

MALLOMONAS CAMERUNENSIS SP. NOV. (CHRYSOPHYCEAE, STRAMENOPILES) FROM A SHALLOW PUDDLE IN THE GUINEO-CONGOLIAN RAINFOREST (CAMEROON)

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Abstract. A new silica-scaled chrysophyte species, *Mallomonas camerunensis* J. Piątek, is described and illustrated from a shallow puddle in the Guineo-Congolian rainforest in Cameroon. This species belongs to section *Papillosae* and series *Papillosa*. It is similar to other *Mallomonas* species placed in *Papillosa*, such as *M. binocularis* Siver, *M. calceolus* D. E. Bradley, *M. delanciana* Siver, *M. kalinae* Rezáčová, *M. papillosa* K. Harris & D. E. Bradley, *M. paxillata* (D. E. Bradley) L. Ş. Péterfi & Momeu, *M. rasilis* Dürschm. and *M. tropica* Dürschm. & Croome, but differs from them in several morphological characters warranting recognition as a distinct species. The dome of *M. camerunensis* is clearly delimited and ornamented with papillae and ribs. The scales lack an anterior submarginal rib, while the posterior rim and V-rib are smooth and unornamented. The shield is thickly ornamented with papillae (18–22 papillae per scale width). The species is described and illustrated using light microscopy and scanning electron microscopy.

Key words: Africa, Cameroon, Chrysophyceae, *Mallomonas camerunensis*, new species, scale morphology, Stramenopiles

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INTRODUCTION

Chrysophyte species are common algae in the plankton of freshwater habitats, rarely in brackish or saline waters, and many of them are considered cosmopolitan (Kristiansen & Preisig 2001). Their greatest species diversity has been recorded from cold and nutrient-poor waters in the subarctic, boreal and temperature zones of the Northern Hemisphere (Cronberg 1989). Research on the diversity and ecology of chrysophytes in tropical and subtropical regions has been much neglected in the past (Vyverman & Cronberg 1993). Systematic studies of tropical waters, especially at different seasons of the year, could fill the gap in this area of chrysophyte research, including discovery of species new to science, as has been recently substantiated in some tropical regions of the world, for example in Southeast Asia (e.g., Gusev 2012, 2015; Wei *et al.* 2014; Gusev *et al.* 2015).

As in other tropical areas, research and documentation of African chrysophytes is still far from satisfactory; up to now the most research has been done in the Democratic Republic of the

Congo (Belgian Congo), Sierra Leone (Woodhead & Tweed 1957), Senegal (Woodhead & Tweed 1959), Chad (Compère 1973, 1974, 1975), Kenya (Wujek & Asmund 1979), Madagascar (Hansen 1996; Hansen & Kristiansen 1995), Botswana (Cronberg 1996), Zimbabwe (Wujek *et al.* 2004), Nigeria (Wujek *et al.* 2004, 2010, 2011), Egypt (Piątek *et al.* 2009) and South Africa (Němcová *et al.* 2011; Němcová & Kreidlová 2013).

In two surveys for chrysophytes (including stomatocysts) in Cameroon in 2007, several sediment and water samples were collected from different water reservoirs. The material included cells and scales of *Mallomonas striata* var. *serrata* K. Harris & D. E. Bradley and *Synura petersenii* f. *kufferathii* J. B. Petersen & J. B. Hansen, both newly recorded in Cameroon and Central Africa (Piątek & Mossebo 2008), encysted specimens of *Dinobryon sertularia* Ehrenb. representing the first finding of an encysted chrysophyte in Africa (Piątek *et al.* 2012), as well as a new chrysophyte stomatocyst (stomatocyst 49 J. Piątek; Piątek & Piątek

2014). Another chrysophyte, an unknown species of *Mallomonas* Perty, was found in material collected from a shallow puddle in the Guineo-Congolian rainforest. This apparently undescribed species belongs to section *Papillosae* (Asmund & Kristiansen 1986) and is described and illustrated here.

