A contribution to the floral anatomy of *Leptospermum laevigatum*

C.T. Johnson

University of Transkei, Umtata, Transkei

. description of the floral parts is given. The anther is
haracterized by a prominent oil gland at the tip of the con-
ective. The structure of the seed coat of the fertile and sterile
eed differs. Most of the integumental tissue is destroyed
uring development and only the epidermis of the inner and
uter integuments develops into the seed coat. A brief descrip-
on of the vascularization of the flower and its floral ontogeny
; also given.
. *Afr. J. Bot.* 1983, 2: 202 – 208

ı Beskrywing van die blomdele word gegee. Die helmknop
·ord gekenmerk deur die prominente olieklier op die punt van
ie helmbindsel. Die saadhuid van die vrugbare en steriele
aadknop verskil. Slegs die epidermis van die buitenste en bin-
este integumente bly in die saadhuid behoue. 'n Kort
eskrywing van die bearing van die blom en sy ontogenie word
ok gegee.
-*Afr. Tydskr. Plantk.* 1983, 2: 202 – 208

T. Johnson

iiversity of Transkei, Private Bag X 5092,
ntata, Transkei

Introduction

Although the general morphology of the Myrtaceae has been
investigated repeatedly and reported in many taxonomic
publications, detailed studies of the internal structure and
ontogeny of the flower of the genus *Leptospermum* do not
exist.

The last reasonably comprehensive account of the floral
morphology of *Leptospermum* was by Bentham (1866). A
publication by Erdtman (1971) contains data on pollen
morphology.

Material and Methods

Material of *Leptospermum laevigatum* (Soland. ex Gaertn.)
F. Muell was collected from introduced but naturalized
plants from various localities in the South Western Cape.
Voucher specimens have been deposited in the herbarium
of the University of the Western Cape.

Mature and developing flowers were fixed in F.A.A.
(Johansen 1940). Material for histological examination was
dehydrated in a tertiary butyl alcohol series (Johansen 1940)
and embedded in paraplast with a melting point of 60 °C.
Floral buds were sectioned serially at $15 - 24 \mu$m and stained
with Astra blue and Safranin. Photomicrographs were made
with a Wild stereomicroscope and Leitz photomicroscope
using 35 mm Panatomic X film.

Observations

Floral morphology

Inflorescence. Although the flowers are solitary, one occa-
sionally finds a cyme. The flower, although described as
sessile or nearly so (Bentham 1866), has a pedicel of $2 - 3$
mm. Each flower is subtended by bracts which imbricate
and bracteoles which cohere. Both bracts and bracteoles are
deciduous.

Perianth. Each flower has five free sepals and five free petals
which imbricate in the bud. The calyx, while in the bud
stage, is pubescent, but is glabrous at a later stage. The
sepals and petals are inserted on the outside of the circular
hypanthium ledge.

Stamens. Numerous stamens are free and inserted in a single
row on the inside of the hypanthium ledge (Figure 12f). An-
thers are dorsifixed but versatile with four microsporangia
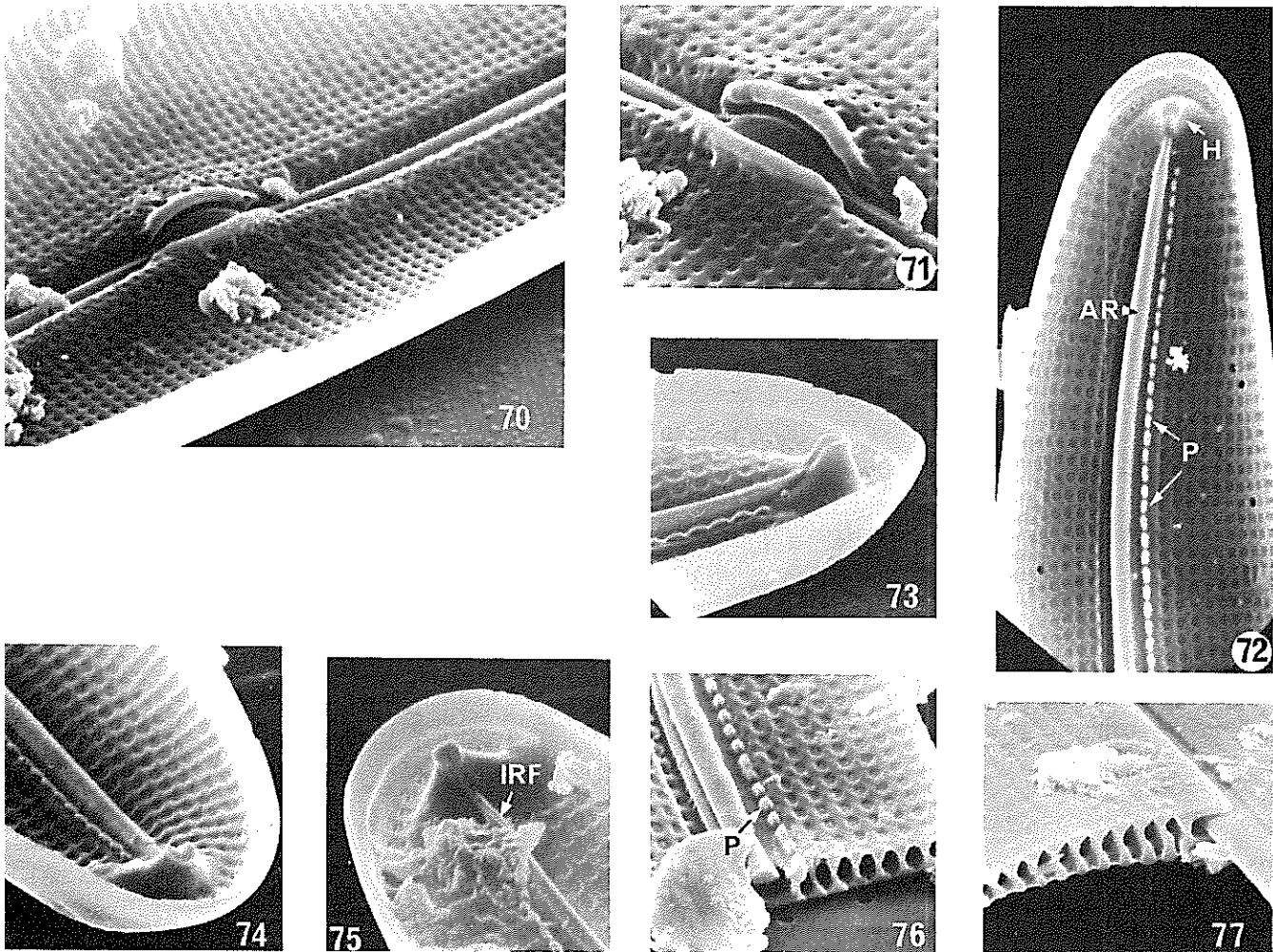which dehisce longitudinally.

A single prominent oil gland occurs at the tip of the con-
nective (Figure 1h). In surface view, the epidermal cells
overlying the gland appear as a disc between the two an-
ther lobes. These epidermal cells are large, polygonal and

Nova Hedwigia Suppl. 64: 193 – 206.

EHRLICH, A. 1973. Quaternary diatoms of the Hula Basin (Northern Israel). *Geol. Survey Israel, Bull.* 58: 1 – 39.

GEISSLER, U., GERLOFF, J., HELMCKE, J.-G., KRIEGER, W. & REIMANN, B. 1963. In: Helmcke, J.-G. & Krieger, W. 1953-, Diatomeenschalen im elektronenmikroskopischen Bild, Part 4, plates 301 – 413. J. Cramer, Weinheim.

GERLOFF, J., NATOUR, R.M. & RIVERA, P. 1978. Diatoms from Jordan. *Willdenowia* 8: 261 – 316.

HUSTEDT, F. 1922. Bacillariales aus Innerasien. In: Southern Tibet, ed. Hedin, S., Vol. 6(3), Botany: 107 – 152, plates 9, 10. Lithographic Institute of the General Staff of the Swedish Army, Stockholm.

HUSTEDT, F. 1930. Bacillariophyta (Diatomeae). In: Die Süsswasser - Flora Mitteleuropas, ed. Pascher, A., Part 10. G. Fischer, Jena, 466 pp.

HUSTEDT, F. 1931 – 59. Die Kieselalgen. In: Kryptogamen - Flora von Deutschland, Österreich und der Schweiz, ed. Rabenhorst, L., Vol. 7, Part 2, 845 pp. Akademische Verlagsgesellschaft Geest & Portig K.-G., Leipzig.

HUSTEDT, F. 1937 – 38. Systematische und ökologische Untersuchungen über die Diatomeen-Flora von Java, Bali und Sumatra. Systematische Teil. *Arch. Hydrobiol.* Suppl. 15: 131 – 177, 187 – 295, 393 – 506.

HUSTEDT, F. 1949. Diatomeen von der Sinai-Halbinsel und aus dem Libanon - Gebiet. *Hydrobiologia* 2: 24 – 55.

HUSTEDT, F. 1955. Neue und wenig bekannte Diatomeen 8. *Abh. naturw. Ver. Bremen* 34: 47 – 68.

