POLLEN MORPHOLOGY OF GENUS *RUBUS* L., PART II. INTRODUCTORY STUDIES ON THE MALESIAN SPECIES OF SUBGENUS *MICRANTHOBATUS*

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ABSTRACT

The results of studies on pollen morphology of 6 Malesian *Rubus* species are presented (*R. clementis*, *R. cordiformis*, *R. diclinis*, *R. megacarpus*, *R. novoguineensis* and *R. royenii* var. *ikilimbu*). The examination has been made by SEM for the first time and also by LM. Detailed descriptions of the pollen grains are given. The pollen grains are small, isopolar and trizonocolporate. Ornamentation is generally classified as striate, although with some modifications. A striate-reticulate pattern has been observed in only one species (*R. cordiformis*). A rugulate-striate pattern represents *R. novoguineensis*. The typical striate patterns differed in form, width and orientation of the muri are observed in *R. clementis*, *R. diclinis*, *R. megacarpus*, *R. royenii* var. *ikilimbu*. The tectum perforations are clearly observed in *R. clementis*, *R. diclinis*, *R. megacarpus*, *R. royenii* var. *ikilimbu*. The relation between the species has also been discussed. Pollen morphological studies confirmed partly the systematic concept. *Rubus megacarpus*, *R. cordiformis*, *R. novoguineensis* show completely different patterns and can not be regarded as closely related species; *Rubus clementis* has its own striate pattern, which resembles the pollen morphological type of *R. lucens* (not included in this study). *Rubus diclinis* and *R. royenii* var. *ikilimbu* have almost the same type of pollen morphology.

KEY WORDS: *Rubus* subgenus *Micranthobatus*, pollen morphology, SEM, LM.

INTRODUCTION

The present article is the second of the planned series of publications on pollen morphology of genus *Rubus*. The first study was devoted to the morphological diversity of European representatives, which belong to the subgenus *Rubus* (Tomlik-Wyremblewska, 1995).

Subgenus *Micranthobatus* includes about 12 species, the distribution of which is connected with tropical areas of the Old World. Five of them are endemic in New Guinea; two occur in Australia; two or three in New Zealand, one in Borneo, the Philippines and Celebes, one in NE India and one in Madagascar.

Based on a few of the above species, Fritsch (1886) erected the section *Micranthobatus*. Foke (1911, 1914) included them all in subgenus *Lampobatus* together with species from South and Central America. Kalkman (1987) established the old section *Micranthobatus* as subgenus. In his opinion the systematic classification suggested by Focke (l.c.) is not enough justifiable, neither for morphological nor for geographical reasons.

Brambles representing the subgenus *Micranthobatus* are usually shrubs, climbing or straggling; their leaves are 3- or 5-palmate, rarely unifoliate. Stipules are absent or very small, usually early deciduous. Fruits are cohering and usually falling as a whole from the torus. According to Kalkman the area covered by subgenus *Micranthobatus* suggests that it is an old group of Gondwanan origin.

In this paper the pollen morphology of all six *Micranthobatus* species growing in Flora Malesiana area have been stu-

died. The basis was the monographic revision of the Malesian species, by Kalkman (1987). The herbarium specimens, that were sampled for pollen, were previously revised by Kalkman.

The species occurring in Malesia that are most related according to Kalkman are: *Rubus cordiformis*, *R. royenii* var. *ikilimbu*, *R. novoguineensis* and *R. diclinis*. *Rubus clementis* shows the closest relation to *R. lucens*, occurring in NE India, whereas *R. megacarpus* is not closely related to any known species. Most of the Malesian brambles are very variable species. As Kalkman states they are still little known; more abundant herbarium material and observations on living plants are required.

Apart from the pollen morphological studies of Malesian species of subgenus *Micranthobatus*, the aim of this study was to check out how the pollen morphology is correlated with the morphological differentiation of particular species.

