Chapter 8

Cenozoic and Recent Dasycladales

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Abstract

Cenozoic Dasycladales include about 43 genera and 200 species. The number of living genera is reduced to 8, with about 40 species.

Calcification encloses sterile and fertile organs to a varying degree, according to genera, species, and individuals. Consequently, preservation of fossils mainly depends on the extent of the initial calcification around the thallus.

Main characters commonly used to define taxa include the type and the position of the reproductive organs, absence or presence of articulation, and division of branches.

A large number of species, belonging to the genera *Neomeris*, *Cymopolia*, and *Acicularia*, is known in Palaeogene sediments. The richest cenozoic assemblages have been found in Sardinia (Palaeocene) and in the Paris basin (Palaeocene and Eocene).

Living representatives have a discontinuous geographical distribution. They are confined to shallow warm marine or brackish waters.

1 Morphology

The thallus of Cenozoic and living Dasycladales (Table 1) is usually cylindrical or club-shaped, undivided or dichotomously branched. Other species are spherical or appear like a disc at the top of an erect axis. In some genera, the thallus is composed of alternate calcified segments and uncalcified joints. The whole plant is attached to the substrate by means of uncalcified rhizoids that are never preserved in fossils.

Primary branches are arranged in regular whorls along the tubular axis (Figs. 3,10–11). Most Cenozoic and Recent species bear two orders of branches: each primary branch produces one (*Montiella*) to eight (*Bornetella*, *Cymopolia*) second order sterile branches. Dilated tips of primaries (*Zittelina*) or secondaries (*Cymopolia*, *Neomeris*, *Bornetella*) may form a faceted outer surface (Fig. 5). Some genera bear more than two orders of branches, exceptionally seven (Table 2).

In Dasycladaceae, fertile organs are spherical or ovoid vesicles usually located at the top or on the sides of primary sterile branches. They are considered as modified branches, assigned to the reproductive function. Each ampulla contains one to several cysts or produces gametes directly (Table 3).

In Acetabulariaceae, fertile ampullae are elongated and radially arranged in specialized verticils. Many cysts occur inside reproductive chambers (Tables 4–6) (Valet 1969; Tappan 1980).

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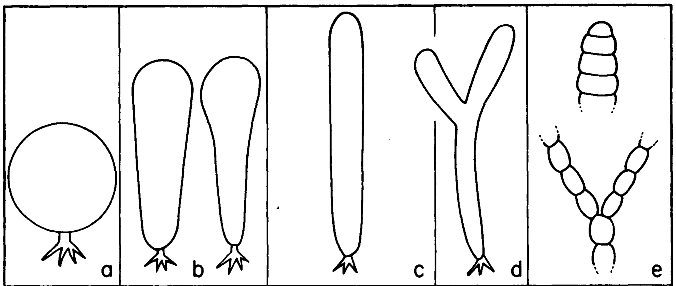
R. Riding (ed.), *Calcareous Algae and Stromatolites*

Table 1. Shape of thallus in Cenozoic and Recent Dasycladaceae



	a	b	c	d	e
	spherical	club - shaped to cylindrical non - divided		divided	articulated
Photographs	Fig.9	Figs.7-8	Figs.1-2		Figs.5-6
GENERA (examples) RECENT	Bornetella		Dasycladus Neomeris	Dasycladus	Cymopolia
GENERA (examples) CENOZOIC		Dactylopora Trinocladus Zittelina	Dissocladella Jodotella Neomeris		Belzungia Broeckella Cymopolia Uteria

Fig. 1. *Neomeris annulata* Dickie, Recent, Rose Island, Bahamas. x7,5. External view of the thallus. **Fig. 2.** *Neomeris fragilis* (Defrance), Lutetian, Grignon, Paris Basin. x35. Transversal section showing axial calcification **Fig. 3.** *Neomeris annulata* Dickie, Recent, Rose Island, Bahamas. x35. Central axis (*right*), primary branches and fertile ampullae (*left*) **Fig. 4.** *Neomeris* sp., Lutetian, Campbon, Brittany. x95. Calcification of fertile ampullae **Fig. 5.** *Cymopolia barbata* (Linné), Recent, Andros Island, Bahamas. x25. Segments of the thallus **Fig. 6.** *Cymopolia* sp., Stampian, Ormoy-la-Rivière, Paris Basin. x40. Isolated segment **Fig. 7.** *Bornetella oligospora* Solms-Laubach, Recent, Cauda, Vietnam. x6. External view of the club-shaped thallus **Fig. 8.** *Dactylopora cylindracea* Lamarck, Auversian, Le Fayel, Paris Basin. x11. External view of the club-shaped thallus **Fig. 9.** *Bornetella sphaerica* (Zanardini), Recent, Oahu, Hawaii. x7. Central axis, branches and fertile ampullae (dry specimen) **Figs. 10–11.** *Neomeris auversiensis* (Morellet), Auversian, Auvers- sur-Oise, Paris Basin. Calcification of the central axis at the top (Fig. 10, x110) and at the base (Fig. 11 x190) of the thallus

