119-126.

Stearn, C.W.

1956: Stratigraphy and palaeontology of the Interlake Group and Stonewall Formation of southern Manitoba; Geological Survey of Canada, Memoir 281, 162 p.

Sweet, W.C.

1979: Late Ordovician conodonts and biostratigraphy of the western Midcontinent Province; Brigham Young University, Geology Studies, v. 26, no. 3, p. 45-85.

Teichert, C.

1937: Ordovician and Silurian faunas from arctic Canada; Report of the Fifth Thule Expedition, 1921-1924, v. 1, no. 5, 169 p.

Troedsson, G.

1928: On the Middle and Upper Ordovician faunas of northern Greenland, Part II; Meddelelser om Grønland, v. 72 (Første Afdeling, pt. 1), 197 p.

Twenhofel, W.H.

1928: Geology of Anticosti Island; Geological Survey of Canada, Memoir 154, 418 p.

Verrill, A.E.

1865: Classification of polyps (Extract condensed from a synopsis of the polypi of the North Pacific Exploring Expedition, under Captains Ringgold and Rodgers, U.S.N.); Essex Institute, Proceedings, v. 4, p. 145-149.

Walcott, C.D.

- 1923: Nomenclature of some post Cambrian and Cambrian Cordilleran formations (2); Smithsonian Miscellaneous Collections, v. 67, no. 8, p. 457-476.
- 1924: Geological formations of Beaverfoot-Brisco-Stanford Range, British Columbia, Canada; Smithsonian Miscellaneous Collections, v. 75, no. 1, p. 1-51.
- 1928: Pre-Devonian Paleozoic formations of the Cordilleran provinces of Canada; Smithsonian Miscellaneous Collections, v. 75, no. 5, p. 175-368.

Wedekind, R.

- 1927: Die Zoantharia Rugosa von Gotland (besonders Nordgotland): Nebst Bermerkungen zur Biostratigraphie des Gotlandium; Sveriges Geologiska Undersökning, series Ca, v. 19, 94 p.

Whiteaves, J.F.

- 1895: Systematic list, with references, of the fossils of the Hudson River or Cincinnati formation at Stony Mountain, Manitoba; Geological Survey of Canada, Palaeozoic Fossils, v. 3, no. 2, p. 111-128.

Wilson, A.E.

- 1926: An Upper Ordovician fauna from the Rocky Mountains, British Columbia, Canada; Department of Mines, Museum Bulletin 44, Geological Series, no. 46, p. 1-34, 100-115.

Winchell, N.H. and Schuchert, C.

- 1895: Sponges, graptolites, and corals from the Lower Silurian of Minnesota, in The Geology of Minnesota, v. 3, no. 1, Paleontology; Minnesota Geological and Natural History Survey, p. 55-95.

APPENDIX 1. Stratigraphic and geographic distribution and frequency of 417 solitary rugose corals from the Beaverfoot Formation, southern Rocky Mountains, British Columbia and Alberta (refer to Figs. 1 and 2 for geographic locations, Fig. 4 for stratigraphic positions of intervals at location K12; all heights measured from top of Mount Wilson Quartzite)

Location	Intervals ^a	Position	<u>Salvadorea distincta distincta</u>	Probably <u>S. distincta distincta</u> Possibly <u>S. distincta distincta</u>	<u>Salvadorea sp. 2</u>	<u>Bighornia patella</u>	Probably <u>B. patella</u> Possibly <u>B. patella</u>	<u>B. sp. cf. B. bottei</u>	<u>Grewingkia haysii haysii</u>	Probably <u>G. haysii haysii</u> Possibly <u>G. haysii haysii</u>	<u>Deiracorallium prolongatum</u>	Probably <u>D. prolongatum</u> Possibly <u>D. prolongatum</u>	<u>G. haysii haysii</u> or <u>S. distincta distincta</u> <u>G. haysii haysii</u> or <u>D. prolongatum</u>	Unidentifiable	Total number of solitary corals
<u>MP</u>	7561	-	1			1					1				3
	7563	-	4						1		1		1		7
<u>WW</u>	7933	-		1											1
	7935	-				1									1
<u>MSP</u>	7969		1												1
<u>F</u>	7793 or 7851	-	1												1
<u>RW</u>	-	-	2				2		1						5
<u>NA</u>	56107	4.9-7.3 m (16-24 ft.)	1	1	1	1			1					3	8
<u>NC</u>	47410	2.4-6.7 m (8-22 ft.)		1										1	2

	57209	2.1-4.9 m (7-16 ft.)	3				1	1	5
<u>ND</u>	47404	173.4-174.7 m (569-573 ft.)	1	1					5 7
	47398	45.4-50.0 m (149-164 ft.)					1		1 2
<u>NG</u>	5062	42.4 m (139 ft.)			4	2	1	1	17 25
	5063	39.3 m (129 ft.)	2		1		1		7 11
	5064 ^{w^b}	25.0-25.2 m (82-83 ft.)			1	3			1 5
<u>NF</u>	45612	61.6-64.6 m (202-212 ft.)							1 1
<u>N4</u>	64584	1.8-3.7 m (6-12 ft.)	1				1	1 1	4
<u>N7</u>	56080	155.8-156.1 m (511-512 ft.)	1						2 3
	56079	154.5-154.8 m (507-508 ft.)							1 1
	56078	133.5-133.8 m (438-439 ft.)							2 2
	56076	32.0-33.2 m (105-109 ft.)	3	2	1		1		5 12
	56075	21.9-24.4 m			3				3

	47414	30.5-91.4 m (100-300 ft.)				1				3	4	
	45579	29.6-33.5 m (97-110 ft.)			1					1	2	
	52158	27.7-31.7 m (91-104 ft.)		1			1				2	
	45578	25-28 m (82-92 ft.)				4				3	7	
	52159	24.4-24.7 m (80-81 ft.)				2				1	3	
<u>N14</u>	58186	24.7-25.0 m (81-82 ft.)		1						1	2	
	58187	20.4-23.5 m (67-77 ft.)						1			1	
	58188	0-9.4 m (0-31 ft.)	2	1	1	1		2	1	1	3	13
<u>N17</u>	47426	4.6-12.2 m (15-40 ft.)				1						1
<u>N31</u>	52186	43.9-44.8 m (144-147 ft.)	2							1	5	8
	52185	22.9-24.7 m (75-81 ft.)			1					1	2	
<u>N40</u>	70016	10.7-16.2 m (35-53 ft.)			1			2	1	3	7	14
	70015	5.2-8.2 m	2		1					7	10	

	(17-27 ft.)							
42017	5.2-12.2 m					1		1
	(17-40 ft.)							
42018	5.2-12.2 m			1			1	4 6
	(17-40 ft.)							
42026	5.2-12.2 m	1				1		2 4
	(17-40 ft.)							
<u>K12</u> <u>BT</u> (talus)	-	1						1
<u>B25</u>	116.7-128 m	2	3	3		2		2 12
	(383-420 ft.)							
<u>B24</u>	110.9-116.7 m			3				3 6
	(364-383 ft.)							
<u>B23</u>	109.2-110.9 m	1				1		2
	(358-364 ft.)							
<u>B22</u>	106.8-109.2 m							0
	(350-358 ft.)							
<u>B21</u>	105.3-106.8 m						1	1
	(345-350 ft.)							
<u>B20</u>	103.3-105.3 m	1						1
	(339-345 ft.)							
<u>B19</u>	103.2-103.3 m							0
	(338-339 ft.)							
<u>B18</u>	101.2-103.2 m							0
	(332-338 ft.)							

