Biometrical analysis and thallus morphology characteristics of *Placopsis antarctica* from King George Island, Antarctica

Short Communication

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Abstract

Placopsis antarctica is an ornithocoprophilous lichen that has been for a long time confused with *P. contortuplicata* I. M. Lamb. In our study, we focused on morphological characteristics of *P. antarctica* thalli. We report biometrical data on dominant morphological structures of *P. antarctica* thallus: cephalodia, marginal lobes, sorediate pits and soralia. Thalli of *P. antarctica* were collected at the King George Island, Antarctica and analyzed in a laboratory using a digital microscopy approach. Central cephalodium was found rather elliptic then round-shaped. Mean length/width was found 2.424/1.720 mm. Marginal lobes were found wider at the apex (1.415 mm) than basal part (0.495 mm). Side cephalodia were smaller, their mean length/width was found 1.034/0.610 mm.

Key words: cephalodium, morphometry, *Nostoc*, algae symbiont, microrelief

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Introduction

The lichen genus *Placopsis* consists of more than 60 species with distinct lobes that form a characteristic radial pattern from central cephalodium to thallus margin (Schmitt et al. 2003, Schneider et al. 2016). Cephalodium is a structure that possess colonies of cyanobacteria as secondary photobionts, while marginal parts formed by lobes have an alga as primary photobiont. The cyanobacterial colonies are capable of both carbon and nitrogen fixation (Rai 1990). Nitrogen fixation is an important feature since fixed nitrogen is beneficial not only for the cyanobacteria, but

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also for the other two partners, *i.e.* heterotrophic fungus and autotrophic algal photobiont. Raggio et al. (2012) suggested that increased intrathalline nitrogen content caused by cyanobacterial nitrogen fixation in cephalodium, may increase the photosynthetic rate of a lichen. Rai et al. (2000) reports that the frequency of heterocysts (cells specialized exclusively for the nitrogen fixation) is higher in cephalodia than when cyanobacteria are primary photobionts in lichen symbiosis.

For *Placopsis* sp., *Nostoc commune* is reported as dominant cyanopartner. However, thallus may include additional cyanobiont genera, such as *Scytonema* or *Stigonema* (Lamb 1947). Lichens of genus *Placopsis* are, therefore, nitrogen-fixing and considered main contributors of nitrogen in nutrient limited habitats. It is assumed that there is a link between nitrogen fixing cephalodia with a cyanobacterium and carbon fixation through more nitrogen being available for constructing photosynthetic machinery in algal part of the lichen. The link between nitrogen and carbon fixation is, however, still poorly understood (de los Ríos et al. 2011). Recently, the algal partners in *Placopsis* sp. from South Shetlands were described and identified as *Stichococcus antarcticus* (Beck et al. 2019). Moreover, the genus *Stichococcus* is being taxonomically investigated and revised (Pröschold and Darienko 2020). Application of chlorophyll fluorescence techniques showed that the cephalodia in *Placopsis contortuplicata* after wetting with water had low but substantial electron transport through PSII (Schroeter 1994, Casanova-Katny et al. 2019a, b).

For Antarctica, four species of *Placopsis* have been reported: *P. antarctica*, *P. contortuplicata*, *P. bicolor*, and *P. pycnotheca* (compiled in Øvstedal and Lewis Smith 2011). *Placopsis* sp. are early successional pioneers in habitats where little else has colonized a rock/soil surface before. However, thanks to nitrogen fixation by cyanobiont in cephalodia, *Placopsis* sp. is considered fast growing species (Sancho et al. 2011) since it is scarcely limited by low nitrogen contents. Recently, the photosynthetic response of *Placopsis* sp. to increased air temperature has been investigated by CO_2 exchange method (Colesie et al. 2018). For *P. contortuplicata*, high rates of net photosynthesis per Chl *a* unit are reported (Palmquist et al. 2002).

For subantarctic regions and Antarctica, *Placopsis* sp. is reported mainly from Southern Chile (*e.g.* Raggio et al. 2012). In maritime Antarctica *Placopsis* sp. is reported for South Georgia, South Orkneys, and South Shetlends (King George Island in particular) – Australian Antarctic data Centre [1], Wirtz et al. (2003), Kim et al. (2006). The lichen genus *Placopsis* is a common component of high-rainfall, temperate biomes in southern South America with 18 species currently known from the region (Galloway 2002, 2010, 2013).