JACKSON, D.C. & LOWE R.L. 1978. Valve ultrastructure of species of the diatom genera *Gyrosigma* and *Pleurosigma* from the Portage River drainage system, Ohio. *Trans. Am. microsc. Soc.* 97: 569 – 581.

KRAMMER, K. 1979. Zur Morphologie der Raphe bei der Gattung *Cymbella. Nova Hedwigia* 31: 993 – 1029.

KRAMMER, K. 1980. Mikroskopie und Fotografie von Kieselalgen 1. Vergrösserung und Auflösung. *Mikrokosmos* 69(7): 226 – 233.

KRAMMER, K. 1981a. Zur Deutung einiger Schalenstrukturen bei pennaten Diatomeen. *Nova Hedwigia* 35: 75 – 105.

KRAMMER, K. 1981b. Morphologic investigations of the valve and girdle of the genus *Cymbella* Agardh. *Bacillaria* 4: 125 – 146.

OKUNO, H. 1974. Freshwater diatoms. In: Helmcke, J.-G., Krieger, W. & Gerloff, J. 1953-, Diatomeenschalen im elektronenmikroskopischen Bild, Part 9, 1 – 45, plates 825 – 923. J. Cramer, Vaduz.

PATRICK, R. & REIMER, C.W. 1966. The diatoms of the United States exclusive of Alaska and Hawaii. Vol. 1. *Monogr. Acad. Nat. Sci. Philad.* 13, 688 pp.

PATRICK, R. & REIMER, C.W. 1975. The diatoms of the United States exclusive of Alaska and Hawaii. Vol. 2. Part 1. *Monogr. Acad. Nat. Sci. Philad.* 13, 213 pp.

REICHARDT, E. 1981. Die Diatomeenflora quelliger und sumpfiger Standorte in der Umgebung von Treuchtlingen. *Nova Hedwigia* 34: 487 – 519.

ROSS, R., COX, E.J., KARAYEVA, N.I., MANN, D.G., PADDOCK, T.B.B., SIMONSEN, R. & SIMS, P.A. 1979. An amended terminology for the siliceous components of the diatom cell. *Nova Hedwigia* Suppl. 64: 513 – 533.

SCHMIDT, A. *et al.* 1874 – 1959. Atlas der Diatomaceenkunde. Continued by Schmidt, M., Fricke, F., Heiden, H., Müller, O. & Hustedt, F., 480 plates. O.R. Reisland, Leipzig.

SCHOEMAN, F.R. 1969. Diatoms from the Orange Free State (South Africa) and Lesotho. No. 2. *Revta Biol.* 7: 35 – 74.

SCHOEMAN, F.R. 1970. Diatoms from the Orange Free State (South Africa) and Lesotho. No. 3. *Botanica mar.* Suppl. 13: 49 – 72.

SCHOEMAN, F.R. 1973. A systematical and ecological study of the diatom flora of Lesotho with special reference to the water quality, 355 pp. and 10 plates. V & R Printers, Pretoria.

SCHOEMAN, F.R. 1982. The diatoms of the Jukskei - Crocodile River system (Transvaal, Republic of South Africa): a preliminary check-list. *Jl. S. Afr. Bot.* 48: 295 – 310.

SCHOEMAN, F.R. & ARCHIBALD, R.E.M. 1976. The diatom flora of southern Africa. No. 1, September 1976. CSIR Special Report WAT 50. No page numbers; series of plates with text, 43 pp. Graphic Arts Division of the CSIR, Pretoria.

SCHOEMAN, F.R. & ARCHIBALD, R.E.M. 1977. The diatom flora of southern Africa. No. 3, September 1977. CSIR Special Report WAT 50. No page numbers; series of plates with text, 61 pp. Graphic Arts Division of the CSIR, Pretoria.

SCHOEMAN, F.R. & ARCHIBALD, R.E.M. 1978. The diatom flora of southern Africa. No. 4, April 1978. CSIR Special Report WAT 50. No page numbers; series of plates with text, 68 pp. Graphic Arts Division of the CSIR, Pretoria.

SCHOEMAN, F.R. & ARCHIBALD, R.E.M. 1979. The diatom flora of southern Africa. No. 5, September 1979. CSIR Special Report WAT 50. No page numbers; series of plates with text, 65 pp. Graphic Arts Division of the CSIR, Pretoria.

SCHOEMAN, F.R. & ARCHIBALD, R.E.M. 1980. The diatom flora of southern Africa. No. 6, May 1980. CSIR Special Report WAT 50. No page numbers; series of plates with text, 111 pp. Graphic Arts Division of the CSIR, Pretoria.

SCHOEMAN, F.R. & ASHTON, P.J. 1982a. The diatom flora of the Pretoria Salt Pan, Transvaal, Republic of South Africa. *Bacillaria* 5: 63 – 99.

SCHOEMAN, F.R. & ASHTON, P.J. 1982b. The diatom flora in the vicinity of the Pretoria Salt Pan, Transvaal, Republic of South Africa I. *Nova Hedwigia* Suppl. 73: 21 – 54.

VAN HEURCK, H. 1880 – 83. Synopsis des Diatomées de Belgique. Atlas: 132 plates. J. Ducaju & Co., Anvers.

VAN HEURCK, H. 1884 – 87. Types du Synopsis des Diatomées de Belgique, Série I-XXII, 123 pp., 550 slides. Anvers.

VAN HEURCK, H. 1885. Synopsis des Diatomées de Belgique. Text: 235 pp. and 3 plates. J. Ducaju & Co., Anvers.

VANLANDINGHAM, S.L. 1969. Catalogue of the fossil and recent genera and species of diatoms and their synonyms, Part 3: *Coscinophaena* through *Fibula*, p. 1087 – 1756. J. Cramer, Lehre.

gures 70 – 77 Figures 70 – 76. *Gyrosigma rautenbachiae* Cholnoky, sample B2, SEM internal views. 70. centre of valve. Note the axial rib within the ial groove (× 4000). 71. central nodule of specimen in 70 enlarged and turned. Note the two, short, longitudinal costa (× 6000). 72. part of a valve owing the axial rib (AR), helictoglossa (H) and tooth-like projections (P) (× 4000). 73. pole of a specimen in 72 turned and tilted to illustrate the iped helictoglossa (× 6000). 74. pole of another valve seen from a different angle (× 6000). 75. pole of a valve showing the internal raphe fissure ₹F) emerging onto the crest of the axial rib and terminating on the helictoglossa (× 6000). 76. cross-section of a valve showing the double-walled ·ucture in which the striae are composed of loculate areolae. Note the tooth-like projections (P) (× 6000).

gure 77. *Gyrosigma rautenbachiae* Cholnoky, Pienaar's River (PR 11), Transvaal. Cholnoky type material. SEM, external view of cross-section through lve. The slight lateral displacement of the valve wall along the raphe shows that the raphe has the form of a deep tongue and groove structure (× 6000).

iicroscopes has revealed that our specimens of *Cymbella icrocephala* Grunow should be divided into two groups. his has been discussed in the light of the available literature id comparisons have been made with examples of this ecies from the van Heurck Type Slide No. 211. Unfortunately we were unable to obtain unmounted type material C. *microcephala* for electron microscopy. Nevertheless, ir observations have focussed attention on this problem.

We have also been able to compare our specimens of *yrosigma rautenbachiae* Cholnoky with Cholnoky's type aterial. This has enabled us to furnish light microscope notographs and electron micrographs for this species which is previously only been illustrated in the literature by a w line drawings.

A number of other taxa are also listed for the record but not require further comment as they are well known.

References

AGARDH, C.A. 1830. Conspectus criticus Diatomacearum. Part 1. Litteris Berlingianis, Lundae, 16 pp.

ANONYMOUS 1975. Proposals for a standardization of diatom terminology and diagnoses. *Nova Hedwigia* Suppl. 53: 323 – 354.

CHOLNOKY, B.J. 1955. Diatomeen aus salzhaltigen Binnengewässern der westlichen Kaap — Provinz in Südafrika. *Ber. dt. bot. Ges.* 68: 11 – 23.

CHOLNOKY, B.J. 1957. Beiträge zur Kenntnis der südafrikanischen Diatomeenflora. *Port. Acta biol.* (B) 6: 53 – 93.

CHOLNOKY, B.J. 1959. Neue und seltene Diatomeen aus Afrika. IV. Diatomeen aus der Kaap — Provinz. *Öst. bot. Z.* 106: 1 – 69.

COX, E.J. 1977a. Variation in valve structure between species of the diatom genus *Cymbella* C.A. Ag. *Nova Hedwigia* 28: 427 – 449.

COX, E.J. 1977b. Raphe structure in naviculoid diatoms as revealed by the scanning electron microscope. *Nova Hedwigia* Suppl. 54: 261 – 274.