APPENDIX 2. Identification of 417 solitary rugose corals
 representing Salvadorea, Bighornia, Deiracorallium and
Grewingkia, from the Beaverfoot Formation, southern Rocky
 Mountains, British Columbia and Alberta

Loc- ation	Interval	Specimen number	Identification
MP	7561	<u>W1-1-1</u>	<u>D. prolongatum</u>
		GSC 6731a	<u>S. distincta distincta</u>
		GSC 6731	<u>B. patella</u>
	7563	<u>W1-2-1</u>	<u>G. haysii haysii</u> or <u>S. distincta distincta</u>
		<u>W1-2-2</u>	<u>S. distincta distincta</u>
		<u>W1-2-3</u>	<u>S. distincta distincta</u>
		<u>W1-2-4</u>	<u>S. distincta distincta</u>
		GSC 6729	<u>G. haysii haysii</u>
		GSC 6729a	<u>S. distincta distincta</u>
		GSC 6729b	<u>D. prolongatum</u>
WW	7933	<u>W7-1-1</u>	possibly <u>S. distincta distincta</u>
	7935	GSC 6732	<u>B. patella</u>
MSP	7969	<u>W2-1-1</u>	<u>S. distincta distincta</u>
F	7793 or	GSC 6730	<u>S. distincta distincta</u>
	7851		
R	-	<u>R211i</u>	<u>G. haysii haysii</u>
		<u>R211ii</u>	<u>B. patella</u>
		<u>R211iv</u>	<u>S. distincta distincta</u>
		<u>R211v</u>	<u>S. distincta distincta</u>

		<u>R211vi</u>	<u>B. patella</u>
NA	56107	<u>NA-1-1</u>	probably <u>S. distincta distincta</u>
		<u>NA-1-2</u>	unidentifiable
		<u>NA-1-3</u>	<u>G. haysii haysii</u>
		<u>NA-1-4</u>	unidentifiable
		<u>NA-1-5</u>	<u>Salvadorea</u> sp. 2
		<u>NA-1-6</u>	unidentifiable
		<u>NA-1-7</u>	<u>S. distincta distincta</u>
		<u>NA-1-8</u>	<u>B. patella</u>
NC	47410	<u>NC-2-1</u>	unidentifiable
		<u>NC-2-2</u>	probably <u>S. distincta distincta</u>
	57209	<u>NC-1-1</u>	<u>S. distincta distincta</u>
		<u>NC-1-2</u>	<u>D. prolongatum</u>
		<u>NC-1-3</u>	possibly <u>Deiracorallium</u>
		<u>NC-1-4</u>	<u>S. distincta distincta</u>
		<u>NC-1-5</u>	<u>S. distincta distincta</u>
ND	47404	<u>ND-2-1</u>	probably <u>Salvadorea</u>
		<u>ND-2-2</u>	unidentifiable
		<u>ND-2-4</u>	unidentifiable
		<u>ND-2-5</u>	unidentifiable
		<u>ND-2-6</u>	unidentifiable
		<u>ND-2-8</u>	unidentifiable
		<u>ND-2-9</u>	<u>S. distincta distincta</u>
	47398	<u>ND-1-1a</u>	possibly <u>G. haysii haysii</u>
		<u>ND-1-1b</u>	unidentifiable
NG	5062	<u>NG-3-1</u>	possibly <u>G. haysii haysii</u>
		<u>NG-3-2</u>	unidentifiable

	<u>NG-3-3</u>	probably <u>Bighornia</u>
	<u>NG-3-4</u>	unidentifiable
	<u>NG-3-5</u>	unidentifiable
	<u>NG-3-6</u>	unidentifiable
	<u>NG-3-7</u>	<u>B. patella</u>
	<u>NG-3-8</u>	<u>B. patella</u>
	<u>NG-3-9</u>	unidentifiable
	<u>NG-3-10</u>	unidentifiable
	<u>NG-3-11</u>	unidentifiable
	<u>NG-3-12</u>	<u>B. patella</u>
	<u>NG-3-13</u>	unidentifiable
	<u>NG-3-14</u>	possibly <u>B. patella</u>
	<u>NG-3-15</u>	unidentifiable
	<u>NG-3-16</u>	unidentifiable
	<u>NG-3-17</u>	unidentifiable
	<u>NG-3-18</u>	probably <u>B. patella</u>
	<u>NG-3-19</u>	unidentifiable
	<u>NG-3-20</u>	unidentifiable
	<u>NG-3-21</u>	unidentifiable
	<u>NG-3-22</u>	<u>B. patella</u>
	<u>NG-3-23</u>	unidentifiable
	<u>NG-3-24</u>	unidentifiable
	<u>NG-3-25</u>	unidentifiable
5063	<u>NG-2-1a</u>	<u>S. distincta distincta</u>
	<u>NG-2-1b</u>	unidentifiable
	<u>NG-2-2</u>	<u>S. distincta distincta</u>
	<u>NG-2-3</u>	<u>B. patella</u>

		<u>NG-2-4</u>	unidentifiable
		<u>NG-2-5a</u>	possibly <u>B. patella</u>
		<u>NG-2-5b</u>	unidentifiable
		<u>NG-2-7</u>	unidentifiable
		<u>NG-2-8</u>	unidentifiable
		<u>NG-2-9</u>	unidentifiable
		<u>NG-2-10</u>	unidentifiable
	5064W	<u>NG-1-1</u>	probably <u>B. patella</u>
		<u>NG-1-2</u>	probably <u>B. patella</u>
		<u>NG-1-3</u>	<u>B. patella</u>
		<u>NG-1-4</u>	unidentifiable
		<u>NG-1-5</u>	probably <u>B. patella</u>
NF	45612	<u>NF-1-1</u>	unidentifiable
N4	64584	<u>N4-1-1</u>	<u>D. prolongatum</u>
		<u>N4-1-2</u>	<u>S. distincta distincta</u>
		<u>N4-1-3</u>	<u>G. haysii haysii</u>
		<u>N4-1-4</u>	possibly <u>G. haysii haysii</u>
N7	56080	<u>N7-6-1a</u>	<u>S. distincta distincta</u>
		<u>N7-6-1b</u>	unidentifiable
		<u>N7-6-2</u>	unidentifiable
	56079	<u>N7-5-1</u>	unidentifiable
	56078	<u>N7-4-1</u>	unidentifiable
		<u>N7-4-2</u>	unidentifiable
	56076	<u>N7-3-1</u>	unidentifiable
		<u>N7-3-2</u>	<u>S. distincta distincta</u>
		<u>N7-3-3</u>	unidentifiable
		<u>N7-3-4</u>	probably <u>S. distincta distincta</u>

		<u>N7-3-5</u>	unidentifiable
		<u>N7-3-6</u>	<u>S. distincta distincta</u>
		<u>N7-3-8</u>	<u>S. distincta distincta</u>
		<u>N7-3-9</u>	probably <u>Salvadorea</u>
		<u>N7-3-10</u>	<u>G. haysii haysii</u>
		<u>N7-3-11</u>	unidentifiable
		<u>N7-3-12</u>	<u>B. patella</u>
		<u>N7-3-13</u>	unidentifiable
	56075	<u>N7-2-1</u>	<u>B. patella</u>
		<u>N7-2-2</u>	<u>B. patella</u>
		<u>N7-2-3</u>	<u>B. patella</u>
	56073	<u>N7-1-1</u>	unidentifiable
		<u>N7-1-2</u>	unidentifiable
N9	52171	<u>N9-4-1</u>	possibly <u>S. distincta distincta</u>
	45606	<u>N9-3-1</u>	<u>S. distincta distincta</u>
		<u>N9-3-2</u>	<u>S. distincta distincta</u>
		<u>N9-3-3</u>	unidentifiable
		<u>N9-3-4</u>	<u>B. patella</u>
		<u>N9-3-5</u>	unidentifiable
	8043	<u>N9-2-1</u>	probably <u>G. haysii haysii</u>
	45604	<u>N9-1-1</u>	<u>S. distincta distincta</u>
		<u>N9-1-2</u>	unidentifiable
N10	52183	<u>N10-1-1</u>	possibly <u>G. haysii haysii</u>
		<u>N10-1-2</u>	<u>B. sp. cf. B. bottei</u>
		<u>N10-1-3</u>	<u>B. patella</u>
		<u>N10-1-4</u>	unidentifiable
		<u>N10-1-5</u>	probably <u>B. patella</u>