MATERIAL AND METHODS

Pollen samples were taken from dried material, present in Rijksherbarium at Leiden (Leiden University). The method of preparing pollen for study was presented in the previous paper (Tomlik-Wyremblewska 1995). The pollen descriptions were performed according to the pollen characteristics and terminology used in the same paper (Tomlik-Wyremblewska l.c.) and due to literature quoted.¹

¹Ham 1990; Hebda et al. 1988; Hebda et al. 1987; Moore et al. 1991; Punt et al. 1976-1991

TABLE 1. Measurements of examined pollen grains in glycerine-jelly. The abbreviations of P, E, P/E are explained in Tomlik-Wyremblewska (1995).

Species	Polar axis P (µm)	Range P (µm)	Standard deviation P (µm)	Equatorial diameter E (µm)	Range E (µm)	Standard deviation E (µm)	P/E Index	Exine thickness (µm)
<i>Rubus clementis</i>	17.83	16-20	1.34	14.5	13-16	0.75	1.22	1.32
<i>Rubus trigonus</i>	18.4	17-19	0.49	16.14	15-17	0.70	1.18	1.20
<i>Rubus declinis</i>	17.78	16-19	1.02	13.28	10-15	1.68	1.36	1.17
<i>Rubus megacarpus</i>	21.00	20-22	0.55	17.84	16-19	0.95	1.18	1.57
<i>Rubus novoguineensis</i>	16.18	15-17	0.63	15.55	15-16	0.50	1.04	1.50
<i>Rubus royeri</i> var. <i>ikilimbu</i>	15.54	14-17	0.99	14.59	13-16	0.31	1.03	1.21

The general morphology of Rubus pollen

All *Rubus* pollen is classified as trizonocolporate, with rugulate-striate ornamentation, apart from *R. chamaemorus*, which has the echinate pollen (Erdtman 1952; Faegri & Iversen 1964; Demchenko 1965). Variation is present in the subgenera *Idaeobatus*, *Malachobatus*, *Micranthobatus* and *Chamaebatus*, which occur in East Asia, Indonesia and Japan. Their pollen has been described as scabrate, granulate, reticulate, striate or as showing combination of these patterns (Huang 1972; Ikuse 1955). Pollen grain size is small or medium according to Erdtman (1952). The pollen morphology of Malesian species were described, using SEM, also to revise some species, examined by Nair (1965).

Subgenus: *Micranthobatus* (Fritsch) Kalkman

Rubus clementis Merr.

Pollen grains are small, (P × E: 17.8 × 14.5 µm), (Table 1); equatorial outline circular to 3 – lobed (Fig. 1), meridional outline elliptical (Fig. 4).

Apertures: Ectoaperture – colpus, long, extending 81% length of polar axis, tapering towards the poles, with acute

ends (Figs 1, 3). The widest part of the colpus is near the porus. Margins of the colpus undifferentiated, finely folded inwards. In some pollen grains a granulate colpus membrane is visible (Fig. 1).

Endoaperture – porus indistinct, because of equatorial bridge and colpus margins constricted at the equator (Fig. 1, marked by arrow).

Exine: The total thickness of the exine is 1.3-1.4 µm in the centre of mesocolpium (Fig. 4). Stratification of exine is not clear in LM observation. Tectum and infratectum: columellae, constitutive of sexine and nexine, are distinct in some parts of in LM photographs (Fig. 4). These layers have not been measured unfortunately. Perforate tectum with perforations of 0.16-0.1 µm in diameter, often covered by muri (Fig. 2).

Ornamentation: Striate pattern in LM and SEM examination, with muri compact arranged, often covering the perforate tectum. The lumina (grooves) are as wide as the muri, ca 0.2 µm. Muri running mostly meridionally, often anastomosing. The anastomose range is 7-9 per 10 µm length of the muri (Figs 1, 2, 3).

Figs 1-4. *Rubus clementis*. The bar on the photo refers to magnification on the plate (SEM); LM photos are magnified (× 2000).
Fig. 1 (SEM). Pollen grains arranged in different directions. The equatorial bridges constricted at the equator marked.
Fig. 2 (SEM). Striate ornamentation with grooves and perforations distinct.
Fig. 3 (LM). Equatorial view. Mesocolpium, striate ornamentation distinct (× 2000)
Fig. 4 (LM). Equatorial view. Meridional outline with exine layers partly distinct (× 2000).

