to PROFESSOR H. YABE

in
congratulation of 88th
anniversary of his birth,
Dec. 3, 1965

DURHAMINIDAE (Tetracoral)

by

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Contents

ABSTRACT

A new family of Upper Palaeozoic rugose corals, Durhaminidae is proposed. Nearly the entire species hitherto known to us, which may be grouped under the present family, are reviewed.

Their geologic and geographic distributions are presented in a concise form. Phylogeny of this new family is compiled. Further, the relationship between the new family and Waagenophyllidae is discussed.

The geographic distribution of Durhaminidae is a matter of importance from the view point of palaeozoogeography during the Carboniferous and Permian, which shows the marked contrast to the Waagenophyllidae province.

INTRODUCTION

In our previous study on Waagenophyllidae (1965) it was evidently proved that this group of corals was widely distributed in the Tethys sea province in the Permian. Further, in the course of the same study, the present authors became aware of the fact that an another group of corals apparently resembled Waagenophyllidae was possibly distributed in still northward region. Actually, the so-called northern group of corals comprises such genera as *Amandophyllum*, *Durhamina*, *Heritschioides*, *Kleopatrina* and *Protolonsdaleiastraea*, besides *Yabeiphyllum*, *Tanbaella*, and *Kleopatrina* (*Porfirievella*) newly proposed in this paper.

As a matter of fact, it was H. YABE (1950)* who first noticed the importance of distinction between such genera as *Heritschioides*, and waagenophyllid corals.

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* A synopsis given by H. YABE in his paper entitled as " Permian corals resembling *Waagenophyllum* and *Corwenia* " will be quoted below :

I. Forms with the tabulae in the medial zone, ascending towards the axial column.

Corwenia SMITH and RYDER, Genotype : *Lonsdaleia rugosum* McCOY, Lower Carboniferous ; Europe.

Yatsengia HUANG. Genotype : *T. asiatica* HUANG. Lower Permian. (Zone of *Parafusulina*) ; China, Japan.

Heritschioides YABE. Genotype : *Waagenophyllum columbicum* (SMITH). Lower Permian (or Upper Carboniferous) ; Canada, Russia ?

II. Forms with the tabulae in the medial zone, nearly horizontal or descending towards the axial column.

Huangia YABE. Genotype : *Corwenia chiitsingensis* CHI. Moscovian (Zone of *Fusulina* and *Fusulinella*) to Lower Permian (Zone of *Parafusulina*) ; China, Japan, Iran.

Heritschia = *Heritschiella* MOORE and JEFFORDS. Genotype : *H. girtyi* MOORE and JEFFORDS. Lower Permian (Zone of *Pseudoschwagerina*) ; Kansas.

Waagenophyllum HAYASAKA. Genotype : *Lonsdaleia indica* WAAGEN and WENTZEL Lower Permian (Zone of *Parafusulina ?*, Zone of *Neoschwagerina- Verbeekina* (Zone of *Polydiexodina*) and Zone of *Yabeina*) ; India, China, Japan, Manchuria, Indochina, Central Asia, Europe and North America ?

Prior to him, there have been much confusions as to the taxonomy of these corals above enumerated, and they have been usually misplaced from case to case either in the families like Lithostrotionidae, Clisiophyllidae, Lonsdaleidae, or Waagenophyllidae. They would be however best grouped into a single new family, for which the name of Durhaminidae is here proposed.

As will be later described in detail, all the corals of the present family are distinct from both Lithostrotionidae and Waagenophyllidae in having different axial structure or tabulae including tabellae in tabularium. It is also easily separable from Clisiophyllidae or Lonsdaleidae in having different axial structure or dissepiments, besides different tabulae and tabellae.

In the present paper, all the genera and species belonging to this family will be first critically reviewed and certain new species will be also described. Then, the phylogeny and geological and geographical distributions of this group of corals will be briefly presented.

The new family Durhaminidae comprises merely seven genera besides two subgenera as above stated, and embraced only some fifty species in all, so far as the present knowledge of the authors is concerned. In spite of the above fact, the geographical distribution of these corals is extending into wide area ranging from North to South Urals, Carnic Alps, Japan, Canada (British Columbia), western coast regions of the United States (Nevada, Oregon, California and Texas), besides Peru.

To describe more in detail, *Amandophyllum* is known from the Carnic Alps, Japan, and Texas; *Durhamina* from Nevada, Texas, Alaska*, Peru and Japan; *Heritschioides*, from Urals, Canada (British Columbia), Nevada, Oregon and Japan; *Yabeiphyllum* from Japan and Texas; *Tanbaella* from Japan only; *Protolonsdaleiastraea* from Urals; while *Kleopatrina* (*Kleopatrina*) and *Kleopatrina* (*Porfirievella*) from Nevada and Urals.

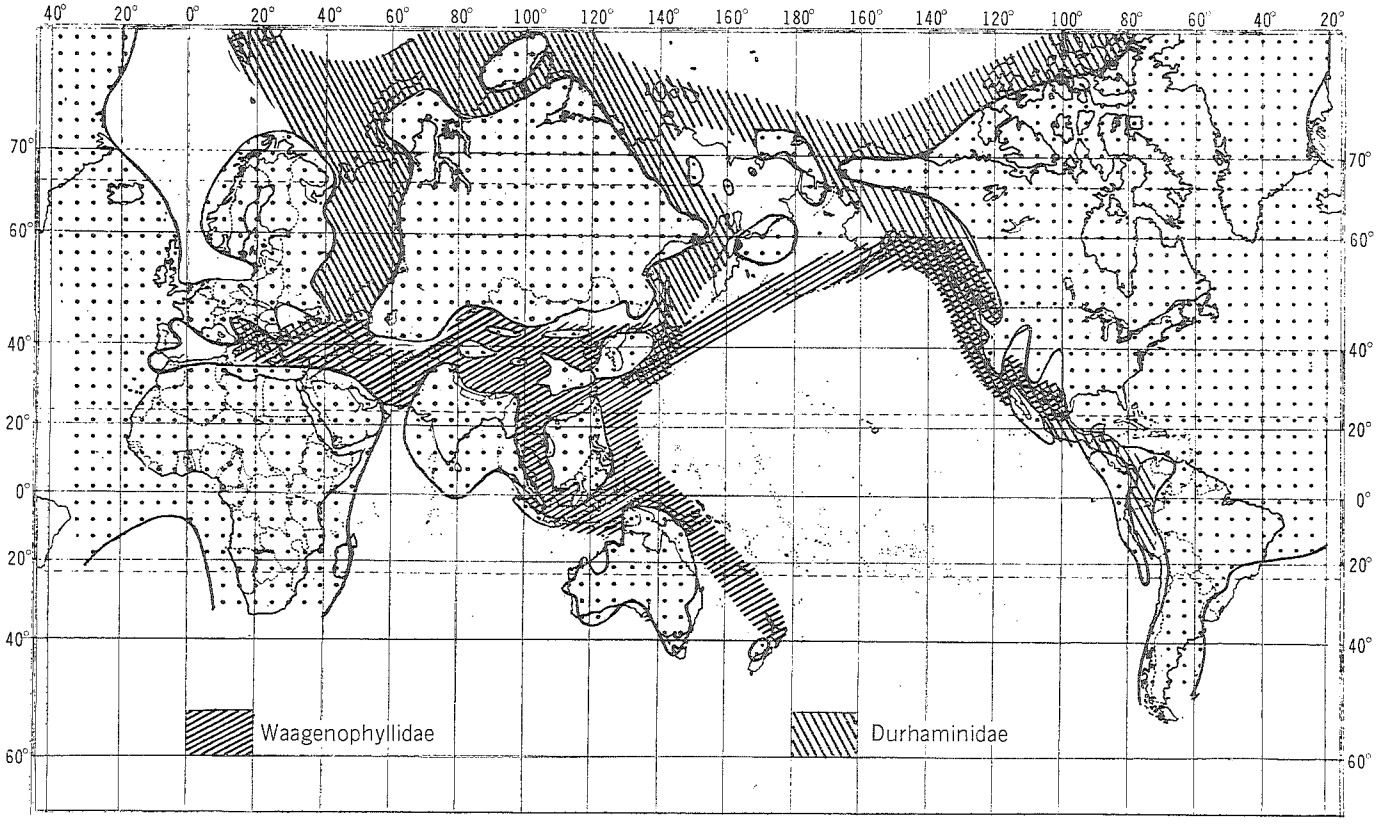
Accordingly the corals belonging to the family Durhaminidae are mostly dis-, tributed outside the region characterized by the presence of waagenophyllid corals. Namely, it is only the west and east ends of the Tethys sea province in Eurasia, where both Durhaminidae and Waagenophyllidae were coexisted. These areas are the Carnic Alps in the west, while the Japanese islands in the east.

Thus, the existence of remarkable opposition in respect to the geographical distributions of coral faunas is almost doubtless especially in the Permian.

These contrasting provinces are Waagenophyllidae versus Durhaminidae province. Of them, the former is the Tethys sea in Eurasia and south and east Circum Pacific region. A single exception for this statement is *Heritschiella girtyi*, which is found from Kansas, U.S.A.

To the contrary, the latter covered wide area ranging from the entire west coast

* Dr. C. L. ROWETT, Alaska Univ., personal communication.



Text-figure 1
Permian palaeogeography together with the extent of distribution of Waagenophyllidae and Durhaminidae. Dotted area: land.

region of the North America and also that of South America as far as Peru. Further, the Durhaminidae province was also extended to the sea of Japan and Carnic Alps perhaps through the Arctic and North Pacific sea of those days.

ACKNOWLEDGEMENTS

The authors acknowledge the encouragement of Drs. H. YABE and I. HAYASAKA during the preparation of this paper.

Our thanks are given to Drs. S. SAKAGUCHI and N. YAMAGIWA of the Osaka Gakugei University for the loan of the type specimen of their *Waagenophyllum izuruhense*; to Dr. Y. HASEGAWA of the Niigata University for the gift of a coral from Akiyoshi; and to Dr. Y. OKIMURA of the Hiroshima University for a coral from Atetsu plateau.

As to Upper Palaeozoic corals of " boreal region " in general, MINATO examined Ellesmereland corals now stored at the palaeontological Museum of Oslo; Spitsbergen & Greenland corals at the Geological Inst. of Stockholm Univ., Palaeont. Inst. of Uppsala Univ., Swedish Natural History Museum (Riksmuseet), and Palaeont Inst. of Lund. Also KATO studied corals from Urals, Melville island, and Devon island at the British Museum of Natural History, London, and corals from Spitsbergen and Canada at the Sedgwick Museum, Cambridge.

We thank heartily Prof. A. HEINTZ and Dr. G. HENNINGSMOEN, Oslo, Prof. I. HESSLAND, Stockholm Univ., Prof. E. STENSIÖ and Dr. H. MUTVEI, Swedish Natural Hist. Museum, Prof. P. THORSLUND, Dr. A. MARTINSSON, Dr. V. JAANUSSON, Uppsala, and Prof. G. REGNÉLL, Dr. P. O. PERSSON, Lund, Dr. H. DIGHTON THOMAS, London, and Dr. C. L. FORBES, Cambrdige, for permitting us to study corals under their care.

Thanks are also due to Dr. C. L. ROWETT of the University of Alaska for the information upon the Alaskan corals and Dr. C. A. ROSS of Western Washington State College for the information on the type materials of some American corals described by Dr. JUNE PHILLIPS ROSS and himself.

Dr. G. ARTHUR COOPER of the United States National Museum kindly supplied us photographs of some American corals. Many other photographs are the work of Mr. S. KUMANO of our department. Mrs. C. MINATO typed the whole manuscript. To all those who assisted us in various ways our cordial thanks are offered.

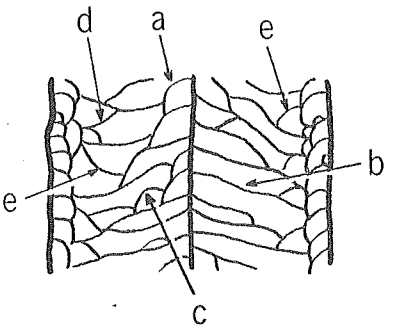
TERMINOLOGY

To avoid any confusions or misunderstandings to be arisen, certain terms adopted in the present paper will be briefly explained, although the present authors wish to follow HILL (1935, 1956) in most of terminology applied to Rugose corals. Namely certain terms will be interpreted in slightly different way and some new terms will be also newly proposed in the present paper.

First of all, tabulae and tabellae will be discussed below. As is already clearly defined by HILL, tabularium can be viewed to be the space or internal area encircled by dissepimentarium or marginarium of the outer area of corallite.

In the present group of corals (Durhaminidae), tabularium cannot be always viewed to definitely differentiate into two parts: inner-and outer-tabularia, but the boundary between them is rather indistinct in many species.

Actually, the tabularium in Durhaminidae is occupied by either relatively large or small tabellae, but tabulae are not developed at all. (In this case, tabulae mean complete and wide plates extending the entire tabularium as are defined by HILL 1956). The tabellae in tabularium may be also called tabular vesicles as once adopted by HERITSCH in 1936, but the authors wish to simply call such small plates in tabularium as tabellae.



Text-figure 2
Diagram showing the mode of tabellae as appeared in the ortho-longitudinal section of a corallite.
a : axial tabella
b : wide tabella
c : periaxial tabella
d : peripheral tabella
e : clinotabella

Among those tabellae found in tabularium in Durhaminidae five kinds can be distinguished, which will be listed below:

a: axial tabellae
b: wide tabellae
c: periaxial tabellae
d: peripheral tabellae
e: clinotabellae

Axial tabellae here defined are the plates, situated at the central part of tabularium, or situated immediately near to the median plates and take part in construction of axial structure.

The term of wide tabellae is linguistically somewhat funny, but they are really existed. Namely there are tabellae extending from the median plate to the boundary between tabularium and dissepimentarium. Such tabellae seem to be somewhat complete and wide, like tabulae and they may be accordingly called wide tabellae.

Next, the periaxial tabellae are the plates situated at the outer side of axial tabellae, while the peripheral tabellae can be defined as the plates distributed only at the outer margins of tabularium.

All the tabellae above stated may be either slightly or highly arched or cystose, facing their convex sides both upwards and outwards. They may be also either highly or slightly ascending towards the axis of corallite.

While the last named tabellae are clinotabellae, which may be also newly introduced into the terminology of Rugose corals. They are always situated at the outer marginal area of taburarium and are either slightly or highly inclined from outward towards inward and downward. They may be also generally highly cystose.

The distinction between clinotabulae in Waagenophyllidae and clinotabellae here defined is obvious, because the former are generally more large in occupying wide space, and not highly cystose, while the latter are represented by small, cystose plates like vesicles, although they incline to the same direction.

The clinotabellae face eventually inwards and downwards, although they are difinitely situated at the marginal area of tabularium. Now, the density or distribution of each type of tabellae above stated in certain vertical distance of tabularium of each coral may be worthy of note. The frequency of appearance of axial plus periaxial tabellae and peripheral tabellae to that of wide tabellae for instance are nearly the same in Durhaminidae, while the wide tabellae are more abundantly found in Lithostrotionidae than the axial tabellae plus periaxial and peripheral tabellae. In short, (axial tabellae + periaxial tabellae + peripheral tabellae) = (wide tabellae) in Durhaminidae, while (axial tabellae + periaxial tabellae + peripheral tabellae) $\ll$ (wide tabellae) in Lithostrotionidae.

Further, clinotabellae seem to be not entirely lacking even in Lithostrotionidae but they are eventually very few in that family. To the contrary clinotabellae are generally more or less well developed in Durhaminidae, than Lithostrotionidae.

NOTES ON STRATIGRAPHIC CORRELATION OF PERMIAN FORMATIONS YIELDING DURHAMINIDAE

It has been generally accepted that biostratigraphic succession of Permian fusulinid assemblages studied and established in the Akiyoshi limestone plateau is widely applicable to Permian formations of Japan. These fusulinid assemblage zones are *Pseudoschwagerina*, *Pseudofusulina**, *Parafusulina*, *Neoschwagerina* and *Yabeina* zones in ascending order. Besides non fusulinid bearing formation overlies the *Yabeina* zone in the Kitakami mountainland, where it has been called Toyoma series.

The Kitakami mountainland has long been considered as standard area for the stratigraphy of Japanese Palaeozoic formations.

Refer to our paper on Waagenophyllidae (1965) for correlation of Permian between the Kitakami and the Akiyoshi.

Japanese durhaminids occur in *Pseudoschwagerina*, *Pseudofusulina* and *Neoschwagerina* zones (NAGAO & MINATO, 1941; MINATO, 1955; SAKAGUCHI & YAMAGIWA, 1958)

In South China SHENG (1963) made most detailed study on Permian fusulinids there, and the work clarifies the stratigraphic distribution of many fusulinid species. As a result, it seems to have been well established that the Mapingian can be correlated with Japanese *Pseudoschwagerina* zone, while the Chihsian corresponds to *Pseudofusulina* zone. Maokou limestone may be faunistically further divisible into *Parafusulina* (*Paraf. splendens* and *sapperi*), *Cancellina*, *Neoschwagerina* and *Yabeina* zones based on fusulinids in ascending order. And these zones are equivalent to *Parafusulina*, *Neoschwagerina* and *Yabeina* zones of Japan. *Cancellina* zone in south China is correlatable with *Minoella* horizon, which occupies the horizon high in the *Parafusulina* zone in Japan. Thus Maokou limestone ranges from *Parafusulina* to *Yabeina* zones in fusulinid zonation. Durhaminids are, however, not known to occur in China at the present moment, but waagenophyllids are dominantly

* The *Pseudofusulina* zone here used is different in sense from the same named Russian one, which is sometimes called as Orenburgian, denoting the topmost Carboniferous in the Soviet Union. *Pseudofusulina* zone used here corresponds the lower half of *Parafusulina* zone (s.l.), and is characterized by the occurrence of the group of *Pseudofusulina vulgaris*, which has large proloculus and very thick spirotheca. Also *Parafusulina* zone in this paper means that a zone characterized by such fusulinids having long axis of coiling as *Parafusulina kaerimizensis*, *Parafusulina lutugini* in Japan. This zone is corresponding to the upper half of *Parafusulina* zone s.l. See also the following articles in connection with the problem concerned. (MINATO, KATO & HASEGAWA, 1964; MINATO & KATO, 1965; MINATO (ed.), 1965).

known in China.

Somewhat similar stratigraphic situation of Permian formations to those in the Kitakami mountains, Japan is found in Carnic Alps, where " Rattendorfer Schichten " roughly corresponding to *Pseudoschwagerina* zone comes to the base of Permian stratigraphic sequence, and is followed by " Trogkofel kalk ". Lower part of the " Trogkofelkalk " may still be considered as belonging to *Pseudoschwagerina* zone, since *Pseudoschwagerina schellwieni* is known to occur in that part of the limestone. The major part of " Trogkofelkalk " may be faunistically correlated with *Pseudofusulina* zone. Durhaminids occur in both of these two formations in the Carnic Alps. As to the stratigraphy and the horizons of coral occurrences in the Carnic Alps, reference is made to HERITSCH (1936) and KAHLER & PREY (1963).

In the Soviet Union, Sakmarian as is customarily used, is further divided into two units in Volga-Ural region. These two units are namely Asselian and Sakmarian (s. str.). Asselian is equivalent to " *Schwagerina* horizon ", and some workers adhere the view of considering it as the top of Carboniferous. Here we follow the view taking the appearance of *Pseudoschwagerina* as the base of Permian as is commonly recognized. Sakmarian s.str. is thus correlatable with *Pseudofusulina* zone. Artinskian in the current usage in the Soviet Union is characterized by the group of *Parafusulina lutugini*, and is wholly corresponding to the *Parafusulina* zone of Japan. After the Kungurian upward terrestrial deposits become dominant in the Permian sequence in Europe Russia, contain very few reliable index fossils of marine organisms, and this fact leads the world correlation of Upper Permian difficult.

Durhaminids occur abundantly in Soviet Union both from the Upper Carboniferous and Lower Permian. As to their stratigraphic horizons we refer to the following articles: DOBROLYUBOVA, 1936, a & b; SOSHKINA et al., 1941; RAUZER-CHERNOUSSOVA, 1951, 1962; " Stratigraphic scheme ", VNIGRI, 1962.

DOBROLYUBOVA (1936) once described a rich coral collection from " Upper Carboniferous " of Middle Urals.

A number of species she described were however later redescribed and partly renamed in SOSHKINA et al. (1941). According to this later publication many of corals described by DOBROLYUBOVA are actually Permian in age.

DOBROLYUBOVA discriminated four coral horizons within " Upper Carboniferous ". But judged from the later description in connection to coral occurrences, the first and second horizons only be correlatable with Upper Carboniferous, in which " *Cystophora* " *biseptata* is reported. The third horizon and the fourth may be correlatable with Lower Permian.

According to SOSHKINA et al. (1941) several horizons are distinguished within Lower Permian sequence in the Sterlitamak region, namely IIa, IIb, III, IV, Va & Vb. Corals are abundant through this succession. And we correlate these

horizons to the standard divisions as shown in the following table, based upon fusulinid and coral occurrences (RAUZER-CHERNOUSSOVA, 1951).

Soviet standard		Sterlitamak region
Artinskian		Vb
Sakmarian s.l.	Sakmarian s. str.	Va IV = Sterlitamak horizon
		III = Tastuv horizon
	Asselian	IIb IIa

Corals only described as occurring in "Artinskian" may be in fact partly of the Sterlitamak age. Thus the geological range of these corals in this paper is assigned to *Pseudofusulina* to *Parafusulina* zones.

In the United States of America, it may be safely conceivable that the Wolfcampian in American Permian standard equals to *Pseudoschwagerina* zone. Leonardian and Wordian have been commonly designated as *Parafusulina* zone (s.l.), and are correlated with Artinskian of the Soviet Union. But the Artinskian s. str. really corresponds to Wordian, which yields *Parafusulina splendens*, and is of *Parafusulina* zone above restricted. Therefore Leonardian may be equivalent to Sakmarian s.str. or *Pseudofusulina* zone. (see also RAUZER-CHERNOUSSOVA, 1962) In the U.S.A. durhaminids occur in both Wolfcampian and Leonardian. (MERRIAM, 1942; EASTON, 1960; MCCUTCHEON & WILSON, 1961; WILSON & LANGENHEIM, 1962).

Our scheme for the correlation of Permian formations of widely distributed areas, where durhaminids occur, is shown in a tabular form as the following. (Text-fig. 3).

