4.7 Minor genera

Nitzschia and Hantzschia are by far the largest genera within the Nitzschiaceae. Several other genera have been described, however, and while these have not often been encountered during the present study (except for species of Bacillaria and Cylindrotheca, which have been found quite often), it is obviously necessary to review them if this study of the Nitzschiaceae is even to approach comprehensiveness.

4.7.1 Allonitzschia

This genus was erected by A.Mann (1925) for a single species, A. munifica. Mann observed only one specimen of this, a complete frustule, and so far as I am aware this represents the only record of the genus. The frustule found was hantzschioid: judging from the asymmetry of the valve about the apical plane, it would appear that A. munifica is always so.

The valve construction seems to be like that of H. amphioxys, H. virgata, H. segmentalis, etc. (see also Nitzschia type 1). The raphe is apparently uninterrupted centrally, and there is no indication that the raphe system is biarcuate. The fibulae are prominent, and seem to represent single subraphe costae.

According to Mann, the margin of the 'ventral side' (i.e. the proximal margin) of the valve is 'gently undulate, the undulations corresponding to barely perceptible elevations and depressions or waves of the valve surface running across the valve and corresponding in number to the polygonal divisions of the dorsal border.' Undulate valve surfaces are rare in the Nitzschiaceae (but see N. spathulifera, sect. Insignes, and Cymatonitzschia), and so this would be a most interesting feature of the genus, if Mann's observations are confirmed.

On the whole, A. munifica seems to be close to some species of Hantzschia, especially H. segmentalis, and it is possible that further

examination will prove that these two genera should be combined.

The 'striking row of polygonal divisions' noted by Mann is probably an optical effect caused by a fairly abrupt fold of the valve near the distal fibula bases.

4.7.2 Bacillaria

Bacillaria was the first diatom genus to be recognized and dates from 1788, when it was established by Gmelin: the type species was described even earlier, by O.F.Müller (1786). As Hendey (1937) pointed out, the correct epithet for this species is 'paxillifer', this being the name given by Müller (as 'Vibrio paxillifer'). Frequently, however, Gmelin's name, viz. 'Bacillaria paradoxa', has been used, sometimes in open and deliberate contravention of the I.C.B.N., e.g. see Simonsen (1974) - 'it is unfortunate that the I.C.B.N. does not provide nomina conservanda on the species level ... In spite of this ... I have chosen to prefer the usage of the combination Bacillaria paradoxa and to consider the epithet "paxillifer" as nomen oblitum.'

The feature which distinguishes the members of this genus and made B. paxillifer particularly obvious to the early microscopists, such as those mentioned above, is the ability to form a unique type of colony, in which all the cells are fully motile, yet remain attached one to the next (see section 4.4). Bacillaria cells, unlike Pseudo-nitzschia or Fragilariopsis cells, seem to be structurally adapted to their colonial existence. One side of the raphe-sternum bears a ridge (F.986, 988), hook-shaped in section, and Drum & Pankratz (1965), who were the first to observe these ridges, suggested that in vivo 'the siliceous extensions from raphes of adjacent cells are interlocked, holding the cells together, so that they remain joined during movement' (see their T.97-98). That these ridges are related to the ability of Bacillaria cells to form their characteristic colony type is suggested

by the fact that they are not to be found in any species of Nitzschia or Hantzschia, where any outward extensions of the raphe-sternum occur on both sides of the raphe (e.g. see Nitzschia sigmoidea, sect. Nitzschia).

In neither of the species studied with the SEM during this investigation, viz. B. linkei (Hustedt) comb. nov. (= N. linkei, see sect. Dissipatae) and Bacillaria sp., were central raphe endings present. In B. linkei (see sect. Dissipatae for details of sample sites) the internal fissure ends at the poles in simple helictoglossae (F.991, unpubl. obs.), while externally there is a very short, hooked terminal fissure (F.989). In the Bacillaria sp., found in a sample from fish-ponds at Eilat, Israel, the external fissure branches above the helictoglossa so that its terminal portion is 'T' shaped (F.988). In both species the ridges noted above end a short distance from the polar raphe endings.