Rubus trigonus* Kalkman*(*Rubus cordiformis* Kalkman)**

Pollen grains are very small, ($P \times E$: $18.4 \times 16.1 \mu\text{m}$); equatorial outline circular to 3-lobed (Figs 5, 11), meridional outline usually elliptical (Figs 5, 7), sometimes circular.

Apertures: Ectoaperture-colpus long, extending ca 86-87% length of polar axis (Table 1), with acute ends. The widest part of the colpus is near the porus and measures up to $1.17 \mu\text{m}$. Colpus membrane distinctly granulate, clearly visible in SEM (Figs 5, 6), because the colpus is constricted only at the equator, where the equatorial bridges are distinct (Figs 5, 7, 9).

Endoaperture – porus is rather indistinct because of the equatorial bridge (Figs 5, 9, marked by arrow); sometimes a dark hole is observed (Fig. 5A, B).

Exine: Total thickness of the exine is $1.2 \mu\text{m}$ in the centres of mesocolpia. The stratification of an exine is visible in LM examination (Figs 8, 11, marked by arrows). Tectum (with supracteal elements), columellae and nexine have not been measured, but the columellate layer seems to be very thin. We are able to observe it looking through very big perforations, where columellae are seen (Fig. 6). Tectum with remarkably large perforations up to $0.5 \mu\text{m}$ is always present (Figs 6, 7, 10, marked by arrows).

Ornamentation: striate, with very remarkably perforations, both in LM and SEM examinations (Figs 5, 6, 7, 10). The muri are running mostly meridionally, sometimes swirling slightly along the mesocolpium. Muri are short, equal in width, approximately up to $0.2 \mu\text{m}$ rounded above and often merging into the perforate tectum. Perforations are much wider than muri and give the ornamentation a reticulate appearance (Fig. 6).

Remarks: Pollen of very regular shape almost without variation (Fig. 5). The ornamentation could be classified as a combination of reticulate and striate patterns, a new type of ornamentation for *Rubus* pollen.

***Rubus diclinis* F. Muell.**

Pollen grains are small, ($P \times E$: $17.8 \times 13.2 \mu\text{m}$, (Table 1); equatorial outline circular (Fig. 15A), meridional outline elliptical (Figs 12B; 14).

Apertures: Ectoaperture-colpus long, ca 85% length of polar axis, with acute ends, sometimes constricted, but often the granulate colpus membrane and the porus are quite well visible (Fig. 12B). Colpus margins undifferentiated, rarely undulated. Equatorial bridges opened. Endoaperture – porus well visible and lalongate (Figs 12B, 15B).

Exine: Total thickness of the exine is $1.17 \mu\text{m}$ in the centre of mesocolpia. In LM examination, stratification of an exine distinct in some parts on Figs 14 (marked by arrow) and 15A. Tectum and nexine separated by infratectum: columellae, are hardly seen. These layers have not been measured, but a perforate tectum is visible (Figs 12A, 12B). Perforations sometimes hidden under the muri and their occurrence is less conspicuous near the colpi (Fig. 12A).

Ornamentation: Striate, or finely striate, both in LM and in SEM examination (Figs 12A 12B, 13). Muri are running mostly meridionally, slightly curving, merging into the perforate tectum. Muri are rather short, sometimes acute ends are distinct (Fig. 12A). They are narrow and have rounded tops and anastomose very often. The anastomose range is 6-7 per $10 \mu\text{m}$ length of the muri. There are some grooves between the muri and granulate elements are seen in some pollen grains (Fig. 12A). Therefore the pattern seems to be more loosely striate comparing with the striate patterns of other species (Figs 12A, 12B compared with Figs 29, 30).

Remarks: First *Rubus* species of the examined subgenera, where the endoaperture is quite well visible.