	Fusulinid zones	CARNIC-ALPS	U. S. S. R. (VOLGA-URAL REGION)		S. CHINA	JAPAN (KITAKAMI MTS.)		U. S. A. (TEXAS)	
PERMIAN		Bellerophon schichten				Toyoma series		Ochoan	
	Zone of Yabeina		Tatarian		Maokou Limestone	Kanokura series	Iwaisaki stage		
			Kazanian						
	Zone of Neoschwagerina	Grödener Schichten	Ufimian					Guadalupian	Capitan
			Kungurian						
	Zone of Parafusulina		Artinskian				Kattisawa stage		Wordian
	Zone of Pseudofusulina	Trogkofel Kalk	"Sakmarian"	Sakmarian s.str.	Chihsia Limestone	Sakamotosawa series	Kabayama stage	Leonardian	
	Zone of Pseudoschwagerina	Rattendorfer Schichten		Asselian	Maping Limestone		Kawaguchi stage	Wolfcampian	

Text-fig. 3
Correlation of world Permian

CLASSIFICATION OF DURHAMINIDAE

Phylum Coelenterata
Class Anthozoa EHRENBERG, 1834
Subclass Zoantharia DEBLAINVILLE, 1830
Order Rugosa MILNE-EDWARDS & HAIME, 1850

Family Durhaminidae nov.

Solitary, fasciculate or massive, cerioid to plocoidal corals with relatively small sized corallites. Axial structure is generally composed of a few irregularly disposed lamellae and axial tabellae except for a single species, "*Palaeosmilia*" *demaneti*, which has diphyphylloid axial structure. In most species of Durhaminidae axial structure may be either loosely or densely constructed. In the early stage of ontogeny, the axial structure is constructed by irregularly curved, vertically sinuous median plate which may locally unite with either only counter septum or both counter and cardinal septa. The median plate or axial structure may be sometimes interrupted to grow upwards in certain ontogenetic stage. In the full grown stage, the axial structure becomes mostly free from septa, and medial area of corallite in the cross section seems to be fairly spaced. Tabulae of this group of coral are mainly small and cystose, although wide tabellae are not seldom developed. In the outermost area of tabularium, clinotabellae are found in most species, although these tabellae are by no means abundant. The boundary between the area occupied by the axial tabellae and outer tabularium is generally not distinct in longitudinal section. Namely, a zone occupied by the axial tabellae cannot be always viewed to be uniform in width. In addition, axial tabellae themselves do not regularly developed throughout the ontogeny. Dissepiments are generally concentric or angular concentric in arrangement in rather primitive forms or the earlier stage of the advanced forms, but they tend to be herringbone or pseudo-herringbone pattern in arrangement in the mature stage. The innermost dissepiments in the dissepimentarium generally tend to take longitudinal arrangement instead of imbricated ones in longitudinal section, and become to face their maximum convexity inwards, instead of upwards. Namely, at least certain dissepiments arranged in the innermost area of dissepimentarium seem to merge into elongate dissepiments. Besides them, lonsdaleoid dissepiments may also develop in various degrees. Septa are of two orders. They are thcik in tabularium in general, and thin in dissepimentarium.

Included genera:

Soliary form	*Amandophyllum*
Fasciculate forms.....	*Durhamina* *Heritschioides* *Tanbaella* gen. nov. *Yabeiphyllum* gen. nov.
Masive forms	*Kleopatrina* (*Kleopatrina*) *Kleopatrina* (*Porfirievella*), subgenus nov. *Protolonsdaleiastraea*

Geological range: Middle Carboniferous to the Middle Permian. Geographical distribution: Urals, Carnic Alps, Japan, Canada, Alaska,* Nevada, Texas, Oregon, California and Peru.

Remarks: The systematic position of the present family can be viewed to occupy between Lithostrotionidae and Waagenophyllidae. The corals of this family may be distinct from Lithostrotionidae in having different types of tabulae in tabularium. Namely in Lithostrotionidae complete or subcomplete tabulae are more abundant than incomplete or cystose ones, while in the present family, tabellae are generally small and cystose, although complete or wide tabulae are also existed. Further, the family Durhaminidae seems to be more progressive in construction of axial structure than Lithostrotionidae, because in the latter, axial structure can be viewed to be a mere vertial prolongation of axial end of a major septum in the fundamental structure, which is sometimes uniting with counter and cardinal septa even in the mature stage, or quite free from any septa. Still in other case, the axial structure tends to be diphyphylloid in Lithostrotionidae. On the other hand, the corals of the present family possess axial structure composed of axial tabellae and septal lamellae with or without distinct median plate in the full grown stage, although it is only represented by palicolumella, like that in *Lithostrotion* in the early stage. Moreover, in the still earlier stage, all the corals belonging to the present family are diphyphylloid in axial structure. In addition, the family Durhaminidae is characterized by the presence of dissepiments arranged in pseudo-herring bone or herring bone pattern, especially in the mature stage of advanced forms, while in Lithostrotionidae dissepiments are mostly concentric in arrangement. Thus, the present family seems to include a little advanced forms than Lithostrotionidae.

In the meantime, the present family can be distinguished from Waagenophyllidae in having different tabellae (tabulae) and dissepiments. First of all, the present family entirely lacks in clinotabulae, besides large elongate dissepiments, while reverse is the condition in Waagenophyllidae.

In Durhaminidae minor elongate dissepiments are more or less developed, besides clinotabellae, but clinotabulae are wholly lacking as above stated. The

* According to the information given by Dr. C. L. Rowett of the University of Alaska.

dissepiments of the Waagenophyllidae are generally concentric in arrangement, against pseudo-herringbone or herringbone pattern in most species of the present family. The absence of tertiary or more high order of septa in Durhaminidae may be also an another important criterion to distinguish the present family from Waagenophyllidae.

In short, the present family can be concluded to be slightly advanced than Lithostrotionidae but a little primitive than Waagenophyllidae, viewed from the construction of axial structure, order of septa, development of elongate dissepiments and clinotabulae including clinotabellae. Although dissepiments themselves seem to be more or less advanced in forms of Durhaminidae than in corals of both Waagenophyllidae and Lithostrotionidae.

I. Solitary forms

Genus ***Amandophllum*** HERITSCH, 1941

Type species: *Clisiophyllum carnicum* HERITSCH, 1936.

Amandophyllum HERITSCH, 1941, p. 131
Amandophyllum, HILL, 1956, p. 290
Amandophyllum, SCHOUPPÉ, 1961, p. 361

Generic diagnosis: Solitary Durhaminidae.

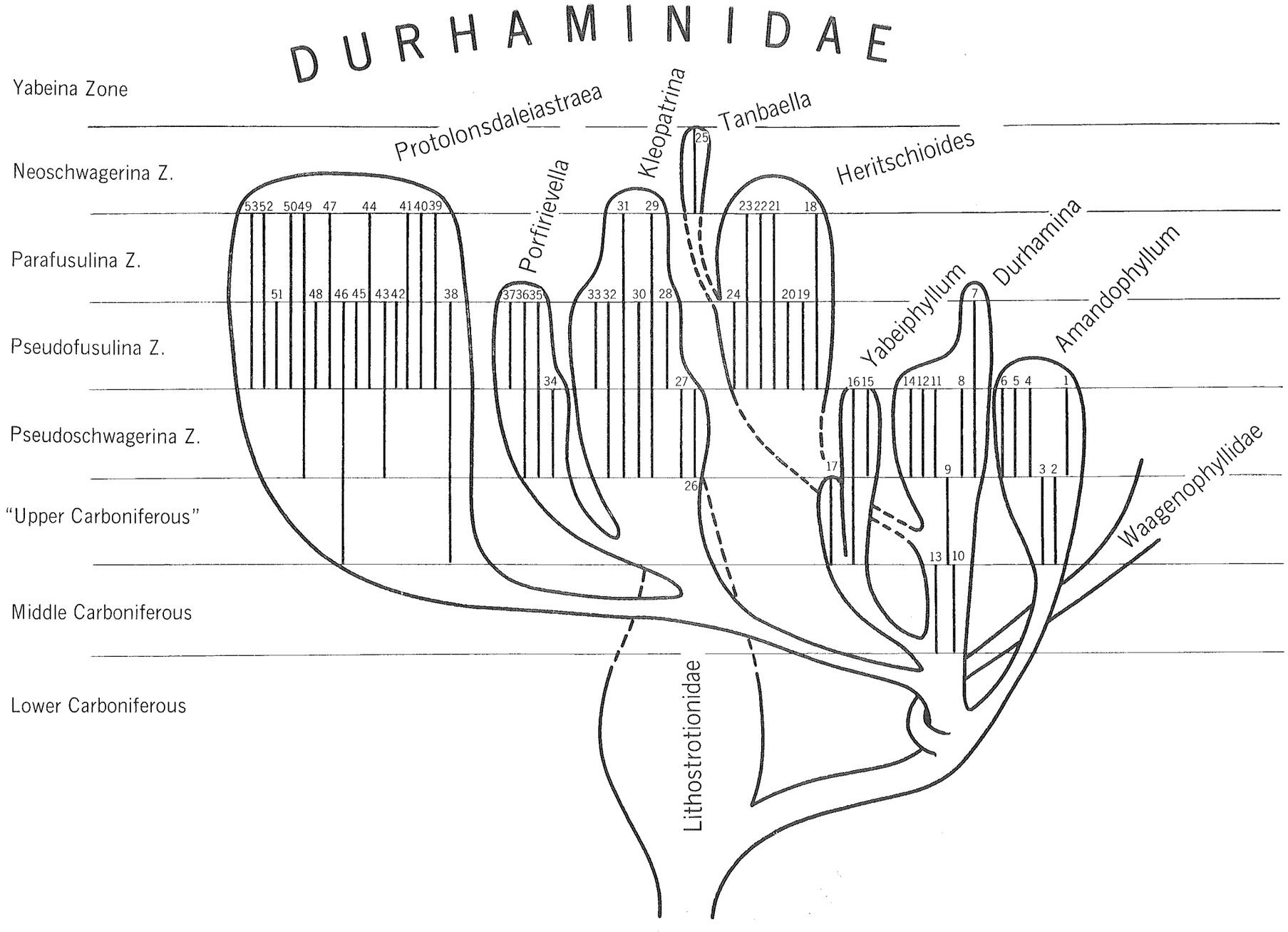
Geological range: Upper Carboniferous (*Triticites* zone) to the Lower Permian (*Pseudoschwagerina* zone).

Geographical distribution: Carnic Alps, Japan and Texas.

The following species will be included in the present genus.

Amandophyllum zeliae (HERITSCH)
Amandophyllum carnicum (HERITSCH)
Amandophyllum schucherti (HERITSCH)
Amandophyllum heritschi, nom. nov.
Amandophyllum sp. a.
Amandophyllum sp. b.

Description of the genus *Amandophyllum:* Corallum solitary, and corallites cylindrical or conico-cylindrical. Outer wall thin. Axial structure is not typical clisiophyllid but waagenophyllid, in which median plate is nearly always indistinct. Septa are of two orders, generally thick in tabularium, and thin in dissepimentarium. Tabellae in tabularium are cystose in general, slightly or steeply inclined from the axis of corallite towards both downward and outward. Dissepiments are herring-



Text-figure 4
Phylogeny of Durhaminidae

1. *Amandophllum zeliae* (Heritsch)
2. *A.* *carnicum* (Heritsch)
3. *A.* *heritschi* sp. nov.
4. *A.* *schucherti* (Heritsch)
5. *A.* sp. a
6. *A.* sp. b
7. *Durhamina cordillerensis* (Easton)
8. *D.* *hasimotoi* (Nagao et Minato)
9. *D.* *uddeni* (Ross et Ross)
10. *D.* *stuckenbergi* (Dobrolyubova)
11. *D.* *kitakamiensis*, sp. nov.
12. *D.* *hessensis* (Ross et Ross)
13. *D.* ? sp.
14. *D.* *ampfereri* (Heritsch)
15. *Yabeiphyllum hayasakai*, sp. nov.
16. *Y.* *rossi*. sp. nov.
17. "*Palaeosmilia*" *demaneti* Heritsch
18. *Heritschioides columbicum* (Smith)
19. *H.* *woodi* Wilson et Langenheim
20. *H.* *hillae* Wilson et Langenheim
21. *H.* *washburni* (Merriam)
22. *H.* *ochocoensis* (Merriam)
23. *H.* *densicolumella* (Dobrolyubova)
24. *H.* *ojiensis* Sakaguchi et Yamagiwa
25. *Tanbaella izuruhensis* (Sakaguchi et Yamagiwa)
26. *Kleopatrina* (*K.*) *ftatateeta* (M'Cutcheon et Wilson)
27. *K.* (*K.*) *wilsoni*, sp. nov.
28. *K.* (*K.*) *uralensis* (M'Cutcheon et Wilson)
29. *K.* (*K.*) *pseudoelegans* (Dobrolyubova)
30. *K.* (*K.*) *pseudoelegans prismatica* (Porfiriev)
31. *K.* (*K.*) *magnifica* (Porfiriev)
32. *K.* (*K.*) *gracilis* (Dobrolyubova)
33. *K.* (*K.*) *intermedia* (Porfiriev)
34. *Kleopatrina* (*Porfirievella*) *grandis* (Dobrolyubova)
35. *K.* (*P.*) *stylidophylloides* (Dobrolyubova)
36. *K.* (*P.*) *stylidophylloides radiata* (Porfiriev)
37. *K.* (*P.*) *illipahensis* (Easton)
38. *Protolonsdaleiastraea biseptata* (Dobrolyubova)
39. *P.* *wischeriana* (Stuckenberg)
40. *P.* *atbassarica* Gorsky
41. *P.* *gorskyi* (Dobrolyubova)
42. *P.* *complexa* (Dobrolyubova)
43. *P.* *delicata* (Dobrolyubova)
44. *P.* *cargalensis* (Dobrolyubova)
45. *P.* *pennata* (Porfiriev)
46. *P.* *monoseptata* (Dobrolyubova)
47. *P.* *columellaris* (Dobrolyubova)
48. *P.* *juresanensis* (Dobrolyubova)
49. *P.* *gerthi* (Dobrolyubova)
50. *P.* *longiseptata* (Dobrolyubova)
51. *P.* *pseudowischeriana* (Porfiriev)
52. *P.* *densireticulata* (Dobrolyubova)
53. *P.* *dobrolyubovae*, nom. nov.

bone or pseudo-herringbone in arrangement. Lonsdaleoid dissepiments may develop in various degrees.

Remarks: In classification of Rugose corals, difference in growth habits has been generally regarded by palaeontologists to be not taxonomically important, if there was not any fundamental difference in internal construction between corallites. Namely, solitary, fasciculate or massive forms have been viewed in general to be congeneric, so far as the internal construction of corallites is fundamentally the same. The difference in growth forms was however proved to be quite important factor in classification of Waagenophyllidae in the recent study by the present authors (1965). *Pavastehphyllum*, *Waagenophyllum* (s.str.) and *Ipciphyllum* for instance must be generically distinguished, because species belonging to each genus above mentioned do not always show the same geological and geographical distributions, although they have a strong resemblance in their fundamental morphology in corallites.

In the similar way of thinking, *Amandophyllum* can be accordingly viewed to have its own generic position in Durhaminidae, because of its having solitary form.

Actually, there is no distinct difference in the structure of corallite between the genus *Amandophyllum* and *Durhamina*, but the latter is fasciculate in growth form.

In the meantime, *Amandophyllum* has been viewed in general to have more intimate relation to *Dibunophylloides* or *Corwenia* than to *Durhamina*. In the present authors' opinion, the genus *Dibunophylloides* is however, entirely synonymous with *Corwenia*, which is definitely fasciculate in form.

If, the difference of growth habits between *Amandophyllum* and *Corwenia* is placed out of consideration for a while, these two genera would be nearly resembled with each other. The axial structure of *Corwenia* is quite characteristic, in which septal lamellae are firmly united with the prolongation of axial ends of major septa. Further, cardinal and counter septa are also directly united with median plate. Accordingly, the axial structure in *Corwenia* is quite regularly constructed by radially arranged septal lamellae and a few concentrically arranged axial tabellae.

In the full grown stage, axial structure becomes sometimes to be partly or entirely free from major septa, but it is firmly united with major septa in most other stages of life history, which may be especially worth while mentioned in *Corwenia*.

In the genus *Amandophyllum*, similar construction of axial structure can be perceived to some extent, especially in the early stage. (1) However, in *Amandophyllum* the arrangement of septal lamellae is not always so regular as in *Corwenia*, because certain major lamellae retreat from axial structure even in the earlier stage; and (2) distinct median plate is nearly always not discerniable. (3) If, the median plate is not lacking in *Amandophyllum*, it is always either sinuous and curved in cross section, or it does not bisect the axial structure into the same two areas. (4) Further, in *Corwenia*, clinotabellae are not wholly lacking but eventually very

sparse, while in *Amandophyllum*, such tabellae are always present. (5) In addition, lonsdaleoid dissepiments may be not originally developed in *Corwenia*. Even in *Amandophyllum* such dissepiments are few, but *Amandophyllum* can be eventually viewed to be somewhat progressive in this regard than *Corwenia*.

Therefore, certain distinctions still exist between *Amandophyllum* and *Corwenia* in morphology of corallites, besides the difference in growth habits.

So far as the present authors' knowledge is concerned, only four species and two unnamed forms can be counted as members of the present genus, which are listed in the foregoing page. Besides so-called " *Dibunophyllum* " *yüi* described by CHI from the Middle Carboniferous of China must be also brought into consideration as a member of *Amandophyllum*. However, this species shows somewhat intermediate nature between Waagenophyllidae and Durhaminidae in certain points of morphology, which will be later stated more in detail.

It would be anyhow best placed in Waagenophyllidae. Therefore, the present species will be excluded from the discussion of the genus *Amandophyllum*.

HERITSCH once placed two Russian corals in the present genus. They are *Cyathoclisia myatshkovensis* DOBROLYUBOVA and *Cyathoclisia symmetrica* DOBROLYUBOVA. These two forms were later classified by FOMITCHEV as members of the genus *Dibunophylloides*. They are definitely fasciculate in form and they must be assigned into *Corwenia*. (DEGROOT, 1963) See also remarks on genus *Heritschioides*.

Amandophyllum zeliae (HERITSCH)

1936 *Clisiophyllum zeliae* HERITSCH, p. 124, pl. 14, fig. 18, text-fig. 27 in text-fig. pl. 3.
1937 *Dibunophyllum clari* FELSER, p. 11, pl. 1, figs. 6a, b and 7a, b.

Holotype: Sample 428–1929, Graz University.
Type locality: Between Garnitzen and Krone; Carnic Alps.
Geological horizon: Lower Permian, *Pseudoschwagerina* zone.
Geographical distribution: Between Garnitzen and Krone; Schulter Kofel; Tressdorf highland; all in Carnic Alps.
Remarks: The present species has relatively narrow dissepimentarium and very thick septa in tabularium.

Amandophyllum carnicum (HERITSCH)

1936 *Clisiophyllum carnicum* HERITSCH, p. 122, pl. 17, figs. 24–28, text-figs. 25, 26 in text fig. pl. 3.
1941 *Amandophyllum carnicum*, HERITSCH, p. 136, text-figs. 1–4.
1961 *Amandophyllum carnicum*, SCHOUPPÉ, p. 361, text-fig. 3.

Holotype: Sample 9.398 Graz University,

Locality: North of Garnitzen, Carnic Alps.
Geological horizon: Upper Carboniferous.

Remarks: The present species possesses relatively narrow peripheral area like the preceding species. However, the septa of the present species are relatively thinner in tabularium and slightly more numerous than that of the preceding species.

Amandophyllum heritschi nom. nov.

1936 *Dibunophyllum carnicum* HERISCH, p. 126, pl. 17, figs. 2, 3, Text-figs. 23 in text-fig. pl. 3 : non *Amandophyllum carnicum* (HERITSCH)

Holotype: 1566, Graz University.
Locality: Watschiger Alp and Noelpling graben in Carnic Alps.
Geological horizon: Upper Carboniferous.

Remarks: The specific name *carnicum* is already occupied by the type species of the present genus. Therefore, the new name *heritschi* is here proposed for the present species. The specific name is dedicated to late Prof. F. HERITSCH in honor of his extensive studies on Rugose corals in Carnic Alps. In the present species, axial structure is somewhat densely constructed and lonsdaleoid dissepiments are well developed.

Amandophyllum schucherti (HERTISCH)

1936 *Palaeosmilia schucherti* HERITSCH, p. 137, pl. 1, figs. 1–7; pl. 2, fig. 10–15.

Holotype: Specimen G., HERITSCH Coll. University of Graz.
Locality: Creek limestone, Southeastern Coleman county, Texas.
Geological horizon: Lower Permian, *Pseudoschwagerina* zone.

Remarks: The present species is quite characteristic in having very short minor septa. They are locally entirely wanting in a certain part of corallite.

Amandophyllum sp. a

1936 *Corwenia* sp. HERITSCH, p. 128, text-fig. 32 in text-fig. pl. 3.
1955 *Huangia?* sp. MINATO, p. 125, pl. 22, fig. 9, text-fig. 10.

Geological horizon: *Pseudoschwagerina* zone, Lower Permian.
Geographical distributions: Carnic Alps and Japan.

Remarks: The synonymity between the two forms above listed is almost beyond doubt. They are strongly resembled with each other in construction of axial

structure, septa and dissepiments, besides septal number and size of corallite. The senior author (M.M) once considered the present form to be fasciculate with doubt, but there is no positive reason to believe it. Similarly, the coral described by HERITSCH as *Corwenia* species seems to be actually a solitary form.

Amandophyllum sp. b

1936 *Palaeosmilia* sp. HERITSCH, p. 154, text-fig. 50 in text-fig. pl. 6

Geological horizon: *Pseudoschwagerina* zone.
Locality: Rattendorf Sattel in Carnic Alps.

Remarks: The present form may be specifically distinct from the preceding species in different nature of axial structure.

II. Fasciculate forms

Genus ***Durhamina*** WILSON et LANGENHEIM, 1962

Type species: *Lonsdaleia cordillerensis* EASTON, 1960

A group of *Palaeosmilia*, HERITSCH, 1936, p. 137
Durhamina WILSON & LANGENHEIM, 1962, p. 405

Generic diagnosis: Fasciculate Durhaminidae with more or less well developed lonsdaleoid dissepiments and weakly constructed axial structure.
Included species will be tabulated as below:

I. Tabellae in tabularium are not highly cystose in general.
  With relatively small corallites and less numerous septa.
    With relatively complicated axial structure. ..... *cordillerensis*
    With very simple axial structure and dilated inner wall. ..... *hessensis*
  With relatively large corallites and numerous septa.
    Lonsdaleoid dissepiments well developed ..... *hasimotoi*
II. Tabellae in tabularium are highly cystose.
  With short minor septa ..... *uddeni*
  With long minor septa
    Elongate dissepiments and clinotabellae developed ..... *kitakamiensis*
    Elongate dissepiments and clinotabellae ill developed ..... *ampfereri*
  With very simple axial structure ..... *stuckenbergi*

Geographical distribution: Nevada, Texas, Alaska*, Japan and Peru.
Geological range: Middle Carboniferous to the Lower Permian (*Pseudoschwagerina* to *Pseudofusulina* zones).