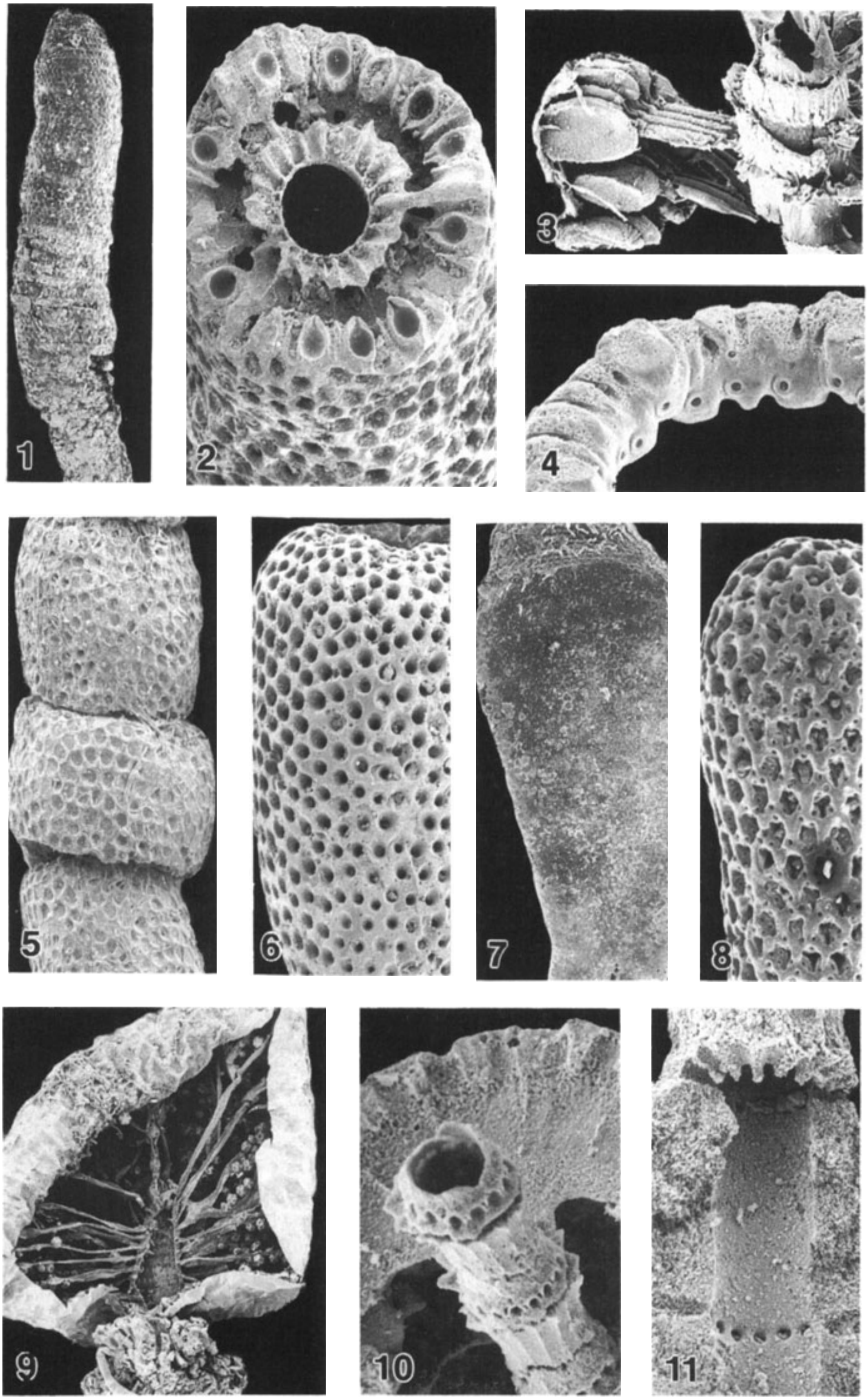

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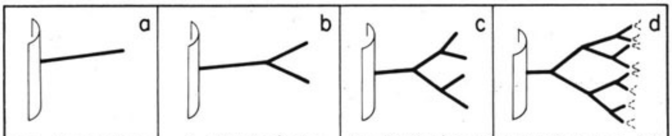
Table 2. Division of branches in Cenozoic and Recent Dasycladaceae