	<u>N10-1-6</u>	possibly <u>S. distincta distincta</u>	
	<u>N10-1-7</u>	<u>B. patella</u>	
	<u>N10-1-8</u>	probably <u>B. patella</u>	
	<u>N10-1-9</u>	<u>S. distincta distincta</u>	
	<u>N10-1-10</u>	possibly <u>B. patella</u>	
	<u>N10-1-11</u>	unidentifiable	
	<u>N10-1-12</u>	unidentifiable	
	<u>N10-1-13</u>	unidentifiable	
	<u>N10-1-14</u>	<u>G. haysii haysii</u> or <u>S. distincta distincta</u>	
	<u>N10-1-15</u>	unidentifiable	
	<u>N10-1-16</u>	unidentifiable	
	<u>N10-1-17</u>	<u>B. patella</u>	
N11	69837	<u>N11-3-1</u>	<u>S. distincta distincta</u>
		<u>N11-3-2</u>	unidentifiable
		<u>N11-3-4</u>	unidentifiable
		<u>N11-3-5</u>	unidentifiable
		<u>N11-3-6</u>	unidentifiable
		<u>N11-3-7</u>	possibly <u>S. distincta distincta</u>
		<u>N11-3-8</u>	unidentifiable
		<u>N11-3-9</u>	unidentifiable
		<u>N11-3-10</u>	probably <u>S. distincta distincta</u>
		<u>N11-3-11</u>	possibly <u>S. distincta distincta</u>
		<u>N11-3-12</u>	unidentifiable
		<u>N11-3-13</u>	unidentifiable
		<u>N11-3-14</u>	possibly <u>S. distincta distincta</u>
	69839	<u>N11-2-1</u>	unidentifiable
		<u>N11-2-2</u>	<u>B. sp. cf. B. bottei</u>

		<u>N11-2-3</u>	<u>B. patella</u>
		<u>N11-2-4</u>	probably <u>B. patella</u>
		<u>N11-2-5</u>	unidentifiable
		<u>N11-2-6</u>	<u>B. patella</u>
		<u>N11-2-7</u>	<u>B. patella</u>
		<u>N11-2-8</u>	possibly <u>B. patella</u>
		<u>N11-2-9</u>	<u>B. patella</u>
		<u>N11-2-10</u>	unidentifiable
		<u>N11-2-11</u>	<u>B. patella</u>
	69844W	<u>N11-1-1a</u>	unidentifiable
		<u>N11-1-1b</u>	unidentifiable
		<u>N11-1-2</u>	unidentifiable
N12	45582	<u>N12-8-1</u>	<u>S. distincta distincta</u>
	52160	<u>N12-7-1</u>	unidentifiable
		<u>N12-7-2</u>	<u>S. distincta distincta</u>
	45580	<u>N12-6-1</u>	<u>B. patella</u>
	47414	<u>N12-5-1</u>	unidentifiable
		<u>N12-5-2</u>	<u>G. haysii haysii</u>
		<u>N12-5-3</u>	unidentifiable
		<u>N12-5-4</u>	unidentifiable
	45579	<u>N12-4-1</u>	<u>B. patella</u>
		<u>N12-4-2</u>	unidentifiable
	52158	<u>N12-3-1</u>	possibly <u>S. distincta distincta</u>
		<u>N12-3-2</u>	probably <u>G. haysii haysii</u>
	45578	<u>N12-2-1</u>	<u>G. haysii haysii</u>
		<u>N12-2-2</u>	unidentifiable
		<u>N12-2-3</u>	<u>G. haysii haysii</u>

		<u>N12-2-4</u>	unidentifiable
		<u>N12-2-5</u>	<u>G. haysii haysii</u>
		<u>N12-2-6</u>	<u>G. haysii haysii</u>
		<u>N12-2-7</u>	unidentifiable
	52159	<u>N12-1-1</u>	<u>G. haysii haysii</u>
		<u>N12-1-2</u>	<u>G. haysii haysii</u>
		<u>N12-1-3</u>	unidentifiable
N14	58186	<u>N14-3-1</u>	unidentifiable
		<u>N14-3-2</u>	probably <u>S. distincta distincta</u>
	58187	<u>N14-2-1</u>	possibly <u>G. haysii haysii</u>
	58188	<u>N14-1-1</u>	<u>G. haysii haysii</u>
		<u>N14-1-2</u>	probably <u>S. distincta distincta</u>
		<u>N14-1-3</u>	<u>D. prolongatum</u>
		<u>N14-1-4</u>	unidentifiable
		<u>N14-1-5</u>	unidentifiable
		<u>N14-1-6</u>	<u>D. prolongatum</u>
		<u>N14-1-7</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>
		<u>N14-1-8</u>	<u>S. distincta distincta</u>
		<u>N14-1-9</u>	<u>B. patella</u>
		<u>N14-1-10</u>	<u>S. distincta distincta</u>
		<u>N14-1-11</u>	unidentifiable
		<u>N14-1-12</u>	probably <u>D. prolongatum</u>
		<u>N14-1-13</u>	probably <u>B. patella</u>
N17	47426	<u>N17-1-1</u>	<u>G. haysii haysii</u>
N31	52186	<u>N31-2-1</u>	<u>S. distincta distincta</u>
		<u>N31-2-2</u>	unidentifiable
		<u>N31-2-3</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>

		<u>N31-2-4</u>	unidentifiable
		<u>N31-2-5</u>	<u>S. distincta distincta</u>
		<u>N31-2-6</u>	unidentifiable
		<u>N31-2-7</u>	unidentifiable
		<u>N31-2-8</u>	unidentifiable
	52185	<u>N31-1-1</u>	unidentifiable
		<u>N31-1-2</u>	<u>B. patella</u>
N40	70016	<u>N40-3-2</u>	unidentifiable
		<u>N40-3-3</u>	possibly <u>D. prolongatum</u>
		<u>N40-3-4</u>	unidentifiable
		<u>N40-3-5</u>	unidentifiable
		<u>N40-3-6</u>	<u>D. prolongatum</u>
		<u>N40-3-7</u>	<u>D. prolongatum</u>
		<u>N40-3-8</u>	unidentifiable
		<u>N40-3-9</u>	unidentifiable
		<u>N40-3-10</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>
		<u>N40-3-11</u>	unidentifiable
		<u>N40-3-12</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>
		<u>N40-3-13</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>
		<u>N40-3-14</u>	<u>B. patella</u>
		<u>N40-3-15</u>	unidentifiable
	70015	<u>N40-2-1a</u>	unidentifiable
		<u>N40-2-1b</u>	unidentifiable
		<u>N40-2-1c</u>	unidentifiable
		<u>N40-2-2</u>	<u>S. distincta distincta</u>
		<u>N40-2-3</u>	unidentifiable
		<u>N40-2-4</u>	unidentifiable

		<u>N40-2-5</u>	<u>B. patella</u>
		<u>N40-2-6</u>	<u>S. distincta distincta</u>
		<u>N40-2-7</u>	unidentifiable
		<u>N40-2-8</u>	unidentifiable
42017		<u>N40-1A-1</u>	possibly <u>G. haysii haysii</u>
42018		<u>N40-1B-1</u>	unidentifiable
		<u>N40-1B-2</u>	unidentifiable
		<u>N40-1B-3</u>	unidentifiable
		<u>N40-1B-4</u>	possibly <u>D. prolongatum</u>
		<u>N40-1B-5</u>	unidentifiable
		<u>N40-1B-6</u>	possibly <u>B. patella</u>
42026		<u>N40-1C-1</u>	<u>S. distincta distincta</u>
		<u>N40-1C-2</u>	unidentifiable
		<u>N40-1C-3</u>	unidentifiable
		GSC 16917	<u>G. haysii haysii</u>
K12	Talus	<u>K12B-T-1</u>	<u>S. distincta distincta</u>
	<u>B25</u>	<u>K12B-25-1</u>	<u>B. patella</u>
		<u>K12B-25-2</u>	<u>B. patella</u>
		<u>K12B-25-3</u>	unidentifiable
		<u>K12B-25-4</u>	<u>S. distincta distincta</u>
		<u>K12B-25-5a</u>	probably <u>S. distincta distincta</u>
		<u>K12B-25-5b</u>	probably <u>S. distincta distincta</u>
		<u>K12B-25-5c</u>	probably <u>S. distincta distincta</u>
		<u>K12B-25-6</u>	<u>G. haysii haysii</u>
		<u>K12B-25-7</u>	unidentifiable
		<u>K12B-25-9</u>	<u>G. haysii haysii</u>
		<u>K12B-25-10</u>	<u>B. patella</u>