Remarks: The present genus seems to be nearly akin to *Heritschioides* in general construction of corallites, but the former can be distinguished from the latter in having more loosely constructed axial structure than that of *Heritschioides*. Namely, the axial structure in *Durhamina* is merely represented by median plate in the early ontogenetical stage, which is irregularly curved or locally discontinuous by frequent interruption in growth. Even in the mature stage, the axial structure is composed of irregularly and loosely disposed very few lamellae and tabellae, which may be not typical axial column like that of *Heritschioides*. In the course of ontogeny, the septal lamellae are sometimes directly uniting with some major septa.

Further, in the present genus, lonsdaleoid dissepiments are slightly well developed than in *Heritschioides*. In addition, clinotabellae are also a little more frequently found in the present genus than in *Heritschioides*.

According to HERITSCH (1936), he established in 1933 " *Palaeosmilia* " *hammeri* from " Trogkofelkalk " of the Carnic Alps. The species is said to have close relationship to " *Palaeosmilia ampfereri*, which is here regarded as a *Durhamina*. Therefore " *Palaeosmilia* " *hammeri* may also be included in *Durhamina*, though we retain the decision in this regard until we see the original publication on that species.

Durhamina cordillerensis (EASTON)

1960 *Lonsdaleia cordillerensis* EASTON, p. 580, text-figs. 17, 18.
1960 *Tschussovskenia* sp., LANGENHEIM et al, p. 154.
1962 *Durhamina cordillerensis*, WILSON and LANGENHEIM, p. 506, pl. 86, figs. 5–7.

Holotype: 5127, Univ. Southern California.
Horizon and locality: Wolfcampian to Leonardian. Eastern Nevada and Providence mountains in San Bernardino county, California.

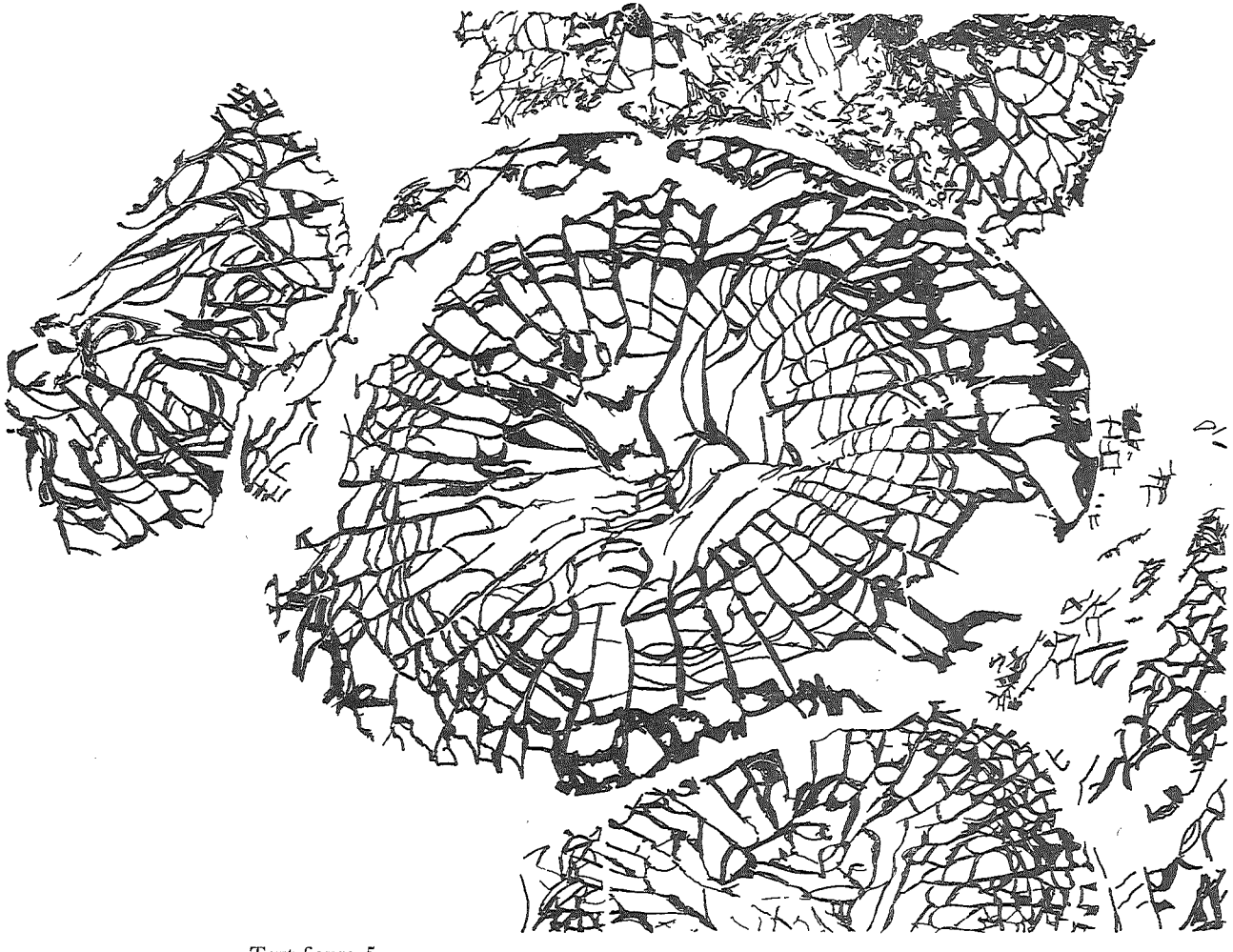
Durhamina hasimotoi (NAGAO et MINATO)

Plate 2, figs. 1–3; Text-figures 5, 6.

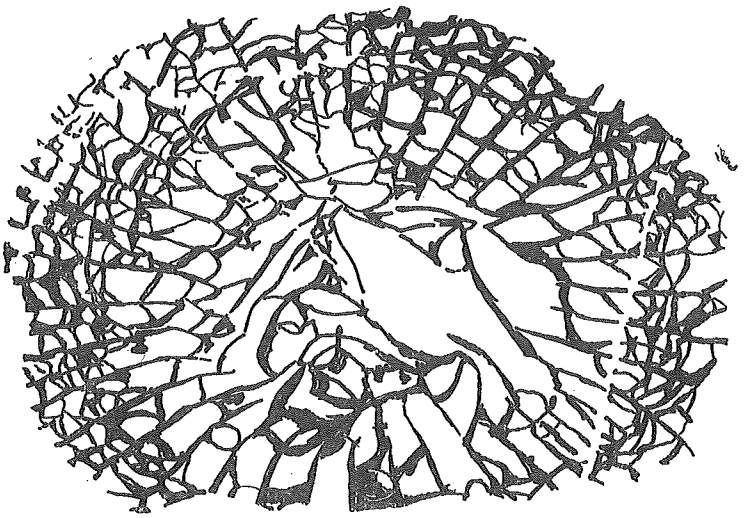
1941 *Corwenia hasimotoi* NAGAO & MINATO, p. 102, pl. 27, figs. 1–6.
1950 *Huangia hasimotoi*, YABE, p. 78
1955 *Huangia hasimotoi*, MINATO, p. 123, pl. 22, figs. 3, 4 6: non pl. 2, figs. 1–3.
1965 *Durhamina hasimotoi*, MINATO & KATO, p. 72

Holotype: UHR 15237–15241

* After Dr. C. L. ROWETT, personal communication.



Text-figure 5
Durhamina hasimotoi (NAGAO et MINATO) (X 5.4)
Tosayama, Kochi Prefecture, Japan. *Pseudoschwagerina* zone. UHR 15241



Text-figure 6
Durhamina hasimotoi (NAGAO et MINATO) (X 6.5)
Tosayama, Kochi Prefecture, Japan. *Pseudoschwagerina* zone. UHR 15241

Type locality: Limestone quarry near Tosayama, about 14 km north of Kochi city, Kochi Pref., Japan.
Horizon: *Pseudoschwagerina* zone.

Remarks: This species is characterized in having very simple axial structure, lonsdaleoid dissepiments and subcomplete tabellae which are not highly arched at the centre of corallite.

Specimen from the Kitakami mountains was once assigned into the present species, but is now separated as a new species. See remarks on *Durhamina kitakamiensis*.

Also a thin section of a coral from southwest of Itokawa, Ishigaki village, Arita-gun, Wakayama Prefecture, Japan was once identified as *Huangia hasimotoi* by MINATO (1955). A reexamination of the section reveals the following characteristics of the specimen.

Corallum simple, large, with large rhodophylloid axial structure, in which median plate is indistinct. Septa are fibro-normal and of two orders. Minor septa rudimentary. Intrathecal dilation strong. Dissepimentarium is comparatively wide, and consists of herringbone dissepiments. Sporadical lonsdaleoid dissepiments are seen in the middle of dissepimentarium. Cardinal fossula present.

This specimen may be rather comparable to *Amandophyllum schucherti*. But the coral now in problem is said to have associated with *Parafusulina japonica*, *Schwagerina* sp. and *Neoschwagerina craticulifera* in a limestone lense at the locality

above quoted. Therefore the age of this small limestone mass must be Upper Permian, judged from these fusulinid remains. However, the coral shows affinity with Lower Permian coral. We wonder therefore that the coral might belong to a reworked fossil migrated to that limestone, or otherwise this coral may be the late representative of the family Durhaminidae.

Durhamina uddeni (ROSS et ROSS)

1963 *Dibunophyllum uddeni* ROSS and ROSS, p. 415, pl. 49, figs. 5–9.

Holotype: United States National Museum 139786
Type locality: Loc. 702 n, saddle just west of hill 4952, east end of Wolfcamp hills, Texas, USA.
Geological horizon: Gaptunk formation, Wolfcampian (=*Pseudoschwagerina* zone)

Durhamina kitakamiensis, sp. nov.

Plate 5; Text-figs. 7, 8.

1955 *Huangia hasimotoi*, MINATO, (par.), pl. 2, figs. 1–3: non pl. 22, figs. 3, 4 & 6.
1965 *Durhamina kitakamiensis* MINATO & KATO, nom. nud., p. 18.

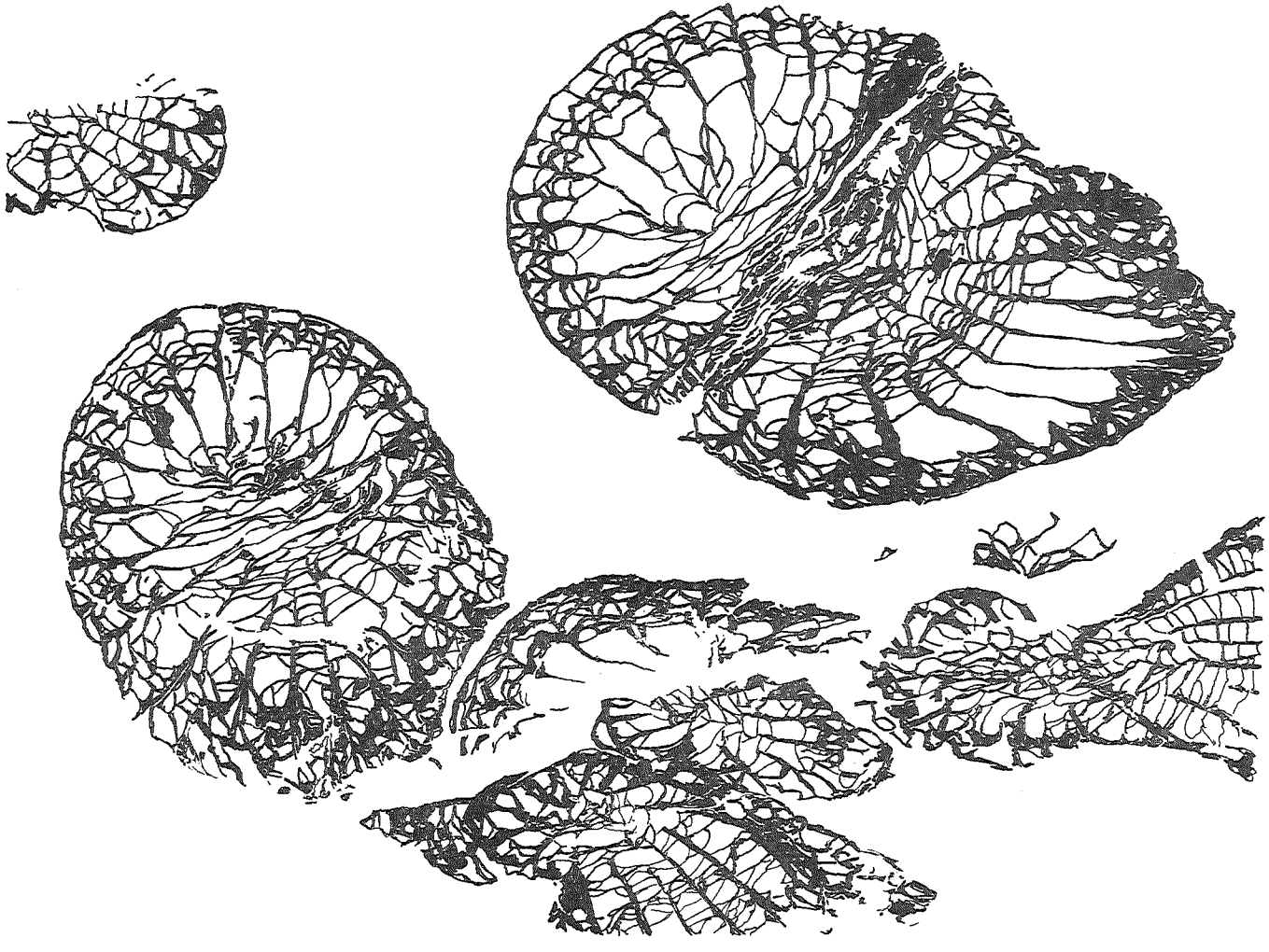
Holotype: UHR 17654–8
Type locality: Sakamotosawa, Hikoroichi-machi, Ofunato city, Iwate Prefecture, Japan.
Geological horizon: Lower Sakamotosawa series=*Pseudoschwagerina* zone.

Specific diagnosis: *Durhamina* with well developed peripheral-, periaxial- and clinotabellae.

Description: The coral is firmly embedded in light gray, massive, somewhat tuffaceous limestone. Skeletons remarkably show reddish tint, and is associated with crinoid stem joints and echinoid spines.

Corallum compound, fasciculate and dendritic. Corallite subcylindrical, slightly curved, and gently tapering downwards. Corallites are laterally spaced with each other rather closely. Increase by peripheral, with two to three new " buds " arising upon the calyx of a " mother " corallite.

In transverse section, corallite round in outline, of which the largest one being 17 mm in its diameter. Most mature corallites measure 12 to 14 mm in diameter. Wall moderately thick. Dissepimentarium is comparatively narrow, occupies only 1.5 mm in width to a corallite of 12 mm diameter; and is provided with several rows of concentric, subangulo-concentric, herringbone as well as pseudo-herringbone dissepiments. No marked innerwall caused by intrathecal



Text-figure 7
Durhamina kitakamiensis MINATO et KATO, sp. nov. (X 6.1)
Sakamotosawa, Hikoroichi-machi, Ofunato city, Iwate Prefecture, Japan. *Pseudoschwagerina* zone. UHR 17656

Text-figure 8
Durhamina kitakamiensis MINATO et KATO, sp. nov. (X 2.7)
Sakamotosawa, Hikoroichi, Ofunato city, Iwate Prefecture, Japan, *Pseudoschwagerina* zone.
UHR 17658

dilation present, though the boundary between the dissepimentarium and tabularium is rather clearly observable. Lonsdaleoid dissepiments are only rarely observed, when a corallite reaches full grown stage.

Septa are in two orders, of which fine structure may be fibro-normal, though not clear owing to secondary obliteration of the structure. Major septa probably reach up to the number of 30 in a full grown corallite, and are numbered as 22 in a corallite of 10 mm in diameter. Middle portion of a major septum is a little thickened, and is tapering towards both peripheral and axial ends. A number of major septa are often extended to the axial part of the corallite, where they meet and form an axial structure together with cut edges of axial tabellae. Minor septa alternate with the major, comparatively long in some corallites, but may be rather short to be confined within dissepimentarium near the periphery in the others. Axial structure may be very simple, consists of a thin plate with several tabellae, but may be rather densely constructed by a number of axial tabellae and septal lamellae which are the axial prolongation of major septa. Fossula indistinct.

In longitudinal section corallite wall is rather smooth. Dissepimentarium is narrow, where small globose dissepiments are regularly disposed in parts, while they are sometimes irregular in the other parts. Elongate dissepiments present. Tabularium wide, cylindrical, and consists of axial and peripheral portions of piled, numerous tabellae. In axial portion gently domed axial tabellae and edges of septal lamellae and axial ends of major septa are making axial complex. Yet no definite axial column is formed. Then outwardly periaxial tabellae are disposed, in slightly more inclined manner towards periphery than the axial ones. Wide tabellae are scarce. But both peripheral- and clinotabellae are well developed, which make sagged peripheral portion in outer tabularium.

In ontogeny appeared in hysterocorallites, tabulae are complete and subhorizontal at first, when no axial structure and dissepiments discernible in longitudinal section. A hysterocorallite seems to arise from peripheral part of tabularium of a mother corallite in probably parricidal way. Rapidly dissepiments appear in one row in the periphery of corallites, and very simple lath like axial structure follows. These young corallites look quite similar to mature corallites of *Yatsengia*. This fact will be important in consideration of the systematic position of both *Durhamina* and *Yatsengia*.

Remarks: The present form was once included in "*Huangia*" *hasimotoi*, though is actually distinguishable from the latter in having almost no remarkable lonsdaleoid dissepiments, highly vesiculate tabularium with peripheral- as well as clinotabellae, and elongate dissepiments. The same characteristics serve as distinguishing points of the present new species from "*Palaeosmilia*" *ampfereri* of the Carnic Alps, to the latter of which the present form is most closely resembled.

We consider it is remarkable that all the species of *Durhamina* above cited indicate the same geological horizon, *Pseudoschwagerina* zone of Lower Permian.

The present species is also resembled " *Palaeosmilia schucherti* " described by HERITSCH from the Permian in Texas, as D. HILL (1957) once pointed out. However the Texas species is definitely a solitary form and cannot be viewed to be congeneric with the Japanese species now in concern. Further, the minor septa are quite rudimentary or almost lacking in the Texas form, while they are fairly well developed in the Japanese species. In spite of it, nature of the longitudinal section is quite same between these two forms; because axial and periaxial thabellae are dense, and cystose; the latter of them rather steeply inclined outwards and downwards; besides, the peripheral tabellae are also numerous and cystose, which are more or less flat, or sagging. While, clinotabellae are also considerably well developed in both forms. Therefore, the peripheral area of tabularium seem to form a somewhat distinct structure of saucer shape, in Japanese *Durhamina* and Texas *Amandophyllum*.

Durhamina ? sp.

1914 *Lonsdaleia floriformis*, MEYER, p. 629, pl. 14, fig. 4 (non MARTIN)

Locality: Tarma, 165 km northeast of Lima, Peru.
Geological horizon: Judged from the association of *Chaetetes* and " *Schellwienia* " *peruana*, which is definitely a *Fusulinella*, a horizon yielding the present coral may be considered as denoting Middle Carboniferous.

Remarks: MEYER described that the present form is fasciculate in form. Therefore the present species cannot be placed in the genus *Amandophyllum*, although the general feature of corallite in cross section figured by MEYER strongly reminds species of *Amandophyllum*. In the present form lonsdaleoid dissepiments are almost obsolete and it may be eventually not assignable into *Lonsdaleia*. The species may be a member of *Durhamina* from the axial structure and the mode of dissepiments and septa, though the coral itself shows similarity to Middle Carboniferous *Corwenia* on the other hand.

Durhamina stuckenbergi (DOBROLYUBOVA)

1936 *Fischerina stuckenbergi* DOBROLYUBOVA, p. 136, text-figs. 70, 71 (67–69 ?) Syntype

Localities and horizon: Podcherem river and Sthugor river, in North Urals. Middle Carboniferous.

Durhamina ampfereri (HERITSCH)

1936 *Palaeosmilia ampfereri* HERITSCH, p. 152, pl. 14, figs. 11–17, text-figs. 48

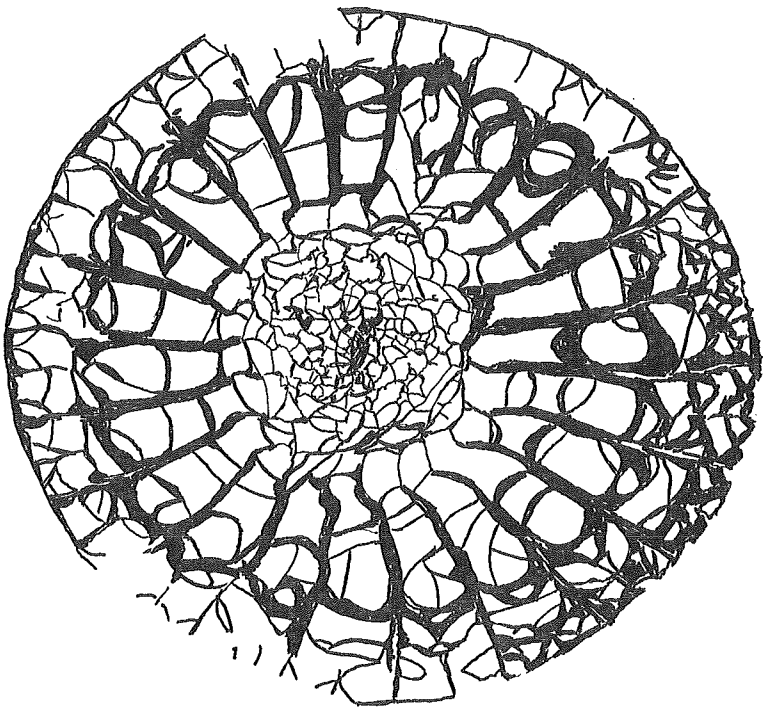
1936 *Palaeosmilia ampfereri*, HERITSCH, p. 135, pl. 2, figs. 16, 17.

Holotype: Sample 1348, HERITSCH coll., Graz University
Type locality: Rattendorf Alps in the Carnic Alps.
Geological horizon: " Schwagerinenkalk " *Pseudoschwagerina* zone.
Distribution: Rattendorfer Alps, Schulterkofel, Rattendorfer Alm, Teufellsschlucht, all in Carnic Alps.