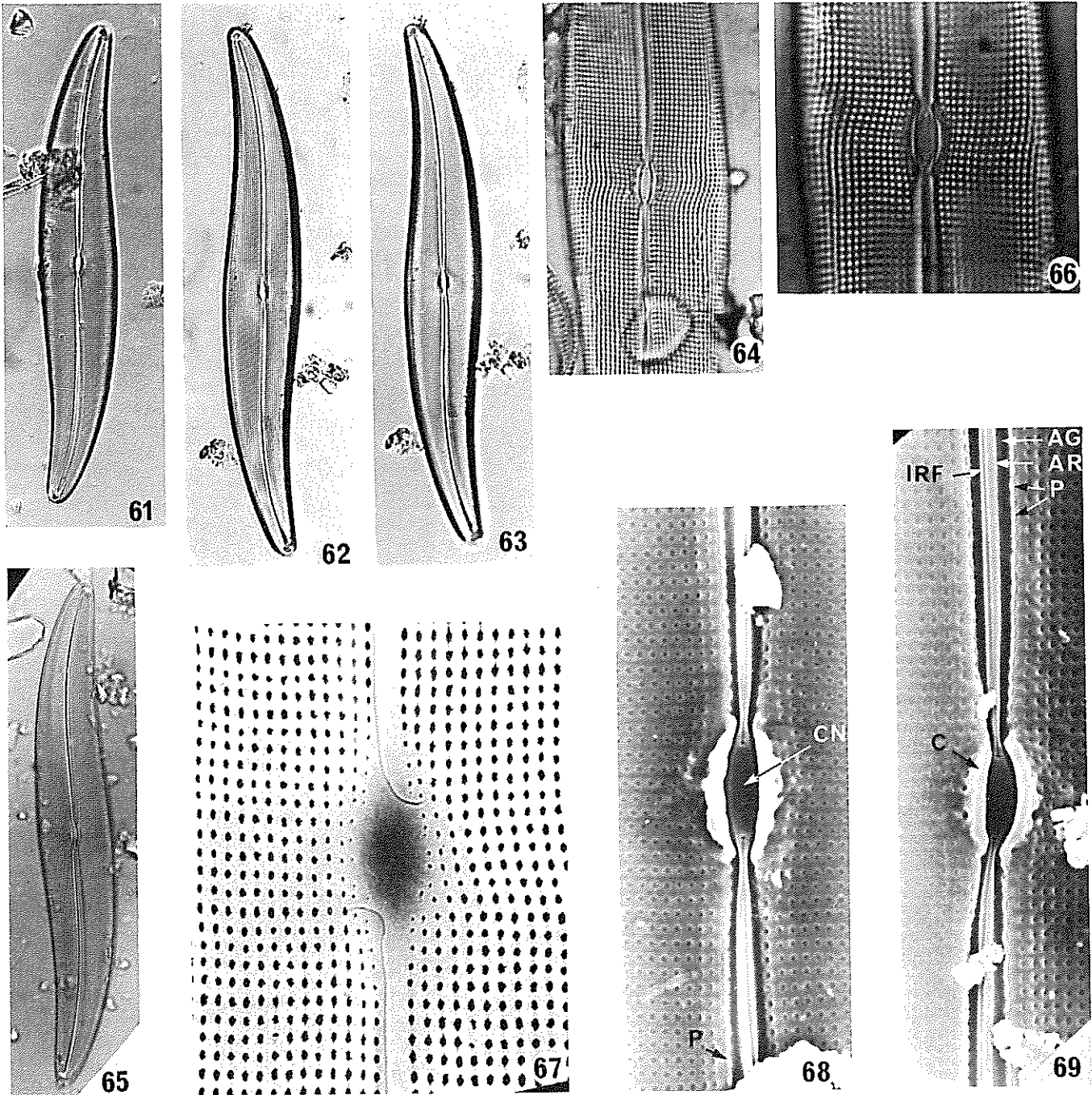COX, E.J. 1979. Symmetry and valve structure in naviculoid diatoms.

cf. Okuno 1974, plate 864; Cox 1979, plate 2, figure 10) and a slit-like aperture to the exterior (Figure 77). Figure 77 provides a particularly good illustration of the raphe structure. A slight lateral displacement of the valve wall along the raphe shows that it has the form of a deep tongue and groove structure. This can be compared to similar structures in *Stauroneis phoenicenteron* and *Pinnularia microstauron* (cf. Krammer 1981a, plate 3, figures 18, 19

and plate 5, figure 42 respectively). A small number of *G. rautenbachiae* valves were recorded from sample B2.

Conclusions

With the aid of type material we have been able to establish the true identity of *Cymbella cymbiformis* Agardh, a species whose taxonomy has previously been much confused.

Critical examination under both light and electron

Figures 61 – 69 Figures 61 – 63. *Gyrosigma rautenbachiae* Cholnoky, sample B2, LM. 62 & 63. same specimen but different illumination in 63 to reveal the raphe branches (× 500).

Figure 64. *Gyrosigma rautenbachiae* Cholnoky, Riet Stream near Nelspruit (Eastern Transvaal), sample ET 30 (NIWR Slide No. 206/4105), L.M. Focused to show the straight, internal, proximal raphe ends (× 1100).

Figures 65 & 66. *Gyrosigma rautenbachiae* Cholnoky, Crocodile River above Hartbeespoort Dam, Transvaal (NIWR Slide No. 123/2458), LM. 66. specimen in 65 enlarged to show the straight, internal, proximal raphe ends (65. × 500; 66. × 1750).

Figure 67. *Gyrosigma rautenbachiae* Cholnoky, Hennops River, Transvaal, SEM. External view of the centre of an etched valve. Note the curved proximal raphe ends (× 5000).

Figures 68 & 69. *Gyrosigma rautenbachiae* Cholnoky, sample B2, SEM. Internal views showing the central nodule (CN), axial groove (AG), axial rib (AR), internal raphe fissure (IRF), longitudinal costa (C) and tooth-like projections (P) (× 4000).

Figures 61, 63 & 65. oblique − bright field illumination. Figures 62, 64 & 66. bright field illumination.

ngated pores thereby resembling more closely our group
:xamples. A further interesting feature in the group 2
:cimens is the lip-like extension of the valve mantle at the
les (Figures 57, 58) which may be a diagnostic characte-
ic of this group.
Finally, internal views of valves from both groups
gures 54, 55, 57, 58) displayed a slightly raised central
lule (not much expanded laterally) and a raised axial
ge. Small helictoglossae were observed in group 2 valves
gures 57, 58). It is evident from this study that further
l studies on authenticated material of *C. microcephala*
necessary to establish the true identity of this taxon. Un-
tunately we have been unable to obtain unmounted type
terial for EM examination. Our studies have, neverthe-
;, shown the taxonomy of this species to be more com-
x than is generally known.
The valve dimensions for the two groups of *C.*
rocephala as distinguished in this study are as follows:

)up 1:   Length 14,0 – 22,5 μm, breadth 3,3 – 4,4 μm.
         Transapical striae 24 – 26 in 10 μm dorsally (off
         centre), 22 – 26 in 10 μm ventrally and 27 – 30
         in 10 μm at the poles (dorsally and ventrally).

)up 2:   Length 13,7 – 19,0 μm, breadth 3,4 – 4,4 μm.
         Transapical striae 26 – 32 in 10 μm (usually a
         little less dense on the ventral side) and 28 – 34
         in 10 μm at the poles (dorsally and ventrally).

:cription of *Cymbella microcephala* Grunow based on
. Heurck's Type Slide No. 211:-

: valves vary in shape from linear-lanceolate to almost
ipletely linear forms, 12,5 – 16,5 μm long and 3,4 – 4,0
 broad. The poles are protracted with rostrate, sub-
itate or capitate apices. Some valves have a convex dor-
nargin and an almost straight ventral margin. The raphe
nches appear robust and arcuate with the convex side
cted towards the ventral valve margin. The central pores
not conspicuous and the hooked terminal fissures are
:ed near the dorsal margin of the pole and curve down
ards the ventral margin. The axial area is narrow,
owing the curvature of the raphe branches and shows
:tically no expansion at the centre. A true central area
lerefore absent. The transapical striae vary from radial
rughout to slightly radial or parallel at the poles.
isured along the raphe the striae number (20) 24 – 28
) μm near the centre on the dorsal side, 20 – 26 in 10 μm
g the ventral side and 24 – 30 in 10 μm at the poles (ven-
y and dorsally).