	<u>K12B-25-11</u>	<u>S. distincta distincta</u>
<u>B24</u>	<u>K12B-24-1</u>	unidentifiable
	<u>K12B-24-2</u>	<u>B. patella</u>
	<u>K12B-24-3</u>	unidentifiable
	<u>K12B-24-4</u>	unidentifiable
	<u>K12B-24-5</u>	<u>B. patella</u>
	<u>K12B-24-6</u>	<u>B. patella</u>
<u>B23</u>	<u>K12B-23-1</u>	<u>S. distincta distincta</u>
	<u>K12B-23-2</u>	<u>G. haysii haysii</u>
<u>B21</u>	<u>K12B-21-1</u>	probably <u>G. haysii haysii</u>
<u>B20</u>	<u>K12B-20-1</u>	<u>S. distincta distincta</u>
<u>B16</u>	<u>K12B-16-1</u>	<u>S. distincta distincta</u>
	<u>K12B-16-2</u>	<u>B. patella</u>
	<u>K12B-16-3</u>	unidentifiable
<u>B12</u>	<u>K12B-12-1</u>	unidentifiable
	<u>K12B-12-2</u>	unidentifiable
	<u>K12B-12-3</u>	unidentifiable
<u>B10</u>	<u>K12B-10-1</u>	<u>B. patella</u>
<u>B7</u>	<u>K12B-7-1</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>
	<u>K12B-7-2</u>	<u>S. distincta distincta</u>
	<u>K12B-7-3</u>	<u>S. distincta distincta</u>
	<u>K12B-7-4</u>	<u>G. haysii haysii</u>
	<u>K12B-7-5</u>	unidentifiable
	<u>K12B-7-6</u>	unidentifiable
	<u>K12B-7-7</u>	unidentifiable
	<u>K12B-7-8</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>

	<u>K12B-7-9</u>	unidentifiable
	<u>K12B-7-10</u>	unidentifiable
<u>B6</u>	<u>K12B-6-1</u>	<u>G. haysii haysii</u>
	<u>K12B-6-2</u>	<u>S. distincta distincta</u>
	<u>K12B-6-3</u>	<u>G. haysii haysii</u>
	<u>K12B-6-4</u>	<u>S. distincta distincta</u>
	<u>K12B-6-5</u>	<u>B. patella</u>
	<u>K12B-6-6</u>	probably <u>G. haysii haysii</u>
	<u>K12B-6-7</u>	probably <u>S. distincta distincta</u>
	<u>K12B-6-9</u>	unidentifiable
	<u>K12B-6-12</u>	unidentifiable
<u>B5</u>	<u>K12B-5-1</u>	unidentifiable
	<u>K12B-5-2</u>	<u>S. distincta distincta</u>
	<u>K12B-5-3</u>	probably <u>G. haysii haysii</u>
	<u>K12B-5-4</u>	<u>G. haysii haysii</u>
	<u>K12B-5-5</u>	<u>S. distincta distincta</u>
	<u>K12B-5-6</u>	<u>B. patella</u>
	<u>K12B-5-7</u>	unidentifiable
	<u>K12B-5-8</u>	<u>B. patella</u>
	<u>K12B-5-9</u>	<u>D. prolongatum</u>
	<u>K12B-5-10</u>	<u>B. patella</u>
	<u>K12B-5-11</u>	probably <u>S. distincta distincta</u>
	<u>K12B-5-12</u>	<u>B. patella</u>
	<u>K12B-5-13</u>	<u>S. distincta distincta</u>
	<u>K12B-5-14</u>	<u>G. haysii haysii</u>
	<u>K12B-5-15</u>	<u>B. patella</u>

	<u>K12B-5-16</u>	<u>S. distincta distincta</u>
	<u>K12B-5-17</u>	unidentifiable
	<u>K12B-5-18</u>	unidentifiable
	<u>K12B-5-19</u>	<u>G. haysii haysii</u>
	<u>K12B-5-21</u>	unidentifiable
	<u>K12B-5-22</u>	unidentifiable
	<u>K12B-5-23a</u>	unidentifiable
	<u>K12B-5-23b</u>	unidentifiable
	<u>K12B-5-23c</u>	unidentifiable
	<u>K12B-5-24</u>	unidentifiable
	<u>K12B-5-25</u>	probably <u>S. distincta distincta</u>
	<u>K12B-5-26</u>	<u>B. patella</u>
	<u>K12B-5-27</u>	unidentifiable
	<u>K12B-5-28</u>	<u>G. haysii haysii</u>
	<u>K12B-5-29</u>	<u>G. haysii haysii</u>
	<u>K12B-5-30</u>	<u>G. haysii haysii</u>
<u>B3</u>	<u>K12B-3-1</u>	unidentifiable
	<u>K12B-3-2</u>	<u>G. haysii haysii</u>
<u>B2</u>	<u>K12B-2-1</u>	probably <u>G. haysii haysii</u>
	<u>K12B-2-2</u>	probably <u>S. distincta distincta</u>
	<u>K12B-2-3</u>	probably <u>S. distincta distincta</u>
	<u>K12B-2-4</u>	probably <u>G. haysii haysii</u>
	<u>K12B-2-5</u>	probably <u>G. haysii haysii</u>
	<u>K12B-2-6</u>	<u>G. haysii haysii</u>
	<u>K12B-2-8</u>	unidentifiable
	<u>K12B-2-10</u>	<u>B. patella</u>

	<u>K12B-2-12</u>	<u>D. prolongatum</u>
	<u>K12B-2-13</u>	unidentifiable
	<u>K12B-2-14</u>	probably <u>G. haysii haysii</u>
<u>B1</u>	<u>K12B-1-1</u>	<u>S. distincta distincta</u>
	<u>K12B-1-2</u>	unidentifiable
	<u>K12B-1-3</u>	probably <u>S. distincta distincta</u>
	<u>K12B-1-4</u>	<u>G. haysii haysii</u>
	<u>K12B-1-6</u>	unidentifiable
	<u>K12B-1-8</u>	unidentifiable
	<u>K12B-1-10</u>	unidentifiable
	<u>K12B-1-11</u>	unidentifiable
	<u>K12B-1-12</u>	unidentifiable
	<u>K12B-1-13</u>	<u>S. distincta distincta</u>
<u>BR</u>	<u>K12B-BR-1</u>	<u>S. distincta distincta</u>
	<u>K12B-BR-2</u>	<u>S. distincta distincta</u>
	<u>K12B-BR-4</u>	unidentifiable
	<u>K12B-BR-5</u>	probably <u>G. haysii haysii</u>
	<u>K12B-BR-6</u>	<u>S. distincta distincta</u>
	<u>K12B-BR-7</u>	<u>G. haysii haysii</u>
<u>A18</u>	<u>K12A-18-1</u>	probably <u>G. haysii haysii</u>
	<u>K12A-18-2</u>	<u>G. haysii haysii</u>
	<u>K12A-18-3</u>	<u>G. haysii haysii</u>
	<u>K12A-18-4</u>	<u>S. distincta distincta</u>
	<u>K12A-18-5</u>	<u>G. haysii haysii</u>
	<u>K12A-18-6</u>	unidentifiable
	<u>K12A-18-8</u>	<u>G. haysii haysii</u>