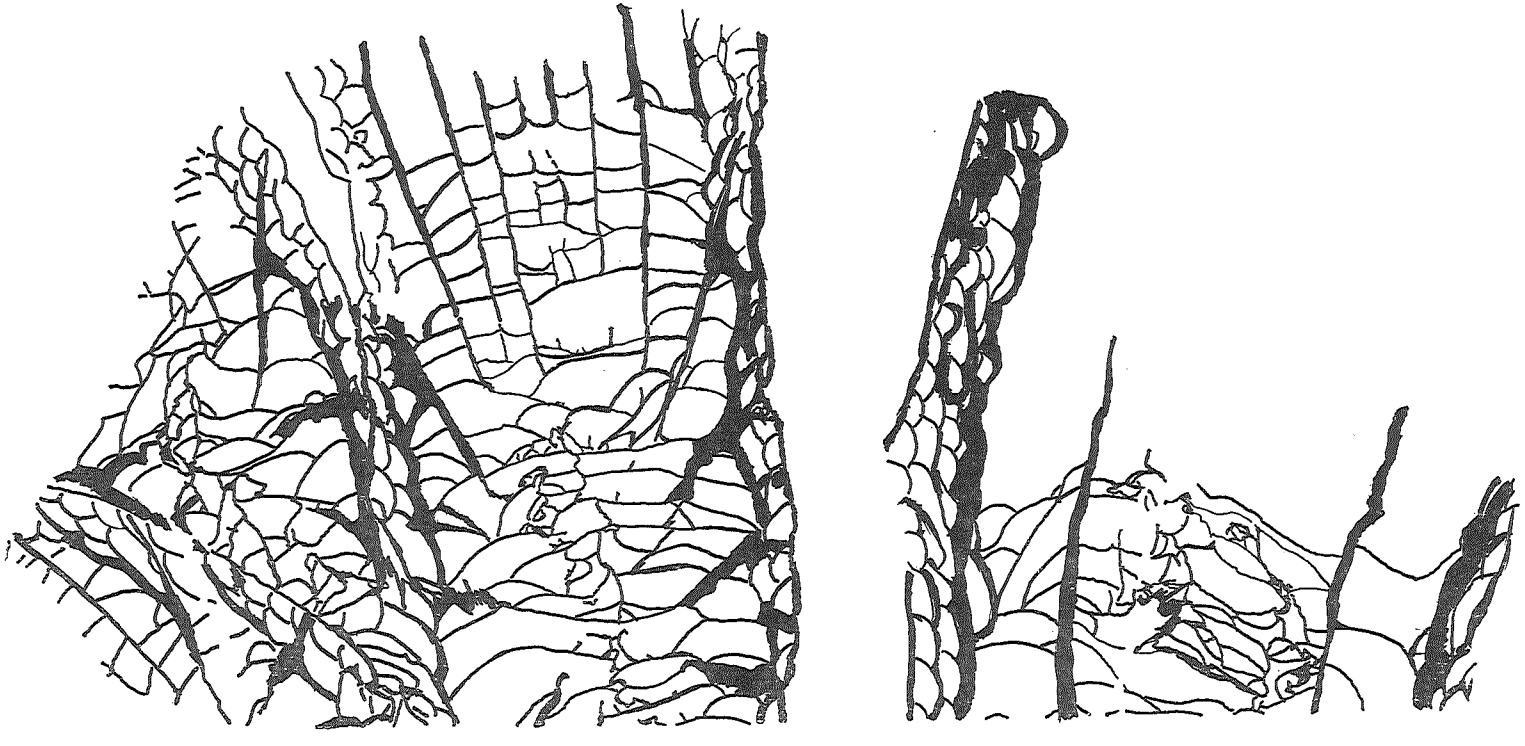
Durhamina hessensis (ROSS et ROSS)

Plate 1; Text figs. 9, 10.

1962 *Dibunophyllum hessensis* ROSS & ROSS, p. 1175, pl. 162, fig. 12; pl. 163, figs. 1–3, text-fig. 4-L.



Text-figure 9
Durhamina hessensis (ROSS et ROSS)
(X 6.6) East face of Leonard mountain, Texas, USA. Lenox hills formation, Wolfcampian. USMN 139731 (Holotype)



Text-figuer 10
Durhamina hessensis (ROSS et ROSS)
(X 7.2) East face of Leonard mountain, Texas, USA. Lenox hills formation, Wolfcampain. USNM 139731 (Holotype)

Holotype: United States National Museum 139731
Type locality East face of Leonard Mountain, Texas, USA.
Geological horizon: Lenox hills formation, Wolfcampian.

Genus ***Yabeiphyllum*** nov.

Type species *Yabeiphyllum hayasakai* MINATO et KATO, nov.

Diagnosis: Fasciculate Durhaminidae with septa bearing distinct carinae.

Included species will be listed below.

Yabeiphyllum hayasakai MINATO et KATO, sp. nov.
Yabeiphyllum rossi MINATO et KATO, sp. nov.

Geographical distribution: Japan and Texas.
Geological range: Upper Carboniferous to Lower Permian (*Pseudoschwagerina* Zone).

Description of the genus *Yabeiphyllum:* Corallum fasciculate. Septa are of two orders. Both major and minor septa are slightly or strongly thick in tabularium, and thin in dissepimentarium. They have carinae, especially in dissepimentarium. The density in distribution of carinae in septa is however different from corallite to corallite. Further, even in a single corallite, carinae are not regularly or uniformly distributed, because they are only locally densely developed.

Axial structure is not typical clisiophyllid but somewhat waagenophyllid, into which major septa are observed to intrude in the early stage, but the axial structure is generally isolated from major septa in mature stage. Distinct median plate is not always observable in the axial structure.

Dissepiments may be mostly concentric to angulo-concentric in arrangement, but may be also arranged in pseudo-herring bone pattern. Lonsdaleoid dissepiments may also develop in various degrees. In addition, dissepiments arranged in the innermost dissepimentarium partly tend to become elongate dissepiments, although they are very small in size. Tabellae in tabularium gradually ascend towards the axis of corallite. There may develop also clinotabellae in the outer margin of tabularium.

Remarks: As a member of Durhaminidae the present genus seems to be somewhat primitive in morphology. Particularly, the dissepiments of the present genus are mostly concentric or sub-concentric in arrangement. Further, clinotabellae are very few.

Accordingly, if the present genus would not have any specialized septa bearing carinae, the present genus can be by no means easily distinguished from *Durhamina*, or *Heritschioides*.

Phylogenetically speaking *Yabeiphyllum* was apparently derived from *Durh-*

amina by the development of strong carinae on septa.

Besides the two species included in the present genus, a coral from the Carnic Alps called by HERITSCH, " *Palaeosmilia* " *demaneti* must be worthy of note, which was found from the Upper Carboniferous limestone of Waschbüchel. The coral now in consideration also possesses septa with carinae and fasciculate corallum. In these regards the present form cannot be congeneric with the type species of *Palaeosmilia*. Further, morphology in longitudinal section of corallite of this species, especially in respect to tabellae of tabularium is not much deviated from *Yabeiphyllum*. However, *Palaeosmilia demaneti* seems to completely lack axial structure, at least so far as the illustrated specimens are concerned. Accordingly, the present form would eventually be best excluded from *Yabeiphyllum*, and it may need its own generic position, other than *Palaeosmilia*.

The stratigraphical position of " *Palaeosmilia* " *demaneti* may be slightly lower than the present genus now in consideration. If the Carnic coral was older in geological range than *Yabeiphyllum*, it could be eventually more primitive form than the latter. The generic distinction between them lies in the absence or presence of axial structure.

Yabeiphyllum hayasakai, sp. nov.

Text- figs. 11, 12.

1965 *Yayeiphyllum hayasakai* MINATO & KATO, p. 28 (nom. nud.)

Holotype: UHR 18470 a,b (thin sections)
Paratype: UHR 18471 (a thin section)
Type locality: Loc. N 65, Southwest of Oniana, Akiyoshi limestone plateau, Yamaguchi prefecture, Japan.
Geological horizon: *Triticites simplex* subzone of *Pseudoschwagerina* zone.

Specific diagnosis: *Yabeiphyllum* with highly vesiculated tabellae in axial structure. Carinae are less numerous in septa.

Description: The outer form was not directly observable, but the present coral may perhaps be fasciculate in form, because, at least two corallites were found, not widely separated with each other in a very small piece of rock specimen.

The wall is fairly thick. Septa are in two orders. Major septa are counted as many as 26 or so in the corallite, the diameter of which is about 8.2 mm in length. Minor septa are only slightly few in number than the major ones. The former is generally slightly thicker than the latter.

The minor structure of both of them represents diffuso-trabecular type, in which tanslucent layer is observable in the central portion in cross section and both sides of this layer are bounded by dark lines, besides fibrous structure is developed

being perpendicular to the plane of dark lines. Fibres are sometimes very long. Consequently both major and minor septa are strongly dilated in some parts of corallite, and they are observable to be almost uniting with each other.

Septa are however, generally thin near the outer wall, where they are mostly flexuous or zigzagging in cross section, and locally tend to projections having carinae.

Axial structure occupies a fairly wide space, the diameter of which is measured about 3 mm in ortho-longitudial section (M. MINATO and KATO, 1965), while it is about 3.4 mm in para-longitudinal section in the corallite of about 8.2 mm in calicular diameter. Median plate is existed, which is however neither thick nor straight, and does not directly unite with any septa. Septal lamellae are little less

Text-figure 11
Yabeiphyllum hayasakai MINATO et KATO, sp. nov.
(X 10) Point. n. 65, southwest of Oniana, Akiyoshi dai, Shuho-cho, Mine-gun, Yamaguchi Prefecture, Japan. *Triticites simplex* subzone of *Pseudoschwagerina* zone. UHR 18470 a (Holotype)

Text-figure 12
Yabeiphyllum hayasakai MINATO et KATO, sp. nov.
(X 7.5) Northwest of Minamiyama, Akiyoshi-dai, Shuho-cho, Mine-gun, Yamaguchi Prefecture, Japan. *-Triticites simplex* subzone of *Pseudoschwagerina* zone. 18471 (Paratype)

than the number of major septa, mostly short and slightly curved in cross section, and only observable in the outer area of axial structure. Namely they do not reach the central area of axial column.

At the same time, the septal lamellae do not unite with any septa, because the outer area of the axial column is only occupied by a number of axial tabellae in

cross section.

Now, the axial tabellae are very numerous, mostly highly vesiculated, although their cut edges in cross section are irregular in size and curvature. Their convex sides always face outwards. They are locally thickened by organic deposits.

Originally they may be somewhat symmetrically disposed on both sides of median plate, but density is locally irregular.

As a whole the axial structure of the present species strongly reminds us that of " *Clisaxophyllum* " *awa* MINATO, especially in numerous, vesiculate axial tabellae, and their arrangement.

Dissepiments are concentric or subconcentric in arrangement, especially near the outer wall. Then they are sometimes irregularly cuved in the medial area of dissepiments.

Septa are in general thin near the wall as above stated, and become locally discontinous. The lonsdaleoid dissepiments may be accordingly not entirely lacking, but they are not originally well developed at any part of corallite.

There is another specimen probably assignable to the present species, collected by Dr. Y. OKIMURA of the Hiroshima University from the Atetsu limestone at a locality, about 200 m south of Iwamoto, Toyonaga-cho, Niimi city, Okayama Prefecture. According to his information the coral is associated with *Pseudofusulina kraffti magna* and other species of *Pseudofusulina* and *Schwagerina*. Therefore the age of this coral is *Pseudofusulina* zone in our sense. Geological range of *Yabeiphyllum* may be thus extended to *Pseudofusulina* zone.

Yabeiphyllum rossi, sp. nov.

Plates 3–4; Text-figs. 13–15.

1963 *Heritschioides* sp., ROSS & ROSS, pp. 417–8, pl. 50, figs. 1, 8, 10 & 12.

Holotype: USNM 139785

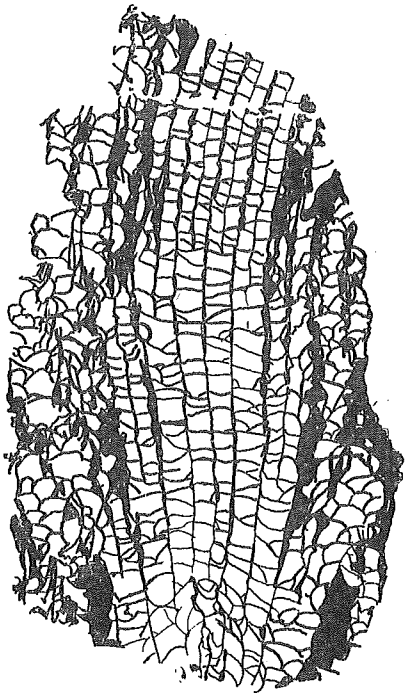
Type locality: Float, north of Wolfcamp well, west end of Wolfcamp hills, Texas, USA.

Geological horizon: Either in Gaptank formation, upper Pennsylvanian, or Neal Ranch formation, lower Permian.

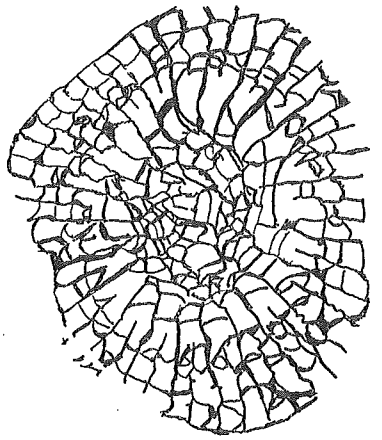
Specific diagnosis: *Yabeiphyllum* with axial column not as compact as that of the preceding species. Also intrathecal dilation of septa is less conspicuous.

Remarks: As ROSSES remarked, the present form differs from *Heritschioides columbicum*, type species of *Heritschioides*, and also from the other species of the genus in having distinct carinae on septa, the character of which is here taken as of generic importance.

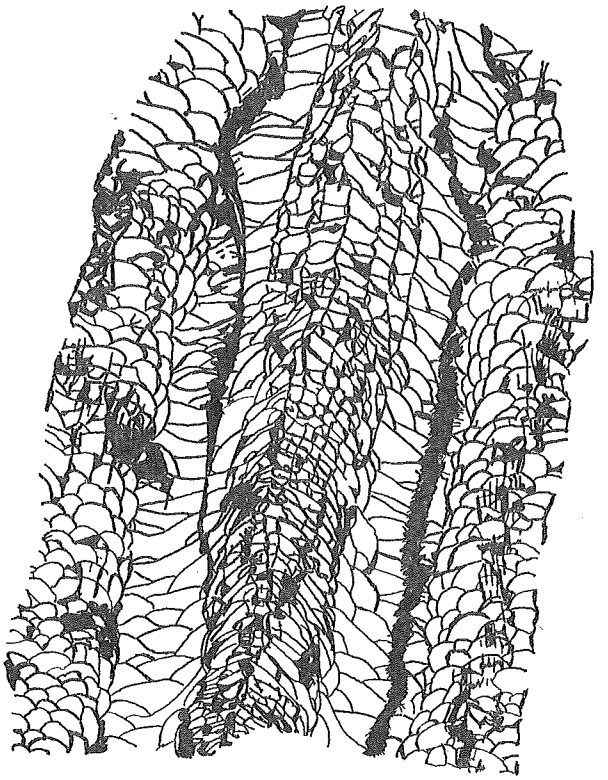
Japanese species of *Yabeiphyllum* is very close to the American one. Both



Text-figure 13
Yabeiphyllum rossi MINATO et KATO, sp. nov.
(X 6.6) The saddle north of the Wolfcamp well, west end of Wolfcamp hills, Texa, USA. Upper Pennsylvanian Gaptunk formatoin or Lower Permain Neal Ranch formation. USNM 139785 (Holotype)



Text-figure 14
Yabeiphyllum rossi MINATO et KATO, sp. nov.
(X 6.6) The saddle north of the Wolfcamp, well, west end of Wolfcamp hills, Texas, USA. Upper Pennsylvanian Gaptunk formation or Lower Permain Neal Ranch formation. USNM 139785 (Holotype)



Text-figure 15
Yabeiphyllum rossi MINATO et KATO, sp. nov.
(X 6.6) The saddle north of the Wolfcamp well, west end of Wolfcamp hills, Texas, USA. Upper Pennsylvanian Gaptunk formation or Lower Permian Neal Ranch formation. UANM 139785 (Holotype)

are provided with long minor septa, prominent carinae at least in parts and inconspicuous median plate in axial column. But they can be distinguished from each other in that *Yabeiphyllum rossi* has relatively loose axial column and less conspicuous intrathecal dilation.

Genus ***Heritschioides*** YABE, 1950

Type species: *Waagenophyllum columbicum* SMITH, 1935

Heritschioides YABE, 1950, p. 75

Heritschioides, WILSON & LANGENHEIM, 1962, p. 508

Generic diagnosis: Fasciculate corals of Durhaminidae, in which tabulae and tabellae are ascending towards the axis of corallite. Dissepimentarium is wide; and axial column is compact and densely constructed. Septa are thick at the thecal region, tapering towards both axial and peripheral ends.

Geographical distribution: Canada, Ural, Nevada, Oregon, and Japan.
Geological horizon: Lower Permian (*Pseudofusulina* to *Parafusulina* zone).
Remarks: Following YABE (1950), WILSON and LANGENHEIM (1962) gave a detailed description on the present genus, it may be accordingly not necessary to add any more. WILSON and LANGENHEIM stated, however, the present genus to be cerioid in form. This may be a mistake, because the present genus is definitly represented by the corals of fasciculate form. Further, they tentatively placed the present genus in Waagenophyllidae, since they thought that clinotabulae are more or less developed in *Heritschioides*.

However, such structure is entirely lacking at least in the type species. Further the so-called clinotabulae observable in *Heritchioides hillae* are generally small and cystose as they correctly described, and the structure seems accordingly not equal to the same named skeletal element found in Waagenophyllidae. The small and cystose clinotabulae reported by WILSON and LANGENHEIM would be rather called clinotabellae only locally and exceptionally occupy the outer area of tabularium.

In the meantime, dissepiments apparently similar to the elongate dissepiments are eventually developed in *Heritschioides hillae*. They are clearly observable in the corallites illustrated by WILSON and LANGENHEIM as fig. 2 in plate 88. Nevertheless, the mentioned elongate dissepiments are not regularly distributed throughout the dissepimentarium in this species. Moreover, they are not appeared in an intimate combination with clinotabulae, as generally found in waagenophyllid corals.

Accordingly, the genus *Heritchioides* cannot be viewed to be assignable into Waagenophyllidae but must be placed in the family Durhaminidae.

The present genus is different from *Durhamina* in having no distinct lonsdaleoid dissepiments, besides dense construction of axial structure.

Recently DEGROOT (1963) merged some solitary as well as fasciculate Late Palaeozoic corals similar to Lower Carboniferous genus *Corwenia* into *Corwenia*. Thus *Amandophyllum*, *Heritschioides*, *Dibunophylloides* and *Sestrophyllum* are all said to be synonymous with *Corwenia*. We, however, are in favour of separation of genera based on the shape of corallum, such as simple, fasciculate and massive forms, especially in the present case. *Amandophyllum* is a genus of solitary corals, thus is distinguished from fasciculate *Corwenia*. *Dibunophylloides* and *Sestrophyllum* are according to FOMITCHEV (1953) belong to solitary corals. But *Dibunophyl-*

loides seems to be actually a fasciculate genus as DEGROOT (1963) remarked. Both *Dibunophylloides* and *Sestrophyllum* have essentially concentric dissepiments in cross section. In both genera differentiation of axial column from tabularium is not clear. Axial structures of *Dibunophylloides*, *Sestrophyllum* and *Corwenia* are similar to each other, although dissepiments are a little different between *Corwenia* and the other two, since dissepiments are typically in herring bone pattern in *Corwenia*, and minor septa are ill developed in the latter genus. Anyhow, they all differ from *Heritschioides*, which typicallly has pseudo-herringbone dissepiments.

Included species may be listed below:

I. Tabellae (somewhat complete) not highly cystose and axial column densely constructed.
   - Ia With incipient lonsdaleoid dissepiments ..... *columbicum*
   - Ib With columella, and small lonsdaleoid dissepiments ..... *densicolumella*
     - With distinct median plate in columella ..... *woodi*
     - Without distinct median plate in columella ..... *hillae*

II. Tabellae highly cystose and axial column loosely and somewhat simply constructed.
   - IIa With incipient lonsdaleoid dissepiments ..... *ochocoensis*
   - IIb Without lonsdaleoid dissepiments
     - With large corallite and numerous septa ..... *washburni*
     - With relatively small corallite and less numerous septa ..... *ojiensis*

Heritschioides columbicum (SMITH)

1935 *Waagenophyllum columbicum* SMITH, p. 30, pl. 8, figs. 9; pl. 9, figs. 1–10.
1941 *Heritschia columbicum*, MOORE and JEFFORDS, p. 97.
1950 *Heritschioides columbicum*, YABE, p. 75.

Holotype: National Museum Canada, Cat, no. 9059: Sedgwick Museum A 6805.
Horizon and locality: Lower Permian (or Upper Carboniferous); ridge between Blaind and Barslow Creeks, near Keremenos, Smilkammen district, British Columbia, Canada.

Heritschioides woodi WILSON et LANGENHEIM

1962 *Heritschioides woodi* WILSON and LANGENHEIM, p. 509, pl. 89, figs. 9–10.

Holotype: 34652, University of California.
Horizon and Locality: Leonardian, locality B-1267, Ely Quadrangle, White Pine County, Nevada.

Heritschioides hillae WILSON et LANGENHEIM

1962 *Heritschioides hillae* WILSON and LANGENHEIM, p. 510, pl. 88, figs. 1–3.

Holotype: 34653, Univ. of California.
Horizon and Locality: Leonardian; Locality B-6206, Ely Quadrange, White Pine County, Nevada.

Heritschioides washburni (MERRIAM)

1942 *Waagenophyllum washburni* MERRIAM, p. 395, pl. 55, figs. 2, 5, 7, 9, 11, 13.
1962 *Heritschioides washburni*, WILSON and LANGENHEM, p. 509.

Holotype: Cornell Univ, no. 38690.
Horizon and Distribution: Leonardian, Central Oregon.

Remarks: Although elongate dissepiments of small size are poorly developed in the present species, there are no clinotabulae. Most of tabellae are quite incomplete and cystose, whose convexity face both upwards and outwards.

WILSON and LANGENHEIM assigned the present form into the genus *Heritschioides*, for which the authors are of the same opinion. The axial structure of the present species is however quite variable as MERRIAM once stated, and there is a case in which a certain individual has quite a loosely and simply constructed axial column (fig. 2,7. on plate 55, MERRIAM 1942 for instance). This is much deviated from that of the typical *Heritschioides* but rather closely akin to that of *Durhamina*. Nevertheless, in the present species lonsdaleoid dissepiments are almost obsolete. Thus the present species can be reasonably viewed to be a member of *Heritschioides* than the *Durhamina*. Actually there is such an individual as the specimen figured as fig. 5 and 9 on plate 55 (MERRIAM, 1942), which possesses rather densely constructed axial column.

Heritschioides ochocoensis (MERRIAM)

1941 *Waagenophyllum ochocoensis* MERRIAM, p. 395, pl. 55, figs. 8, 10, pl. 56, fig. 3.

Holotype: Cornell Univ., no. 38691.
Horizon and geographical distribution: Leonardian, Central Oregon.