MATERIALS AND METHODS

The samples were collected on 12th December 2007 from a shallow puddle in the Guineo-Congolian rainforest in the East Region of Cameroon. Plankton, water and sediment were taken using a pipette. The samples were fixed with Lugol's solution. Water temperature (°C), conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$) and pH were measured immediately after collection. Temperature and conductivity were measured using a CC-102 conductivity meter (Elmetron IP67), and pH was measured using a CP-103 waterproof pH-meter (Elmetron IP67).

The specimens were examined and identified using standard light and phase contrast microscopy (LM) and scanning electron microscopy (SEM). Slide preparations mounted in water were observed using a Nikon Eclipse 600 light microscope. Micrographs were taken with a Nikon DS-Fi1 camera. For SEM analyses each sample was pipetted onto clean cover glasses, air-dried, and affixed to an aluminum stub with double-sided transparent tape. The stubs were sputter-coated with carbon using a Cressington sputter-coater and viewed with a Hitachi S-4700.

The description of the new *Mallomonas* species follows the terminology of Siver (1991), Kristiansen (2002) and Kristiansen & Preisig (2007). All measurements of cells were taken from the present material directly under the light microscope, and scales and other elements were measured from SEM micrographs. The major diagnostic features of cells, scales and bristles of closely related taxa used to distinguish *Mallomonas camerunensis* *sp. nov.* are summarized in Table 1.

Wet samples and SEM holders are deposited in the Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

RESULTS AND DISCUSSION

Mallomonas camerunensis J. Piątek, *sp. nov.*

Figs 1–11

TYPE: Cameroon, East Region, Department of Haut-Nyong: between Ngolambélé and Dimako, ca 2 km S of Ngolambélé, 21 km SW from Bertoua, 04°24'26"N,

13°35'52"E, elev. ca 655 m a.s.l., leg. J. Piątek & M. Piątek, 12 December 2007 (HOLOTYPE: Fig. 10).

LM DESCRIPTION. Cells oval and obovate with bristles, at least one chloroplast, and two flagella (long and short). Cells 23.5–24.2 μm long and 7.5–10.4 μm wide.

SEM DESCRIPTION. Cells 18.7–24.2 μm long and 9.0–10.0 μm wide. Scales oval, ovate or rhomboid, tripartite, composed of a dome, shield, and flange; well-developed V-rib separates shield from posterior flange. Scales 3.5–4.4 μm long and 1.5–2.7 μm wide. Scales lack anterior submarginal rib. Posterior rim encircling up to half of perimeter of scale. Clearly delimited dome and shield, covered with densely spaced, well-developed papillae, 0.07–0.1 μm in diameter; dome additionally ornamented usually with 1 to 4 ribs. Posterior flange smooth and unornamented. Bristles serrate, short, thick, slightly curved, without bifurcated tip, 6.5–11.2 μm long and 0.2–0.4 μm wide. Shield densely ornamented with papillae, 18–22 papillae per scale width (counted at place where V-rib ends).