The valve construction in Bacillaria is very like that of Nitzschia. In B. linkei the transapical costae are separated, one from the next, by single rows of poroids (F.989-91), while in Bacillaria sp. adjacent costae are separated by what may be regarded either as a single row of poroids each of which is bisected by a transapically aligned bar of silica, or possibly as a double row of poroids (F.565, 986-7). In both species the poroids are closed by hymena, in which the pores are in hexagonal array (F.565-6).

There is a well-defined subraphe canal, whose walls are porose (F.986-7, 990, unpubl. obs.). Both the distal and proximal fibula bases are joined by longitudinal ridges (F.987, 990), and the fibulae, which are slender structures resembling those in H. virgata vars. gracilis and intermedia, bear no exact spatial relationship to the transapical costae. The raphe system is central (F.986, 990).

B. paxillifer and B. linkei have the same chromatophore arrangement as in the majority of Nitzschia species (unpubl. obs.), i.e.

two chromatophores disposed ± symmetrically, one on each side of the median transapical plane.

There are some characters, e.g. the particular morphology of the raphe-sternum, short terminal fissure, type of colony formed, which support the separation of Bacillaria from other genera of the Nitzschiaceae. Nevertheless, it is questionable whether these are sufficient for generic status, and the valve, raphe and subraphe structure indicate that Bacillaria is very closely allied to Nitzschia. There are many practical reasons why these genera should not be combined (e.g. all Nitzschia species would have to become Bacillaria species, since Bacillaria, dating from 1788, would take precedence over Nitzschia, 1845), but perhaps these ought not to be taken into account in the development of a natural classification.

4.7.3 Cylindrotheca

In a review of the genus Cylindrotheca Reimann & Lewin (1964) referred four species to it, namely the type species Cyl. gracilis, Cyl. closterium, Cyl. fusiformis and Cyl. signata. Reimann & Lewin's conclusions concerning Cyl. closterium have not been accepted by many other diatomists (e.g. Prof.G.R.Hasle, pers. comm.), who consider that this species belongs in Nitzschia, where it was placed before 1964 (e.g. see Hustedt 1930).

Reimann & Lewin (1964) listed several characters - 'the cylindrical shape of the cell body, the structure of the canal raphe, and the large number and arrangement of the girdle bands' - by which Cylindrotheca may be differentiated from 'typical species in the genus Nitzschia.' Hasle (1964) claimed, however, that N. longissima also has a cylindrical cell body, and that N. lecointei has many bands, and so she preferred to retain Cyl. closterium in Nitzschia 'because of its close similarity to other species in the group Nitzschiella in shape

and in structure of the valve and canal raphe.' It is clear from the present study, however, that N. longissima is ± rectangular in section (F.955, unpubl. obs.), while neither Hasle's text, nor her illustrations (1964, Pl.4 f.5) give much indication of the extent or nature of the cincture in N. lecointei.

It should be pointed out that the characters listed by Reimann & Lewin as being diagnostic comprise only those possessed by all Cylindrotheca species, but not by any typical Nitzschiae. This does not mean, however, that these are the only characters which may be used to separate these genera. As noted elsewhere (e.g. see Nitzschia sect. Fragilariopsis), if diatom taxonomy is allowed to operate on a polythetic basis, then other characters may be brought into the diagnosis of Cylindrotheca, even though these characters may not be shared by all its species. Thus, for instance, in this genus there is a tendency for the frustule to be only very lightly silicified, and for it to be twisted about the apical axis. The valve is usually much reduced, sometimes (Cyl. signata) being represented by the raphe system alone. There is no rigid alternation of costae and striae as in most Nitzschia species, and no sign of hymena; in Cyl. closterium Hasle (1964) noted some forms with more heavily silicified valves in which costae and poroids may perhaps be distinguished (her Pl.9 f.6), but even here the valve construction is far from similar to that of any other member of the Nitzschiaceae. The fibulae of Cylindrotheca species are slender, arcuate ribs; they are widely spaced and entirely separate from each other, and are unrelated spatially to any thickenings of the valve face (where this is present). There are few species in Nitzschia, Hantzschia, etc., where such a subraphe construction is to be found, and where it is (e.g. N. vulpeculoides, sect. Dubiae) other characters ensure that a close relationship cannot be thought likely. Some forms (e.g. Cyl. closterium) have two chromatophores, arranged as in the majority of Nitzschiae, while others have 4, 8 or 16 ± discoid chromato-

phores (F.336, unpubl. obs., and see Reimann & Lewin 1964).