<table>
<tr><td colspan="2"></td><td>a
no division</td><td>b
1 division</td><td>c
2 divisions</td><td>d
more(up to 6)</td></tr>
<tr><td colspan="2">Photographs</td><td>Fig.12</td><td>Figs.13,16,17</td><td></td><td>Fig.14</td></tr>
<tr><td rowspan="3">GENERA (examples)</td><td rowspan="2">RECENT</td><td rowspan="2"></td><td rowspan="2">Bornetella
Cymopolia
Neomeris</td><td colspan="2">Dasycladus</td></tr>
<tr><td></td><td>Batophora</td></tr>
<tr><td>CENOZOIC</td><td>Dactylopora
Zittelina</td><td>Broeckella
Cymopolia
Dissocladella
Jodotella
Neomeris</td><td>Trinocladus</td><td>Belzungia
Thyrsoporella</td></tr>
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Fig. 12. *Zittelina dactyloporoides* (Morellet), Auversian, Baron, Paris Basin. x130. Primary branch **Fig. 13.** *Cymopolia elongata* (Defrance), Lutetian, Coislin, Brittany. x250. Primary and secondary branches **Fig. 14.** *Belzungia terquemi* Morellet, Lutetian, Campbon, Brittany. x220. Numerous divisions of the branches **Fig. 15.** *Bornetella nitida* (Harvey), Recent, Palawan, Philippines. x170. External view of the upper faces of two secondary branches **Fig. 16.** *Cymopolia barbata* (Linné), Recent, Andros Island, Bahamas. x190. Primary branch, secondary branches and fertile ampulla **Fig. 17.** *Cymopolia zitteli* Morellet, Auversian, Le Fayel, Paris Basin. x125. Primary branches, secondary branches and fertile ampullae **Fig. 18.** *Neomeris larvarioides* (Morellet), Lutetian, Le Bois-Gouët, Brittany. x110. Primary branch, secondary branches (partially preserved) and fertile ampulla **Fig. 19.** *Neomeris herouvalensis* Steinmann, Cuisian, Hérouval, Paris Basin. x90. Secondary branches and fertile ampullae (primary branches are not calcified) **Fig. 20.** *Batophora oerstedii* Agardh, Recent, Key West, Florida. x45. Fertile ampulla **Fig. 21.** *Parkerella* sp., Montian, Mons, Belgium. x190. Fertile ampullae arranged in pairs **Fig. 22.** *Carpenterella jonesi* Morellet, Lutetian, Campbon, Brittany. x250. Tuft of fertile ampullae

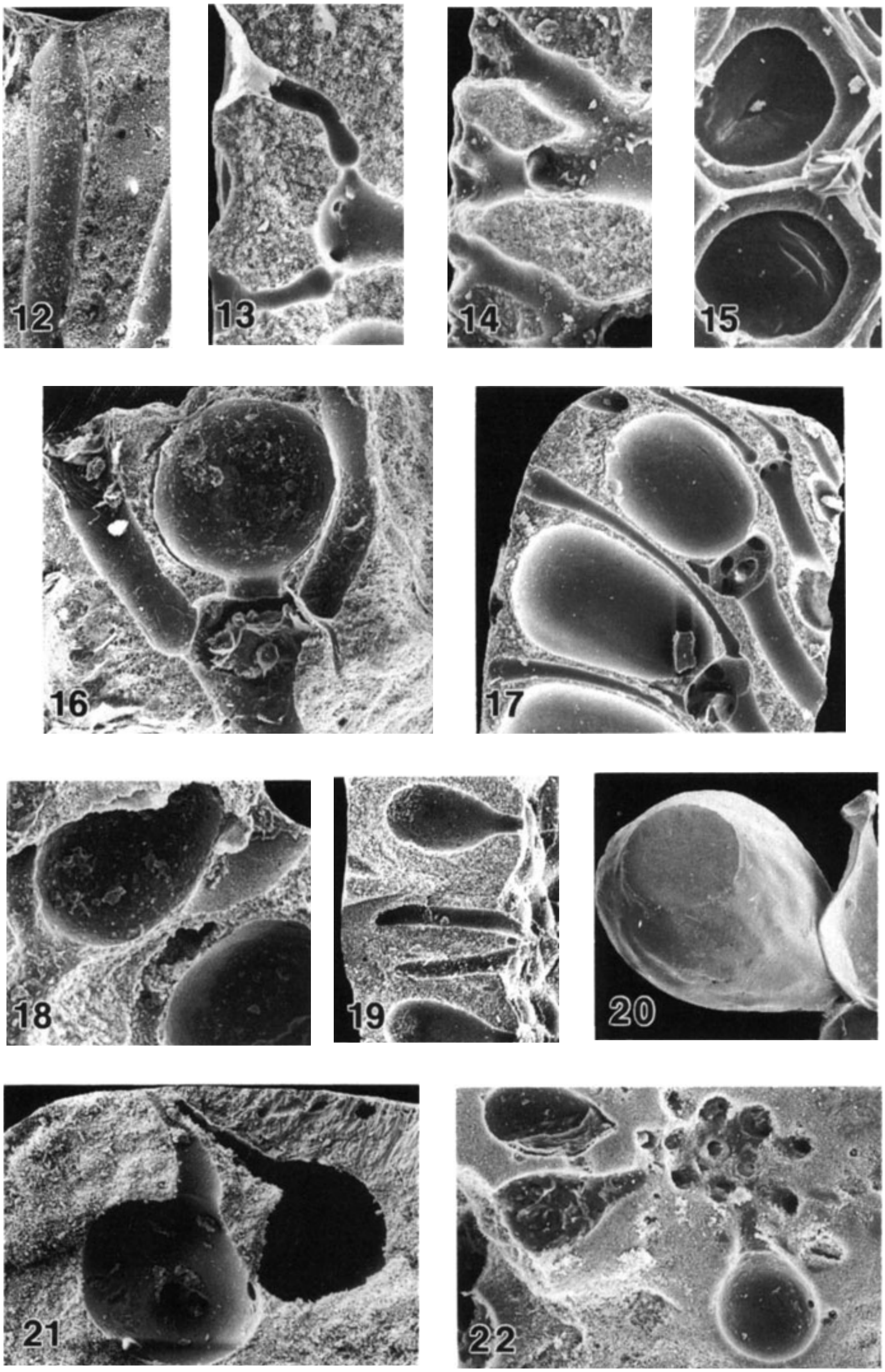
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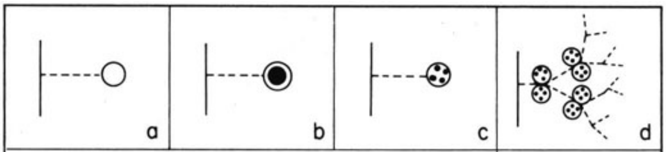
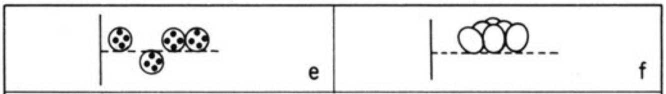
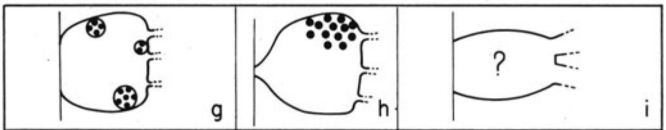
Table 3. Fertile organs in Cenozoic and Recent Dasycladaceae