The aim of our study was to evaluate basic biometrical parameters for *Placopsis antarctica*. Our attention was payed mainly to dominant morphological structures forming a thallus: cephalodia, marginal lobes, sorediate pits and soralia.

Material and Methods

Lichen collection and handling

Thalli of *Placopsis antarctica* were collected from several particular localities at King George Island, Antarctica (La Cruz mesa, Ardley peninsula and Collins bay) during the Chilean expedition in January 2019. The collections were done by two

expedition members (A. Casanova-Katny and M. Barták) who monitored in situ responses of *P. antarctica* to manipulated warming by OTCs (Casanova-Katny and Barták 2019a, b). Thalli were dried under natural (field conditions), then transferred to the laboratory where subjected to the optical microscopy study.

Description of the species

P. antarctica was described in detail by Galloway et al. (2005) in the study reporting the species for the first time. Here we overview the most important characteristics from his study. *P. antarctica* thallus is closely orbicular and sometimes spreading in irregular patches. It has 1–3(–6) cm in diameter, margins neatly plicate, entire, flabellate, swollen to somewhat flattened in parts, without a marginal prothallus. Lobes are convex, typically 0.5–1.0 mm diameter. They expand to 2.5 mm at apices. They are contiguous to somewhat overlapping, parallel, radiating from centre to periphery, separated by narrow to deeply gaping cracks, 0.5–1.2 cm long, then becoming areolate cracked centrally, areolae angular, 1–3 mm diam., separated by deep, gaping cracks, surface of areolae comprising crowded, and often eroded dactyls.

The upper surface is creamish, dull-white, sometimes ivory to pale pinkish or greyish, with patches of glistening, crystalline, white pruina, suffused olive-brown at margins. Smooth to minutely pitted or irregular, dactyls are present. Dactyls are laminal, subglobose to globose, 0.2–1.0 mm diameter, 0.2–0.5 mm tall, solitary, to densely clustered. Hollow, apices are verrucose-areolate to erose, disintegrating into coarse, granular, white soredia, or abrading and leaving excavate, white, sorediate pits.

The photobiont in white part of the thallus is a green coccoid alga, cells of which are globose, 8–10 m diam. Cephalodia are submarginal to central, scattered, orbicular 2–8(–15) mm diam., sessile, spreading over thallus, globose at first, soon becoming conglomerate-convolute, to plicate-ridged, and breaking apart into island-like-structures separated by deep cracks when mature. Cephalodium colour is bluish purple, translucent when wet. The colour turns to pale pinkish brown to fawn when dry. Symbiotic cyanobiontis reported *Scytonema* sp.

Physiological characteristics, as well as biochemical features of *P. antarctica* are rather unknown. However, Strzalka et al. (2011) report that α-tocopherol is present in high quantities in similar species *Placopsis contortuplicata* (40.4 mg/g DW). The species do possess γ-tocopherol as well. The same authors reported xanthophyll-cycle pigments as well as neoxanthin and lutein. It is likely that the compounds are present also in *P. antarctica*. Confirmation of this is, however, matter of follow-up studies on *P. antarctica*.

Results and Discussion

Morphological characteristics are documented by the photographs (Fig. 1 to 16). The marginal lobes were found divided at the ends, and typically wider at the apical part than at the lobe's base. They tended to be wider at the terminal then basal side by the factor of 2.86 (*see* Fig. 17).

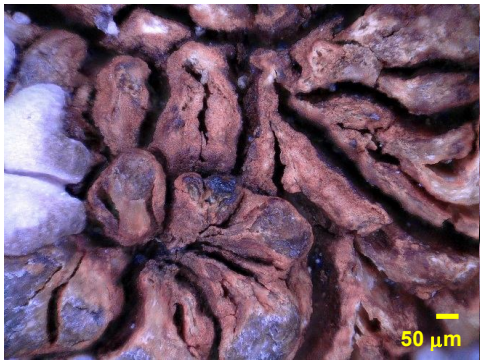

Fig. 1. Central part of dry cephalodium (*see* deep cracks).