osigma rautenbachiae Cholnoky (Figures 61 – 77)
lnoky 1957, 65, figure 61.
gth 155,0 – 175,0 μm, breadth 25,0 – 26,0 μm. Trans-
al striae 13 – 14 in 10 μm, longitudinal striae about 15
0 μm.
his taxon appears to be more common than originally
ight and has been recorded by the senior author from
ral localities in the Transvaal (Schoeman 1982, 301, as
p. 1 affin. *rautenbachiae;* various unpublished data).
specimens from the vicinity of the Pretoria Salt Pan
: carefully compared with Cholnoky's Type material
l the Pienaar's River, Transvaal (Cholnoky 1957, 65),
found to be identical in all respects. Examination of

other authenticated Cholnoky material for this taxon re-
vealed that in certain cases a species having a strong
resemblance to *G. acuminatum* (Kützing) Rabenhorst had
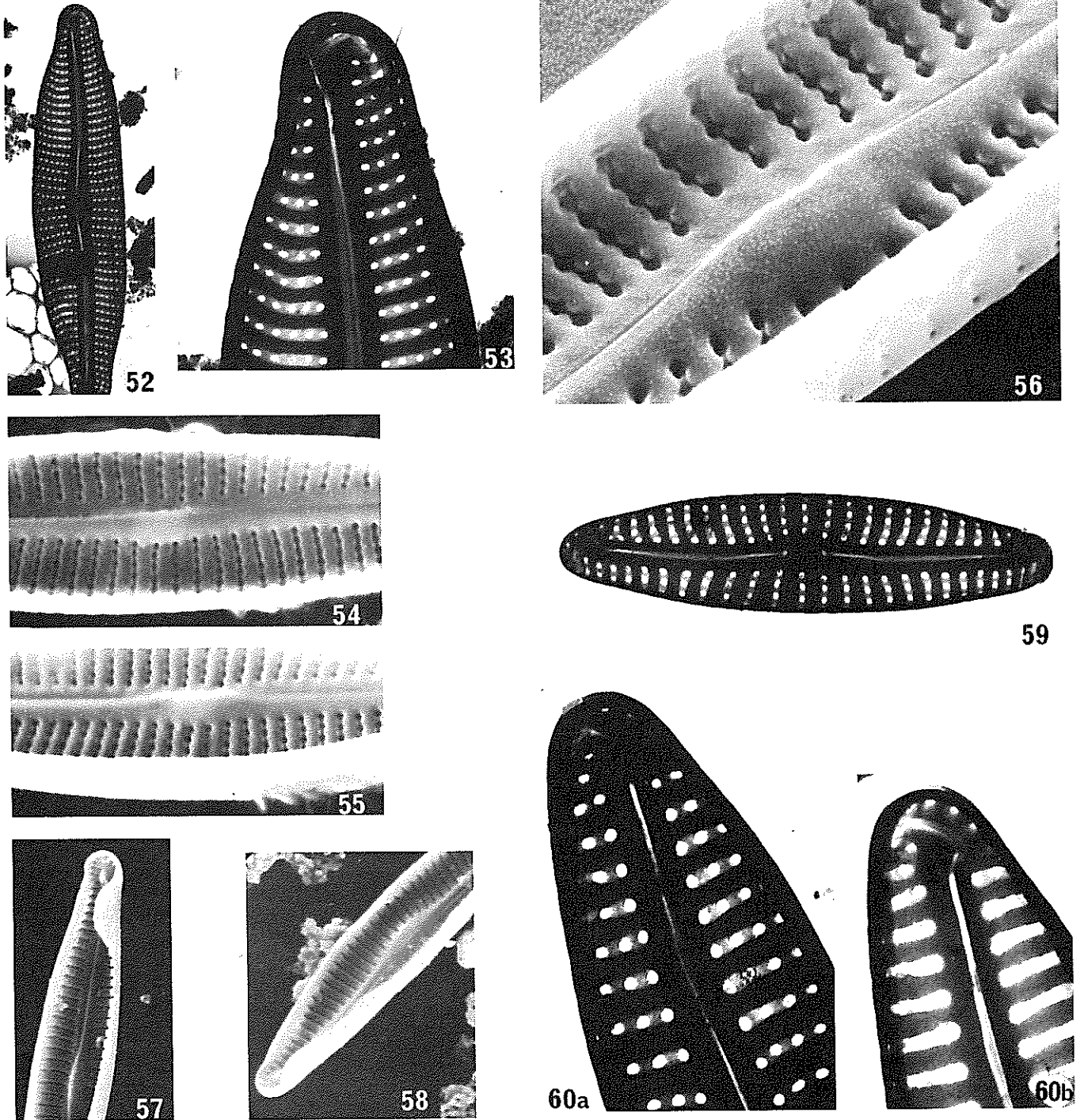been misidentified as *G. rautenbachiae* Cholnoky.

In general appearance and shape, as seen under the light
microscope, *G. rautenbachiae* Cholnoky (Figures 61 – 63,
65) resembles *G. acuminatum* (Kützing) Rabenhorst
(Hustedt 1930, 222, figure 329; Patrick & Reimer 1966, 314,
plate 23, figures 1 – 3) and *G. attenuatum* (Kützing)
Rabenhorst (Hustedt 1930, 224, figure 330; Patrick &
Reimer 1966, 319, plate 24, figure 1). It is distinguished from
G. acuminatum by its broader valves and by possessing
fewer transapical and longitudinal striae in 10 μm.
Gyrosigma rautenbachiae differs from *G. attenuatum* in the
number of longitudinal striae, *G. attenuatum* having only
10 – 12 longitudinal striae in 10 μm whereas *G. rauten-
bachiae* usually has 14 – 15 in 10 μm.

In LM the internal and external proximal ends of the
raphe fissures in *G. rautenbachiae* can be resolved by focus-
ing in two planes. Internally, the proximal ends of the raphe
fissure are straight (Figures 64, 66), while externally, the
proximal ends of the raphe fissure are hooks curving in op-
posite directions. These external hooked proximal raphe en-
dings are clearly visible under SEM (Figure 67; cf. *G.
acuminatum sensu* Jackson & Lowe 1978, figure 3) and ex-
tend across two rows of the longitudinal striae on either side
of the central nodule. They differ from those of *G. at-
tenuatum sensu* Cox (1977b, plate 4, figure 31; 1979, plate
1, figure 1) which appear sinuate in the curved portion and
do not cut across the striae. Internally the raphe fissures
extend only a short distance onto the central nodule and
end abruptly in slightly expanded pores (Figure 68). Figure
67 shows the arrangement of the pores in intersecting
traverse and longitudinal striae. The raphe runs in an axial
rib which is flush with the valve surface on the outside
(Figure 67) but internally is a ridge lying within a groove
(Figures 69, 71, 74, 76). The external (Figure 67) and inter-
nal (Figures 69, 76) raphe fissures run along the side of the
axial rib except at their internal proximal and distal ends
where they emerge on the crest of the rib (Figures 68, 75).
In the central parts of the valve the groove containing the
axial rib appears to be rather deep (Figures 70, 71) but
towards the poles it becomes shallower so that the rib often
projects above the inner valve surface (Figures 73, 74, 75).
Internally at the centre of the valve the axial rib is expanded
into a spindle-shaped central nodule (Figures 68, 71). On
either side of this central nodule there is a short longitudinal
costa (both of equal length) which does not extend further
than this region (Figures 68 – 71; cf. *G. attenuatum sensu*
Cox 1979, plate 1, figure 8). It is interesting to note that
Cox illustrates *G. attenuatum* with both uneven (Cox 1977b,
plate 4, figure 29) and even (Cox 1979, plate 1, figure 8)
length axial costae. Further towards the poles, along the
edge of the axial groove on the side opposite that facing
the opening of the raphe fissure in the axial rib, there is
a row of tooth-like projections (Figures 72, 74, 76; cf. Cox
1979, plate 1, figure 8). This is clearly demonstrated in
Figure 76. The well developed terminal nodule takes the
form of a lipped structure or helictoglossa in which the distal
ends of the raphe terminate (Figures 73 – 75). In Figures
76 and 77 the valve is also shown as a double walled struc-
ture having a thin outer wall and a slightly thicker inner
wall. The striae are comprised of loculate areolae with a
more or less rectangular occluded inner opening (Figure 76;

appear to lie in a groove with a crenulate margin. This structure is clarified when valves are viewed under the SEM. The slit-like pores are then seen to represent the outer pore openings on the surface of the valve, while the internal pore openings are round (cf. Ehrlich 1973, plate 7, figure 6) thereby creating the crenulate image observed under TEM. The round internal pore openings lie in narrow grooves which are separated by transapical costae (Figures 54 – 56).