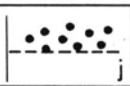
A - Fertile organs at the top of branches	a	b	c	d
	one ampulla on each primary branch — no cyst	one ampulla on each primary branch — one cyst	one ampulla on each primary branch — cysts	numerous ampullae and cysts
Photographs	Figs.16-17	Figs.3,18,19		Fig.20
GENERA — RECENT	Cymopolia Dasycladus	Neomeris (cyst unknown in fossils)	Chlorocladus	Batophora
GENERA — CENOZOIC	Cymopolia Montiella			



B - Fertile organs around the sides of branches	e	f
	Numerous cysts	Tufts of organs without cyst
Photographs	Figs.9,23	Figs.21-22
GENERA — RECENT	Bornetella	
GENERA — CENOZOIC	Zittelina (including Maupasia, Digitella)	Carpenterella, Jodotella Parkerella



C - Fertile organs inside branches	g	h	i
	Ampullae and cysts	Cysts	Non-calcified organs ?
Photographs	Fig.26	Fig.27	Fig.28
CENOZOIC GEN.	Uteria	Broeckella	Thyrsoporella



D - Particular cases	Grouped or scattered cysts around branches (j)	Isolated ampullae (k)
Photographs	Fig.24	Fig.25
CENOZOIC GEN.	Dactylopora	Terquemella Frederica

Fig. 23–32. (see pp 138 for caption)