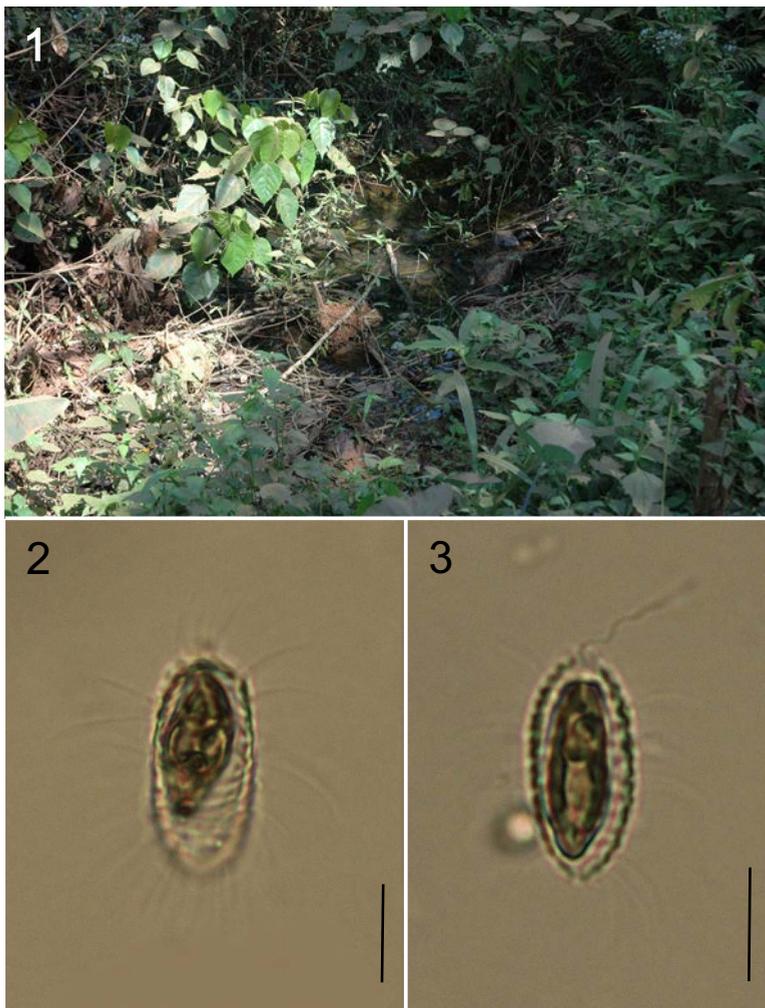
STOMATOCYST. Unknown.

ETYMOLOGY. The epithet refers to the country where this species was found.

DISTRIBUTION. This species is currently known only from the type locality in eastern Cameroon.

ECOLOGY. The material with *Mallomonas camerunensis* was collected in a semi-shaded place at the bottom of a disturbed rainforest from a small shallow puddle rich in leaf litter (Fig. 1); the pool resulted from overflowing of the neighboring river. The water was black, with temperature 24.5°C, conductivity 26 $\mu\text{S}\cdot\text{cm}^{-1}$ and pH 7.0. *Mallomonas camerunensis* co-occurred with other algae, especially with many specimens of Bacillariophyceae, colored and colorless Euglenophyta, and single specimens of Cyanophyta and Dinophyta.

COMMENTS. *Mallomonas camerunensis* is a new species belonging to section *Papillosae* and series *Papillosa* of the genus *Mallomonas*. It has several distinct morphological features that warrant its description as a new species: (1) the dome is clearly delimited and ornamented with



Figs 1–3. *Mallomonas camerunensis* J. Piątek, sp. nov. **1** – Sampling site (type locality) – shallow puddle in the Guineo-Congolian rainforest, Cameroon (photo M. Piątek). **2 & 3** – Whole cells with scales and bristles (LM). Scale bars = 10 μ m.

papillae and ribs, (2) the scales lack an anterior submarginal rib, (3) the posterior rim and V-rib are smooth and unornamented, (4) the shield is thickly ornamented with papillae (18–22 papillae per scale width). This species is assigned to section *Papillosae*. This section includes two series, *Papillosa* and *Ouradiatae*, with a total of 17 specific and infraspecific taxa (Kristiansen 2002; Řezáčová 2006; Kristiansen & Preisig 2007; Gusev 2012). *Mallomonas camerunensis* is similar to several species from series *Papillosa* (Table 1), which are contrasted and discussed below.

Mallomonas binocularis Siver has shorter cells and scales than *M. camerunensis*, and the dome is ornamented with a few papillae, without ribs (ribs are present in *M. camerunensis*). *Mallomonas binocularis* differs from *M. camerunensis* in having two conspicuous pores resembling pair of eyes, situated in the V-rib angle (Kristiansen 2002), small tooth-like projections on the left side of the scale (absent in *M. camerunensis*), smooth bristles, and only 6–9 papillae per scale width (counted at place where V-rib ends, from pictures in Kristiansen 2002; Kristiansen & Preisig 2007).