	<u>K12A-18-9</u>	<u>G. haysii haysii</u>
	<u>K12A-18-10</u>	<u>G. haysii haysii</u>
	<u>K12A-18-12</u>	unidentifiable
	<u>K12A-18-13</u>	<u>G. haysii haysii</u>
	<u>K12A-18-14</u>	<u>G. haysii haysii</u>
	<u>K12A-18-15</u>	<u>G. haysii haysii</u>
	<u>K12A-18-16</u>	unidentifiable
	<u>K12A-18-17</u>	unidentifiable
	<u>K12A-18-18</u>	unidentifiable
	<u>K12A-18-19</u>	unidentifiable
	<u>K12A-18-20</u>	unidentifiable
	<u>K12A-18-21</u>	<u>S. distincta distincta</u>
	<u>K12A-18-22</u>	<u>G. haysii haysii</u>
<u>A15/16W</u>	<u>K12A-15/16-1</u>	<u>S. distincta distincta</u>
	<u>K12A-15/16-2</u>	probably <u>G. haysii haysii</u>
	<u>K12A-15/16-3</u>	probably <u>S. distincta distincta</u>
	<u>K12A-15/16-4</u>	<u>G. haysii haysii</u>
<u>A14/15W</u>	<u>K12A-14/15-1</u>	<u>D. prolongatum</u>
	<u>K12A-14/15-2</u>	<u>S. distincta distincta</u>
	<u>K12A-14/15-3</u>	<u>S. distincta distincta</u>
	<u>K12A-14/15-4a</u>	<u>S. distincta distincta</u>
	<u>K12A-14/15-4b</u>	<u>G. haysii haysii</u>
	<u>K12A-14/15-5</u>	probably <u>S. distincta distincta</u>
	<u>K12A-14/15-6</u>	<u>B. patella</u>
	<u>K12A-14/15-7</u>	<u>D. prolongatum</u>
	<u>K12A-14/15-8</u>	<u>D. prolongatum</u>

<u>K12A-14/15-9</u>	unidentifiable
<u>K12A-14/15-10</u>	<u>G. haysii haysii</u>
<u>K12A-14/15-11</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-12</u>	<u>G. haysii haysii</u>
<u>K12A-14/15-13</u>	unidentifiable
<u>K12A-14/15-14</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-15</u>	unidentifiable
<u>K12A-14/15-16</u>	<u>G. haysii haysii</u> or <u>D. prolongatum</u>
<u>K12A-14/15-17</u>	probably <u>G. haysii haysii</u>
<u>K12A-14/15-18</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-19</u>	<u>B. patella</u>
<u>K12A-14/15-20</u>	<u>D. prolongatum</u>
<u>K12A-14/15-21</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-22</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-23</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-24</u>	unidentifiable
<u>K12A-14/15-25</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-26</u>	<u>B. patella</u>
<u>K12A-14/15-27</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-28</u>	<u>B. patella</u>
<u>K12A-14/15-30</u>	unidentifiable
<u>K12A-14/15-31</u>	<u>B. patella</u>
<u>K12A-14/15-32</u>	unidentifiable
<u>K12A-14/15-33</u>	<u>S. distincta distincta</u>
<u>K12A-14/15-34</u>	<u>B. patella</u>
<u>K12A-14/15-35</u>	unidentifiable

APPENDIX 3. Biometric data (- = no information, X = not applicable, e = estimate)

A = Diameter of transverse section (mm).

B = Counter-cardinal dimension (mm).

C = Alar-alar dimension (mm).

D = Average dimension (mm).

E = Height above tip (mm).

F = Number of major septa.

G = Epizoans; colonial coral = CC, bryozoan = B, none visible = 0. Position; cardinal = C, counter = K, alar = A. Specimen abraded beneath epizoan = __, specimen nonabraded beneath epizoan = ^, longitudinal sections = (L).

H = Borings; Trypanites = T, none visible = 0. Position; as above.

I = Abrasion; epitheca present = EP, epitheca absent = EA, stereozone partially or all absent = SA.

J = Salvadorea cross-sectional shape; triangulate = Tr, circular = Cr.

K = Length of cardinal septum in Salvadorea and Bighornia; long = l, short = s.

L = Bighornia cross-sectional shape; depressed and triangulate = dt, oval = o, crescentic with concave cardinal side = cs, crescentic with concave counter side = cs-k, rectangular = r.

Specimen

number	A	B	C	D	E	F	G	H	I	J	K	L
<u>Salvadorea distincta distincta</u>												
GSC 6731a	13	X	X	X	-	36	-	-	-	Cr	-	X
<u>W1-2-2</u>	12	X	X	X	-	35	-	-	-	Cr	s	X
GSC 6729a	17.5	X	X	X	-	37	-	-	-	Cr	s	X
<u>W2-1-1</u>	11	X	X	X	-	-	-	0	-	Cr	-	X
<u>R211iv</u>	18e	X	X	X	-	-	0	0	EP	Cr	1	X
<u>R211v</u>	6	X	X	X	-	22	0	0	-	Cr	1	X
<u>NA-1-7</u>	10	X	X	X	-	34	-	-	-	Tr	s	X
<u>NC-1-1</u>	10	X	X	X	-	32	-	-	-	Cr	-	X
<u>NC-1-4</u>	14	X	X	X	-	35	-	-	-	Cr	s	X
<u>NC-1-5</u>	7.5	X	X	X	-	29	-	-	-	Cr	s	X
<u>ND-2-9a</u>	4.5	X	X	X	-	21	0	0	EP	Cr	1	X
b	6.5	X	X	X	-	26	0	0	EP	Cr	1	X
<u>NG-2-1a</u>	22	X	X	X	-	41	0	0	EP	Tr	s	X
<u>NG-2-2</u>	9	X	X	X	-	30	-	-	-	-	-	X

<u>N4-1-2</u>	18	X	X	X	-	44	0	0	-	Cr	-	X
<u>N7-3-2</u>	8.5	X	X	X	-	24	0	0	-	Cr	1	X
<u>N7-3-6</u>	22	X	X	X	-	-	0	0	-	Cr	s	X
<u>N7-3-8a</u>	6	X	X	X	-	-	0	0	-	Cr	-	X
b	10.5	X	X	X	-	29	0	0	-	Cr	1	X
c	11	X	X	X	-	33	0	0	-	Cr	1	X
<u>N7-6-1a</u>	6	X	X	X	-	-	0	0	EA	Cr	1	X
<u>N9-3-1</u>	22	X	X	X	-	43	B,A	0	-	Cr	s	X
<u>N9-3-2</u>	19	X	X	X	-	43	-	-	-	Cr	s	X
<u>N9-1-1</u>	12	X	X	X	-	33	-	-	-	Cr	s	X
<u>N10-1-9a</u>	3	X	X	X	-	-	0	0	-	Cr	1	X
b	5.5	X	X	X	-	24	0	0	-	Cr	1	X
<u>N11-3-1</u>	4	X	X	X	-	18	-	-	-	Cr	1	X
<u>N12-8-1</u>	25	X	X	X	-	45	0	0	EP	Cr	s	X
<u>N12-7-2</u>	28	X	X	X	-	44	0	T,C,K(L)	EP	Cr	s	X
<u>N14-1-8</u>	6	X	X	X	-	23	0	0	-	Cr	1	X
<u>N14-1-10</u>	10.5	X	X	X	-	30	0	0	-	Cr	1	X
<u>N31-2-5</u>	9	X	X	X	-	28	0	0	-	Cr	1	X

<u>N40-2-2</u>	16	X	X	X	-	41	0	0	-	Tr	s	X
<u>K12A-14/15-2</u>	19	X	X	X	-	37	0	0	EP	Cr	1	X
<u>K12A-14/15-3</u>	16	X	X	X	-	37	0	0	-	Cr	1	X
<u>K12A-14/15-4a</u>	16	X	X	X	-	40	-	-	-	Cr	1	X
<u>K12A-14/15-11a</u>	15	X	X	X	15	36	0	0	-	Cr	1	X
b	20	X	X	X	23	40	0	0	-	Cr	1	X
<u>K12A-14/15-14</u>	27	X	X	X	-	51	0	0	-	Cr	s	X
<u>K12A-14/15-18</u>	16	X	X	X	-	44	0	T(L)	-	Cr	s	X
<u>K12A-14/15-21</u>	23	X	X	X	-	40	-	-	-	Cr	s	X
<u>K12A-14/15-22</u>	9	X	X	X	-	29	0	0	-	Cr	1	X
<u>K12A-14/15-23</u>	19	X	X	X	-	44	0	0	-	Cr	s	X
<u>K12A-14/15-25a</u>	5	X	X	X	-	22	0	0	-	Cr	1	X
b	12	X	X	X	-	34	0	0	-	Cr	1	X
c	13	X	X	X	-	36	B,C	0	-	Cr	1	X
<u>K12A-14/15-27</u>	16	X	X	X	-	34	0	0	EP	Cr	1	X
<u>K12A-14/15-33</u>	13	X	X	X	-	38e	0	T,2K,A	-	Cr	1	X
<u>K12A-15/16-1</u>	21	X	X	X	-	45	0	T,K(L)	-	Cr	s	X