In view of the doubts raised by Hasle and others about the circumscription of Cylindrotheca proposed by Reimann & Lewin, it will be necessary to undertake further studies of this genus, but there seems little reason to expect that the outcome of these will be other than to confirm Reimann & Lewin's views.

4.7.4 Cymatonitzschia

The erection of Cymatonitzschia by Simonsen (1974) marked the most recent addition to the genera included within the Nitzschiaceae. The two species of this genus, Cym. marina and Cym. shulzei, are to be distinguished from other members of the family by their possession of an undulate valve face, and by the 'irregularly limited areolae or puncta with no particular order in the arrangement' (Simonsen 1974). Simonsen noted further that 'the areolation is limited to the "valleys" of the valves so that an areolated depressed transapical zone alternates with an elevated hyaline zone.' It is not proven, however, that the 'puncta' visible in the troughs represent holes through the valve since it is quite possible that they are artefactual - that the areolae are too small or obscure to be resolved with the light microscope, and that the 'puncta' in fact represent groups of poroids or other structures. Such an optical effect may be observed in N. tryblionella or N. circumsuta (Nitzschia sect. Tryblionella), if a lens of insufficiently high aperture is used to study the areolation. This contention is supported by Simonsen's finding that the distal mantle, when seen in section, is finely striated (his 'fluting', Pl.41 f.6), suggesting that there are transapical striae as in other members of the Nitzschiaceae. Simonsen's micrograph of a frustule lying in girdle view (his Pl.41 f.9) suggests that the valve is quite thick (cf. N. tryblionella), and also shows that each trough on one valve is opposite a trough on the other.

The raphe system is strongly eccentric. The fibulae would appear to be long, plate-like structures, rather like those of Nitzschia sp.C (Eilat)(see sect. Nitzschiella), separated by oval portulae. The central portula seems to be slightly larger than the others, suggesting perhaps that central raphe endings are present.

The valve morphology would seem to separate Cymatonitzschia from the remainder of the Nitzschiaceae, but clearly much further study is necessary before its affinities can be determined fully. As Simonsen (1974) has pointed out, the taxonomic position of Cymatonitzschia marina has caused many difficulties in the past, with authors referring it variously to Cymatopleura, Fragilaria, Denticula or Nitzschia. Simonsen's claim that 'Cymatopleura is ... the last genus which can be thought of in this connection', based on the fact that Cymatopleura species have a raphe system which occupies the whole perimeter of the valve face, not half of it as in Cymatonitzschia or in the Nitzschiaceae in general, is premature. What if Cymatonitzschia were found to agree with Cymatopleura in all other characters save raphe structure? Would it still be unthinkable to place these two genera close together? In fact, the subraphe structure of Cymatopleura seems to be quite different from that of Cymatonitzschia (unpubl. obs.), but until detailed studies can be made of both genera it would be best to avoid a priore assumptions such as that made by Simonsen. Such assumptions are illustrative of the 'monothetic philosophy' and weighting of characters of traditional diatom taxonomy.

4.7.5 Cymbellonitzschia

This genus appears to be a heterogeneous group. The first species to be described, C. minima (by Hustedt, in A.Schmidt Atlas, T.352), is a small diatom with valves which are asymmetrical about the apical plane such that each valve has one virtually straight and one strongly convex margin. All the Cymbellonitzschia species are hantzschioid in

frustule symmetry, but while C. minima is raphid on the convex, or 'dorsal' side of the frustule, the other two species, C. hossamedinii (Salah 1955) and C. diluviana (see Foged 1960), are raphid on the 'ventral' side (F.410).

The valves appear to be very similar, in valve, raphe and subraphe structure, to those of Nitzschia sect. Lanceolatae, from which they differ ?only in the shape and symmetry of the frustule. There seems little reason to think that C. minima is any more closely related to C. hossamedinii or C. diluviana than any of these is to Nitzschia. Again, however, further study is required.

4.7.6 Chuniella and Clavularia

Chuniella was first described by Karsten (1905-7) in his report on the antarctic phytoplankton collected by the 'Valdivia' Expedition. In his diagnosis of the genus Karsten noted that its members possess 'canal raphes', decussate striae, and many 'bandförmige' chromatophores per cell. It is not clear ,however, what the distinction between Chuniella and Nitzschia is: as Karsten said 'Die Grenze gegen das Genus Nitzschia selber ist nun schwierig zu ziehen, und es wird die eine oder andere Form vielleicht einmal mit ebensoviel Recht dem Genus Nitzschia einverleibt werden.'