Fig. 2. Central part of dry cephalodium.

Fig. 3. Small cephalodium.

Fig. 4. Fungi inviding marginal part of thallus.

Fig. 5. Fungi inviding marginal part of thallus.

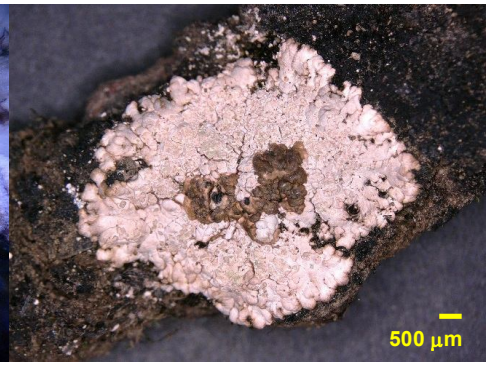

Fig. 6. Overall view on *P. antarctica*.

Fig. 7. Numerous sorediate pits.

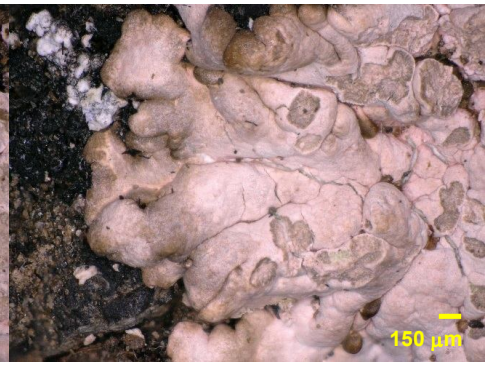

Fig. 8. Sorediate pits.

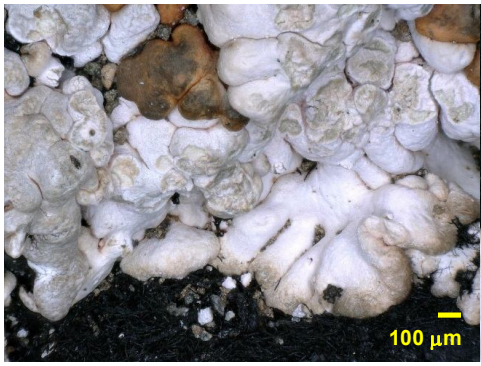

Fig. 9. Detail view on sorediate pits.

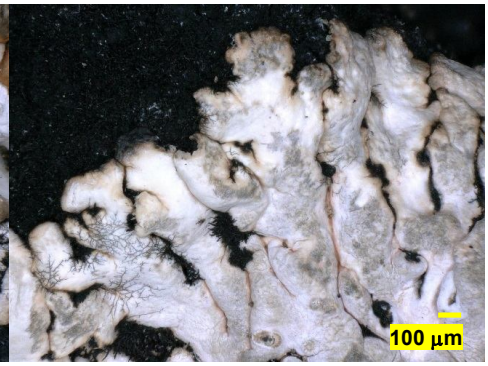

Fig. 10. Cover shape of the marginal lobes.

Fig. 11. Small-sized cephalodia.

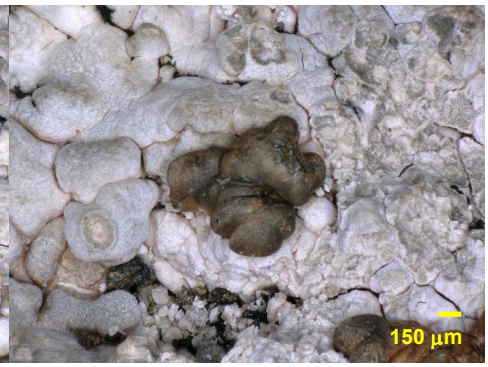

Fig. 12. Small-sized cephalodium.

Fig. 13. Early soralium.