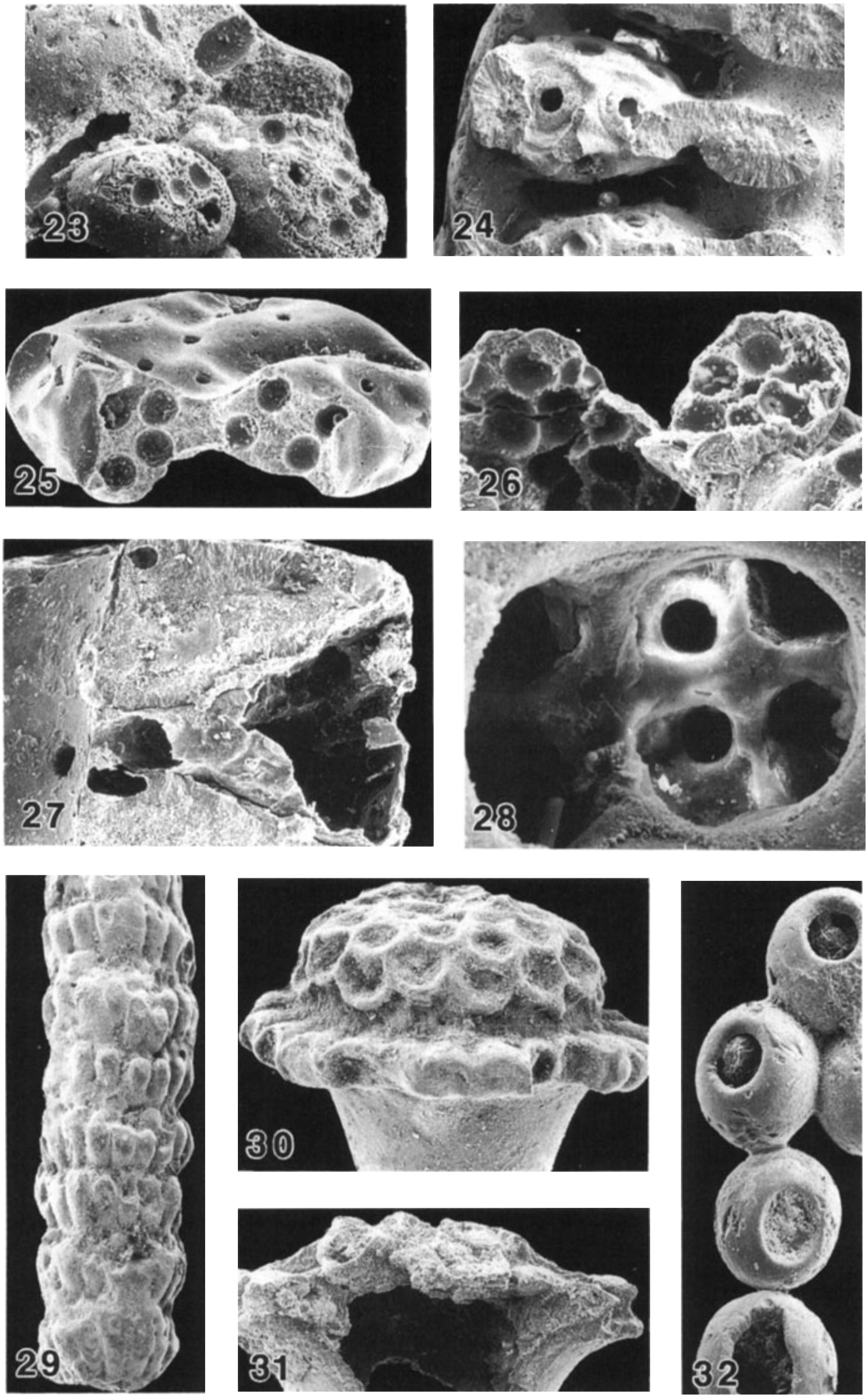

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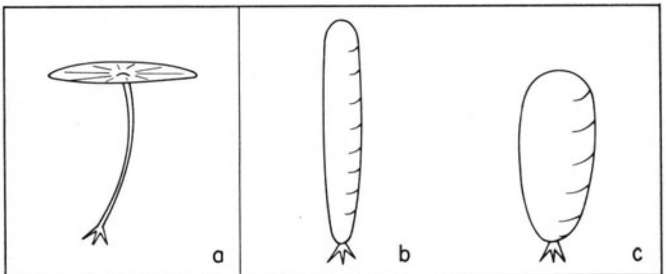
Fig. 23. *Zittelina dactyloporoides* (Morellet), Auversian, Baron, Paris Basin. x115. Fertile ampullae around a primary branch **Fig. 24.** *Dactylopora cylindracea* Lamarck, Auversian, Le Fayel, Paris Basin. x70. Group of cysts inside ovoid area of the wall **Fig. 25.** *Terquemella dissimilis* Morellet, Lutetian, Campbon, Brittany. x100. Section of an isolated fertile ampulla **Fig. 26.** *Uteria brocchii* Morellet, Montian, Mons, Belgium. x165. Section of two fertile ampullae showing the location of cysts **Fig. 27.** *Broeckella belgica* Morellet, Montian, Mons, Belgium. x90. Primary branch and short secondary branches. Cysts are not preserved in this specimen **Fig. 28.** *Thyrsoporella cancellata* Guembel, Lutetian, Fercourt, Paris Basin. x250. Division of branches inside the wall. Very wide primary branch **Fig. 29.** *Clypeina digitata* (Parker and Jones), Lutetian, Montjavoult, Paris Basin. x12. Exceptionally preserved specimen with numerous fertile verticils **Fig. 30.** *Clypeina* sp., Lutetian, Montjavoult, Paris Basin. x45. Terminal verticil **Fig. 31.** *Clypeina* sp., Lutetian, Chambors, Paris Basin. x50. Section of a terminal verticil **Fig. 32.** *Halicoryne morelleti* (Pokorny), Sarmatian, Podivin, Czechoslovakia. x70. Group of calcified cysts