Since Karsten's time Chuniella species have been reported only rarely (e.g. by Hendey 1937), and the whole genus requires much study, when material again becomes available.

Clavularia is another virtually unknown genus, placed in the Nitzschiaceae by Karsten (1928). Karsten's reasons for this classification remain obscure and cannot be deduced from his text, nor from the illustrations given, unless he thought that the small knobs present in a single row along the valve represent fibulae: it is clear from the illustration, however (op. cit., f.405B), that these knobs

project outwards, not inwards. There seems no good reason for classifying Clavularia in the Nitzschiaceae.

4.7.7 Gomphonitzschia

As the Cymbellonitzschia species were separated from Nitzschia on the basis that their valves are asymmetrical about the apical plane and superficially resemble those of Cymbella, so the species of Gomphonitzschia are to be distinguished by their resemblance to Gomphonema spp., their valves being asymmetrical about the median transapical plane. Gomphonitzschia was established in 1870 by Grunow, who at that time included one species within it, namely G. ungeriana (often called 'G. ungeri', even by Grunow himself, e.g. in Grunow 1880). Since then five other species have been added, namely G. clevei, G. saigoni, G. indica, G. exigua and G. agma.

G. clevei and G. saigoni appear to be closely related, both being large forms with similar valve and subraphe constructions (Grunow 1880, Meister 1932). In both, the valves are crossed by many prominent bars, much as in Nitzschia ventricosa or N. epithemioides (sects. Nitzschiella and Epithemioides). Hustedt (1929) stated that in G. clevei several striae can be seen between each pair of the 'Rippen', and it is quite likely that the valve construction is similar to that in the majority of Nitzschia, Hantzschia and Bacillaria (see Nitzschia type 1, section 4.6.2). The raphe system is somewhat eccentric (G. clevei) or near central (G. saigoni). The raphe is interrupted at a point nearer the wider than the narrower pole (Hustedt 1929, Meister 1932; cf. Gomphonema, see Hustedt 1930). In G. saigoni certain of the transapical 'Rippen' continue under the raphe, and this is probably true also of G. clevei: the fibulae, then, are extended across the whole, or at least half of the width of the valve.

The resemblance of these two species to N. ventricosa is quite marked, and it will be interesting to see whether electron microscopic

studies confirm a close relationship between these taxa.

Within the sample (from Oahu, Hawaii) in which N. ventricosa was found there were also other 'Nitzschia' forms with valve and raphe structure like that of N. ventricosa or G. clevei/G. saigoni. Some of these forms were isopolar, others heteropolar as in Gomphonitzschia, but all had the same fibula and stria densities, and identical valve and subraphe structure (F.985). These findings have not yet been analysed in detail, but they suggest that the relationship between Nitzschia and Gomphonitzschia may be very close, or even that the G. clevei/G. saigoni group may belong in Nitzschia itself.

The other Gomphonitzschia species seem to resemble another group within Nitzschia, namely the sect. Lanceolatae. G. exigua, in particular, is like a heteropolar member of that section (see Sovereign 1958, Pl.4 f.41-42). In these species the raphe system is strongly eccentric, and the fibulae are small. Except for the heteropolarity of the cell, they little resemble G. clevei or G. saigoni. The similarity of this group to Nitzschia sect. Lanceolatae may be deceptive, however, and again EM studies will be necessary if further progress is to be made in the elucidation of taxonomic relationships. It may be relevant that several Nitzschia species belonging to the sect. Lanceolatae form stellate colonies (see section 4.4), which are, perhaps, only a short step from the stipitate colonies formed by G. ungeriana (Grunow 1870).

In conclusion, I would suggest that Gomphonitzschia is a heterogeneous genus which upon further investigation will prove to consist of two entirely separate groupings.

4.7.8. Pseudoeunotia

This genus is undoubtedly very close to Nitzschia sect. Fragilariopsis, from which it differs mainly in that the frustules are asymmetrical about the apical plane (see Hustedt 1958, Hasle 1972b).

This difference is probably insufficient to justify separation at generic level. It too forms band-shaped colonies (Cupp 1943).