***Rubus megacarpus* P. Royen**

Pollen grains small ($P \times E$: $21.00 \times 17.84 \mu\text{m}$), but the biggest among the examined species (Table 1); equatorial outline circular to 3-lobed (Figs 16A, 19); meridional outline elliptical usually (Figs 16B, 21).

Apertures: Ectoaperture – colpus long, extending ca 86% length of polar axis (Table 1), with acute ends. The widest part of the colpus is near the porus (Fig. 16). The edges of the colpus are undifferentiated (Figs 16, 17) and sometimes folded in wards, but the granulate colpus membrane is quite well visible (Fig. 17). Colpus is constricted at the equator; equatorial bridge present, with constricted margins making the porus invisible (Figs 16A, 16B, 20, 21).

Endoaperture – porus indistinct, hidden under the wide equatorial bridge.

Exine: Total thickness of the exine is $1.4-1.6 \mu\text{m}$ in the centre of mesocolpium. Stratification of exine distinct in some parts of in LM examination (Fig. 19, marked by arrow). The layers of exine (tectum, infratectum substitutive of sexine and nexine) have not been measured, however a perforate tectum is present, although hardly seen between the wide muri, which are close together (Figs 16A, 16B, 17).

Ornamentation: Striate, both in LM and SEM examinations (Figs 16, 17, 18, 20). Muri are very wide approximately up to $0.6-0.8 \mu\text{m}$, rounded above, short, compact arranged, often merging into the perforate tectum and anastomosing. Anastomose range is 6-7 per $10 \mu\text{m}$ of the muri. Muri are running mostly meridionally. They are close together, so the tectum, perforations and columellae are hardly visible (Fig. 17). The grooves between the muri are inconspicuous, this pattern makes the ornamentation almost smooth in LM (Fig. 20).

Remarks: Pollen of regular shape, almost without variation, characteristic wide muri make the tectum and perforations almost invisible. Relatively thick exine is distinct.

***Rubus novoguineensis* Merr. & Perry**

Pollen grains are small ($P \times E$: $16.2 \times 15.5 \mu\text{m}$), (Table 1), circular to 3-lobed in equatorial outline (Figs 26, 28); meridional outline circular and rarely elliptical (Figs 22, 24, 25, 27).

Apertures: Ectoaperture-colpus extends ca 79% length of polar axis (Table 1), with acute ends. Colpus often partly invisible, because of edges folded in wards (Figs 22, 23, 27). The colpus is constricted at the equator. Equatorial bridge present with constricted margins (Figs 22, 23, 24, 27).

Endoaperture – porus indistinct, hidden under the equatorial bridge (Figs 22, 23, 24, 27).

Exine: Total thickness of the exine is $1.5 \mu\text{m}$, measured in the centre of mesocolpia. Stratification of exine is distinct in LM examination on Figs 25, 28 (marked by arrows). The layers (tectum, infratectum-columellae, substitutive of sexine and nexine), have not been measured, but a perforate tectum is quite well visible (Figs 22, 23).

Ornamentation: The presented ornamentation is a combination of rugulate and striate patterns. In the rugulate pattern the muri are often merging and are orientated in different directions. They are often sinuous near the colpi. The number of muri is higher in apocolpium region and near the colpi. Irregular elements are arranged sometimes between the muri (Figs 22, 23). Perforate tectum is distinct between the irregular elements of the rugulate pattern (Fig. 23).

Remarks: The rugulate ornamentation of the pollen of *Rubus novoguineensis* differs from the ornamentation in the

Figs 5-11. *Rubus trigonus* pollen.

Fig 5 (SEM). Pollen grains arranged in different directions, the equatorial view and polar view distinct, striate-reticulate ornamentation and the equatorial bridges constricted at the equator distinct.

Fig. 6 (SEM). Detail of striate-reticulate ornamentation with wide grooves distinct. Large perforations like reticulate sculpture distinct.

Fig. 7 (LM). Equatorial view and mesocolpium ornamentation distinct, large perforation distinct ($\times 2000$).