Table 4. Shape of thallus in Cenozoic and Recent Acetabulariaceae



	umbrella-shaped	cylindrical to ovoid	
Photographs	Figs.33,40	Fig.29	
GENERA RECENT	Acetabularia	Halicoryne	
GENERA CENOZOIC	Acicularia Orioporella	Clypeina Halicoryne	Rostroporella

Table 5. Position of verticils in Cenozoic and Recent Acetabulariaceae

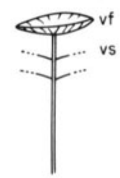
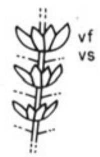
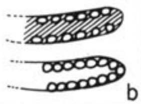
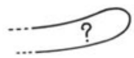
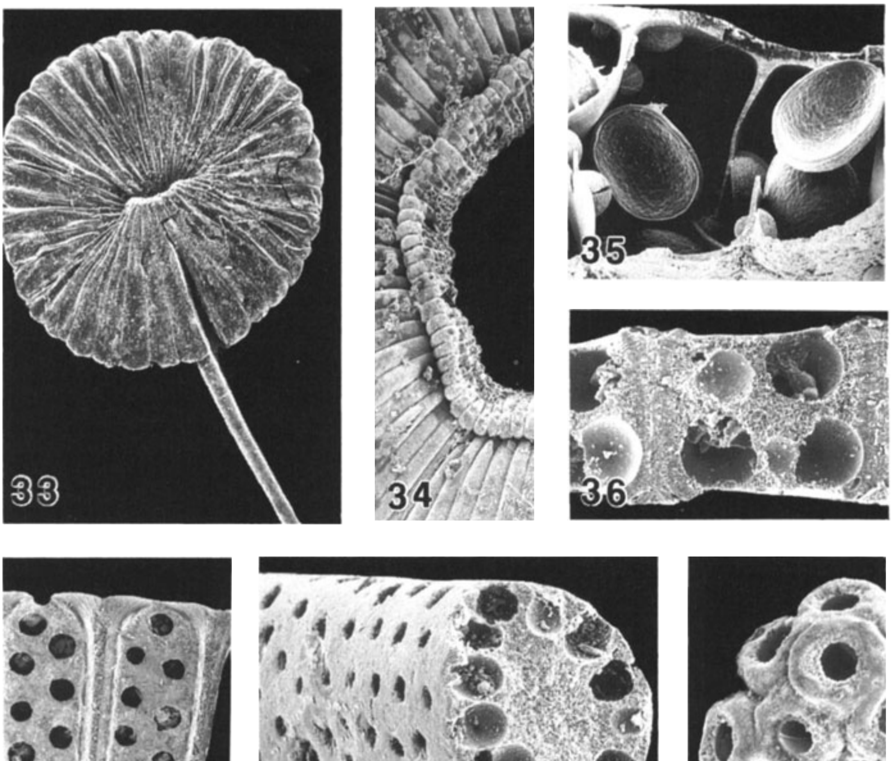
	Fertile (vf) and sterile (vs) verticils			Fertile verticils only known
	non alternate		alternate	
	Fertile verticil at the top	Fertile verticils along the axis		
	 a	 b	 c	 d
Photographs	Fig.33	Fig.29		Figs.37,40
GENERA — RECENT	Acetabularia		Halicoryne	
GENERA — CENOZOIC	(Acicularia) ?	Clypeina Rostroporella		Acicularia Orioporella

Table 6. Fertile organs in Cenozoic and Recent Acetabulariaceae

	 a	 b	 c	 d
	Ampullae and cysts			Ampullae without cysts (non-calcified cysts ?)
	Non - calcified	Calcified cysts strongly	partially	
Photographs	Fig.35	Figs.32,36,39	Figs.42,43	Fig.31
RECENT	Acetabularia			
CENOZOIC		Halicoryne Acicularia	Orioporella	Clypeina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When fertile organs are unknown in fossils, thick primary branches are usually presumed to be reproductive structures.

In some particular cases the calcified wall may contain groups of cysts or scattered cysts along the branches (Table 3D).

2 Calcification

Aragonitic calcification covers the outer layer of the organs. In fossil species, aragonite may be diagenetically replaced by calcite.

Calcification encloses organs to a varying degree; for example, in *Neomeris*, calcium carbonate impregnates different parts of the plant (Figs. 2–4, 10–11): almost the entire thallus in *N. larvarioides*, only reproductive organs in *N. pseudo-eruca* (Génot 1987).

Some living Dasycladales are never calcified (*Batophora*).

3 Definition of Taxa

The main characters commonly used to define Cenozoic and Recent subfamilies, tribes, and genera are: type of reproductive organs (single or clustered ampullae without cysts, or containing one or several cysts); position of reproductive organs; type of thallus (absence or presence of articulation); division of branches. Taxonomic importance of the shape of the thallus and aspect of the outer surface is variable according to authors (specific or generic level).