Remarks: The axial structure of the present species is more loosely and simply constructed than that of the type species of *Heritschioides*. Unlike the genus *Durhamina*, the present form however possesses only weakly developed lonsdaleoid dissepiments.

Heritschioides densicolumella (DOBROLYUBOVA)

1936 *Corwenia densicolumella* DOBROLYUBOVA, p. 155, text-figs. 72–75.
1941 *Corwenia densicolumella*, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, p. 261, pl. 40, figs. 1–2.
1950 *Heritschioides densicolumella*, YABE p. 75.

Holotype: no. 182/280, presumably at the Palaeont. Inst. Akad. Nauk, USSR.
Type locality: Podcherem river, North Urals.
Horizon: Lower Permian, probably Sakmarian to Artinskian, since *Pseudofusulina* ex. gr. *anderssoni* is said to have associated with the coral.

Heritschioides ojiensis SAKAGUCHI et YAMAGIWA

1958 *Heritschioides ojiensis* SAKAGUCHI and YAMAGIWA, p. 170, pl. 1, figs. 4, 5, 6.

Holotype: I.A.G.G. Osaka Gakugei Univ., 59009,59010.
Horizon and Locality: *Pseudofusulina vulgaris* zone, Oji, Sino-mura. Minamikuwata-gun, Kyoto Prefecture, Japan.

Genus *Tanbaella* nov.

Type species: *Waagenophyllum izuruhensis* SAKAGUCHI et YAMAGIWA, 1958, p. 176, pl. 3, figs. 5a, 5b; pl. 4, fig. 6; pl. 5, figs. 3.
Generic diagnosis: Fasciculate Durhaminidae with axial column somewhat densely constructed like *Heritschioides*, but with highly developed lonsdaleoid dissepiments.
Included species is *Tanbaella izuruhensis* (SAKAGUCHI et YAMAGIWA) only.
Geologic and geographic distribution: *Neoschwagerina* zone; Japan.
Remarks: Except for relatively thick dissepimentarium, in which a number of irregularly sized dissepiments are found, the present form may be doubtlessly akin to *Heritschioides* in general structure, especially in the construction of axial column. The column occupies relatively narrow area, but is rather densely constructed by regularly distributed septal lamellae and very numerous concentric axial tabellae. The median plate is not always distinct in axial column. Thus, the feature of the axial column strongly reminds us that in *Heritschioides*.

Nevertheless, the lonsdaleoid dissepiments are irregular in size and form, and very abundant throughout dissepimentarium, where the growth of septa is observed to be very frequently interrupted by these vesicles.

SAKAGUCHI and YAMAGIWA assigned the type species of the present genus into *Waagenophyllum*, but it is by no means correct, because of the presence of highly

developed londaleoid dissepiments, and lacking in clinotabulae in the present form.

Tanbaella izuruhensis (SAKAGUCHI et YAMAGIWA)
Text-figs. 16–19.

1958 *Waagenophyllum izuruhense* SAKAGUCHI et YAMAGIWA, p. 176, pl. 2, fig. 5a, 5b; pl. 4, fig. 6; pl. 5, figs. 2, 3.
1965 *Tanbaella izuruhensis*, MINATO and KATO, listed only, p. 134.

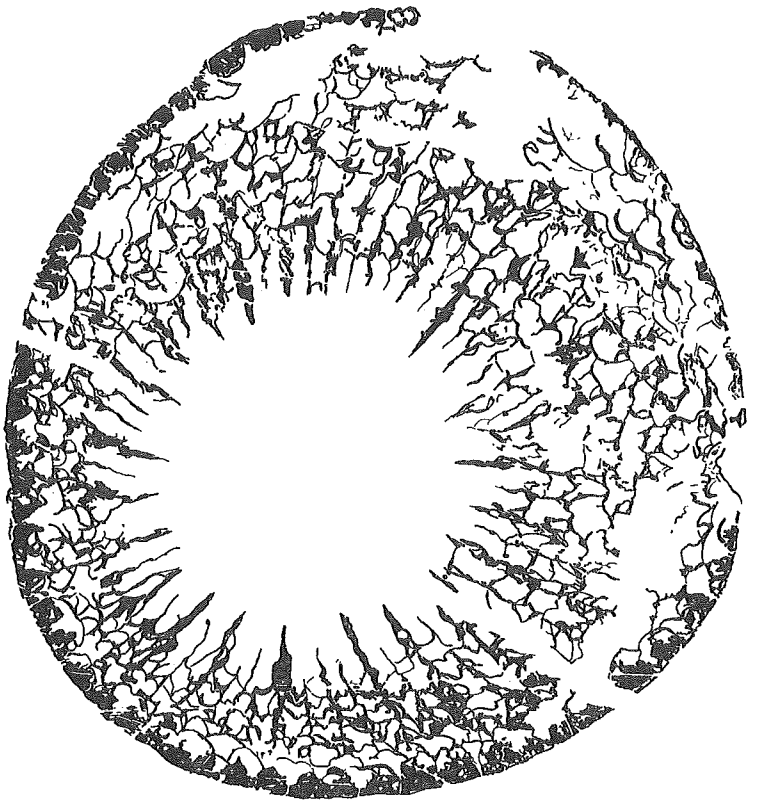
Type specimens: IAGG, Osaka Gakugei Univ., nos. 59026–59028 (Holotype) no. 59029 (Paratype)
Geological horizon: *Neoschwagerina craticulifera* zone
Type locality: Izuruha-shimojo, Takatsuki city, Osaka Pref., Japan.

Description of thin sections. Corallum fasciculate, composed of sub-cylindrical corallites. Corallites are less than 14 mm in calicular diameter, even at their maximum size. Wall may be originally not thick, but is strengthened by strong septal ridges, which may be either directly united with septa or discontinuous with the latter. The septal ridges mentioned above are usually very broad at their base, and their outer configurations are either triangular or semicircular in cross section. They are just corresponding to the major and minor septa in disposition, encircling along the inner side of the outer wall. Septa are of two orders. Major septa are numbered 24 to 28 in the full grown stage, alternating with the same number of minor ones. Major septa are definitely longer and thicker than the minor ones. Especially, the former is very thick in the medial area, although they are rather thin in dissepimentarium.

Both major and minor septa are of diffuso-trabecular type in minor structure. Black layers are observable on both sides of translucent layer in the cross section of a septum. Septa are usually straight or sub-straight in cross section, but tend to be flexuous or zig-zag, especially in dissepimentarium. Further, they become to possess carinae like processes which are sometimes quite indistinct. Besides, septa are locally quite thin and interrupted by frequent development of lonsdaleoid dissepiments.

The axial structure is somewhat clisiophyllid, not unlike spider-web in appearance. It is composed of rather regularly disposed septal lamellae and axial tabellae, in which median plate is discernible. The median plate does not however clearly bisect the axial column. It is neither remarkably thick nor long in cross section. Not only the median plate but also any septal lamellae are not directly united with any septa, so far as the mature stage is concerned.

Dissepiments are irregular in size and arrangement. They are however, mostly arranged in angulo-concentric pattern, although rather widely and irregul-

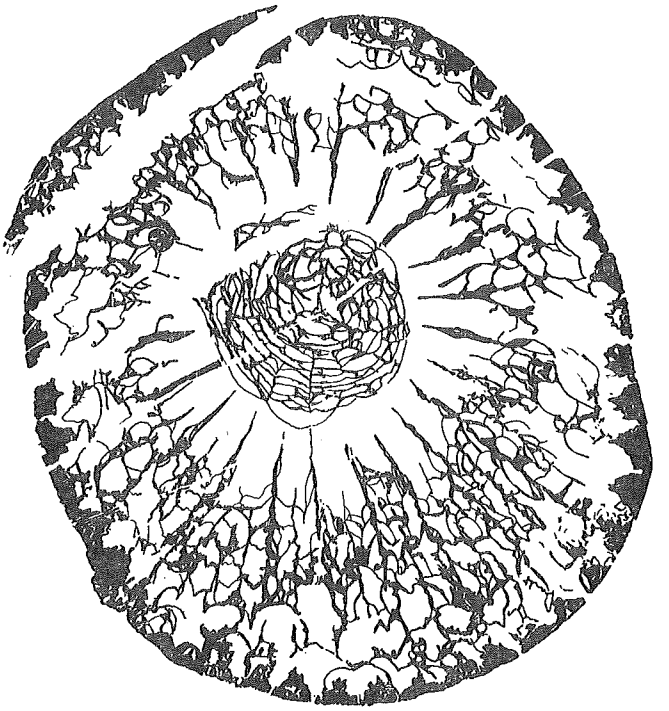


Text-figure 16
Tanbaella izuruhensis (SAKAGUCHI et YAMAGIWA)
(X 7.7) Izuruha-shimojo, Takatsuki city, Osaka Prefecture, Japan. *Neoschwagerina craticulifera* zone. IAGG 59026 (Holotype)

arly spaced. Locally the cut edges of dissepiments are observed to dispose in parallel to the septa, instead of being concentric in arrangement. Lonsdaleoid dissepiments are also irregular in size and arrangement. Locally they replace nearly the entire space of dissepimentarium, where septa are also represented by short crestal ridges.

In the longitudinal section, tri-areal arrangement is distinct. The peripheral or outer area is occupied by very unequally sized vesicles. The larger one among them may be of lonsdaleoid, while the smaller may be mostly of interseptal dissepiments. The inner boundary of tabularium is quite clear as is indicated by the outer margin of axial column, while the outer edge of tabularium is marked by the inner margin of dissepiments.

Now the peripheral tabellae found in the tabularium are variously inclined.



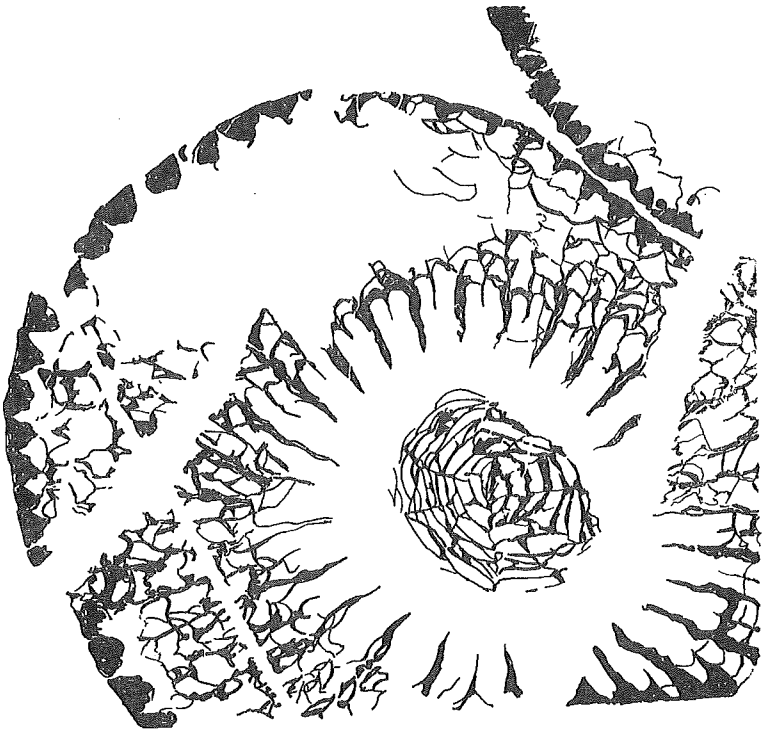
Text-figure 17
Tanbaella izuruhensis (SAKAGUCHI et YAMAGIWA)
(X 7.5) Izuruha-shimojo, Takatsuki city, Osaka Prefecture, Japan.
Neoschwagerina craticulifera zone. IAGG 59027 (Holotype)

Some of them are rather complete, nearly horizontal or only slightly arched upward. Some others are inclined outwards especially near the dissepimentarium. There are also such tabellae which are inclined from outward towards inward. Further, most of tabellae are rather distantly spaced. In short, the tabellae ascending towards the axial column are more or less well developed than the other types.

Remarks: The present species entirely lacks in elongate dissepiments and clinotabulae. It must be accordingly excluded from Waagenophyllidae.

The present species may be however comparable to a certain species of *Akagophyllum*, because of well developed lonsdaleoid dissepiments. As a matter fact, SAKAGUCHI and YAMAGIWA made such a comparison, and they placed the present form in *Waageonphyllum*, in admitting *Lonsdaleia* (*Waagenophyllum*) *indica* var. *akagoense* OZAWA to be entirely congeneric with *Lonsdaleia indica*.

However, from the different structure of tabularium and axial column, the



Text-figure 18
Tanbaella izuruhensis (SAKAGUCHI et YAMAGIWA)
(X 8.3) Izuruha-shimojo, Takatsuki city, Osaka Prefecture, Japan. *Neoschwagerina craticulifera* zone. IAGG 59029 (Paratype)

Text-figure 19
Tanbaella izuruhensis (SAKAGUCHI et YAMAGIWA)
(X 7.7) Izuruha-shimojo, Takatsuki city, Osaka Prefecture, Japan. *Neoschwagerina craticulifera* zone. IAGG 59028 (Holotype)

present species can not be viewed to be a member of *Waagenophyllum* or *Akagophyllum*, but it needs its own generic position.

Further, SAKAGUCHI and YAMAGIWA were of the opinion that the present species may be somewhat akin to the genus *Lonsdaleoides*, because of development of lonsdaleoid dissepiments. The fundamental structure of axial column is however quite distinct with each other. There cannot be any intimate relation between them at all.

III. Massive forms

Genus ***Protolonsdaleiastraea*** GORSKY, 1932

Type species: *Protolonsdaleiastraea atbassarica* GORSKY, 1932

Protolonsdaleiastraea GORSKY, 1932, p. 44, 80.
Protolonsdaleiastraea, DOBROLYUBOVA, 1936, p. 54.
Protolonsdaleiastraea, SOSHKINA et al., 1941, p. 265.
Lonsdaleiastraea, DOBROLYUBOVA, 1936, p. 56 (non GERTH)
Lonsdaleiastraea, SOSHKINA et al., 1941, p. 265.
Cystophora, DOBROLYUBOVA, 1936, p. 36 (non YABE et HAYASAKA)
Cystophora, DOBROLYUBOVA, 1936 b, p. 128.
Cystophora, SOSHKINA et al., 1941, p. 259.
Dobrolyubovia FOMITCHEV, 1953, p. 593 (nom. nud.)
Gorskyia FOMITCHEV, 1953, p. 593 (nom.nud.)

Generic diagnosis: Plocoid Durhaminidae.

Included species: The species being included into the present genus may be tabulated as follows in a form of key.

I. Minor septa more or less well developed
  Ia Axial structure generally rather simple
    Minor septa as long as the major
      Diphyphylloid tendency present in axial structure ..... *biseptata*
      Axial structure simple ..... *dobrolyubovae*
    Minor septa present, but not very long
      Corallite small. Septa rather thick ..... *atbassarica*
      Corallite large. Axial structure more simple.
      Wall largely retained ..... *gorskyi*
  Ib Axial structure rather complicated
      Septa and wall thin ..... *delicata*
      Septa and wall thick ..... *cargalensis*

II. Minor septa weakly developed
  IIa Axial structure simple
    Major septa short ..... *pennata*
    Major septa do not reach axial structure
      Wall weakly plocoidal
        Median plate thin ..... *monoseptata*
        Median plate solid ..... *columellaris*
      Wall highly plocoidal
        With thin inner wall ..... *juresanensis*
        With thick inner wall ..... *gerthi*
    Major septa almost reach axial structure
        Tabularium relatively narrow ..... *longiseptata*
        Tabularium relatively wide ..... *pseudowischeriana*
  IIb Axial structure complicated ..... *densireticulata*

Description of the genus *Protolonsdaleiastraea:* Plocoidal nature in this genus shows variable development from species to species; in other words walls may be still remained in various degrees.

Axial structure is originally rather simple. It is merely composed of a median plate in the early stage, and is sometimes discontinuous, although it becomes slightly complicated by the additional participation of septal lamellae and axial tabellae. Tabellae in tabularium ascend towards the main axis of corallite. Elongate dissepiments, clinotabellae and lonsdaleoid dissepiments may develop to some extent.

Geological range: (Lower Carboniferous?), Upper Carboniferous (*Triticites* zone) to the Middle Permian (Artinskian).
Geographical distribution: Urals, (North, Middle and South Urals (= Ufa, Sterlitamak and Aktiubinsk regions).
Remarks: The present genus differs from *Orionastraea* in having slightly more complicate axial structure than the latter. Further, complete tabulae and wide tabellae are more dominantly found in *Orionastraea*, while tabulae are almost entirely lacking in the present genus. Besides, thin, wide tabellae are less frequently developed in *Protolonsdaleiastraea* than in *Orionastraea*. The present genus may be still distinct from *Orionastraea* in the degree of plocoidal nature. Namely, *Orionastraea* is in highly plocoidal tending to become thamnasterioid while in the present genus walls are largely retained in most species. If the walls are disappearing in considerable degrees, most of corals in the present genus show partly thamnasterioid and partly aphroid coralla by the replacement of well developed lonsdaleoid dissepiments in the peripheral area.

A number of species once described by DOBROLYUBOVA from the Urals under the name of *Cystophora* were later classified by FOMITCHEV into *Dobrolyu-*

bovia. Indeed, certain forms among the so-called "*Dobrolyubovia*" are distinct from the type species of the genus *Protolonsdaleiastraea*, because of having simple axial structure and largely retained walls. But such nature may be only a problem of degree, and it is almost impossible to generically distinguish them from the type species of *Protolonsdaleiastraea*.

Further, certain species of Urals classified by DOBROLYUBOVA (1936) under the genus *Lonsdaleiastraea* were later re-described by SOSHKINA, DOBROLYUBOVA and PORFIRIEV in 1941. Those corals seem to be slightly progressive in plocoidal nature and axial construction than that of so-called "*Dobrolyubovia*". But the so-called "*Lonsdaleiastraea* " of DOBROLYUBOVA has merely two orders of septa. Further they lack in clinotabulae and large elongate dissepiments. These are the corals termed as comprising *Gorskyia* FOMITCHEV (1953).

Therefore, these corals now in consideration must be eventually excluded from the genus *Lonsdaleiastraea* which is a member of Waagenophyllidae and would be best placed in the present genus, *Protolonsdaleiastraea*.

Dobrolyubovia and *Gorskyia* are both considered as *nomina nuda* by HILL (1957), since FOMITCHEV (1953) failed to cite any definite designation of type species for them.

Finally, the most species belonging to the present genus were described from the Lower Permian "Sakmarian" and "Artinskian", except for two species: *Protolonsdaleiastraea monoseptata* and *biseptata*. While the type species was once reported to have been found from the Lower Carboniferous. Inspite of this, SOSHKINA, DOBROLYUBOVA and PORFIRIEV stated (1941) in their text (description) that the type species of *Protolonsdaleiastraea* indicates the Artinskian in age. Therefore we wish to follow this description regarding the geological horizon of the present species. It may be noted however, in the same paper, SOSHKINA, DOBROLYUBOVA and PORFIRIEV also described (in the explanatory text to plates), that the type species of the genus *Protolonsdaleiastraea* could be doubtfully placed as a member of Lower Carboniferous coral fauna.

Protolonsdaleiastraea biseptata (DOBROLYUBOVA)

1936 *Cystophora biseptata* DOBROLYUBOVA, pp. 37–39, pl. 23, figs. 59–61.
1936 *Cystophora biseptata*, DOBROLYUBOVA, pp. 129–130, text-fig. 57.
1936 ?*Cystophora biseptata* var. *minor* DOBROLYUBOVA, pp. 39–40, pl. 24, figs. 62–63.
1941 *Cystophora biseptata*, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, p. 259, pl. 32, figs. 1a-b; pl. 33, figs. 1a-c.

Holotype: Museum of the цнигри 254–305
Type locality: Right bank of the Juresan river.
Geological age: Upper Carboniferous to Lower Permian. (*Psendoschwagerina*

to *Pseudofusulina* Zone)
Geographic distribution: Urals.

Protolonsdaleiastraea wischeriana (STUCKENBERG)

1895 *Phillipsastraea wischeriana* STUCKENBERG, p. 108, pl. 18, fig. 5.
1936 *Cystophora wischeriana*, DOBROLYUBOVA, pp. 45–47, pl. 28, figs. 76–80.
1941 *Cystophora wischeriana*, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, p. 261, pl. 39, figs. 1–2; text-figs. 41a-b.

Lecto-type: Museum of the цнигри, no. 743/305
Type locality: Wischera river, Ural.
Geological age: " Lower " Permian (*Pseudofusulina* to *Parafusulina* Zone).
Geographic distribution: Ufa plateau and Urals

Protolonsdaleiastraea dobrolyubovae, nom. nov.

1936 *Lonsdaleiastraea longiseptata* DOBROLYUBOVA, pp. 59, pl 37, figs. 106–109 (non *Cystophora longiseptata* DOBROLYUBOVA)

Holotype: The figured specimen, OSIPOV collection.
Type locality: Juresan river.
Geological age: Probably Sakmarian (*Pseudofusulina* Zone) to "Artinskian ", " Lower " Permian.
Geographical distribution: South Urals.

Protolonsdaleiastraea atbassarica GORSKY

1932 *Protolonsdaleiastraea atbassarica* GORSKY, pp 44–46, pl. 5, figs 3–5; text-figs. 5a-b·
1936 ?*Protolonsdaleiastraea* cf. *atbassarica*, DOBROLYUBOVA, pp. 55–56, pl. 33, figs. 95–96; pl. 34, fig. 97.
1941 *Protolonsdaleiastraea atbassarica*, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, p 265, pl. 55, figs. 1a-d, 2a-b.

Holotype: No. 354/2612, Palaeontological Institute, USSR? (fide SOSHKINA et al., 1941, p. 302)
Type locality: Aktiubinsk region, Dgesdy river. Atbassarsky region, exposure 32–33.
Geological age: " Lower " Permian, possibly *Pseudofusulina* to *Parafusulina* zone.
Geographic distribution: Southern Urals.

Protolonsdaleiastraea gorskyi DOBROLYUBOVA

1941 *Protolonsdaleiastraea gorskyi* DOBROLYUBOVA, in SOSHKINA et al., pp. 265–266, pl. 56, figs. 1a-b.

Holotype: No. 1199/146, Presumably of the Palaeontological Institute, USSR.
Geological age: "Artinskian" = *Pseudofusulina* to *Parafusulina* zone.
Type locality: Aktiubinsk region, Kargala river, exposure no. 745.
Geographic distribution: South Urals.

Protolonsdaleiastraea complexa (DOBROLYUBOVA)

1936 *Lonsdaleiastraea complexa* DOBROLYUBOVA, p. 58, pl. 36, figs. 101–105.
1941 *Lonsdaleiastraea complexa*, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, p. 267, p . 59, figs. 2a-b; pl. 60, figs. 1a-e; pl. 61, figs. 1a-b.