Fig. 8 (LM). Equatorial view with stratification of exine ($\times 2000$).

Fig. 9 (LM). Equatorial bridge with ornamentation elements distinct ($\times 2000$).

Fig. 10 (LM). Polar view with ornamentation of apocolpium ($\times 2000$).

Fig. 11 (LM). Polar view stratification of exine distinct ($\times 2000$).

Figs. 12-15. *Rubus diclinis* pollen.

Fig. 12A (SEM). Pollen grain with striate ornamentation of mesocolpium distinct.

Fig. 12B (SEM). Pollen grain with porus distinct. Fig. 13 (LM). Equatorial view of pollen grain. Details of striate ornamentation distinct ($\times 2000$).

Fig. 14 (LM). Equatorial view of pollen grain, layers of exine distinct (marked by arrow), ($\times 2000$).

Fig. 15A (LM). Polar view of pollen grain. Circular outline distinct ($\times 2000$).

Fig. 15B (LM). Equatorial view of pollen grain. Details of striate ornamentation distinct ($\times 2000$).

other species of subgenus *Micranthobatus*, (where striate ornamentation dominates). *Rubus novoguineensis* has the thickest exine among examined species.

***Rubus royenii* var. *ikilimbu* (P. Royen) Kalkman**

Pollen grains are small ($P \times E$: $15.0 \times 14.6 \mu\text{m}$), the most circular among the examined species (Figs 29, 30); equatorial outline circular to 3-lobed (Figs 30, 33, 34); meridional outline circular to elliptical (the ratio P/E is almost 1 see Table 1), (Fig. 29).

Apertures: Ectoaperture – colpus long, extending ca 88% length of polar axis (Table 1), with acute ends. The widest part of the colpus is in the porus area and the granulate colpus membrane is quite well visible (Figs 29, 30). The edges of the colpus undifferentiated and sometimes folded inwards. At the equator, the edges are sometimes constricted and form an equatorial bridge. The bridges are usually open (Figs 29, 20, 31, 32, marked by arrows) and the elongate endoaperture is often distinct (Fig. 29, marked by arrow).

Exine: Total thickness of the exine is $1.2 \mu\text{m}$ in the centre of mesocolpium. Stratification of exine is visible in some parts in LM examination (Figs 32, 34), but the layers are not distinct quite well. Tectum, infratectum: columellae and nexine have not been measured, however a perforate tectum is visible (Fig. 30).

Ornamentation: Striate, both in LM and SEM examination. Muri are short, $1-4 \mu\text{m}$ long, often anastomosing (the range is 8-9 per $10 \mu\text{m}$ length of the muri), ca $0.3 \mu\text{m}$ wide and often merging into the perforate tectum. Perforations are in the apocolpium and in the mesocolpium, relatively less near the colpi. Muri are running mostly meridionally. Perforations well visible in the grooves (Figs 29, 30, 31).

Remarks: Pollen of regular shape. This species is the only one with pollen almost round in meridional outline (Table 1), (Fig. 29).

DISCUSSION

The six Malesian *Rubus* species grouped in Subgenus *Micranthobatus*, established by Kalkman (1987) present very uniformly sized and shaped pollen, which belongs to the *Rubus* pollen type: isopolar, radially symmetrical, 3-colporate according to Erdtman (1962), Reitsma (1966) and Eide (1981). Comments are presented below:

Shape and size

The equatorial outline of the grains is circular or 3-lobed while the meridional outline is elliptical to circular. Three of examined species: *Rubus cordiformis*, *R. novoguineensis* and *R. royenii* have an almost circular meridional and equatorial outline (Table 1, P/E ratio 1.03; 1.04). The size of the grains of all taxa is $14-22 \mu\text{m}$ for the polar axis (P) and $10-19 \mu\text{m}$ for the equatorial diameter (E). This classifies the pollen in the range of small grains ($10-25 \mu\text{m}$), according to Erdtman (1952). The biggest pollen within the subgenus was found in *R. megacarpus* (21.00×17.84), and the smallest in *R. novoguineensis* ($16.2 \times 15.5 \mu\text{m}$). The standard deviation indicates the most variability in *R. clementis* pollen; the smallest variability was found in *R. cordiformis*, which in LM and SEM examination looks the most constant and almost without variation. The P/E index of the other species did not indicate much variation in shape (*R. novoguineensis*, *R. megacarpus*).