<u>K12A-18-4a</u>	9	X	X	X	-	27	0	0	-	Cr	1	X
b	21	X	X	X	-	47	0	0	EP	Cr	1	X
<u>K12A-18-21</u>	10	X	X	X	-	32	0	0	-	Cr	1	X
<u>K12A-BR-1</u>	19	X	X	X	-	45	0	0	-	Cr	1	X
<u>K12A-BR-2</u>	8	X	X	X	-	25	0	0	-	Cr	1	X
<u>K12A-BR-6</u>	16	X	X	X	-	42	0	0	-	Cr	1	X
<u>K12B-1-13</u>	7	X	X	X	-	27	0	0	-	Cr	1	X
<u>K12B-5-2</u>	-	X	X	X	42	-	-	-	-	-	-	X
<u>K12B-5-5</u>	11	X	X	X	-	29	-	-	-	Tr	s	X
<u>K12B-5-13</u>	7	X	X	X	-	24	0	0	-	Cr	1	X
<u>K12B-5-16</u>	-	X	X	X	-	-	0	0	SA	Cr	-	X
<u>K12B-6-2</u>	16	X	X	X	-	42	0	0	EA	Cr	1	X
<u>K12B-6-4a</u>	19	X	X	X	-	44	0	0	-	Cr	s	X
b	27	X	X	X	-	48	0	0	-	Cr	s	X
<u>K12B-7-2</u>	10	X	X	X	-	31	0	0	-	Cr	1	X
<u>K12B-7-3</u>	22	X	X	X	-	46	0	0	-	Cr	s	X
<u>K12B-16-1a</u>	6	X	X	X	-	22	0	0	-	Cr	1	X
b	10	X	X	X	-	32	0	0	-	Cr	1	X

c	16	X	X	X	-	39e	0	0	EP	Cr	1	X
d	19	X	X	X	-	42	0	0	EP	Cr	s	X
<u>K12B-20-1</u>	-	X	X	X	-	42e	0	0	-	Cr	s	X
<u>K12B-23-1a</u>	10	X	X	X	-	33	0	0	-	Cr	1	X
b	19	X	X	X	-	43	0	0	-	Cr	1	X
<u>K12B-25-4</u>	18	X	X	X	-	39	0	0	EA	Tr	1	X
<u>K12B-25-11</u>	11	X	X	X	-	-	B,A	0	EP	Cr	s	X
<u>K12B-T-1a</u>	22e	X	X	X	-	45	0	0	SA	Cr	1	X
b	30	X	X	X	-	52	<u>B,A-C</u>	0	SA	Cr	s	X

Salvadorea sp. 2

<u>NA-1-5a</u>	3.5	X	X	X	-	-	0	0	EA	Cr	-	X
b	8	X	X	X	-	31	0	0	EA	Cr	1	X
c	10.5	X	X	X	-	40	0	0	EA	Cr	1	X

Bighornia patella

GSC 6731	X	9	10	9.5	-	24	-	-	-	X	s	o
GSC 6732	X	16e	17e	16.5	-	46e	-	-	-	X	s	dt
<u>R211-iiia</u>	X	-	-	-	-	-	0	0	-	X	s	dt
b	X	-	-	-	-	44	<u>B̄,C</u>	0	-	X	s	dt

c	X	19	22	20.5	-	44	B̄,C	0	-	X	s	dt
<u>R211-vi</u>	X	7.5	11	9.25	-	32	0	0	EP	X	s	dt
<u>NG-3-7</u>	X	12	14.5	13.25	-	32	0	0	EP	X	s	dt
<u>NG-3-8</u>	X	4	6	5	-	-	0	0	-	X	s	o
<u>NG-3-12a</u>	X	2	4	3	-	19e	0	0	-	X	l	dt
b	X	2.5	6	4.25	-	22e	0	0	-	X	l	dt
c	X	5.5	10.5	8	-	32	0	0	EP	X	s	dt
d	X	6	11	8.5	-	34	0	0	EP	X	s	dt
<u>NG-2-3</u>	X	11	19	15	-	46	0	0	-	X	s	dt
<u>NG-1-3</u>	X	-	-	-	-	-	0	0	-	X	s	dt
<u>N10-1-3</u>	-	-	-	-	-	-	-	-	-	-	-	dt
<u>N10-1-7</u>	X	7	15	11	-	-	0	0	-	X	s	cs
<u>N10-1-17</u>	X	5	10.5	7.75	-	-	-	-	-	X	s	o
<u>N11-2-3a</u>	X	4	4.5	4.25	-	18	0	0	EP	X	l	dt
b	X	6.5	10	8.25	-	30	0	0	EP	X	l	dt
c	X	7.5	11	9.25	-	34	0	0	EP	X	l	dt
d	X	10	14	12	-	36	0	0	EP	X	s	dt

e	X	11	15	13	-	36	0	0	EP	X	s	dt
<u>N11-2-7a</u>	X	4	6.5	5.25	-	22	0	0	-	X	l	o
b	X	7.5	11	9.25	-	32	0	0	-	X	s	o
<u>N11-2-9</u>	X	-	-	-	-	-	0	0	-	X	s	dt
<u>N11-2-11</u>	X	-	-	-	-	-	0	0	EA	X	s	o
<u>N12-6-1</u>	X	-	-	-	-	-	0	0	-	X	l	dt
<u>N12-4-1a</u>	X	4	9	6.5	-	-	0	0	-	X	l	cs
b	X	6	10	8	-	-	0	0	-	X	l	cs
c	X	9.5	12	10.75	-	37	0	0	-	X	s	r
d	X	14e	16e	15e	-	43	0	0	-	X	s	o
<u>N14-1-9a</u>	X	-	-	-	-	-	0	0	-	X	s	dt
b	X	10	16	13	-	-	0	0	-	X	s	dt
<u>N40-2-5</u>	X	8e	15e	11.5	-	33e	0	0	-	X	s	cs
<u>K12A-14/15-6a</u>	X	1	4	2.5	1.5	-	0	0	-	X	l	o
b	X	6	10	8	5	34e	0	0	-	X	l	o
c	X	10	13.5	11.75	10	38	0	0	-	X	l	o
<u>K12A-14/15-19</u>	X	11	14	12.5	-	41	0	0	-	X	s	o
<u>K12A-14/15-28a</u>	X	7.5	10	8.75	-	34	0	0	-	X	l	o

	b	X	11	13	12	-	36	0	T,C,A	-	X	s	o
	c	X	13	14	13.5	-	36	0	T,C,A	-	X	s	o
	<u>K12A-14/15-31a</u>	X	5	10	7.5	3	31e	0	0	-	X	l	o
	b	X	10	13	11.5	10	38	0	0	-	X	s	o
	<u>K12A-14/15-34</u>	X	12	15	13.5	-	37	0	0	-	X	s	o
	<u>K12B-2-10</u>	X	9	11	10	-	32	0	0	-	X	l	dt
	<u>K12B-5-10</u>	X	-	-	-	-	-	0	T,C	-	X	s	dt
	<u>K12B-5-12a</u>	X	2	-	-	-	-	0	0	EP	X	l	cs
	b	X	4.5	11	7.75	-	38	0	0	EP	X	s	cs
	c	X	7	13e	10	-	-	0	0	EP	X	s	cs
	<u>K12B-5-26</u>	X	10	18	14	-	-	0	0	-	X	l	dt
	<u>K12B-6-5</u>	X	16.5	17	16.75	-	47	0	0	-	X	s	cs
	<u>K12B-16-2a</u>	X	1	5	3	1	21e	0	0	EP	X	l	r
	b	X	5	12.5	8.75	4	40	0	0	EP	X	l	r
	c	X	8.5	18	13.25	7	46	0	0	EP	X	s	o
	<u>K12B-24-2</u>	X	9	11	10	-	31	0	0	EP	X	s	dt
	<u>K12B-24-5a</u>	X	4	8	6	3e	28	0	0	EP	X	l	dt
	b	X	7	16	11.5	5e	37	0	0	EP	X	s	dt