Table 1. Comparison of *Mallomonas camerunensis* J. Piątek, *sp. nov.* with morphologically similar species (morphological

Taxon	Cells	Scales	Dome	Shield	Posterior rim
<i>M. binocularis</i>	ovoid, 8.0–12.0 × 7.0–9.0 μm	oval, 2.2–2.7 × 1.4–1.8 μm	small with a few papillae	with papillae and with two conspicuous pores	usually extends less than halfway around perimeter of scale
<i>M. calceolus</i>	ovoid, 11.0–18.0 × 9.0–12.0 μm	oval, suboval, 3.0–4.0 × 1.0–2.0 μm	smooth or with some papillae	with papillae	N/A
<i>M. camerunensis</i>	oval, 18.5–24.2 × 7.5–10.4 μm	oval, ovate, rhomboid, 3.5–4.4 μm × 1.5–2.7 μm	with papillae and ribs	with papillae	smooth
<i>M. delanciana</i>	ovoid, 10.0–14.0 × 8.0–9.0 μm	elliptical, 3.5–4.0 × 2.0–2.7 μm	with papillae	with papillae	usually extends less than halfway around perimeter of scale
<i>M. kalinae</i>	ellipsoid, 15.0–17.5 × 8.0–9.5 μm	tripartite, 3.7–3.9 × 1.7–2.0 μm	small, smooth	with small papillae and one or two pores in proximal area	N/A
<i>M. papillosa</i>	broadly ellip- soidal, 7.0–12.0 × 5.0–12.0 μm	oval, 2.0–4.0 × 1.5–3.5 μm	small, smooth or partially covered with papillae	with papillae	narrow
<i>M. paxillata</i>	ovoid, 12.0–24.0 × 9.0–12.0 μm	suboval with slightly lateral incurving, 4.0–5.7 × 2.5–4.0 μm	small, with papillae	with papillae	N/A
<i>M. rasilis</i>	ellipsoidal, 15.0–20.0 × 8.0–11.0 μm	suboval, 3.0–4.1 × 2.0–2.5 μm	smooth or with papillae	with papillae	with irregular struts
<i>M. tropica</i>	ellipsoid, 15.0–20.0 × 5.0–9.0 μm	body scales oval, 3.0–4.1 × 2.0–2.2 μm	small and rounded, not clearly delimited from the shield	with papillae except in the angle of V-rib	N/A

* counted at place where V-rib ends

Mallomonas calceolus D. E. Bradley has shorter cells, and the dome is smooth or ornamented with papillae but without ribs (ribs are present in *M. camerunensis*). The anterior submarginal rib is weakly developed in *M. calceolus* (absent in *M. camerunensis*), the bristles are smooth with bifurcated tips and the number of papillae per scale width is 3–6 (counted in place where V-rib ends, from pictures in Kristiansen 2002; Kristiansen & Preisig 2007).

Mallomonas delanciana Siver has shorter cells than *M. camerunensis*, and the dome is or-

namented only with papillae (with papillae and ribs in *M. camerunensis*). An anterior flange is present in *M. delanciana* and ornamented with struts (absent in *M. camerunensis*), and the bristles are shorter, smooth and with a bifurcated tip, not serrate as in *M. camerunensis*. Moreover, the number of papillae per scale width is 4 (counted in place where V-rib ends, from pictures in Kristiansen 2002; Kristiansen & Preisig 2007) in *M. delanciana* while 18–22 in *M. camerunensis*.

Mallomonas camerunensis is also similar to *M. kalinae* Řezáčová, but this latter species differs

characters according to Kristiansen 2002; Řezáčová 2006; Kristiansen & Preisig 2007).