Apertures

Ectoapertures: Except *Rubus novoguineensis*, all examined *Rubus* species tend to have long, acute colpi, covering 81-88% of the length of the polar axis and approximately $1.17 \mu\text{m}$ wide in their widest part near the pori (*R. cordiformis*). The longest colpi occur in *R. royenii* var *ikilimbu*, (ca 88%), the shortest in *R. novoguineensis* (79% the length of the polar axis). The furrows taper to acute ends in examined species

Figs 16-20. *Rubus megacarpus* pollen.

Fig. 16 (SEM). Pollen grains in almost polar (A) and equatorial view (B), striate ornamentation and the equatorial bridges distinct.

Fig. 17 (SEM). Details of striate ornamentation. Narrow grooves distinct.

Fig. 18 (LM). Polar view and apocolpium details of ornamentation ($\times 2000$).

Fig. 19 (LM). Polar view. Outline with stratification of exine distinct (arrow) ($\times 2000$).

Fig. 20 (LM). Equatorial view with equatorial bridges distinct ($\times 2000$).

Fig. 21 (LM). Equatorial view. Elliptical outline of pollen, equatorial bridges and exine sublayers distinct ($\times 2000$).

Figs 22-28. *Rubus novoguineensis* pollen.

Fig. 22 (SEM). Pollen grain in equatorial view, ornamentation, equatorial bridges distinct.

Fig. 23 (SEM). Details of ornamentation in mesocolpium area, the combination of rugulate and striate pattern distinct.

Fig. 24 (LM). Equatorial view, equatorial bridges distinct ($\times 2000$).

Fig. 25 (LM). Equatorial view. Outline with stratification of exine distinct (marked by arrow), ($\times 2000$).

Fig. 26 (LM). Polar view and ornamentation of apocolpium distinct ($\times 2000$).

Fig. 27 (LM). Equatorial view of pollen grain, equatorial bridges cover the porus area, folded margins distinct ($\times 2000$).

Fig. 28 (LM). Polar view: outline and stratification of exine distinct (marked by arrow), ($\times 2000$).

Figs 29-30. *Rubus royenii* var. *ikilimbu* pollen.

Fig. 29 (SEM). Equatorial view, striate ornamentation of mesocolpium and porus visible.
Fig. 30 (SEM). Striate ornamentation of apocolpium. Granulate membrane and undifferentiated colpus margins near endoaperture visible.

Fig. 31 (LM). Equatorial view. Striate ornamentation of mesocolpium with equatorial bridges visible (marked by arrow), ($\times 2000$).

Fig. 32 (LM). Equatorial view. Circular outline with equatorial bridges visible (marked by arrow), ($\times 2000$).

Fig. 33 (LM). Polar view. 3-lobed outline. Striate ornamentation of apocolpium distinct ($\times 2000$).

Fig. 34 (LM). Polar view. Outline with stratification of exine distinct ($\times 2000$).

and rarely join across the pole. The colpus membrane is granulate in all species and it is quite well visible, except in *R. novoguineensis*. Equatorial bridges are present in all species. In *R. diclinis* and *R. royenii* var. *ikilimbu* the bridges are usually stretched (opened). The other species appear to have constricted margins of colpus in the equator, and well developed bridges, sometimes constricted deep in the colpus (*R. clementis*), wide with constricted edges (*R. megacarpus*) or narrow which margins close together on very narrow area (*R. cordiformis*).

Endoapertures: Pori are not seen except in *R. diclinis* and *R. royenii* var. *ikilimbu*, where sometimes alongate endoapertures are visible. LM and SEM examination do not help in determination of pori in the other species, because of equatorial bridges hide the pori.