Holotype: No. 353/4765, Presumably of Palaeontological Institute, USSR
Type locality: Ai river, right bank. 1.5 km downstream of the country Abdulino.
Geological age: Lower Permian (*Pseudofusulina* zone)
Geographical distribution: Sterlitamak region, South Urals.

Protolonsdaleiastraea delicata (DOBROLYUBOVA)

1941 *Lonsdaleiastraea delicata* DOBROLYUBOVA, in SOSHKINA et al , p. 268, pl. 63, figs. 2a-b.

Holotype: No. 1205/146, Presumably of Palaeontological Inst., USSR.
Type locality: Kurasha river, Ak-Tukalskie hills, section across the elevation 167.6 m, exposure no. 90 (k).
Geological age: Lower Permian, " Sakmarian ". (s.l.)
Geographical distribution: Aktiubinsk region, South Urals.

Protolonsdaleiastraea cargalensis (DOBROLYUBOVA)

1941 *Lonsdaleiastraea cargalensis* DOBROLYUBOVA, in SOSHIKNA et al., p. 1267, pl. 62, figs. 1a-b.

Holotype: No. 1203/146, Presumably of Palaeontological Inst., USSR.
Type locality: Kargala river, exposure no. 745.
Geological age. "Artinskian ", *Pseudofusulina* to *Parafusulina* zone.
Geographic distribution: Aktiubinsk region, South Urals.

Protolonsdaleiastraea pennata (PORFIRIEV)

1941 *Cystophora pennata* PORFIRIEV, in SOSHIKNA et al., p. 260, pl. 37, figs. 1–2.

Holotype: No. 6a, Shak-tau, near Sterlitamak. Presumably of the Palaeont. Inst. USSR.
Type locality: See above.
Geological age: Sterlitamak horizon, *Pseudofusulina* zone, Sakmarian, Lower Permian.
Geographical distribution: Sterlitamak region, South Urals.

Protolonsdaleiastraea monoseptata (DOBROLYUBOVA)

1936 *Cystophora monoseptata* DOBROLYUBOVA, pp. 40–41, pl. 24, fig. 64; pl. 25, figs. 65–67. varieties 1 to 4, pp. 41–45, pl. 26, figs, 68, 69; pl. 26, figs. 70, 71; pl. 27, figs. 72, 73; pl. 27, figs. 74, 75.
1936 *Cystophora monoseptata*, DOBROLYUBOVA, pp. 130–131, text-figs. 58, 59.
1941 *Cystophora monoseptata*, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, p. 259, pl. 34, figs. 1–2.

Holotype: No. 275/4765, Presumably of Palaeont. Inst. of the USSR.
Type locality: Shesham river, near Shugurova.
Geological age: Upper Carboniferous to Lower Permian (*Pseudoschwagerina* and *Pseudofusulina* zone)
Geographical distribution: North to south Urals.

Protolonsdaleiastraea columellaris (DOBROLYUBOVA)

1941 *Cystophora monoseptata* var. *columellaris* DOBROLYUBOVA, in SOSHKINA et al., p. 260, pl. 35, figs. 1a-c.

Holotype: No. 1190/146, Presumably of the Palaeont. Inst. Acad. Nauk USSR.
Type locality: Balka Kara-Murunsay, Aktiubinsk region.
Geological horizon: "Artinskian" -Redeposited limestone block. Most probably *Pseudofusulina* to *Parafusulina* zone.
Geographic distribution: South Urals.

Protolonsdaleiastraea juresanensis (DOBROLYUBOVA)

1936 *Lonsdaleiastraea vinassai* var. nov., DOBROLYUBOVA (non GERTH) pp. 57–58, pl. 35, figs. 99–100.

1941 *Lonsdaleiastraea gerthi* var. *juresanensis* DOBROLYUBOVA, in SOSHKINA et al., pp. 266, pl. 59, figs. 1a-b.

Holotype: No. 351/4765, Presumably of the Palaeont. Inst., Akad. Nauk, USSR.
Type locality: Yuresan river, right bank, 1 km downstream of the country Agyrsa.
Geological age: Lower Permian, Sakmarian s. str. (= *Pseudofusulina* zone)
Geographical distribution: South Urals.

Protolonsdaleiastraea gerthi (DOBROLYUBOVA)

1936 *Lonsdaleiastraea* cf. *vinassai*, DOBROLYUBOBA (non GERTH), pp. 56–57, pl. 34, fig. 98.
1941 *Lonsdaleiastraea gerthi* DOBROLYUBOVA, in SOSHKINA et al., p. 2266, pl. 57, figs. 1, 2a-b; pl. 58, figs. 1a-b, 2a-b.

Holotype: No. 350/4765 Palaeont. Inst. Akad, Nauk USSR?
Type locality: Yuresan river, right bank, 4 km downstream of the country Egeovka.
Geological horizon: Lower Permian, & "Artinskian".
Geographical distribution: Ufa and Aktiubinsk regions, South Urals.

Protolonsdaleiastraea longiseptata (DOBROLYUBOVA)

1936 *Cystophora longiseptata* DOBROLYUBOVA, p. 47–48, pl. 29, figs. 81–93. (non *Lonsdaleiastraea longiseptata* DOBROLYUBOVA).
1941 *Cystophora longiseptata*, SOSHKINA DOBROLYUBOVA & PORFIRIEV, p. 260, pl. 35, figs. 2a-b; pl. 36, figs. 1a-b, 2a-b.

Holotype: No. 325/4765, Palaeont. Inst. Akad, Nauk, USSR?
Type locality: Juresan river.
Geological horizon: *Pseudofusulina* to *Parafusulina* zone.
Geographical distribution: Ufa, Sterlitamak and Aktiubinsk regions. South Urals.

Protolonsdaleiastraea pseudowischeriana (DOBROLYUBOVA)

1941 *Cystophora pseudowischerian* PORFIRIEV, in SOSHKINA et al., p. 260, pl. 37, figs. 1–2.

Holotype: N. 37, Palaeont. Inst. Akad. Nauk USSR?
Type locality: Shak-tau, near Sterlitamak.
Geological horizon: *Pseudofusulina* zone of Sakmarian.
Geographical distribution: Sterlitamak region, South Urals.

Protolonsdaleiastraea densireticulata (DOBROLYUBOVA)

1941 *Lonsdaleiastraea densireticulata* DOBROLYUBOVA, in SOSHKINA et al., p. 267–8, pl. 63, figs. 1a-b.

Holotype: No. 1204/146, Palaeont. Inst. Akad. Nauk, USSR, 1963?
Type locality: Exposure 743, Kargala river, Aktiubinsk region.
Geological horizon: "Artinskian" (= *Pseudofusulina* to *Parafusulina* zone).
Geographical distribution: South Urals.

Genus ***Kleopatrina*** McCUTCHEON et WILSON

Type species: *Ptolemaia ftatateeta* McCUTCHEON et Wilson, 1961.

Wentzelella, DOBROLYUBOVA, 1936, p. 145 (non GRABAU)
Wentzelella, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, 1941, p. 262 (non GRABAU)
Ptolemaia McCUTCHEON & WILSON, 1961, p. 1020 (non OSBORN)
Kleopatrina McCUTCHEON & WILSON, 1963, p. 299. nom. nov.

Geological horizon: Wolfcampian or Sakmarian (s.l.) to Artinskian.
Geographical distribution: Nevada, U.S.A., and Ural in USSR.
Generic diagnosis: Ceriod Durhaminidae, with relatively thick wall; Columella waagenophyllid; septa of two orders, which are very thick in the intrathecal region. Tabellae mostly cystose, ascending gently or steeply upwards along the axis of corallite. Minor elongate dissepiments and lonsdaleoid dissepiments may lack or develop in various degree.
Remarks: The present genus widely differs from *Ipciphyllum* in having tabulae ascending towards the axis of corallum. McCUTCHEON and WILSON placed many Russian species formerly called as *Wentzelella* into the present genus. The present authors are of the same opinion in this regard. Especially such species as *uralensis*, *intermedia*, *gracilis*, *pseudoelegans* and its subspecies *prismatica* are closely akin to the type species of the present genus, the American form. Yet, it may be remembered that in most of the Russian forms of this group, lonsdaleoid dissepiments are more or less developed. Namely so far as the illustrated figures are concerned, nearly all the Russian species except for *uralensis* and *prismatica*, possess lonsdaleoid dissepiments to some extent, at least in certain corallites. Especially in the species called *intermedia*, *gracilis*, and *magnifica*, lonsdaleoid dissepiments are observed to occupy relatively wide area of the peripheal zone of corallites. Further in such forms as *stylidophylloides* or its subspecies *radiata*, lonsdaleoid dissepiments are also well developed. And they are apparently quite different in this concern from the most of other species belonging to the present genus. In these

species above mentioned, lonsdaleoid dissepiments are generally larger than those of the other species. The maximum convexity of dissepimental vesicles seem to face upward in the longitudinal section, instead of facing inward. In addition, the minor septa are less developed in these forms. Finally, the species called *Wentzelella grandis* DOBROLYUBOVA may be also a member of the present genus. However in this species, minor septa are almost obsolete, while lonsdaleoid dissepiments are remarkably well developed. Thus these three species above stated could be eventually best distinguished from the other species as belonging to a subgenus of *Kleopatrina*. The American form called *Lonsdaleia illipahensis* EASTON may belong to the same category, the subgenus of *Kleopatrina*, because of its incipient development of minor septa and rather well developed lonsdaleoid dissepiments.

Thus the present genus will be divided into two subgenera, *Kleopatrina* (*Kleopatrina*) and *Kleopatrina* (*Porfirievella*).

Subgenus ***Kleopatrina*** McCUTCHEON et WILSON, 1963

Type species: As for genus *Kleopatrina*.

Subgeneric diagnosis: *Kleopatrina* with relatively well developed minor septa and with very weakly developed lonsdaleoid dissepiments.

Included species will be listed below:

Kleopatrina (*Kleopatrina*) *ftatateeta* (McCUTCHEON et WILSON)
Kleopatrina (*Kleopatrina*) *wilsoni* sp. nov.
Kleopatrina (*Kleopatrina*) *uralensis* (McCUTCHEON et WILSON)
Kleopatrina (*Kleopatrina*) *pseudoelegans* (DOBROLYUBOVA)
Kleopatrina (*Kleopatrina*) *pseudoelegans prismatica* (PORFIRIEV)
Kleopatrina (*Kleopatrina*) *magnifica* (PORFIRIEV)
Kleopatrina (*Kleopatrina*) *intermedia* (PORFIRIEV)
Kleopatrina (*Kleopatrina*) *gracilis* (DOBROLYUBOVA)

Kleopatrina* (*Kleopatrina*) *ftatateeta (McCUTCHEON et WILSON)

1961 *Ptolemaia ftatateeta* McCUTCHEON and WILSON, p. 1025, pl. 123, figs. 2, 4 & 5. (non figs. 3, 6)
1962 *Ptolemaia ftatateeta*, WILSON & LANGENHEIM, p. 507, pl. 82, figs. 1–2.

Holotype: UCMP (Univ. California Museum Palaeont.) 30267.
Type locality: Gray limestone, Ward Mountains, White Pine County, Nevada.
Geological horizon: Wolfcampian.

Kleopatrina (*Kleopatrina*) *wilsoni*, sp. nov.

Holotype: UCMP, 30268, figured by McCutcheon and Wilson as figs. 3 and 6 on their plate 123 may be designated as the type of the present species.
Type locality: Gray limestone, Arrow Canyon Mountains, Clark County, Nevada.
Geological horizon: As the preceding species.
Specific diagnosis: *Kleopatrina* with simple axial structure, single row of dissepiments, gently curved tabulae, which are slightly uparching along the axis of corallite.
Remarks: In the writers' opinion, there are actually two species amongst the specimens described by McCutcheon and Wilson as the type species of the genus *Ptolemaia*. The holotype specimen (UCMP 30267) figured by them as figs. 1, 2, 4, and fig. 5 (paratype UCMP 30268) are no doubt belonging to the same species. However, the specimens (paratype UCMP 30268 figured as fig. 3 and fig. 6) show marked difference from the holotype specimen in the axial structure, tabulae and dissepiments.

In the holotype specimen, axial tabellae are rather well developed in the axial structure while septal lamellae are rather sparse. Besides this, the tabellae are somewhat straight in cross section and their junctions are angular as McCutcheon and Wilson described. The reverse is the condition in the axial structure of the present species, in which axial tabellae are sinuous and very irregularly spaced. Further, the tabulae in the present species are gently uparching in general compared to the type species of the genus *Kleopatrina*. Moreover, the dissepiments are irregular in size in the type species against dissepimental vesicles of subequal size in the present species.

Perhaps, certain large dissepimental vesicles may be inter-septal elongate dissepiments, the existence of which is clearly shown in the type species (fig. 1, 2, and 4). Such structure is apparently lacking in the present species.

The difference between the present species and the holotype of the type species *Kleopatrina* (then *Ptolemaia*) was regarded by McCutcheon and Wilson to be only of individual variations within a single species. However, the present authors are of different opinion in this concern.

Kleopatrina (*Kleopatrina*) *uralensis* (McCutcheon et Wilson)

1941 *Wentzelella* aff. *indica*, Soshkina, Dobrolyubova & Porfiriev, (non Waagen & Wentzel), p. 262, pl. 42, figs. 1a-c.
1961 *Ptolemaia uralensis* McCutcheon & Wilson, nom. nov. p. 1025.

Holotype: No. 42 (Presumably of the Palaeont. Inst. Akad. Nauk USSR)

Type locality: Shak-tau, near Sterlitamak, USSR.
Horizon: Sterlitamak horizon (*Pseudofusulina* zone), Sakmarian s.str., Lower Permian.

Kleopatrina (*Kleopatrina*) *pseudoelegans* (DOBROLYUBOVA)

1936 *Wentzelella* cf. *elegans*, DOBROLYUBOVA, p. 145–6, text-figs. 80–81 (non HUANG)
1941 *Wentzelella pseudoelegans* DOBROLYUBOVA, in SOSHKINA et al., p. 263, pl. 43, figs. 2a-b; pl. 44, figs. 1–2; pl. 34, figs. 1a-b; pl. 46, figs. 1a-b.
1961 *Ptolemaia pseudoelegans*, MCCUTCHEON & WILSON, p. 1025.

Holotype: No. 195–196/280 (Presumably of the Palaeont. Inst. Akad. Nauk. USSR.)
Type locality: Exposure no. 45, Podcherem river, North Urals.
Geological horizon: Lower Permian (*Pseudoschwagerina* to *Pseudofusulina* zone).
Geographic distribution: North and South Urals.

Kleopatrina (*Kleopatrina*) *pseudoelegans prismatica* (PORFIRIEV)

1941 *Wentzelella pseudoelegans* var. *prismatica* PORFIRIEV, in SOSHKINA et al., p. 263, pl. 47, figs. 1a-b.
1961 *Ptolemaia pseudoelegans* var. *prismatica*, MCCUTCHEON & WILSON, p. 1025.

Holotype: No. 0–20 (Palaeont. Inst. Akad. Nauk. USSR?)
Type locality: Shak-tau, near Sterlitamak, USSR.
Horizon: Talus supposedly II-III layers=*Pseudoschwagerina* to *Pseudofusulina* zone.

Kleopatrina (*Kleopatrina*) *magnifica* (PORFIRIEV)

1941 *Wentzelella magnifica* PORFIRIEV, in SOSHKINA et al., p. 265, pl. 53, figs. 1a-c; pl. 54, figs. 1a-b.
1961 *Ptolemaia magnifica*, MCCUTCHEON & WILSON, p. 1024.

Holotype: No. 0–13. Probably of the Palaeont. Inst. Akad. Nauk USSR.
Type locality: Shak-tau near Sterlitamak, USSR.
Geological distribution: *Pseudoschwagerina* to *Parafusulina* zone ("Artinskian")
Geographic distribution: Sterlitamak and Aktiubinsk regions, South Urals.

Kleopatrina (*Kleopatrina*) *gracilis* (DOBROLYUBOVA)

1941 *Wentzelella gracilis* DOBROLYUBOVA, in SOSHKINA et al., p. 264, pl. 48, figs.1a-b,

2a-b; pl. 49, figs. 1a-b.
1961 *Ptolemaia gracilis*, McCutcheon & Wilson, p. 1024.

Holotype: No. 1194/146. Probably of the Palaeont. Inst. Akad. Nauk USSR.
Type locality: Jaksy-Kargala river. Aktiubinsk region, USSR.
Geologic distribution: Lower Permian (*Pseudoschwagerina* to *Pseudofusulina* zone).
Geographic distribution: Sterlitamak and Aktiubinsk regions, South Urals.

Kleopatrina* (*Kleopatrina*) *intermedia (Porfiriev)

1941 *Wentzelella timorica* var. *intermedia* Porfiriev, in Soshkina et al., p. 263, pl. 43, figs. 1a-b. (non " *Wentzelella* " *timorica* Gerth).
1961 *Ptolemaia intermedia*, McCutcheon et Wilson, p. 1024.

Holotype: No. 106. Palaeont. Inst. Akad. Nauk USSR?
Type locality: North slope of Shak-tau, near Sterlitamak, USSR.
Geologic horizon: Sakmarian, *Pseudofusulina* zone. Lower Permian.

Subgenus ***Porfirievella*** nov.

Type species: *Wentzelella grandis* Dobrolyubova, 1941
Subgeneric diagnosis: *Kleopatrina* with well developed lonsdaleoid dissepiments. Minor septa may be lacking or only quite rudimentary.
Geologic distribution: Lower Permian (*Pseudoschwagerina* to *Pseudofusulina* zone)
Geographic distribution: Urals and Nevada in North America.

Included species:
Kleopatrina (*Porfirievella*) *grandis* (Dobrolyubova)
Kleopatrina (*Porfirievella*) *stylidophylloides* (Dobrolyubova)
Kleopatrina (*Porfirievella*) *stylidophylloides radiata* (Porfiriev)
Kleopatrina (*Porfirievella*) *illipahensis* (Easton)

Kleopatrina* (*Porfirievella*) *grandis (Dobrolyubova)

1941 *Wentzelella grandis* Dobrolyubova, in Soshkina et al., p. 264, pl. 52, figs. 1a-b.
1961 *Ptolemaia grandis*, McCutcheon & Wilson, p. 1024.

Holotype: No. 1196/146. Possibly of the Palaeont. Inst. Akad. Nauk USSR.
Type locality: Aktiubinsk region. Ural river. Section up to the way from the

country Pekhotnoy to farms No. 4, over the Psi river.
Geological horizon: Middle part of the *Schwagerina* horizon=*Pseudoschwagerina* zone.

Kleopatrina* (*Porfirievella*) *stylidophylloides (DOBROLYUBOVA)

1941 *Wentzelella stylidophylloides* DOBROLYUBOVA, in SOSHKINA et al., p. 264, pl. 50, figs. 1a-b.
1961 *Ptolemaia stylidophylloides*, MCCUTCHEON & WILSON, p. 1025.

Holotype: No. 1195/146 Palaeont. Inst. Akad. Nauk USSR.?
Type locality: Aktiubinsk region. Ural river. Exposure no. 420. Section along the road from the country Pekhotnoy to the farm no. 4, over the Psi spring. USSR.
Geological horizon: Lower Permian, Sakmarian s.l.

Kleopatrina* (*Porfirievella*) *stylidophylloides radiata (PORFIRIEV)

1941 *Wentzelella stylidophylloides* var. *radiata* PORFIRIEV in SOSHKINA et al., p. 264, pl. 51, figs. 1a-b.
1961 *Ptolemaia stylidophylloides* var. *radiata*, MCCUTCHEON & WILSON, p. 1025.

Holotype: No. 48 Palaeont. Inst. Akad. Nauk USSR?
Type locality: Shak-tau, near Sterlitamak, USSR.
Geologic horizon: Lower Permian: (*Pseudoschwagerina* to *Pseudofusulina* zone)

Kleopatrina* (*Porfirievella*) *illipahensis (EASTON)

1960 *Lonsdaleia illipahensis* EASTON, p. 580, text-figs. 15–16.

Holotype: Univ. Southern California 5122.
Type locality: 1.1 miles west of Ruby valley Truck Trail and 6 miles north of U. S. Highway 50. SE, SW, Sec. 8, T. 18 N, R. 59 E, Illipah quadrangle, Nevada, USA.
Geological horizon: Arcturus formation and Cyclical limestone and sandstone, Leonardian.

NOTE ON A NEW WAAGENOPHYLLID CORAL GENUS, *Chielasma* NOV.

After the completion of a monograph of Waagenophyllidae (1965) we noticed that there were some more Chinese corals yet to be ascribable to Waagenophyllidae. They are all in solitary form and were ascribed by CHI (1931) as *Dibunophyllum*. We consider that they constitute a group, which ought to be clearly distinguished from *Dibunophyllum* and clisiophyllids in general, and should be placed under the family Waagenophyllidae though rather primitive in its nature for that family. Here we propose a new generic name of *Chielasma* for these corals.

Before discussing the phylogeny, geologic as well as geographic distributions of Durhaminidae in comparison to those of Waagenophyllidae, short remarks on a new waagenophyllid may be added as an appendix to the present paper.

Family Waagenophyllidae WANG, 1950
Subfamily Waagenophyllinae WANG, 1950
Genus ***Chielasma*** nov.

Dibunophyllum, CHI (pars), 1931, p. 36
Type species: *Dibunophyllum yüi* CHI, 1931
Generic diagnosis: Simple Waagenophyllidae with lonsdaleoid dissepiments. Axial column is distinct, and in anstomosing character with a sinuous median plate. Septa are in two orders. Minor septa are thin, short, often indistinct. Longitudinally, tabularium is rather well differentiated from axial column and dissepimentarium. Elongate dissepiments absent. Tabulae incomplete and gently inclined clinotabulae present.
Included species:
Chielasma yuei (CHI), 1931
Chielasma? *tushanensis* (CHI), 1931
Chielasma? *weiningensis* (CHI), 1931
Geological age: Middle Carboniferous.
Geographic distribution: Yunnan and Kueichow in South China.
Remarks: *Huangia* is the closest ally to the present new genus, but is distinguishable from the latter in having fasciculate corallum. *Pavastehphyllum* (*Pseudocarniaphyllum*) also resembles the present genus. However, the former is provided with well developed elongate dissepiments and clinotabulae, while transverse tabulae are rather complete and distantly spaced. Further axial column seems to be comparatively small and simple in *Pavastehphyllum* (*Pseudocarniaphyllum*).

At a glance the present genus shows similarity to *Hertitschioides*. Yet, the present genus has concentric dissepiments in cross section, and many sub-horizontal tabellae in tabularium. While *Heritschioides* normally shows pseudo-herringbone dissepiments in cross section, and tabellae are uparching towards the axial column.

Also the nature of tabellae, lonsdaleoid dissepiments furnish clear distinction between the present genus and *Dibunophyllum*.