Under TEM the striae of the group 2 specimens (Figures 52, 53) consist of round to oblong-shaped pores (40 – 44 in 10 μm) which lie within very narrow grooves that possess
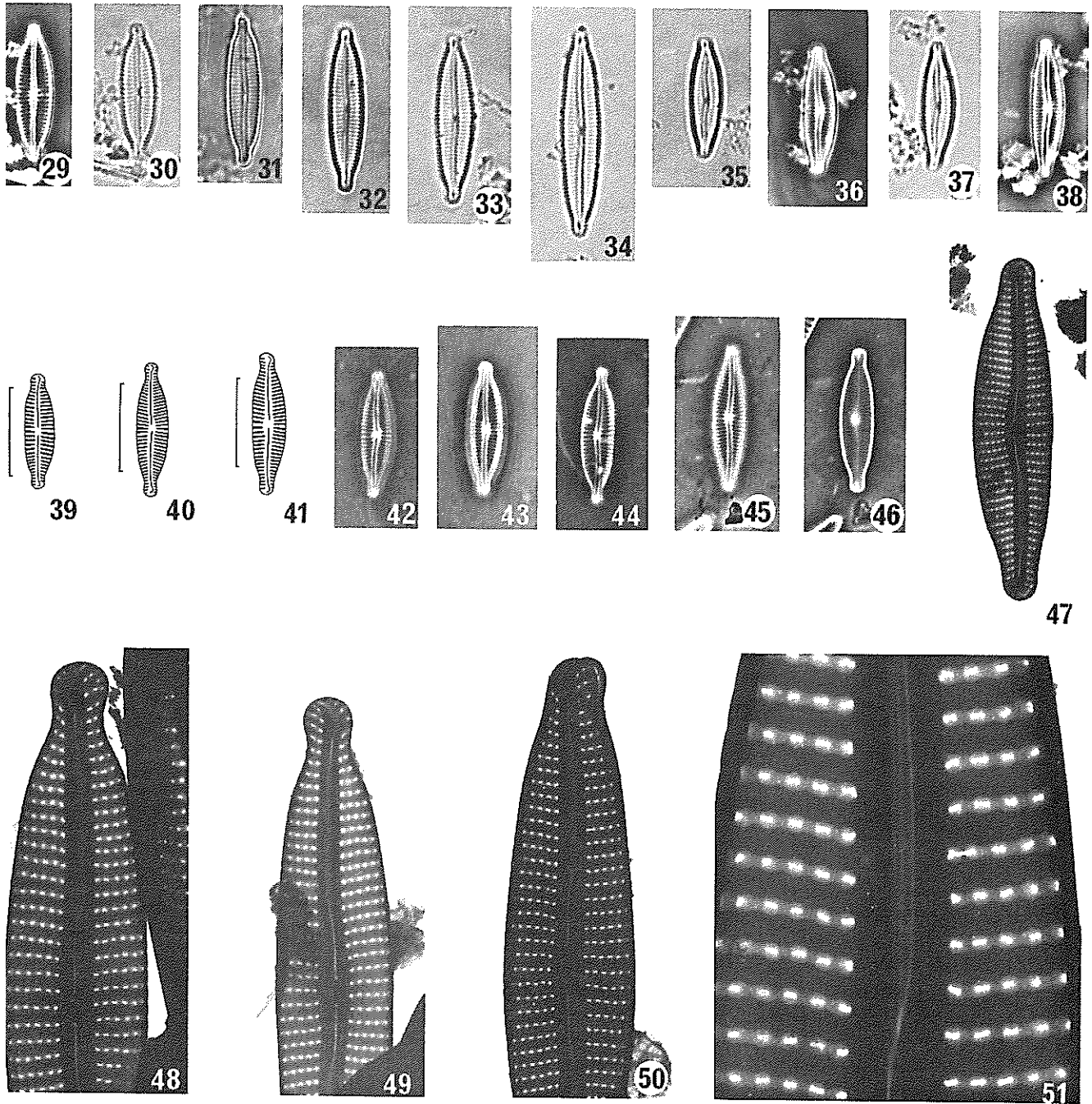
straight (non-crenulate) sides (Figure 53; cf. Figures 59, 60 as examples from Lesotho previously identified as *C. microcephala*). When viewed (under SEM) from the inside of the valve (Figures 57, 58) these straight-sided grooves (group 2 specimens) are found to be narrower than those of the group 1 valves. The structure of the outer valve surface (group 2) as seen under SEM is basically similar to that illustrated by Ehrlich (1973, plate 7, figure 5) and Gerloff *et al.* (1978, plate 11, figure 3). The illustration of Krammer (1981b, plate 1, figure 7) of the outer surface of a *C. microcephala* valve depicts both round and transapically

Figures 52 – 60 Figures 52 & 53. *Cymbella microcephala* Grunow (group 2), TEM. 53. upper pole of specimen in 52 enlarged (52. × 3500; 53. × 11400)
Figures 54 & 55. *Cymbella microcephala* Grunow (group 1), SEM, internal views of the same specimen but valve tilted in 55 (× 10000).
Figure 56. *Cymbella microcephala* Grunow, SEM micrograph of internal view by kind permission of Dr Kurt Krammer, Meerbusch, West Germany (× 15000)
Figures 57 – 60. *Cymbella microcephala* Grunow (group 2). 57 & 58. SEM, internal views (× 6000). 59 & 60. TEM, specimen from Lesotho (59. × 8400). 60a & b. part of specimen in 59 enlarged but taken at different exposure times to illustrate the striae structure in 60a and raphe detail in 60b (× 17300)

ent of inner and outer raphe fissures from the perpen-
cular plane. Grunow's drawings in van Heurck (1880 – 83,
ate 8) illustrate a slight dorsal curvature of the raphe
anch in his Figures 36 and 37 and a ventral one in his
gure 39! According to Krammer's classification (1979,
05, plate 3, figure 22) our specimens belong to the group
Cymbellae possessing lateral raphe systems. Our TEM
crographs also clearly illustrate the narrow axial area
ich follows the curvature of the raphe branches. A cen-
l area is absent, though occasionally there may be a slight
dening around the central nodule. The terminal areas are
all.

Cox (1977a, 431, plate 3, figures 13 – 15) recorded three
types of striae pores within the genus *Cymbella*. The pore
structure of our specimens does not fit any of her types.
Under TEM we observed two distinct transapical striae types
thereby lending support to the division of our specimens
into two *C. microcephala* groups. The striae of specimens
in our group 1 (Figures 47 – 51) contained 36 – 41 puncta
in 10 μm. These puncta are linear or slightly dumbbell in
shape and are aligned with their long axes parallel to the
striae. Near the valve apices a few pores occasionally assume
a trifid shape. Under TEM we also observed that in these
specimens (Figure 51) the transapically aligned slit-like pores

res 29 – 51 Figures 29 – 34. *Cymbella microcephala* Grunow (group 1), LM. 29 & 30. same specimen (× 1500).
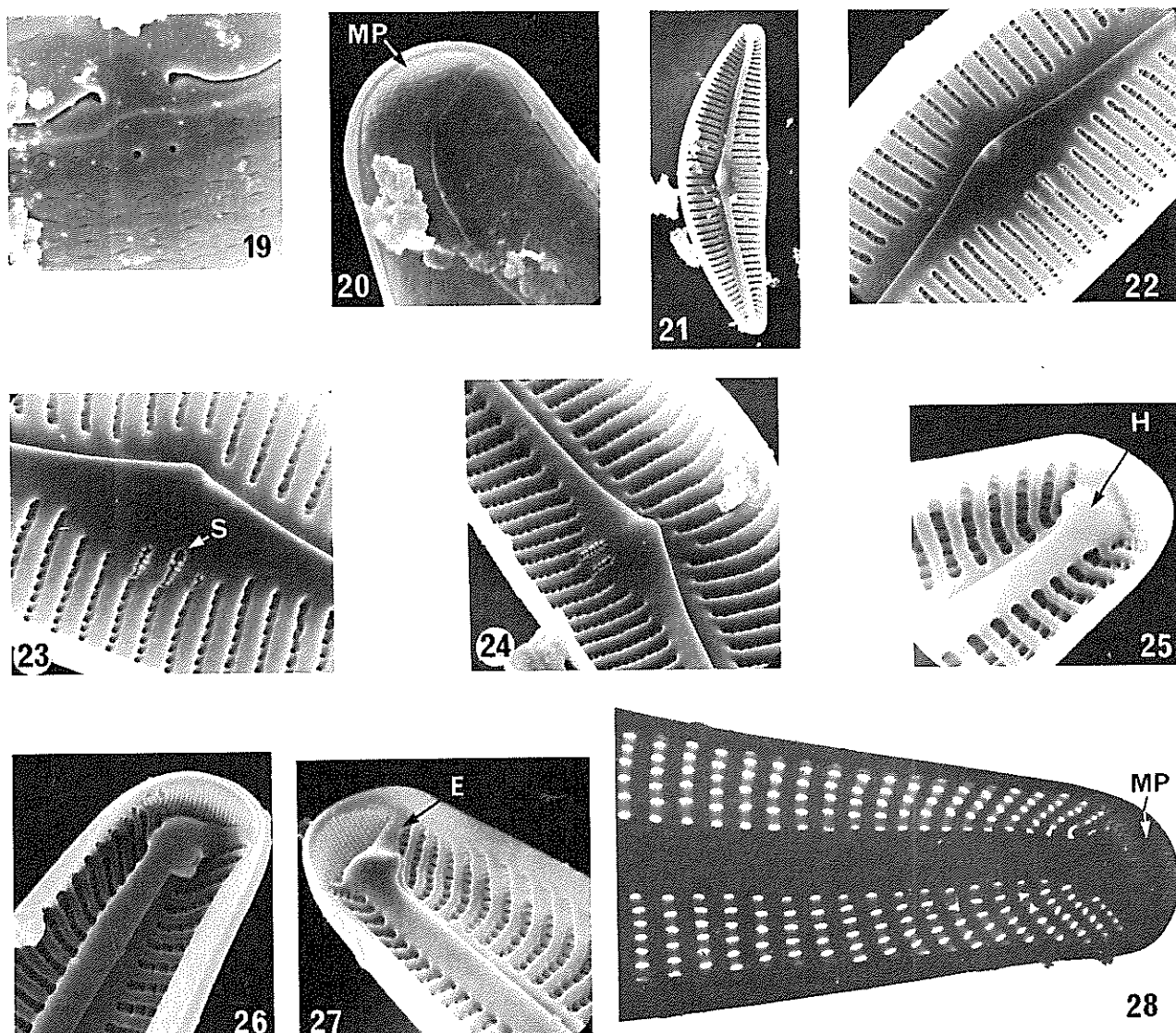res 35 – 38. *Cymbella microcephala* Grunow (group 2), LM (× 1500).
res 39 – 46. *Cymbella microcephala* Grunow, Bruxelles, Belgium. Van Heurck Type Slide No. 211 = NIWR Slide No. 11/211. 39 – 41. camera
la drawings (*delin.* R.E.M. Archibald). 42 – 46. LM. 45 & 46. same specimen with 45 illustrating the transapical striae and 46 the valve outline (× 1500).
res 47 & 48. *Cymbella microcephala* Grunow (group 1). TEM (47. × 3200; 48. × 6400).
res 49 – 51. *Cymbella microcephala* Grunow (group 1), TEM. 51. part of specimen in 50 enlarged to show the structure of the transapical striae
& 50. × 5400; 51. × 18000).
res 29, 36, 38 & 42 – 46. phase contrast illumination; Figures 30 – 35 & 37. oblique – bright field illumination.