c	X	9	18	13.5	8e	39	0	T,C	EP	X	s	dt
<u>K12B-25-2</u>	X	11	18	14.5	-	39	0	0	EP	X	s	dt
<u>K12B-25-10a</u>	X	5.5	11.5	8.5	-	38	0	0	EP	X	1	cs-k
b	X	8	17	12.5	-	46	0	0	EP	X	s	cs-k
c	X	12	21	16.5	-	50	0	T,A	EP	X	s	dt
MMH 2995	X	10	13	11.5	14	-	0	0	EA	-	-	o
PMO A10585a	X	9	12	10.5	-	31	0	0	EA	-	s	o
PMO A10586a	X	-	-	-	-	-	-	-	SA	-	-	-
b	X	5	9e	7	-	-	-	-	SA	-	1	o
PMO A10587a	X	8	12	10	-	32	0	0	EA	-	1	dt
b	X	11	13	12	-	33	0	0	EA	-	s	o
PMO A10588a	X	4	4.5	4.25	-	-	0	0	SA	-	1	dt
b	X	8	9	8.5	-	26	0	0	EA	-	s	o
<u>Bighornia wilsonae</u>												
<u>UM 215a</u>	X	11	13	12	-	39	0	0	EA	-	1	o
b	X	12	13.5	12.75	-	39	0	0	EA	-	s	o
<u>UM RJE 1-271a</u>	X	9	12	10.5	-	38	0	T,A	EA	-	1	o
b	X	11	14	12.5	-	41	0	T,A	EA	-	s	o

<u>UM RJE 1-293a</u>	X	7	10	8.5	-	36	0	0	EA	-	1	o/cs
b	X	8	12	10	-	39	0	0	EA	-	s	o/cs

Bighornia sp. cf. B. bottei

<u>N10-1-2a</u>	X	5e	20e	12.5	3	-	-	-	-	-	-	cs
b	X	5e	24e	14.5	4	-	-	-	-	-	s	cs
c	X	9e	30e	19.5	8	-	-	-	-	-	s	cs
<u>N11-2-2a</u>	X	5e	19e	12	-	-	-	-	-	-	-	cs
b	X	15e	27e	21	-	52	-	-	-	-	s	cs
c	X	23e	30e	26.5	-	-	-	-	-	-	s	o

Grewingkia haysii haysii

GSC 6729	X	-	19	-	-	54e	-	-	-	X	X	X
<u>R211-i</u>	X	-	-	-	-	-	-	T,3A	-	X	X	X
<u>N4-1-3</u>	X	18	14.5	16.25	-	44	0	0	-	X	X	X
<u>N7-3-10</u>	X	13	11.5	12.25	-	-	0	0	-	X	X	X
<u>N12-5-2a</u>	X	30	32	31	-	70	\overline{CC},A	-	-	X	X	X
b	X	45	45	45	-	-	\overline{CC},A	T,K,A	-	X	X	X
c	X	45	46	45.5	-	-	\overline{CC},A	T,C	-	X	X	X
<u>N12-2-1</u>	X	-	-	-	-	-	0	0	EA	X	X	X

<u>N12-2-3</u>	X	29.5	33	31.25	-	79e	0	T,2K,5A,5C	SA	X	X	X
<u>N12-2-5</u>	X	29	31	30	-	66e	0	0	-	X	X	X
<u>N12-2-6</u>	X	21	21	21	-	51	0	T,4K,1C	SA	X	X	X
<u>N12-1-1a</u>	X	14e	15	14.5	-	-	0	0	EA	X	X	X
b	X	24e	26	25	-	-	0	0	EA	X	X	X
<u>N17-1-1</u>	X	-	-	-	-	-	CC,C-A	0	-	X	X	X
GSC 16917	X	25	23	24	-	66	-	-	-	X	X	X
<u>K12A-14/15-4ba</u>	X	7	6e	6.5 e	-	24e	0	0	-	X	X	X
b	X	15	12	13.5	-	40	0	0	-	X	X	X
<u>K12A-14/15-10</u>	X	37	27	32	-	71	0	T,K	-	X	X	X
<u>K12A-14/15-12</u>	X	29	25	27	-	64	0	T,A	EA	X	X	X
<u>K12A-15/16-4</u>	X	32	24	28	-	67	0	T,2K,A	-	X	X	X
<u>K12A-18-2</u>	X	-	-	-	-	-	0	T,2C,A	SA	X	X	X
<u>K12A-18-3a</u>	X	22	17	19.5	-	59	0	T,K,5A	SA	X	X	X
b	X	33	30	31.5	-	80	0	0	SA	X	X	X
<u>K12A-18-5</u>	X	44	45	44.5	-	99	0	0	SA	X	X	X
<u>K12A-18-9</u>	X	38	39	38.5	-	71e	0	0	-	X	X	X
<u>K12A-18-14a</u>	X	20	16	18	-	50	0	T,2A	SA	X	X	X

b	X	30	25	27.5	-	63	0	T,A	SA	X	X	X
<u>K12A-18-15</u>	X	29	26	27	-	-	-	-	-	X	X	X
<u>K12A-18-22a</u>	X	38	38	38	-	79e	0	0	EA	X	X	X
b	X	65.5	62.5	64	-	-	-	-	-	X	X	X
<u>K12A-BR-7</u>	X	-	-	-	-	-	CC,K;B,K	0	-	X	X	X
<u>K12B-1-4</u>	X	31	30	31.5	-	72	0	0	-	X	X	X
<u>K12B-2-6</u>	X	29	35	32	-	-	-	-	-	X	X	X
<u>K12B-3-2a</u>	X	8	6	7	-	-	0	T,A	-	X	X	X
b	X	12	9	11.5	-	-	0	0	-	X	X	X
c	X	19	15	17.5	-	-	0	0	-	X	X	X
<u>K12B-5-4</u>	X	26	21	23.5	-	51	0	T,2K,2A	-	X	X	X
<u>K12B-5-14</u>	X	28	35	31.5	-	63	0	0	EA	X	X	X
<u>K12B-5-19</u>	X	40	40	40	-	98	CC,K	0	-	X	X	X
<u>K12B-5-29</u>	X	25	25	25	-	54	0	0	-	X	X	X
<u>K12B-5-30</u>	X	-	-	-	-	-	CC,K-A	0	-	X	X	X
<u>K12B-6-3a</u>	X	11	12	11.5	-	34	0	T,C	SA	X	X	X
b	X	20	20	20	-	47	0	0	SA	X	X	X
c	X	32	32	32	-	75	0	T,2K	SA	X	X	X

<u>K12B-7-4</u>	X	15	13	14	-	-	0	T,C,A	SA	X	X	X
<u>K12B-23-2</u>	X	12	14	13	-	-	-	T,A,K	-	X	X	X
<u>K12B-25-9</u>	X	34	32 _e	33 _e	-	-	\overline{CC} ,C	T,2C	EA	X	X	X