PHYLOGENY, GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTIONS OF DURHAMINIDAE, IN COMPARISON TO THOSE OF WAAGENOPHYLLIDAE

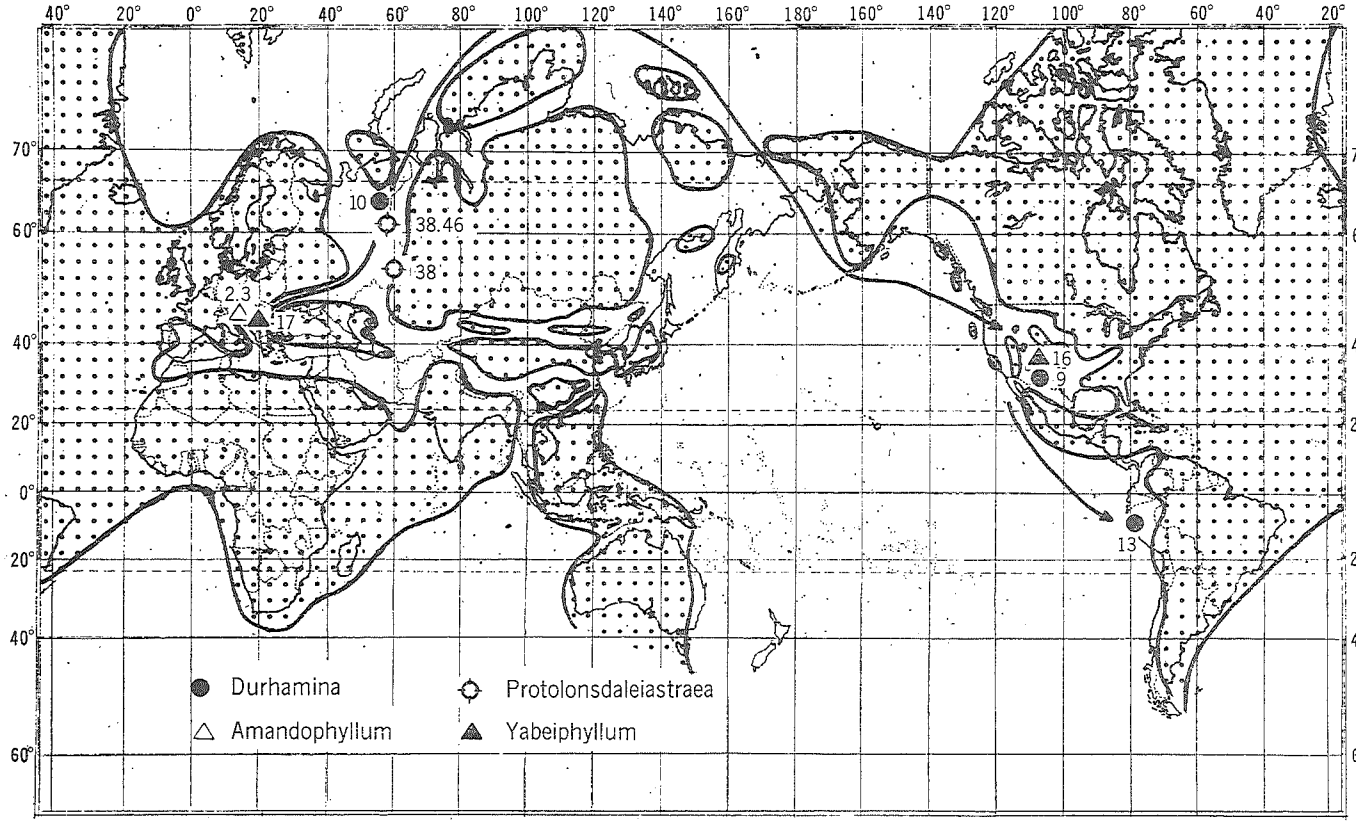
Basic ideas in reconstructing phylogeny of Durhaminidae are following the line described in our former paper on Waagenophyllidae (1965). And a scheme of phylogeny of Durhaminidae is shown in text-figure 4.

Much ambiguities are still remained to be clarified in the phylogeny of Durhaminidae and Waagenophyllidae, although they are now considered to have been branched from the common ancestor. (See remarks on Durhaminidae) It might be perhaps some time during the Lower Carboniferous, when the branching was really occurred.

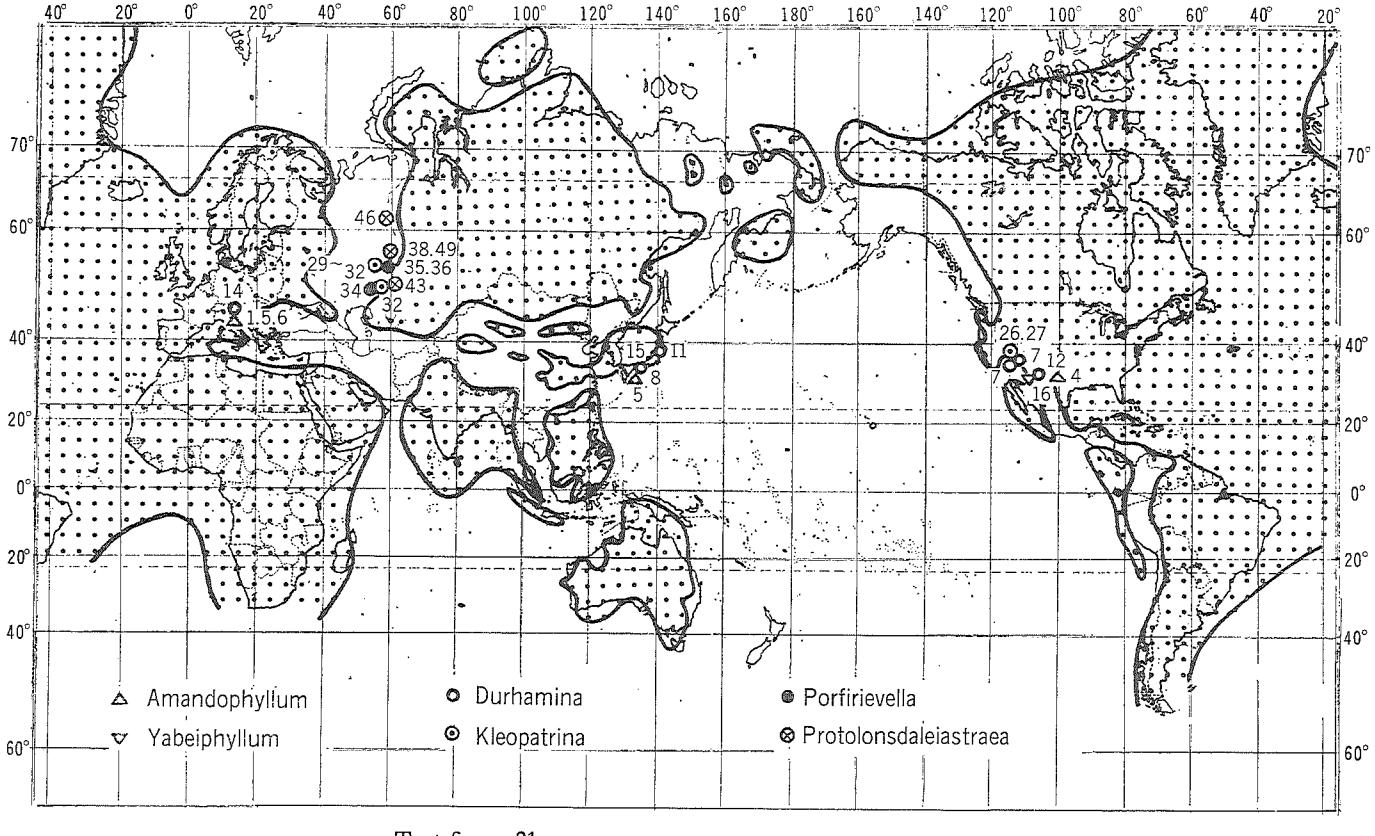
The oldest representatives of the family Durhaminidae are the Middle Carboniferous forms, so far as the species are concerned in which no ambiguity is retained about their stratigraphical position. As a matter of fact, there is so-called Lower Carboniferous species being assignable into Durhaminidae, but their true geological range seems to be somewhat uncertain for us at the present moment.

In the meantime, in Waagenophyllidae, the oldest species hitherto known for us are also the Middle Carboniferous forms. Accordingly, the ancestral form between Durhaminidae and Waagenophyllidae may have eventually already existed in the Lower Carboniferous.

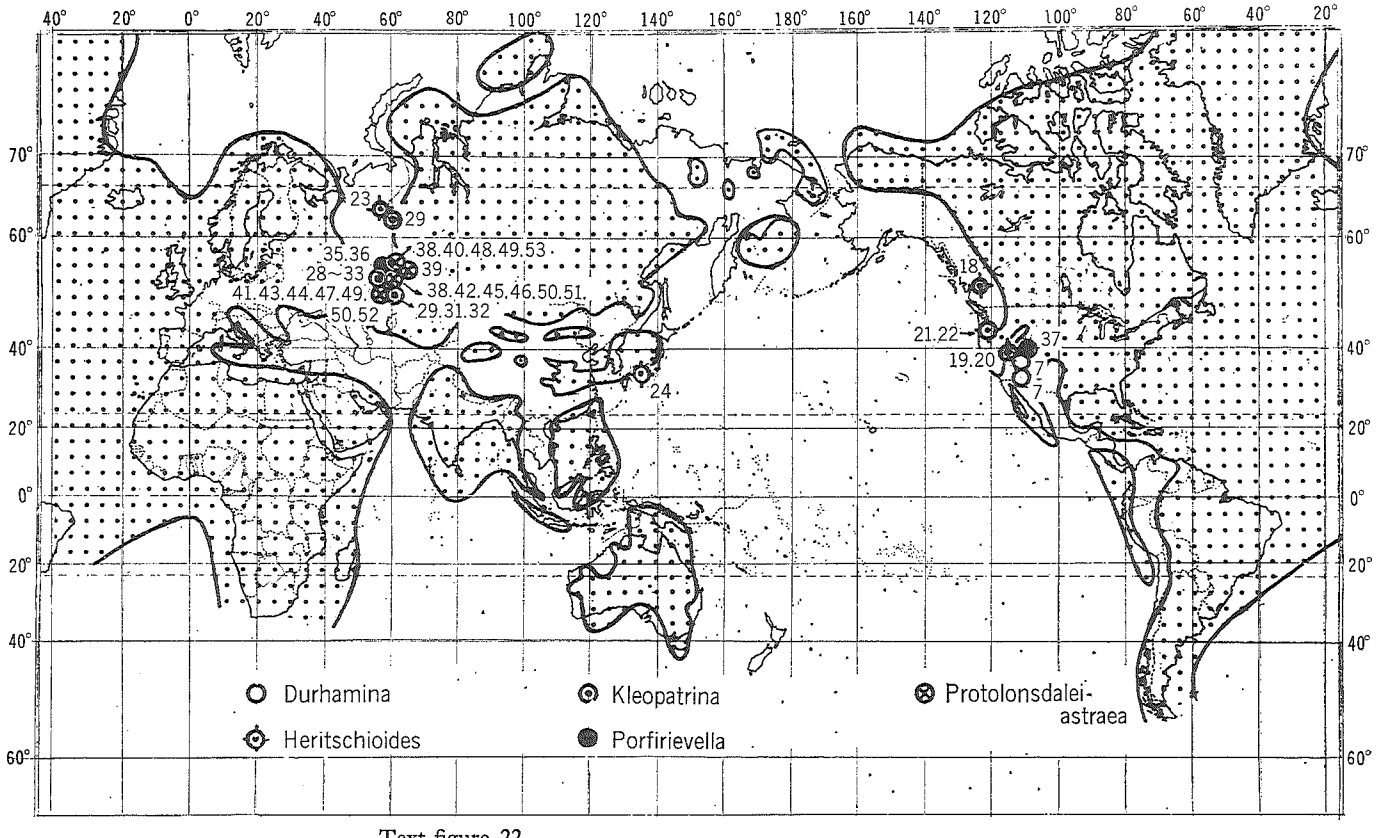
The common ancestor between Durhaminidae and Waagenophyllidae is now supposed to have been also branched from a certain form of Lithostrotionidae. The family Lithostrotionidae was already very rich either in generic or specific numbers in the Lower Carboniferous. In addition, a great number of species belonging to that family were already geographically widely distributed in the Lower Carboniferous. The common ancestor between Durhaminidae and Waagenophyllidae could be eventually existed among the forms of the Lower Carboniferous Lithostrotionidae. It may be quite difficult to know however, where the common



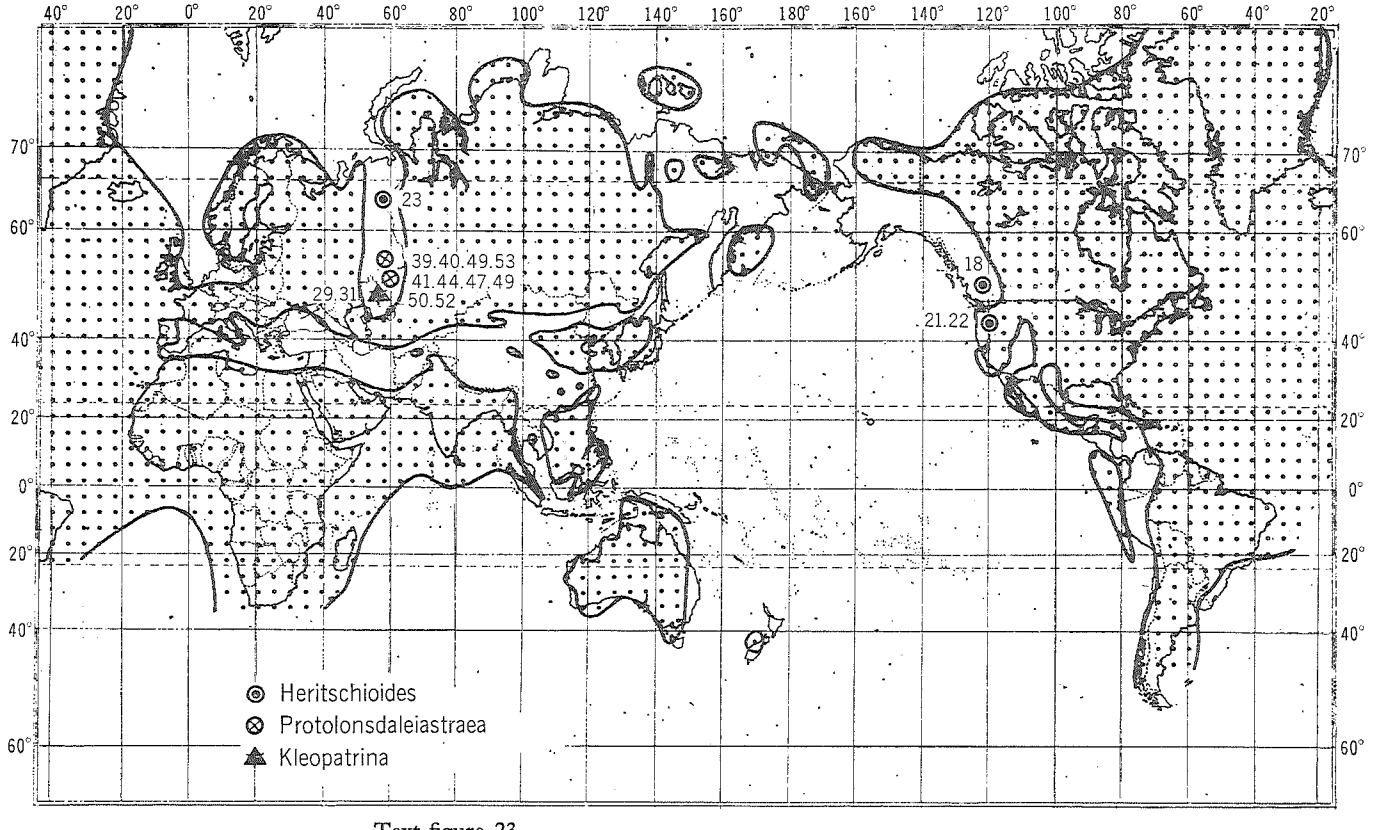
Text-figure 20
Distribution of Durhamindae in Middle and Upper Carboniferous. (A number is referring to each species. See explanation to text. fig. 4)



Text-figure 21
Distribution of Durhaminidae in *Pseudoschwagerina* zone.
(See explanation to text-fig. 4)



Text-figure 22
Distribution of Durhaminidae in *Pseudofusulina* zone.
(See explanation to text-fig. 4)



Text-figure 23
Distribution of Durhamidae in *Parafusulina* zone.
(See explanation to text-fig. 4)

ancestor first appeared in the wide region represented by the distribution of Lithostrotionidae in those days.

In this concern, the fact must be noted that the Middle Carboniferous Durhaminidae have been found only in the Urals, while the Middle Carboniferous forms of Waagenophyllidae have been exclusively known from the South Chinese basin.

Thus, the earlier froms of both families, perhaps branched from the common ancestor are now found in the different basins widely separated with each other.

This means that the branching of the common ancestor from Lithostrotionidae may have already occured at the time far back to the past; it might be perhaps in the early Lower Carboniferous. The common ancestor may have arisen either in somewhere in North Urals or in somewhere between the Urals and South China, and it might have migrated from its native sea towards the Urals and South China. On the way of this migration, it has likely branched into Durhaminidae and Waagenophyllidae respectively, and the former may have become to inhabitate in the Ural basin, while the latter in South China. It was the later Lower Carboniferous or the early Middle Carboniferous in age.

Assuming the preocess above stated, the geographical distribution of Durhaminidae may be well explainable in comparison to that of Waagenophyllidae. As will be later stated in detail, Durhaminidae seems to have been distributed in rather distinct province, against Waagenophyllidae, throughout the Carboniferous and Permian. And such an opposition in geographical distributions between the two families seems to have been already originated with certainty in the Middle Carboniferous.

In the Middle Carboniferous, Durhaminidae became to be abruptly extended from Urals to North America. Namely, certain forms migrated into the western region of North America from Urals, through perhaps the arctic sea region of the present day. Finally, some of them, a certain species of *Durhamina* for instance, reached as south as Peru in South America. At the same time, certain other forms made migration towards southwest from the Urals to the basin of the Carnic Alps.

To the contrary, from the Upper Carboniferous deposits, even a single species belonging to Waagenophyllidae has never been found until the present, at least so far as the present authors' knowledge is concerned. However, certain representatives of this family might be eventually existed in the Upper Carboniferous, because the Middle Carboniferous forms are known, besides a number of forms of the Permian. Only, such representatives for the Upper Carboniferous have been not yet found.

Accordingly, it is still remained to be solved in future, whether the Upper Carboniferous waagenophyllids were still inhabitated only somewhere in South Chinese sea like the Middle Carboniferous forms, or already widely distributed in the regions outside South China.

However, there is no positive indication that even a single species of waagenophyllids were really coexisted with durhaminids during the Upper Carboniferous, although the latter shows wide extension in its geographical distribution. Accordingly, the durhaminid corals have not likely far extended in geographical distribution in this age.

In the Early Permian (*Pseudoschwagerina* zone), somewhat remarkable change can be perceived in the geographical distribution of Durhaminidae.

Namely, in the regions along the eastern coast of the Pacific, the family Durhaminidae began to gradually retreat from the southern region at this stage. While, certain forms newly became to enter into the eastern end of the Tethys sea in Eurasia, viz. in the sea of the present Japanese islands. This migration might have occurred through the North Pacific of the present day across the Arctic sea region. Further, in the western end of the Tethys sea, viz. in the sea of the Carnic Alps, Durhaminidae was still existed, besides in the sea of Urals.

While in this stage, waagenophyllids tended to widely extend towards east and west from the sea of South China. Namely, waagenophyllids were abruptly widely distributed in entire Tethys sea in Eurasia. Further, a certain species, *Heritschiella girtyi* for instance, migrated far eastwards until Kansas. Perhaps, such a form may have had also its origin in somewhere in South China in the Pre-Permian, and migrated far away until Kansas, through perhaps the Northern Pacific route during the Upper Carboniferous.

In short, in the Early Permian, waagenophyllids were abruptly extended in geographical distribution, while durhaminids seem to have been more or less shrinking in distribution. Further, the two families became to coexist at least in two regions at this stage: Carnic Alps in the west, and Japan in the east. Nevertheless, the entire region of the Urals was still characterized by the presence of only durhaminids, and the most Tethys sea in Eurasia, except for its western and eastern ends, was characterized by waagenophyllids.

Thus, the fundamental opposite situation between the Durhaminidae province and Waagenophyllidae province was still maintained in this age.

In *Pseudofusulina* zone only one species of Durhaminidae is known to occur within east Tethys province, where the present Japanese islands are situated.

In the *Parafusulina* stage, both Waagenophyllidae and Durhaminidae provinces become slightly shringking or a little less extensive as a whole than in the Lower Permian. However, Durhaminidae and Waagenophyllidae were mostly still distributed in different provinces.

In the Upper Permian (*Neoschwagerina* zone plus *Yabeina* zone), Durhaminidae became already much declined either in specific or generic number. In fact, only a single species being assignable into the present family was found from the Upper Permian of Japan. It is *Tanbaella izuruhensis* (SAKAGUCHI et YAMAGIWA). To the constrary, waagenophyllids were still in full flourishing state in this stage.

In addition, they became newly extended at this stage towards New Zealand from South China via the sea of Indonesia. Further, they were still extensively distributed in the entire Tethys sea in Eurasia.

In the latest Permian, viz. in the post *Yabeina* stage, representatives of both families became completely disappeared from any regions.

In summary, Durhaminidae was quite distinct from Waagenophyllidae in geographical distribution throughout the Carboniferous and Permian. In other words, two distinct palaeozoogeographical provinces can be recognized in the distribution of coral faunas in those ages, namely Durhaminidae and Waagenophyllidae provinces.