Figures 19 – 28 Figures 19 – 23. *Cymbella cymbiformis* Agardh, SEM. Examples from sample B2. 19 & 20. external views showing a valve centre (19) with two stigmata, and a pole (20) with distal raphe end and mucilage pore area (MP) (× 6000). 21 – 23. internal views. 21. whole valve of a small specimen (× 1000). 22. valve centre with central nodule and inner openings of the stigmata (× 3250). 23. centre part of specimen in 22 tilted and enlarged to show the stigmata (S) (× 4680).
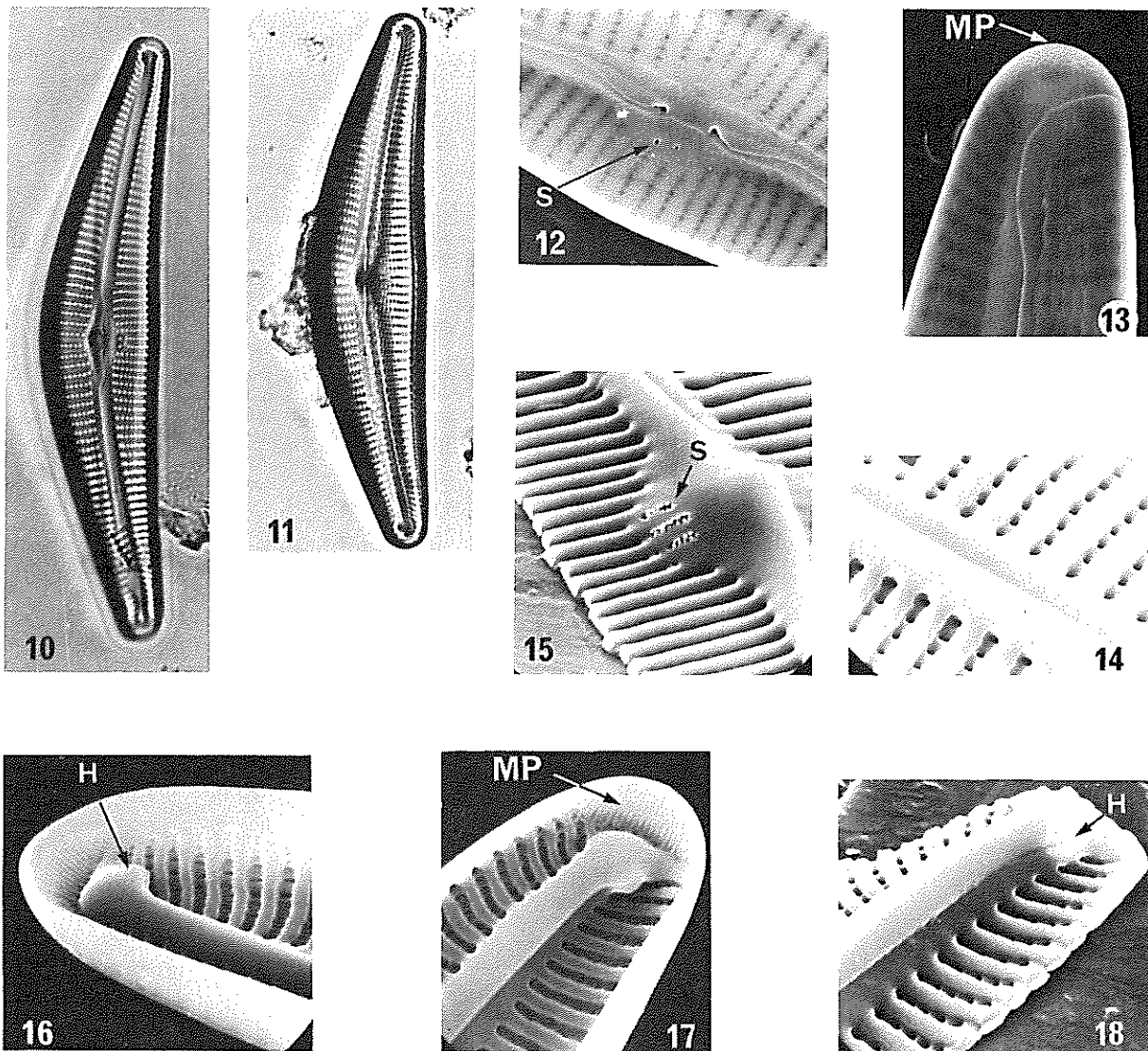
Figures 24 – 27. *Cymbella cymbiformis* Agardh, sample B2, SEM internal views. 24. centre with raised axial rib, thickened central nodule and two stigmata (× 3250). 25 – 27. poles of different specimens. Note the helictoglossa (H), the dorsal thickened extension (E) of the terminal nodule and the terminal mucilage pore area (25. × 6000; 26 – 27. × 4680).

Figure 28. *Cymbella cymbiformis* Agardh, sample B2, TEM. Enlargement of valve apex to show the striae structure and the striate nature of the terminal mucilage pore area (MP) (× 4680).

of the structure can be seen, though in valve outline they do resemble this taxon. Grunow's first reference to *C. microcephala* is to be found in van Heurck's Atlas (1880 – 83, plate 8, figures 36 – 39) of the diatoms of Belgium, and van Heurck (1885, 63) cited his Type Slide No. 211 as containing this species. Since Grunow (in van Heurck 1884 – 1887, series 9) substantiated the identity of *C. microcephala* on van Heuck's Type Slide No. 211 we may thus assume it is either the syntype slide or properly authenticated material for this taxon. We examined this slide (obtained from the Grunow diatom collection in Vienna) and found that the specimens (Figures 39 – 46; cf. Patrick & Reimer 1975, 33, plate 4, figures 12, 13) resemble many of our group 2 valves. A description of the valves observed on this slide (No. 211) is given at the end of the discussion on *C. microcephala*. According to van Heurck (1885, 63) the raphe is weakly arcuate, but specimens we examined on the van Heurck Type Slide No. 211 usually had raphe bran-

ches slightly more arcuate than those illustrated by Grunow in van Heurck (1880 – 83, plate 8, figures 36 – 39). Hustedt's illustrations (1930, 351, figure 637; 1949, plate 1, figures 34 – 38), on the other hand, tend to depict almost straight raphe branches which come closer to our group 1 specimens.

It was only after completing an EM study on the Pretoria Salt Pan specimens (with emphasis on the transapical striae) that we found better evidence for our suspected separation of this taxon into 2 groups, as mentioned earlier. Under TEM (both groups) the raphe in valvar view (Figures 47 – 50, 52) is more or less centrally placed. The terminal fissures (Figures 48, 49) are directed ventrally and the small central pores sometimes show a slight dorsal deflection (Figures 47, 50, 52). The central section of each raphe branch (Figures 47 – 50, 52; cf. Geissler *et al.* in Helmcke & Krieger 1963, 33, plate 391, figure lower left) is ventrally curved and appears band-shaped owing to slight displace-

igures 10 – 18 Figures 10 & 11. *Cymbella cymbiformis* Agardh, LM. Examples from our sample B2 (× 1000; bright field illumination).
igures 12 – 18. *Cymbella cymbiformis* Agardh, SEM. Agardh (Stangby No. 4612) type material. 12 & 13. external views. 12. centre of a specimen show-
ig stigmata (S) (× 2880). 13. pole of a valve with outer raphe fissure and mucilage pore area (MP) (× 4680). 14 – 18. internal views. 14. enlargement
ɔ show that the striae puncta open into transapically aligned grooves (× 6000). 15. internal openings of three stigmata (S) (× 4680). 16 & 17. same
ole of a specimen but turned and tilted in 17. Note the helictoglossa (H) and mucilage pore area (MP) (× 6000). 18. pole of broken valve with inner
iphe fissure terminating in the helictoglossa (H) (× 6000).