Exine: The glycerin-jelly measurements showed not so much variation in exine thickness in the centres of mesocolpia. The range was 1.2-1.57 μm for different species. The thickest exine was observed in *R. megacarpus* and *R. novoguineensis*, which seems to be correlated with ornamentation, especially with the suprategal elements, which are quite different from the other species. The thinnest exine was found in *R. cordiformis*, the ornamentation of which is finely striate, while its muri are relatively low and thin. Unfortunately the layers of the exine have not been measured and it is difficult to say something about the thickness of the exine subunits (tectum and nexine, separated by infrategum: columellae). But as far as we could observe the suprategal elements contribute most to the variation in thickness of exine.

Ornamentation

Each of the 6 species studied has its own ornamentation, which is generally classified as striate, although with some modifications. The patterns, which have not been reported up till now in previous studies (Huang l.c.; Ikuse l.c.; Nair l.c.) are presented as follows:

- 1) *Rubus cordiformis*: finely striate-reticulate pattern because of characteristic large perforations in the tectum.
- 2) *Rubus megacarpus*: striate pattern with wide muri, arranged very compact each other so that grooves are very narrow and perforations are hardly visible; it makes the ornamentation almost smooth in LM examinations.
- 3) *Rubus novoguineensis*: combination of rugulate and striate patterns with striate muri lying on the irregular rugulate elements.

The ornamentation of the other species (*Rubus royenii* var. *ikilimbu*, *R. clementis*, *R. diclinis*) present striate pattern differing themselves by the length, width, height and orientation of the muri. *Rubus royenii* var. *ikilimbu* and *Rubus diclinis* could be placed in the same type of striate ornamentation characterized by short muri, often anastomosing or merging into the perforate tectum, perforations quite well visible. *Rubus clementis* differs from the pattern in other species by muri running mostly meridinally.

Compared with the ornamentation types of European *Rubus* pollen (presented in Tomlik-Wyremblewska l.c.), only 2 species, *R. clementis* and *R. diclinis*, seem to have very similar ornamentation to European species. However muri of these species are wider, higher and anastomose more often (6-9 per 10 μm length of the muri). The type of ornamentation in *R. clementis* and *R. diclinis* falls in the second sculptural type of European species, as represented by *R. armeniacus*, (compare Tomlik-Wyremblewska l.c. Fig. 11).

CONCLUSIONS

From the macromorphological point of view (Kalkman l.c.), the species regarded as closely related are *R. cordiformis*, *R. royenii* var. *ikilimbu*, *R. novoguineensis* and *R. diclinis*. *R. clementis* has close connections with *R. lucens* from NE India, and *R. megacarpus* is not related with any of the species known from Malesia. The present pollen morphological study confirmed partly this systematic division.

- 1) *Rubus megacarpus* has its ornamentation pattern within the subgenus *Micranthobatus* and from this point of view it is not related to any other of the species in this subgenus.
- 2) *Rubus diclinis* and *Rubus royenii* var. *ikilimbu* have almost the same type of pollen morphology, which confirms the systematic division proposed by Kalkman (l.c.).
- 3) *Rubus cordiformis* and *Rubus novoguineensis* represent completely different patterns (striate-reticulate and rugulate-striate) and could not be regarded as closely related species. They could not be placed in the same pollen morphological pattern as *R. diclinis* and *R. royenii* var. *ikilimbu* (Fig. 35).
- 4) *Rubus clementis* has its own striate pattern, which resembles pollen morphological that of *Rubus lucens* from NE India (the examination of which has been made separately, not placed in this study).

Based on this conclusions, the systematic division within the subgenus *Micranthobatus*, which had been presented by Kalkman (l.c.) could be compared with hypothetic pollen morphological division. The following scheme is proposed (Fig. 35).

Fig. 35. Hypothetical scheme showing affinities between Malesian species of *Rubus* subgenus *Micranthobatus*. A: based on macromorphology according to Kalkman (1987), B: based on pollen morphology.

The samples studied were taken from the following herbarium specimens present in the Rijksherbarium at Leiden University. Photographs of pollen grains are presented in this article were taken from material indicated with an asterisk (*).