4 Stratigraphical and Geographical Distributions

A few genera that arose during the Mesozoic (*Acicularia*, *Acroporella*, *Clypeina*, *Cymopolia*, *Dissocladella*, *Neomeris*, *Praturlonella*, *Trinocladus* and *Triploporella*) have Cenozoic representatives. Two of them are known in present seas:

Fig. 33. *Acetabularia crenulata* Lamouroux, Recent, Barranquilla, Colombia. x6. Axis and reproductive cap **Figs. 34–35.** *Acetabularia acetabulum* (Lamouroux), Mediterranean coast, France. Upper corona in the central part of the cap (Fig. 34, x40) and internal view of two rays showing the cysts (Fig. 35, x140) **Fig. 36.** *Acicularia munieri* Morellet, Lutetian, Grignon, Paris Basin. Internal view of a ray showing the location of the cysts **Fig. 37.** *Acicularia* cf. *munieri* Morellet, Lutetian, Villiers-Saint-Frédéric, Paris Basin. x50. External view of two rays **Fig. 38.** *Acicularia pavantina* d'Archiac, Auversian, Le Guépelle, Paris Basin. x90. Transverse section of a ray showing the location of cysts **Fig. 39.** *Acetabularia schenckii* Moebius, Recent, Key Largo, Florida. x130. Group of calcified cysts **Figs. 40–42.** *Orioporella villattae* Segonzac, Thanetian, Carla-de-Roquefort, Pyrenees. External view of a reproductive cap (Fig. 40, x13,5). Longitudinal section (Fig. 41, x22,5). Transverse sections of two rays (Fig. 42, x32,5). **Fig. 43.** *Orioporella bonieri* Morellet, Montian, Mons, Belgium. x580. Detail of the internal view of a ray showing the location of a cyst

Cymopolia and *Neomeris*. About 25 genera are restricted to the Cenozoic, each one including very few species (Deloffre and Génot 1982).

Acicularia, *Cymopolia* and *Neomeris* have the most numerous species, particularly during Palaeocene and Middle Eocene (Tables 7–8).

The number of species greatly decreases after the Eocene. Some genera are short-lived, such as *Broeckella*, which is widespread in the Tethyan Palaeocene.

Richest Cenozoic assemblages (Table 9) have been discovered in the Palaeocene of Belgium (Mons basin), France (Aquitaine – Pyrenees area and Paris basin), Italy (Sardinia), USSR (Ukraine), Yugoslavia (Slovenia), Czechoslovakia (Carpathian Mountains), Middle East (Iraq, Iran) and China (Tibet), in the Eocene of France (Paris basin, Brittany, Cotentin), southern England (Sussex), Hungary and China (Xizang), and in the Miocene of Romania and Poland.

Only eight genera are living in modern oceans and seas, including about 40 species, mainly of *Neomeris* and *Acetabularia* (Table 7). They have a discontinuous geographical distribution in the Indo-Pacific, Atlantic (tropical America and West Indies) and Mediterranean areas.

5 Environmental Distribution

Most living Dasycladales are growing in tropical and subtropical marine waters. Few species occur in warm-temperate seas (Valet 1979). They are confined to shallow environments, usually less than 5 metres depth. Maximum abundances occur in quiet areas sheltered from wave action. Individuals are attached to rocks, small stones, shell or coral fragments, mangrove roots, etc. Some species, such as *Halicoryne spicata* and *Acetabularia mediterranea*, tolerate substantial salinity fluctuations. *Batophora oerstedii* is found in marine and brackish environments, even sometimes in freshwater.

Ecological requirements of Cenozoic Dasycladales seem to be the same as those of living representatives (Elliott 1984). Richest assemblages have been found in sediments and with other organisms that suggest shallow warm marine environments: lagoonal waters behind reefs, coastal bays, etc. [Palaeocene-Lower Eocene of the Middle-East; Lutetian of the Paris basin (Génot 1987); Palaeocene of Sardinia (Dieni et al. 1985)]. No fossil species is known in freshwater deposits.

Table 7. Proportional representation of species number in Cenozoic and Recent Dasycladales genera