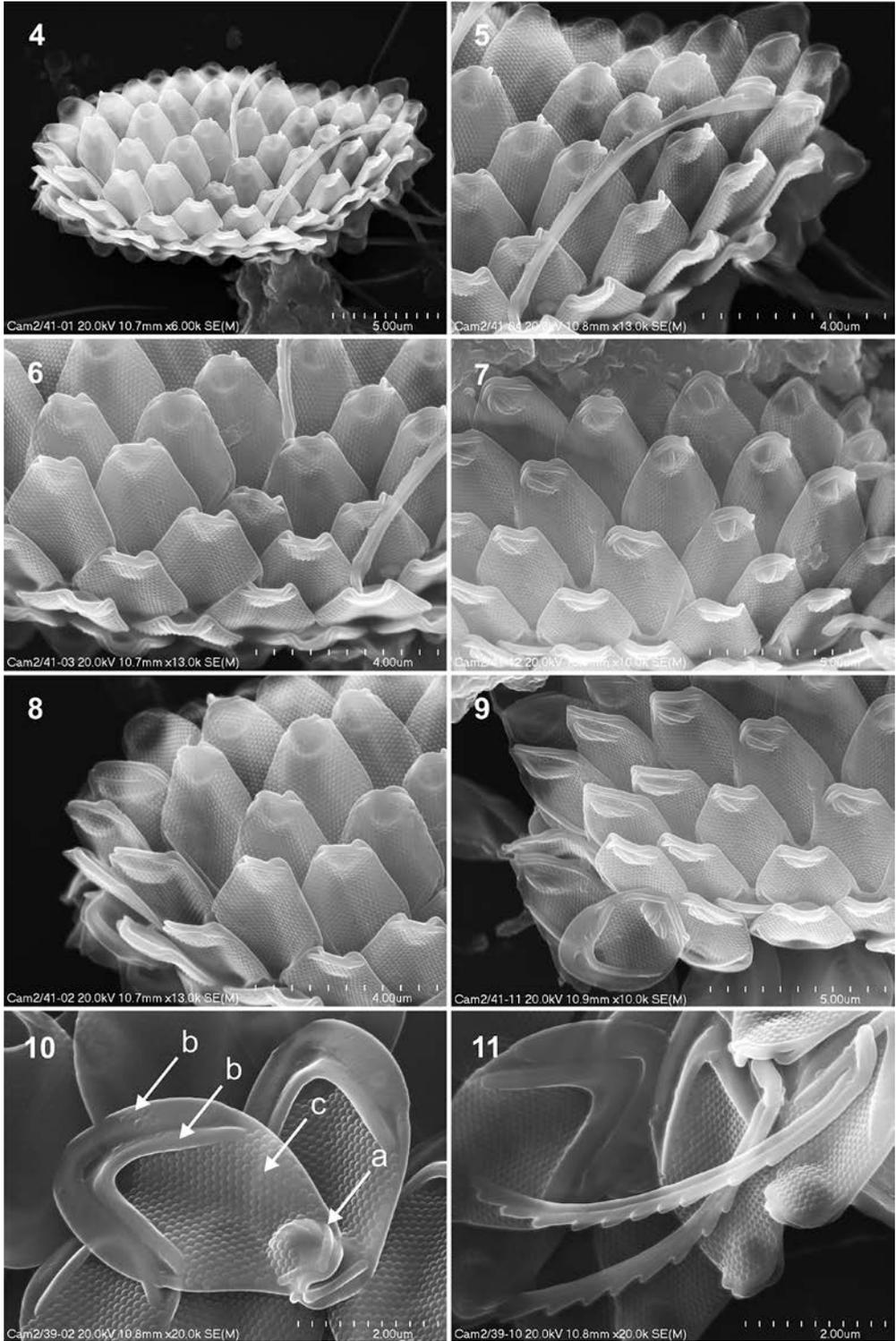
Pores of base plate	Posterior flange	Anterior flange	Anterior sub-marginal ribs	V-rib	Number of papillae per scale width*	Bristles
N/A	smooth	smooth	usually lacking	broadly rounded	6–9	slightly curved, short, thick, smooth, ending in a distinct point, 2.5–3.3 µm long
lack	smooth	smooth	weakly developed	with hood	3–6	slightly curved, smooth with bifurcated tip 4.0–15.0 µm long
lack	smooth, unornamented	lacking	lacking	well developed	18–22	thick, slightly curved, serrate, 6.5–11.2 µm long, 0.2–0.4 µm wide
N/A	smooth	with a series of evenly spaced, parallel struts	N/A	well developed	4	small, ribbed, smooth with bifurcated tip, 3.4–3.5 µm long
N/A	smooth	smooth	well developed	N/A	11–14	smooth, slightly curved and pointed, 4.1–7.7 µm long
present	smooth	with evenly spaced struts	well developed	narrow, hooded, often toothed	8–12	slightly curved, with short teeth, 4.0–11.0 µm
lack	smooth	with papillae	well developed, forming a tooth, or obscure	acute-angled, narrow, hooded	15–20	short, slightly curved, shaft smooth, with bifurcated tip, 4.5–8.0 µm long
lack	smooth	narrow, with papillae	lacking or inconspicuous	with rounded base and struts and a large pore	7–8	unilaterally serrate, with short, pointed teeth, 6.0–15.0 µm long
N/A	smooth	N/A	with short struts, the front part much reduced	with struts and smooth hood	9–10	curved, serrated and attenuated, 8.0–16.0 µm long