ɔmbella cymbiformis was recorded from two samples, B1
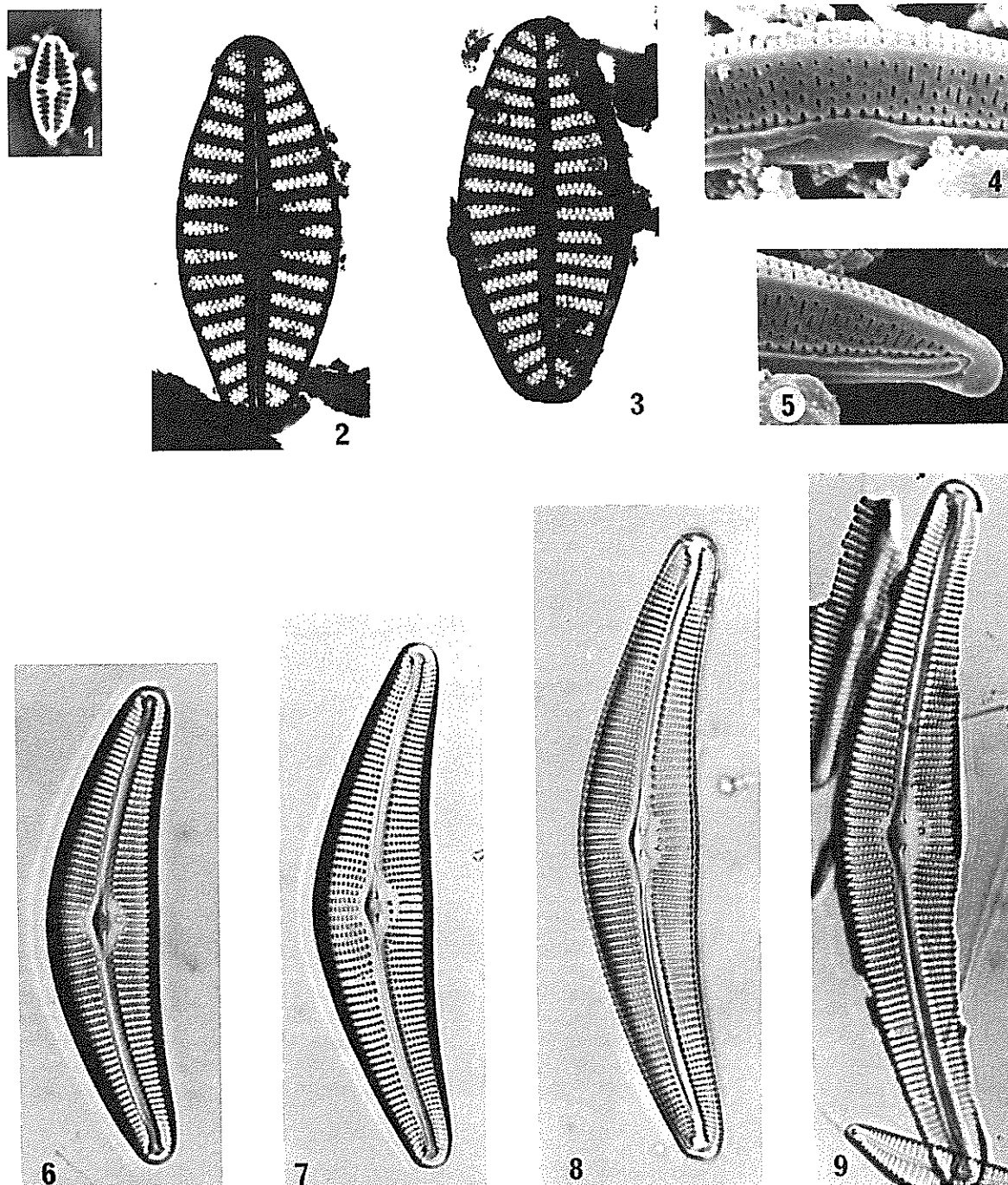nd B2.

ɔmbella microcephala Grunow (Figures 29 – 60).

'he initial examination of the slides showed this species to
e the dominant taxon in samples B1 and B9. Further study
nder the light microscope revealed that these specimens
ɔuld be divided into two groups on the grounds of some
iinor differences, namely, *C. microcephala* group 1
ʾigures 29 – 34) and *C. microcephala* group 2 (Figures
5 – 38). Group 1 specimens were recorded from sample B9,
'hile a few examples were also present in sample B1. Group
 specimens were present only in sample B1, where they
:presented the dominant diatom taxon.

 Valves of group 1 have almost straight or slightly curved
iphe branches whereas those in group 2 have clearly ar-
iate and slightly thicker raphe branches. The number of
orsal transapical striae (off centre) is usually between 24
id 26 in 10 μm for group 1 and slightly denser for group
(26 – 32 in 10 μm). However, the occasional intermediate
ɔecimen was inevitably present, making it extremely dif-

ficult to distinguish between the two groups. The transapical
striae of specimens in both groups may be radial throughout
or can become parallel or even convergent at the poles.

  Examination of the available literature revealed that very
little of the variation displayed by *C. microcephala* has been
illustrated. Hustedt (1949, plate 1, figures 34 – 38) and
Schoeman (1970, 52, plate 1, figures 15 – 22) figure some
valve variation and Schoeman (1970), based on his light
microscopy studies of Lesotho material, has proposed the
sinking of *C. ruttneri* Hustedt (in Schmidt *et al.* 1874 – 1959,
plate 373, figures 39 – 44; Hustedt 1937 – 38, 421, plate 25,
figures 4 – 9; cf. Schoeman 1969, 43, figures 15 – 17) into
the *C. microcephala* species. Electron microscopical studies
of *C. ruttneri*-type material may prove otherwise.

  According to VanLandingham's 'Catalogue of the fossil
and recent genera and species of diatoms and their
synonyms' (1969, 1212 – 1213), the earliest reference to this
taxon comes under the name *Cymbella minuscula* Grunow
and comprises a series of figures in Schmidt *et al.*
(1874 – 1959 (1875), plate 9, figures 58 – 61). Our
photographic copy of these illustrations is poor and little

Figures 1 – 9 Figures 1 – 3. *Achnanthes engelbrechtii* Cholnoky. 1. LM, raphe valve (× 2000; phase contrast illumination). 2. TEM, raphe valve (× 5900). 3. TEM, rapheless valve (× 5900). 2 & 3. specimens from Lake Chrissie, Transvaal.
Figures 4 & 5. *Amphora veneta* Kützing, SEM, external views of the same valve showing the centre in 4 and a pole in 5 (× 6000).
Figures 6 – 9. *Cymbella cymbiformis* Agardh, NIWR Slide No. 422/8439 prepared from Agardh type material (Stangby No. 4612) kindly provided by Dr. O. Almborn of the Lund Botanical Museum, Sweden. LM (× 1000; 6 – 8. bright field illumination; 9. oblique – bright field illumination).

12, 19). The distal ends are deflected dorsally (Figures 13, 20). The central nodule is very thickened internally (Figures 15, 24) thereby obscuring the proximal raphe endings (cf. Cox 1977a, 432). The distal ends of the axial rib are also thickened and are developed on the dorsal side into a two-lipped structure, the helictoglossa (Figures 17, 25 – 27) in which the inner raphe fissure terminates (Figure 18). The distal ends of the inner raphe fissures appear to run ventrally along the base of the raised axial rib before entering the helictoglossae. From the thickened terminal nodule there is a fairly broad extension towards the dorsal margin (Figures 17, 26, 27) separating the striae from the mucilage pore area (apical pore field). Cox (1977a) has suggested that

the development of a hooded raphe ending seems to be associated with the presence of a mucilage pore area at the valve apex. Externally these mucilage pores appear as rows of small closely arranged circular openings (Figure 20; cf. Cox 1977a, plate 5, figure 30) which are separated internally by narrow ribs (Figures 17, 27). On the ventral side of the central area two or occasionally three stigmata are present. Furthermore, specimens with a single stigma were observed in Agardh's-type material. Externally they appear as rather conspicuous, simple, circular openings (Figures 12, 19; cf. Krammer 1981a, plate 3, figure 20). Internally they are slit-like and are partly occluded by outgrowths of silica (Figures 15, 22 – 24; cf. Cox 1977a, 434).

camera lucida with adjustable magnification changer. The original drawings were made at a magnification of 4000 × and then suitably reduced for reproduction.

Additional material (slides and exsiccati) for comparative purposes was obtained from the University of Lund Botanical Museum in Sweden (for *Cymbella cymbiformis* Agardh), the Naturhistorisches Museum in Vienna (for *Cymbella microcephala* Grunow) and the NIWR diatom collection in Pretoria (for *Gyrosigma rautenbachiae* Cholnoky). Terminology used is that suggested by the Working Party on Diatom Terminology (Anon. 1975; Ross *et al.* 1979).

Observations and Discussion

A further number of diatom taxa identified from samples collected in the vicinity of the Pretoria Salt Pan are listed below in alphabetical order. Where necessary, their dimensions and some comments on their structure are also given.

Achnanthes engelbrechtii Cholnoky (Figures 1 − 3)

Cholnoky 1955, 16, figures 1 − 8.
Cholnoky 1959, 7, figures 16 − 33.
Length 8,0 − 11,0 μm, breadth 3,5 − 4,2 μm. Transapical striae (raphe and rapheless valves) 16 − 18 in 10 μm (a little denser at the apices).