Deiracorallium prolongatum

<u>W1-1-1</u>	X	17	10	13.5	-	14	-	-	-	X	X	X
GSC 6729 b	X	37	27	32	-	-	-	-	-	X	X	X
<u>NC-1-2</u>	X	7.5	3.5	5.5	-	-	-	-	-	X	X	X
<u>N4-1-1</u>	X	25	18	21.5	-	60	0	-	-	X	X	X
<u>N14-1-3</u>	X	31	21	26	-	51 _e	0	-	-	X	X	X
<u>N14-1-6</u>	X	11.5	8	9.5	-	33	0	T,A	-	X	X	X
<u>N40-3-6</u>	X	8.5	5	6.75	-	23	0	-	-	X	X	X
<u>N40-3-7</u>	X	12	7.5	9.75	-	35 _e	0	-	-	X	X	X
<u>K12A-14/15-1a</u>	X	12	7.5	9.75	-	-	0	T,A	-	X	X	X
b	X	16	11	13.5	-	48	0	-	-	X	X	X
c	X	23	16	19.5	-	56	0	T,3K,C	-	X	X	X
d	X	-	-	-	-	-	0	T,2K,C	-	X	X	X
<u>K12A-14/15-7a</u>	X	16	11.5	13.75	-	39	0	0	-	X	X	X
b	X	21	14	17.5	-	49	0	T,A	-	X	X	X

<u>K12A-14/15-8a</u>	X	25	14	19.5	-	51	0	-	EP	X	X	X
b	X	31	19	25	-	54	0	-	EP	X	X	X
<u>K12A-14/15-20a</u>	X	9	6	7	-	31	0	-	SA	X	X	X
b	X	15	11	13	-	44	<u>B</u> ,K	T,K	SA	X	X	X
c	X	21	17	19	-	53	0	T,2K,2A,C	SA	X	X	X
d	X	23	18	20.5	-	56	0	-	SA	X	X	X
<u>K12B-2-12</u>	X	12	9	10.5	-	32	0	-	-	X	X	X
<u>K12B-5-9</u>	X	8	5	6.5	-	28	0	-	EP	X	X	X
GSC 10848a	X	15	13	14	-	42	0	-	-	X	X	X
b	X	23	19	21	-	58	0	-	-	X	X	X
c	X	29	24	26.5	-	60	0	-	-	X	X	X
d	X	33e	26e	29e	-	-	0	-	-	X	X	X
GSC 10850a	X	17	14	15.5	-	41	0	-	-	X	X	X
b	X	33	23e	28	-	-	0	-	-	X	X	X
c	X	39	31e	35	-	-	0	-	-	X	X	X

APPENDIX 4. Additional data on Salvadorea distincta distincta

1. Specimens with triangulate cross sections in late stage;

<u>NG-2-1a</u>	39.2 ^a
<u>N40-2-2</u>	5.2- 12.2
<u>K12B-25-4</u>	116.7-128+

2. Specimens with greatly dilated septa in late stage, from locality K12;

<u>K12A-14/15-2</u>	25.1- 27.4
<u>K12A-14/15-3</u>	25.1- 27.4
<u>K12A-14/15-33</u>	25.1- 27.4
<u>K12B-5-16</u>	47.4- 55.4
<u>K12B-6-2</u>	55.4- 57.4
<u>K12B-23-1</u>	109.2-110.9

3.				Width of	Minor	Axial
Specimen		Radius	stereozone	septae	struc-	
numbers	Heights (m)	(mm)	(mm)	(mm) ^b	ture ^c	
<u>NG-2-1a</u>	39.3	11	3	(27%) ^d	1	4
<u>N7-3-6</u>	32.0- 33.2	11	4	(36%)	confined	-
<u>N9-3-1</u>	51.8- 54.3	11	2	(18%)	1	5
<u>N12-8-1</u>	91.4-152.4	12.5	3	(24%)	0.5	5
<u>N12-7-2</u>	25 - 28	14	4	(29%)	2	10
<u>N40-2-2</u>	5.2- 12.2	8	1.5	(19%)	confined	4
<u>K12A-14/15-11</u>	25.1- 27.4	10	2	(20%)	confined	5
<u>K12A-14/15-14</u>	25.1- 27.4	13.5	4	(30%)	1	9

<u>K12A-14/15-18</u>	25.1- 27.4	8	1	(13%)	confined	4
<u>K12A-14/15-23</u>	25.1- 27.4	9.5	2	(21%)	confined	4
<u>K12A-18-4</u>	32.8- 35.1	10.5	2	(19%)	1	4
<u>K12A-BR-1</u>	not <u>in situ</u>	9.5	1	(11%)	confined	3
<u>K12B-7-3</u>	57.4- 70.4	11	3.5	(32%)	confined	7
<u>K12B-16-1</u>	86.2-100.2	9.5	3	(32%)	confined	3
<u>K12B-25-4</u>	117 -128+	9	3	(33%)	1	4
<u>K12B-T-1</u>	not <u>in situ</u>	15	2	(13%)	1	12

4a. Specimens with simple axial structure in late stage;

<u>NG-2-1a</u>	39.3 m
<u>N9-3-1</u>	51.8- 54.3 m
<u>N12-8-1</u>	91.4-152.4 m
<u>N40-2-2</u>	5.2- 12.2 m
<u>K12A-BR-1</u>	not <u>in situ</u>
<u>K12B-25-4</u>	117 -128 m

4b. Specimens with complex axial structure in late stage;

<u>N12-7-2</u>	100 -101
<u>K12A-14/15-11</u>	25.1- 27.4
<u>K12A-14/15-14</u>	25.1- 27.4
<u>K12A-14/15-18</u>	25.1- 27.4
<u>K12B-23-1</u>	109.2-111

^aHeights, in metres, measured above top of Mount Wilson Quartzite.

^bLength of minor septa (portion that extends beyond stereozone).

^cDiameter of axial structure.

^dWidth expressed as percentage of coral radius.

APPENDIX 5. Length of cardinal septum

Specimen number	Cardinal septum long ^a	Cardinal septum short ^b
<u>Bighornia patella</u> , Beaverfoot Formation		
<u>NG-3-8</u>		X
<u>NG-3-12</u>		X
<u>N11-2-3</u>		X
<u>N14-1-9</u>		X
<u>N40-2-5</u>		X
<u>K12A-14/15-6</u>		X
<u>K12A-14/15-28</u>		X
<u>K12B-2-10</u>	X	
<u>K12B-5-12</u>		X
<u>K12B-24-2</u>		X
<u>K12B-24-5</u>		X
<u>K12B-25-2</u>	X	
<u>K12B-25-10</u>		X
<u>B. patella</u> , Stony Mountain Formation		
GSC 67741		X
GSC 67742		X
GSC 67745		X
GSC 67746		X
GSC 67747		X
<u>UM 1-549</u>		X
<u>UM 1-273</u>		X

B. patella, Ellesmere Island

PMO A 10585	X
PMO A 10587	X
PMO A 10588	X

B. patella, Bighorn Dolomite

USNM 127576	X
USNM 127577	X

B. patella, Vauréal Formation

YPM 28770 ^c	X
------------------------	---

Bighornia wilsonae, Red River Formation

GSC 60752	X
GSC 60753	X
GSC 60754	X
GSC 60755	X
<u>UM 215</u>	X
<u>UM RJE 1-271</u>	X
<u>UM RJE 1-293</u>	X

B. wilsonae, Second Value Dolomite

USNM 381185	X
USNM 381203	X
USNM 381204	X
USNM 381207	X

Deiracorallium prolongatum, Beaverfoot Formation

<u>N40-3-6</u>	X
<u>N40-3-7</u>	X
<u>K12A-14/15-7</u>	X

<u>K12A-14/15-8</u>	X
<u>K12A-14/15-20</u>	X
<u>K12B-5-9</u>	X

D. angulatum angulatum, Vauréal Formation

GSC 66592	X
GSC 66594	X

D. angulatum gunni, Stony Mountain Formation

GSC 67727	X
GSC 67729	X
GSC 67730	X
GSC 67731	X
GSC 67754	X
<u>UM 1-40</u>	X
<u>UM 1-T</u>	X
<u>UM 1-263</u>	X

^a Sediment fills interseptal spaces.

^b Below level at which sediment fills interseptal spaces.

^c Peabody Museum, Yale University, New Haven, Connecticut.