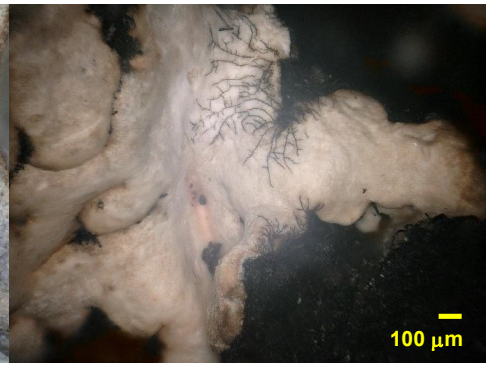

Fig. 14. Fungi inviding marginal part of thallus.

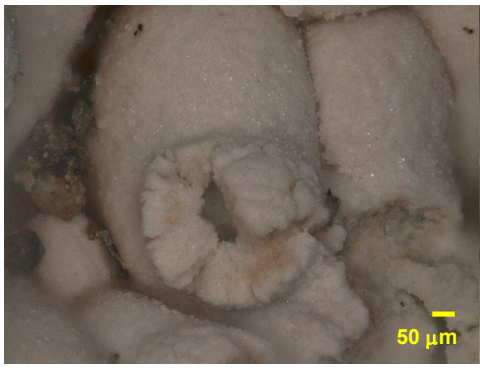

Fig. 15. Globulose soralium.

Fig. 16. Early soralium.

Sorediate pits are numerous over the upper surface, typically of elliptic shape. The ratio of the length to the width of the sorediate pits reached 1.36±0.3. The length of sorediate pits varied from 233 to 652 µm, reaching mean value of 439.4 µm (*see* Fig. 17). Mean width was 323.0 µm.

Central cephalodium was of orange colour and had numerous deep cracks in dry state. The shape of central cephalodium was found elliptic (length/width was 2.424/1.720 mm). Small-sized cephalodia situated outside the central one had orange to olive green colour and elliptic shape as well. Mean length/width of the cephalodia reached 1 034/611 µm.

The biometrical parameters found in our study were in accordance to the data reported for *P. antarctica* by Galloway et al. (2005). However, further morphological investigations and detailed analysis of biometrical parameters of *P. antarctica* thalli are recommended in follow-up studies. It is because of the fact that *P. antarctica* and *P. contortuplicata* were shown to be clearly separable by both morphological and molecular means (Beck et al. 2019) but still the two species are relatively similar. This may lead to difficulties in determination of the two species in field studies.

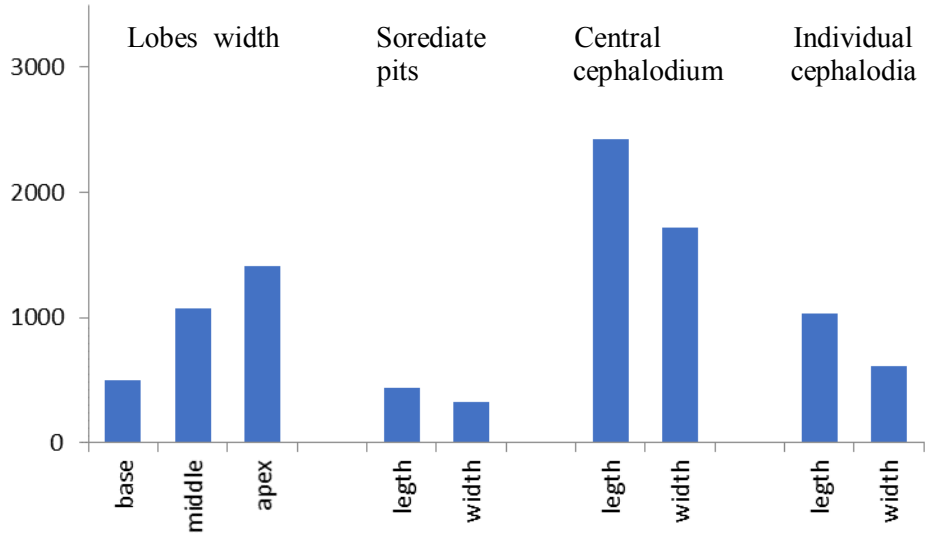

Fig. 17. Biometrical parameters of *P. antarctica* from King George Island. Mean values (in µm, calculated for 20-70 replicates for particular parameter) are presented with standard deviation ranging 28-48% of the means – not shown here).

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Web sources / Other sources

[1] Australian Antarctic Data Centre (https://data.aad.gov.au/)