This species shows some similarity to *A. pinnata* Hustedt 1922, 123, plate 9, figures 15 − 18; 1937 − 38, 201, plate 13, figures 54 − 57) and a detailed study of Hustedt's type material is required to make a proper comparison. It is also interesting to note that under TEM the striae structure is reminiscent of that of *A. lanceolata* Brébisson *ex* Kützing. *A. engelbrechtii* occurred only rarely in sample B9.

Achnanthes exigua Grunow

Schoeman & Archibald 1977, no. 3.
Schoeman & Ashton 1982a, 84, figures 1 − 8, 75 − 79, 105 − 110.
Length 8,0 − 12,0 μm, breadth 4,3 − 5,0 μm. Transapical striae: raphe valve 26 − 28 in 10 μm near the centre (slightly denser at the poles); rapheless valve 25 − 27 in 10 μm near the centre (denser at the poles).
A. exigua was observed in samples B2 and B4.

Achnanthes lanceolata Brébisson ex Kützing

Hustedt 1931 − 59, 408, figure 863.
Patrick & Reimer 1966, 269, plate 18, figures 1 − 10.
A few valves were recorded from sample B2.

Amphora ovalis (Kützing) Kützing var. *affinis* (Kützing) van Heurck *ex* De Toni.

Patrick & Reimer 1975, 69, plate 13, figures 3,4.
A single specimen was observed in sample B2.

Amphora veneta Kützing (Figures 4, 5)

Schoeman & Archibald 1978, no. 4.
Schoeman & Archibald 1979, no. 5.
Length 18,0 − 27,5 μm, breadth 3,2 − 4,0 μm. Transapical striae on the dorsal side, punctate, 26 − 28 in 10 μm, more widely spaced at the centre (about 22 in 10 μm) and slightly denser at the poles (28 − 30 in 10 μm); striae along the ventral side 28 − 30 in 10 μm. A critical study of this taxon has been presented by Schoeman and Archibald (1978; 1979). Under SEM the fairly high dorsal mantle is partially seen in Figure 4. Also clearly visible is the outer raphe fissure. It runs in a broad, flat, axial rib which is slightly extended

dorsally to form a poorly developed conopeum (previously referred to as a flap by Schoeman & Archibald 1978; 1979). Externally the terminal fissure of the raphe is strongly recurved towards the dorsal side (Figure 5) ending in the last punctum of the most distal dorsal stria.
A. veneta was recorded from samples B1 and B5.

Cyclotella atomus Hustedt

Schoeman & Archibald 1976, no. 1.
Diameter 4,0 − 5,0 μm; marginal costae 13 − 15 in 10 μm. This species was observed in sample B9.

Cyclotella meneghiniana Kützing

Schoeman & Archibald 1980, no. 6.
A few valves were observed in sample B5.

Cymbella cymbiformis Agardh (Figures 6 − 28)

Length 70,0 − 89,0 μm, breadth about 16,0 μm (one specimen 12,5 μm). Transapical striae (dorsal and ventral) about 8 in 10 μm near the centre but denser at the poles, 12 − 16 in 10 μm. The striae are punctate with 14 − 20 puncta in 10 μm (20 − 22 in 10 μm according to Krammer 1980, 232, figures 15,16) but denser at the poles. In our specimens two conspicuous stigmata are located on the ventral margin of the central area (Figure 10), while occasionally a third smaller stigma is also visible.

There appears to be a great deal of confusion concerning the taxonomy of this taxon and its relationship with other closely related taxa, namely, *C. cistula* (Hemprich) Kirchner and *C. affinis* Kützing (cf. Schoeman 1973, 55; Patrick & Reimer 1975, 54 − 55; Reichardt 1981, 502 − 503). This is partly due to Hustedt's (1955, 50 − 51) investigation and interpretation of this taxon in which he concluded that *C. cymbiformis* was characterized by the lack of an isolated stigma in the central area. It is evident that Hustedt (1955) did not examine any Agardh material and based his observations mainly on the Kützing material of *Cocconema cymbiforme* Kützing. We were fortunate to obtain some of the Agardh (1830, 10) type material from Stangby (No. 4612) for EM study from the University of Lund Botanical Museum (Sweden), together with a lectotype slide prepared from this material by Reimer (*vide* Patrick & Reimer *op. cit.*). Some illustrations of the Agardh-type specimens (Figures 6 − 9, 12 − 18) are presented here for the purpose of direct comparison with our valves (Figures 10, 11, 19 − 27), which were found to be identical.

Under TEM the pores of the transapical striae appear linear and are aligned with their long axes perpendicular to the striae (Figure 28). In lightly cleaned material these slit-like pores are very narrow, but harsh cleaning results in etching so that the pores appear wider and more oblong in shape. SEM examination showed that these slits represent the outer openings of the striae pores (Figures 12, 13, 19). The internal openings of these pores appear to be larger (round-oblong) and open into transapically aligned grooves (Figures 14, 22, 23).

According to Krammer's classification (1979, 1005, plate 3, figure 22, plate 4, figures 40, 41) the raphe system is of the reverse-lateral type. It lies in an axial rib which is rather flat externally (Figure 12), but appears as a raised ridge internally (Figures 15, 18, 24, 27). Viewed under SEM the external raphe fissure becomes sinuate near the valve centre with a ventrally directed arch terminating in a fairly conspicuous central pore which also bends ventrally (Figures

The diatom flora in the vicinity of the Pretoria Salt Pan, Transvaal, Republic of South Africa. Part II

F.R. Schoeman and P.J. Ashton

National Institute for Water Research, Council for Scientific and Industrial Research, Pretoria

This is the second in a series of three contributions covering the diatom flora recorded in the vicinity of the Pretoria Salt Pan. Of the ten species described in this publication, three viz. *Cymbella cymbiformis* Agardh, *C. microcephala* Grunow and *Gyrosigma rautenbachiae* Cholnoky, are discussed in detail with notes on their taxonomy and valve structure, the latter based on both light and electron microscopy. In an attempt to verify the correct identity of these taxa, certain authenticated materials were also examined.

S. Afr. J. Bot. 1983, 2: 191 – 201

Hierdie is die tweede in 'n reeks van drie publikasies oor die diatoomflora wat in die omgewing van die Pretoria Soutpan gevind is. Drie van die tien spesies wat in hierdie publikasie behandel word, naamlik *Cymbella cymbiformis* Agardh, *C. microcephala* Grunow en *Gyrosigma rautenbachiae* Cholnoky, word in besonderhede bespreek, met notas oor hul taksonomie en skaalstruktuur. Laasgenoemde is gebaseer op beide lig- en elektronmikroskopie. Om die ware identiteit van hierdie taksons te probeer vasstel, is sekere egverklaarde voorbeelde ook ondersoek.

S.-Afr. Tydskr. Plantk. 1983, 2: 191 – 201

F.R. Schoeman and P.J. Ashton
National Institute for Water Research, Council for Scientific and Industrial Research, P.O. Box 395, Pretoria 0001, Republic of South Africa

Introduction

The hypersaline Pretoria Salt Pan with its saline artesian spring is the only example of a maar lake in southern Africa. In a recent publication, the diatom flora of this floristically unknown system was discussed (Schoeman & Ashton 1982a). The water sources in the farmlands (the Soutpan agricultural experimental farm) surrounding the salt pan and its volcanic crater consist of a perennial stream and several boreholes whose hydrochemistry is quite different to that of the spring feeding the Pretoria Salt Pan. Since the diatom flora of the surface waters in this area was virtually unknown, the diatoms recorded from these different water sources were studied by both light and electron microscopy. The first results dealing with several taxa recorded from this area have already been published (Schoeman & Ashton 1982b).

The present paper lists additional taxa from these localities and provides dimensions, comments and comparisons with authenticated materials where these are deemed necessary. A final paper dealing with the remaining taxa will be submitted in the near future. For details on hydrochemical conditions pertaining to these sampling points, readers are referred to Schoeman & Ashton (1982b).

Study area and sampling points

The Soutpan agricultural experimental farm is located at 25°24′S and 28°05′E in the Transvaal Province, South Africa (Schoeman & Ashton 1982b) and surrounds the volcanic crater with its saline lake, the Pretoria Salt Pan. Algal samples were collected from a stream and various open water reservoirs and cattle drinking troughs associated with several boreholes on the farm (full details of these sampling points are given in Schoeman & Ashton 1982b).

These waters had relatively low concentrations of total dissolved solids (TDS) $(190 - 500$ mg $l^{-1})$ and total alkalinity $(1,5 - 6,0$ mequiv $l^{-1})$ and their pH values ranged from 7,0 to 7,6. In contrast, the corresponding values for the artesian springs were 3 380 mg l^{-1}, 12 mequiv l^{-1} and 8,8 while those for the surface waters of the Pretoria Salt Pan were 78 830 mg l^{-1}, 390 mequiv l^{-1} and 10,4 respectively.

Materials and Methods

Methods for the preparation and examination of the diatom samples (light and electron microscopy) have also previously been presented (Schoeman & Ashton 1982b). The line drawings (Figures 14 – 16) were made with the aid of a Zeiss