in having a small, smooth dome. Additionally, the shield in *M. kalinae* is ornamented with papillae and one or two pores in the proximal area (pores absent in *M. camerunensis*), the anterior submarginal rib is well developed and smooth (absent in *M. camerunensis*), and the anterior flange is smooth (absent in *M. camerunensis*). Moreover, the number of papillae per scale width is *ca* 11–14 (counted in place where V-rib ends, from pictures in Řezáčová 2006; Kristiansen & Preisig 2007) in *M. kalinae*, but 18–22 in *M. camerunensis*.

Mallomonas papillosa K. Harris & D. E. Bradley has shorter cells, the dome is mainly

smooth or partially covered with papillae, and pores of the base plate are present (absent in *M. camerunensis*). The number of papillae per scale width is 8–12 (counted in place where V-rib ends, from pictures in Kristiansen 2002; Kristiansen & Preisig 2007) in *M. papillosa* (18–22 in *M. camerunensis*).

Mallomonas camerunensis is also similar to *M. paxillata* (D. E. Bradley) L. Ş. Péterfi & Momeu but differs in lacking an anterior submarginal rib. The latter is well developed in *M. paxillata* and forms a prominent tooth. *Mallomonas paxillata* has smooth bristles with bifurcated tips, contrasting



with the serrate bristles of *M. camerunensis*, and larger scales (4.0–5.7 $\mu\text{m} \times$ 2.5–4.0 μm).

Mallomonas camerunensis resembles *M. rasilis* Dürschm. but differs in having a dome ornamented with papillae and ribs, as well as a smooth posterior rim. This contrasts with the smooth dome and the posterior rim ornamented with irregular struts of *M. rasilis*. Moreover, *M. rasilis* has ca 7–8 papillae per scale width (counted in place where V-rib ends, from pictures in Kristiansen 2002; Kristiansen & Preisig 2007) (18–22 in *M. camerunensis*).

Mallomonas tropica Dürschm. & Croome has similar markings but *M. camerunensis* has a dome ornamented with papillae and ribs, whereas *M. tropica* has a small rounded dome which is not clearly delimited from the shield. *Mallomonas camerunensis* lacks an anterior submarginal rib; *M. tropica* has an anterior submarginal rib ornamented with struts. The bristles in *M. tropica* are longer than in *M. camerunensis* (8–16 μm vs. 6.5–11.2 μm). Finally, *M. tropica* has ca 9–10 papillae per scale width (counted in place where V-rib end, from pictures in Kristiansen 2002; Kristiansen & Preisig 2007) (18–22 papillae in *M. camerunensis*).

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Figs 4–11. *Mallomonas camerunensis* J. Piątek, sp. nov. seen by SEM. **4** – Whole cell with scales and bristles. **5** – Group of anterior scales. **6** & **7** – Group of body scales. **8** & **9** – Group of posterior scales. **10** – Body scales with characteristic features: (a) clearly delimited dome ornamented with papillae and ribs, (b) smooth, unornamented posterior rim and V-rib, (c) shield thickly ornamented with papillae (18–22 papillae per scale width, counted in place where V-rib ends). Individual diagnostic features are arrowed. **11** – Slightly curved, serrate bristles. Scale bars: Figs 4, 7, 9 = 5 μm ; Figs 5, 6, 8 = 4 μm ; Figs 10, 11 = 2 μm .

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