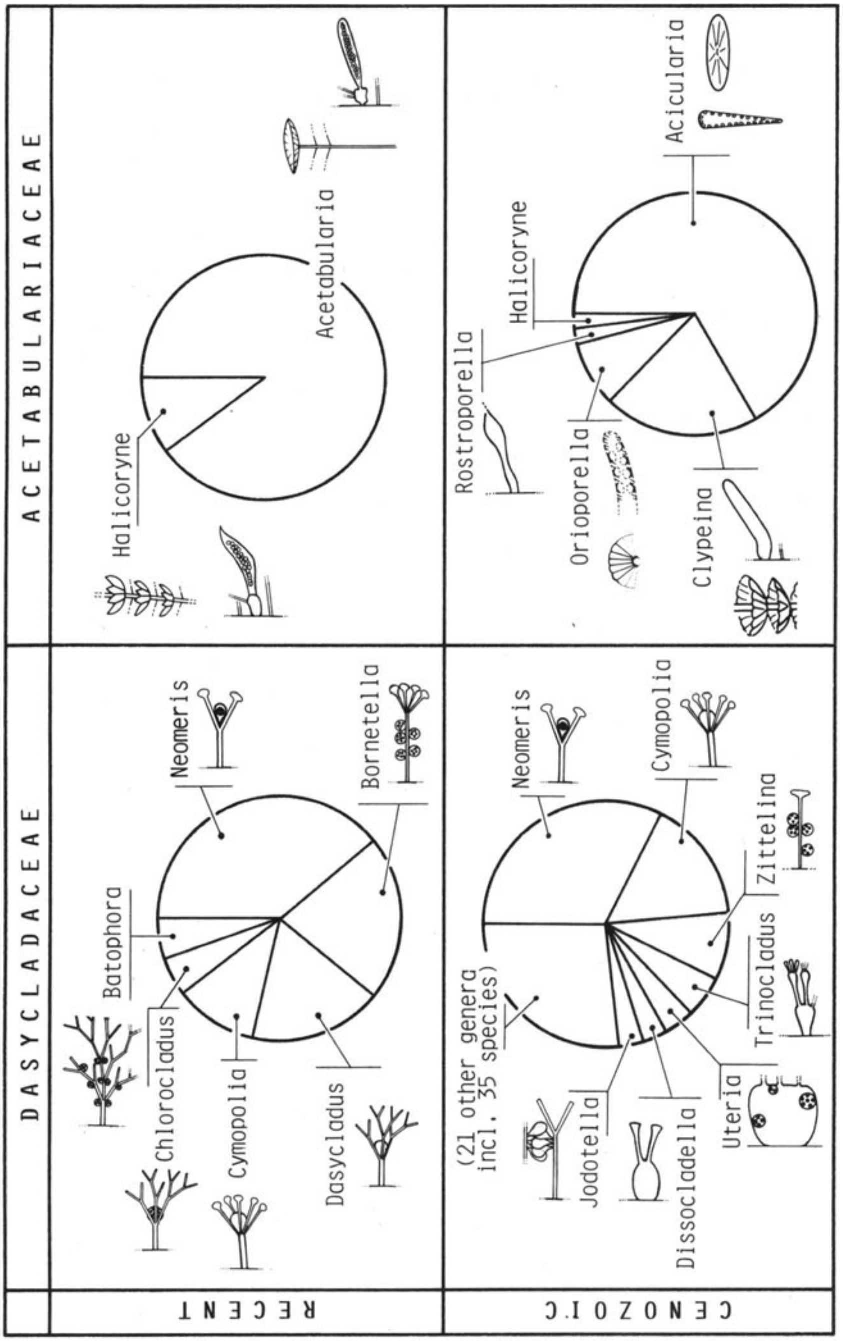

Table 8. Main Dasycladales genera: evolution of the number of species during the Cenozoïc

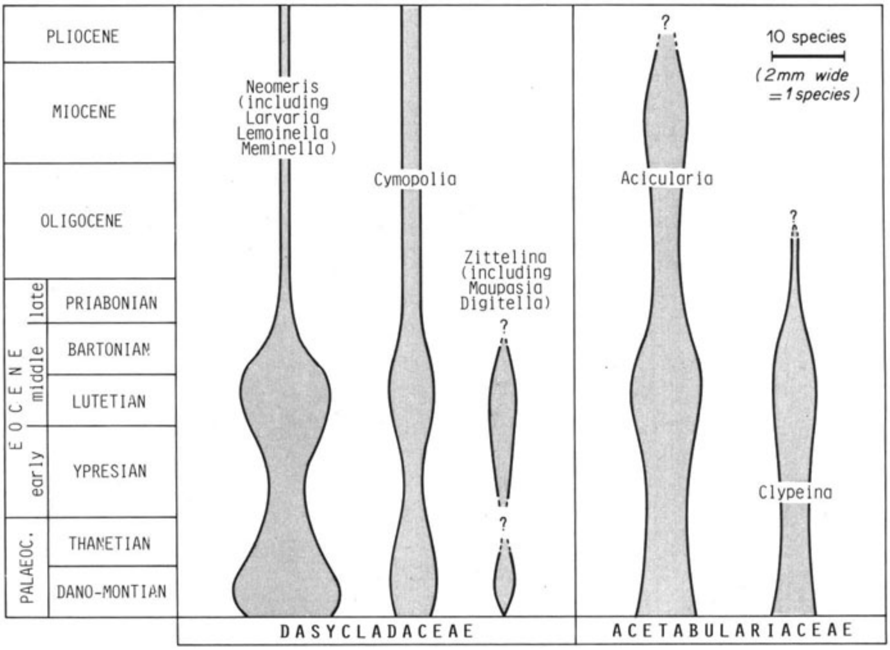

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Table 9. Dasycladales: main discoveries of Palaeogene species in the world