● *Rubus clementis*

Sumatra. Athej: Mt Goh Lemboh, *van Steenis* 8961.

Borneo. Sarawak: Third div., Ulu Mujong, Carpa pila, Bal-leh. Basalt scarp, mixed dipterocarp forest, 900 m alt., *Ashton S.* 19628 (*).

● *Rubus cordiformis*

New Guinea. Papua New Guinea. Western Highlands Province: Nondugl, *Womersley NGF* 5332. Eastern Highlands Province: Goroka Subprovince, Asar-Mairifutica, ca 3200 m alt., *Pullen* 436 (*).

● *Rubus diclinis*

New Guinea. Papua New Guinea. Southern Highlands Province: Mendi Subprovince, Kagaba, montane forest, 2743 m alt. *Leach LAE* 56187; Tari Subprovince, *Frodin NGF* 28434 (*).

● *Rubus megacarpus*

New Guinea. Papua New Guinea. Chimbu Province: Mt. Wilhelm. Subalpine forest 3750 m alt. *van Balgooy* 340, 883 (*).

● *Rubus novoguineensis*

New Guinea. Papua New Guinea. Central Province: Mt Albert Edward. Subalpine forest, 3500 m alt. *Croft & Vinas LAE* 61465 (*); Mt. Scratchley, *Stevens & Coode LAE* 51476.

● *Rubus royeri* var. *ikilimbu*

New Guinea. Papua New Guinea. Western Highlands Province: Upper Wahgi valley, Kumun, Pin-Divide, E of Korn, 1050 m alt, *Hoogland & Pullen* 6179 (*).

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MORFOLOGIA PYŁKU RODZAJU *RUBUS* L. II. WSTĘPNE BADANIA NAD MALEZYJSKIMI GATUNKAMI Z PODRODZAJU *MICRANTHOBATUS*

STRESZCZENIE

W niniejszej pracy przedstawiono wyniki badań nad morfologią pyłku 6 malezyjskich gatunków jeżyn (*Rubus clementis*, *R. cordiformis*, *R. diclinis*, *R. megacarpus*, *R. novoguineensis* and *R. royeri*). Badania opierały się nad analizie mikroskopowej skaningowej, wykonanej dla tych gatunków po raz pierwszy oraz na analizie ziarn pyłku pod mikroskopem świetlnym. Wszystkie ziarna pyłku były małe, izopolarne i trójbruzdowe z porami w bruzdach w płaszczyźnie równika. Ogólnie, ziarna pyłku charakteryzowały się rzeźbą prążkowaną z pewnymi modyfikacjami. Za właściwy tylko jednemu gatunkowi (*Rubus cordiformis*), okazał się wzór prążkowano-siatczkowaty (striate-reticulate); pomarszczono-prążkowaną (rugulate-striate) rzeźbę wykazał tylko *R. novoguineensis*, natomiast prążkowana rzeźba, którą reprezentowały pozostałe gatunki (*R. clementis*, *R. diclinis*, *R. megacarpus*, *R. royeri*), różniła się w formie, grubości, orientacji prążków a także stopniem widoczności perforacji. W pracy tej poddano dyskusji systematyczne pokrewieństwo gatunków. Badania morfologiczne ziarn pyłku potwierdziły częściowo podział systematyczny wewnątrz podrodzaju. Ziarna pyłku: *Rubus megacarpus*, *R. cordiformis*, *R. novoguineensis* reprezentowały zupełnie inne urzębienie i na tej podstawie nie mogą być uznane za blisko spokrewnione gatunki. *Rubus clementis* ma swój własny wzór rzeźby i typem przypomina *R. lucens*. Za najbardziej spokrewnione ze sobą uważane są: *R. diclinis* i *R. royeri*, gdyż mają prawie ten sam typ morfologii pyłku.

SŁOWA KLUCZOWE: *Rubus*, podrodzaj *Micranthobatus*, morfologia pyłku, mikrofotografie LM i SEM.

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