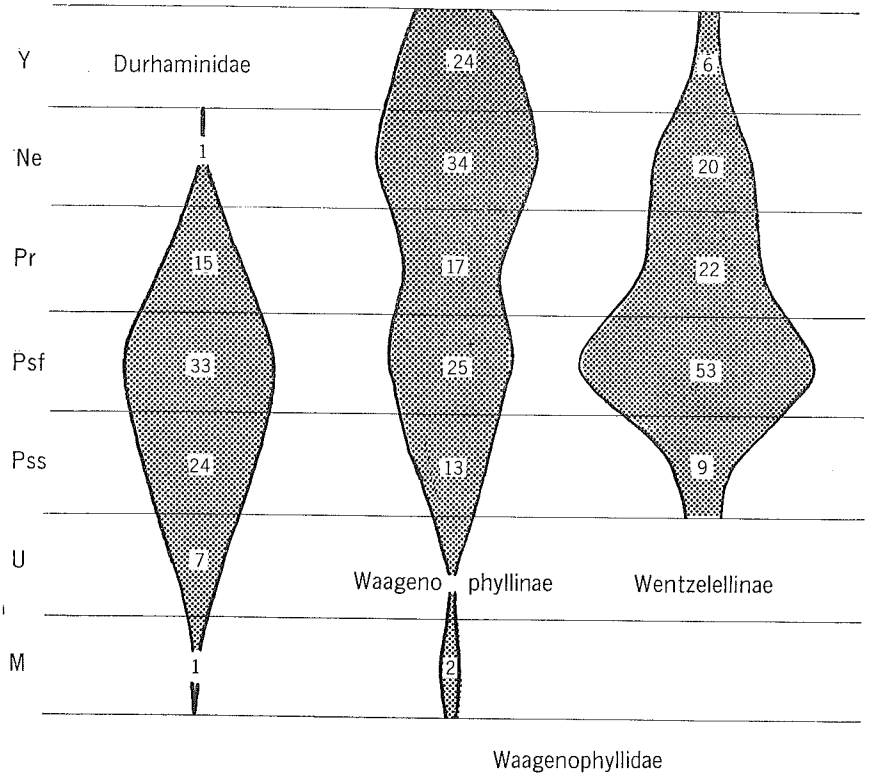
As was described in detail, no doubt the family Waagenophyllidae was first appeared in the sea of South China, and abruptly widely extended in distribution since the Lower Permian. Namely, it was distributed in the entire Tethys province in Eurasia, and Kansas in North America in the Lower Permian. While it was further extended into the Southwestern Pacific as far as New Zealand in the Upper Permian.

To the contrary, Durhaminidae may have arisen somewhere in the sea of North Urals or Arctic sea province of the present day, then it extended towards the sea of the Carnic Alps in one side. Further, this family was migrated at the same time towards the sea of the Japanese islands through the Arctic sea in other side. Besides, it reached Peru in South America through the route along the western regions of North America facing the Pacific. It was as early as Middle Carboniferous in age. Since then, Durhaminidae began to gradually decline in geographical distribution. And in the *Yabeina* stage, it seems to have been completely extinct.

It may be beyond doubt, that there were certain representatives among Waagenophyllidae in the Upper Carboniferous, although none of fossil evidences for them has been ever detected yet. This may be the result from the fact that the Tethys sea province was regressive in general in the Upper Carboniferous and waagenophyllids were either oblidged to migrate for a while to somewhere outside the Tethys sea province, or they may have inhabitated in rather isolated basins in somewhere in the Tethys province still covered by sea water during the Upper Carboniferous.

Further, Durhaminidae remarkably declined its prosperity after the *Parafusulina* stage. This may be concluded to have been partly resulted from the general upheaval in the Durhaminidae province since the dawn of the *Neoschwagerina* stage. This may be especially true in the sea of Durhaminidae in Eurasia. Actually, only a single species belonging to Durhaminidae was found in the *Neoschwagerina* limestone in Japan.

Nevertheless, in the future study, certain representatives of Durhaminidae of the Upper Permian are now expected to be found somewhere in the coastal regions in North America facing the Pacific, because the area was still largely under the sea



Text-figure 24
Phylogeny of Durhaminidae and Waagenophyllidae (simplified). Numeral shows the number of species contained in a family or a subfamily within each limited geological age.
M —Middle Carboniferous
U —Upper Carboniferous
Pss—*Pseudoschwagerina* zone
Psf—*Pseudofusulina* zone
Pr —*Parafusulina* zone
Ne—*Neoschwagerina* zone
Y —*Yabeina* zone

water in most regions, like the Japanese islands in the Upper Permian.

It is far from doubtful that both Durhaminidae and Waagenophyllidae provinces were belonging to the warm sea water regions in the Carboniferous and Permian. Of them, whether the Waagenophyllidae province was more warmer than that of Durhaminidae or not is, however, remained to be further studied, although more numerous species are found in the former than the latter among coral faunas. Further it may be also an open question, whether or not the regions-

for climatic optimum for coral fauna was really shifted from north to south through ages, although it is suggested by the extension of Durhaminidae province in the Upper Carboniferous to that of Waagenophyllidae province in the Permian.

It may also need further study in future in this connection to reach final conclusion. To settle the palaeo-climatic zones in the Carboniferous and Permian, instead of merely presenting zoogeographical provinces of corals, such other faunas as brachiopods, cephalopods, foraminifers for instance besides land plants must be also brought into consideration.

Yet, the major disposition recognized in palaeozoogeography among coral faunas may be eventually viewed to be of prime importance in consideration of this problem.

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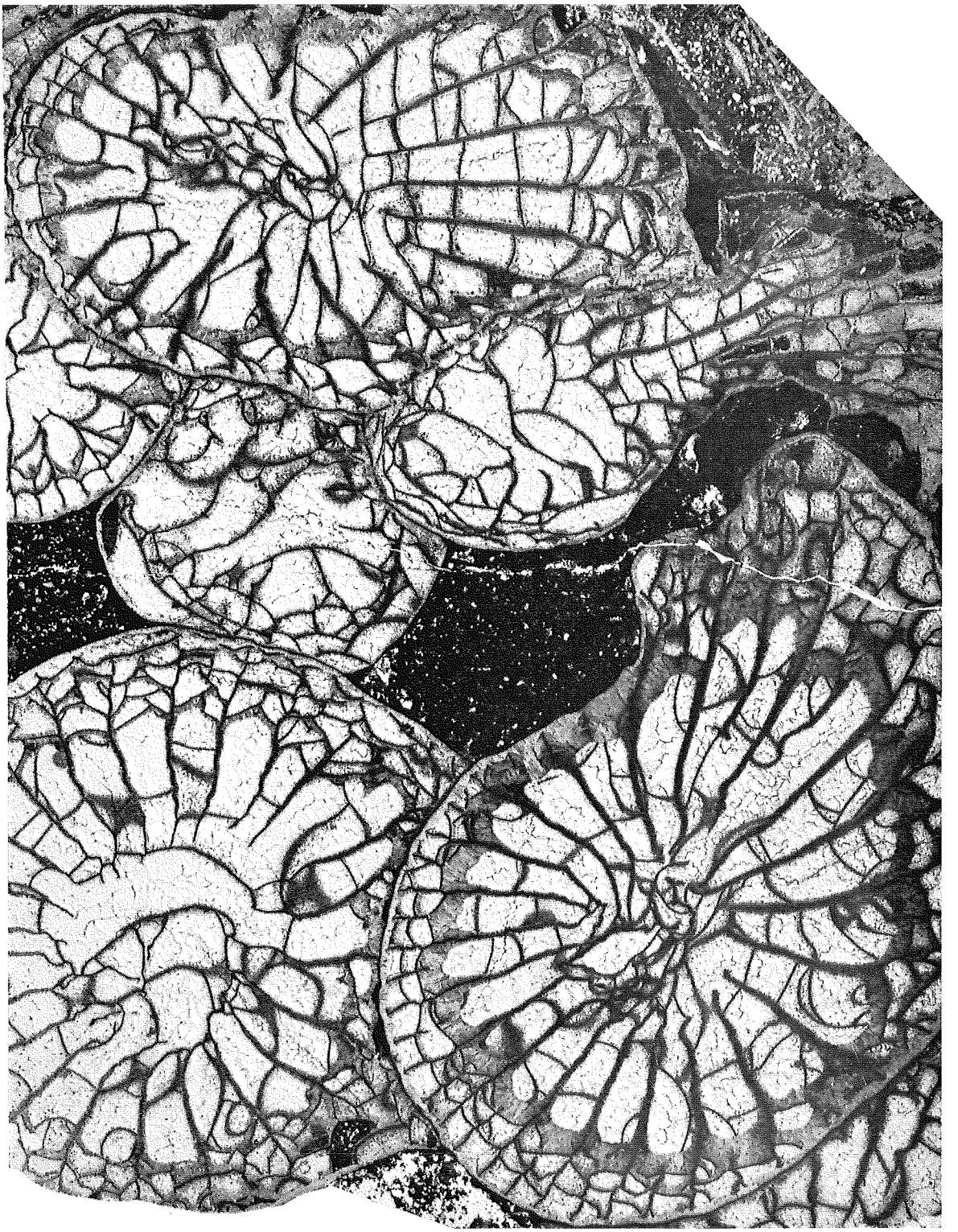
PLATES AND EXPLANATIONS

Explanation of plate 1

Durhamina hessensis (ROSS et ROSS) ..... P. 43

Transverse section showing weak axial structure, strong intrathecal dilation and small lonsdaleoid dissepiments in mature corallites. Note thysanophylloid young corallites. USNM 139731 (Ten times natural size).

East face of Leonard mountain, Texas, USA. Lenox hills formation, Wolfcampian.



Explanation of plate 2

Durhamina hasimotoi (NAGAO et MINATO)·····P. 35

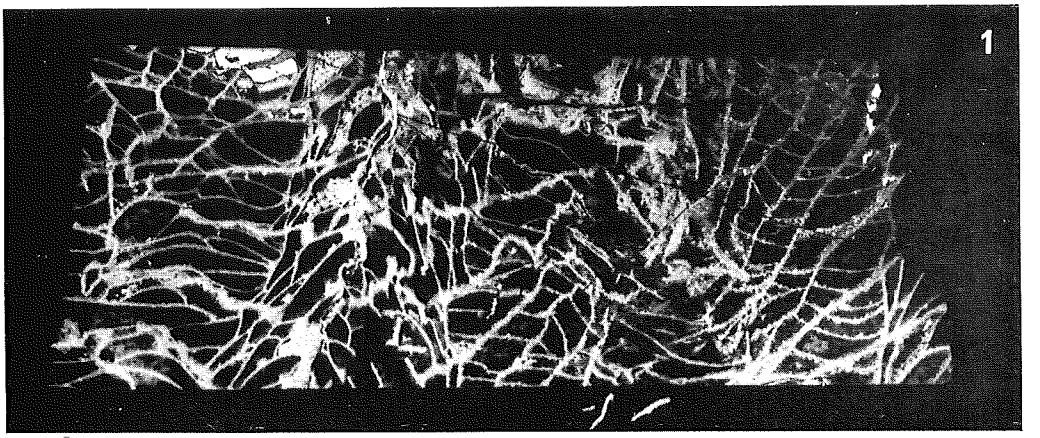
(All figures 6.6 times natural size).

Fig. 1 : Longitudinal section showing two corallites. UHR 15239 Syntype

Fig. 2 : Transverse and oblique sections of corallites. UHR 15240 Syntype

Fig. 3 : Longitudinal section showing the presence of almost flat and wide tabellae UHR 15237 Syntype

All are from a quarry in Tosayama, Kochi Prefecture, Japan.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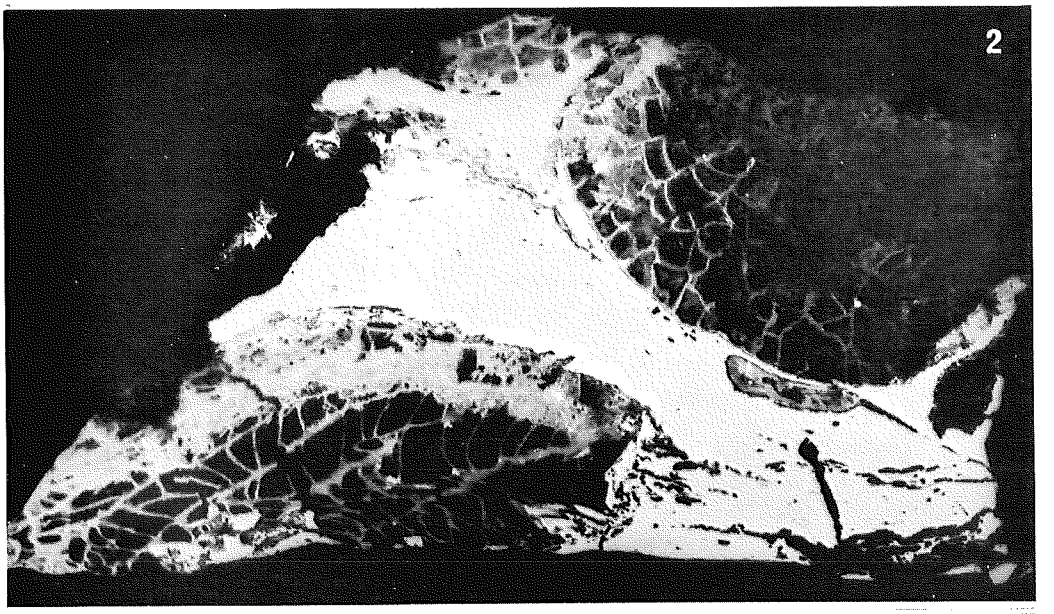
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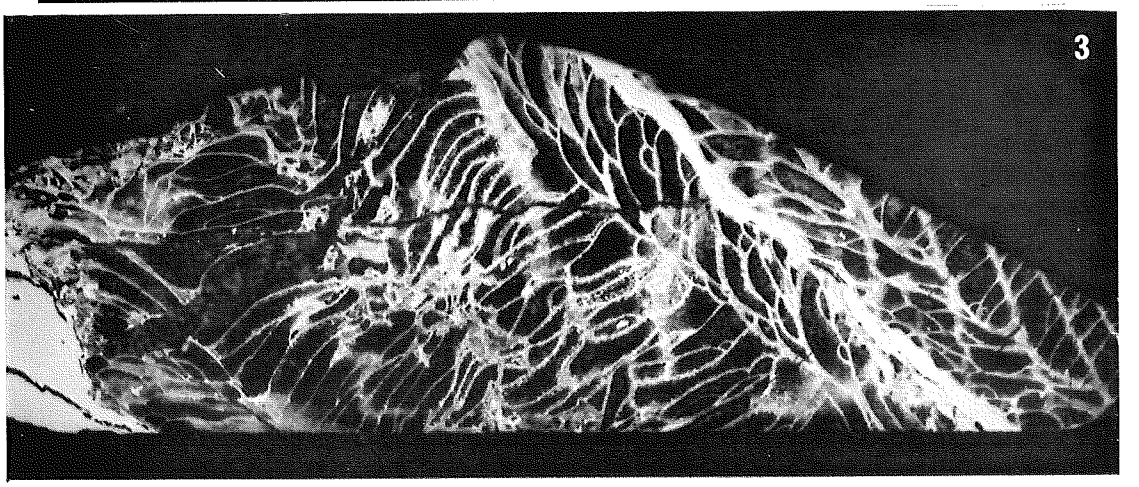
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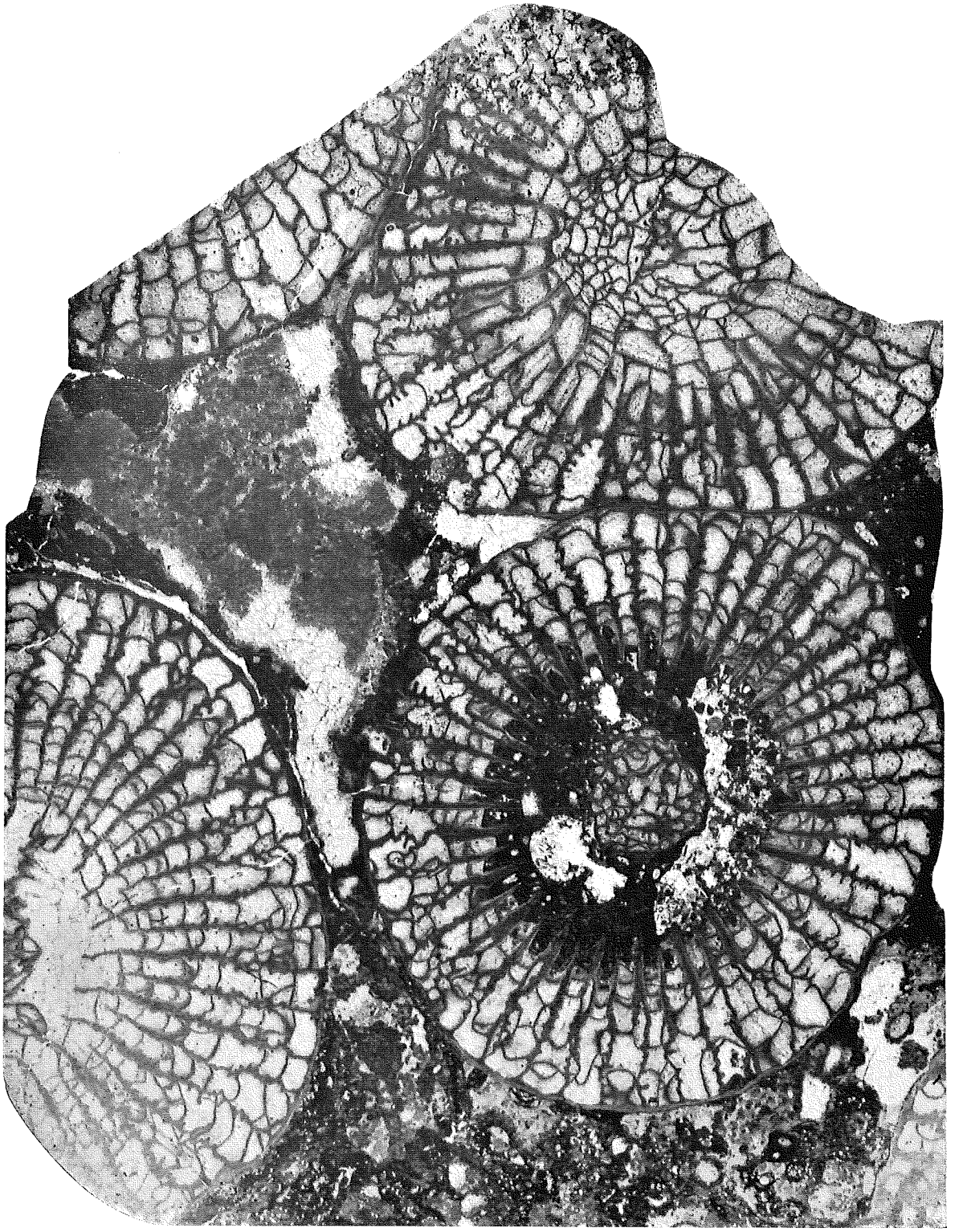
Explanation of plate 3

Yabeiphyllum rossi MINATO et KATO, sp. nov. ..... P. 49

Transverse section. Note the presence of strong carinae on septa in dissepimentarium. USNM 139785. Float specimen in the saddle north of the Wolfcamp well, west end of Wolfcamp hills, Texas, USA. (x10)

Upper Pennsylvanian Gaptunk formation or Lower Permian Neal Ranch formation.

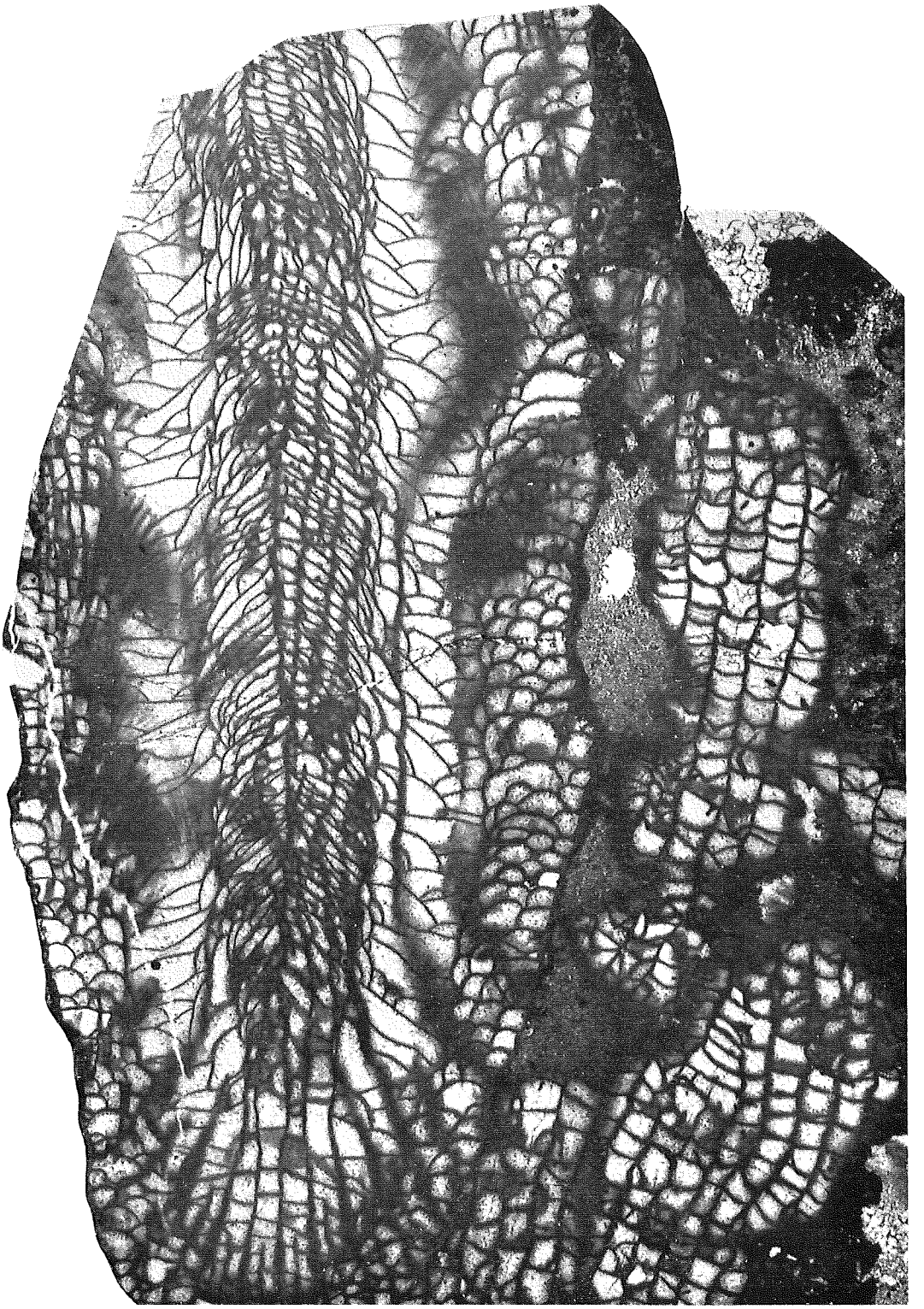


Explanation of plate 4

Yabeiphyllum rossi MINATO et KATO, sp, hov.....P. 49

Ortho-longitudinal section. Carinae are arranged in fan-like manner in the dissepimentarium. USNM 139785. Float specimen in the saddle north of the Wolfcamp well, west end of Wolfcamp hills, Texas, USA. (x10)

Upper Pennsylvanian Gaptunk formation of Lower Permian Neal Ranch formation.



Explanation of plate 5

Durhamina kitakamiensis MINATO et KATO, sp. nov. ..... P 38

Longitudinal section (×4). UHR 17657
Sakamotosawa, Hikoroichi, Ofunato city, Iwate Prefecture, Japan.
Pseudoschwagerina zone. Sakamotosawa series.