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NEW CYCAD FOLIAGE OF *PSEUDOCTENIS BABINENSIS* FROM THE BOHEMIAN CENOMANIAN

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Abstract. New cycad foliage *Pseudoctenis babinensis* sp. nov. is described from the locality of Pecínov. It occurs in mudstones of the Peruc – Korycany Formation which is Cenomanian in age. The leaf description is based on macro- and micro- morphological characters. The most important diagnostic characters are: bipinnate leaves, pinnae arising at a sharp angle; leaf hypostomatic, consisting of isodiametric epidermal cells and haplocheilic stomata surrounded by 8 subsidiary cells. The diagnostic characters are discussed and compared to the previously described Cenomanian genus *Jirusia* BAYER and to other species of the genus *Pseudoctenis* SEWARD. It is the first representative of the genus described from the Bohemian Cenomanian.

■ *Pseudoctenis*, cycad foliage, Cenomanian, Late Cretaceous.

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Introduction

During the Triassic and Jurassic until Early Cretaceous times, cycads represented one of the most important plant groups of the vegetation (Watson and Cussack 2005). Their gradual, but quite fast decline in the mid-Cretaceous resulted in their accessory occurrence in Late Cretaceous floras. A low percentage of cycads is also typical of the Cenomanian flora of the Peruc-Korycany Formation from the Bohemian Cretaceous Basin. However, due to the high diversity of the flora, the number of cycads in the Bohemian Cretaceous Basin reaches a total of six or seven species. Unequivocal cycads found there are: *Jirusia jirusii* (BAYER) DOMIN (Bayer 1914, 1920, Vinikláŕ 1933, Domin 1938, Kvaček 1995), *Nilsonia bohemica* VELENOVSKÝ (Kvaček 1995), *N. holyi* J. KVAČEK (in Kvaček and Knobloch 1997), *Microzamia gibba* (REUSS) CORDA in REUSS (J. Kvaček 1997) and *Mesenea bohemica* (CORDA in REUSS) J. KVAČEK, 1999. Other species, particularly *Dioonites cretosus* (REICHENBACH) SCHIMPER, 1870 are represented by leaf impressions and their affinity to cycads is only tentative (Göppert 1844, Bayer 1901, Velenovský and Vinikláŕ 1927, Němejc 1968). Cuticle of the type of the genus *Dioonites* MIQUEL, 1851 is not known, and it is improbable that it will ever be known. However, *Dioonites* serves as a good morphogenus for compound leaf impressions of cycads or bennettits.

Knowledge of the cuticle is crucial for identification of cycadaceous leaves. Otherwise they are difficult or even impossible to distinguish from leaves of Bennettitales, which also occur in the same horizon (J. Kvaček 1995, Knobloch and J. Kvaček 1997). Therefore it could be that *Dioonites cretosus* may represent a leaf-impression morphotaxon, parent to the presently introduced species *Pseudoctenis babinensis*.

The first cycad from the Bohemian Cenomanian was described by A. E. Reuss (1844: 169) as *Conites gibbus* = *Microzamia gibba* (REUSS) REUSS, 1846. Later Velenovský, 1885 described *Nilsonia bohemica* VELENOVSKÝ and Bayer (1901) described *Encephalartos jirusii* combined later as *Jirusia jirusii* (BAYER) DOMIN (Bayer 1914, 1920, Domin 1938).

The aim of this paper is to describe the first occurrence of the genus *Pseudoctenis* in the Bohemian Cenomanian.

Material and methods

The Bohemian Cretaceous Basin, as defined by Čech et al. (1980) is located in the Bohemian Massif, Middle Europe (text-fig. 1). It is infilled by Upper Cretaceous freshwater, brackish and marine sediments of Cenomanian to Campanian age.

The Peruc-Korycany Formation is situated in the basal most position of the Bohemian Cretaceous Basin. The Pecínov Quarry, 60 km west of Prague, is a working quarry showing a complete sedimentary set of the Peruc-Korycany Formation. The sedimentary succession in Pecínov was divided by Uličný & Špičáková (1996) into 5 units. Units 1-2 typically include fluvial pebbly sands, conglomerates and sandstones with interbedded mudstones. Unit 3 consists of mudstones rich in pyrite concretions. They are products of marginal marine and brackish sedimentation in back swamps and in supratidal marshes. Unit 4 is represented by cross-bedded sandstones, mudstones and laminites, products of sedimentation on a tidal flat crossed by meandering tidal creeks. The lower part of unit 5 is built of sandstones containing rich marine fauna and occasionally preserved stems of tree ferns and poorly preserved leaf impressions. Intertidal to supratidal mudstones bearing a rich megaflora are locally preserved in the uppermost part of unit 5 (Uličný et al. 1997) reflecting a local regression.

Detailed biostratigraphical studies based on pollen spectra (Pacltová 1977) date the unit 2 of the Peruc-Korycany Formation to the upper part of the Middle Cenomanian.

From leaf compressions, carbonised material was carefully selected using a preparation needle and treated for cuticle analysis. Carbonised material obtained by needle sampling was cleaned by treatment in HF. When clean it was ready for the bleaching procedure which includes maceration in Schulze's reagent: $HNO_3 + KClO_3$, neutralisation in water and treatment in a low concentration solution of KOH, which was used for washing out oxidized coal matter. The time for oxidation was about 5 minutes. After chemical treatment, cuticles were washed in water in Petri dishes. Some preparations were stained by 2% safranine solution in water. Cuticles for light microscopy were embedded in glycerine framed by Noyere Framing Cement. Preparations usually required more work with needles under binoccular microscope to separate lower (abaxial) and upper (adaxial) cuticles and adjust them properly on the preparation glass before covering. During this phase of the work, mesophyllous tissues were isolated and removed.

Cuticles prepared for SEM observations were treated in the same way in Schulze's reagent, and then washed in distilled water. Before drying, cuticles were put in a drop of distilled water and stuck to the emulsioned surface of small pieces of glossy film. The whole sheets were air dried and glued onto stubs.

Cuticle preparations were studied by light microscopy in interference contrast and by Nomarski DIC (Olympus BX50) and by SEM (Tesla BS340). All the studied material is housed in the collection of the National Museum, Prague.

Systematic part

Genus: *Pseudoctenis* Seward, 1911

Type: *Pseudoctenis eathiensis* (Richards) Seward 1911: 692, (= *Zamites eathensis* Richards, 1834: 117, H. Miller collection).

The genus *Pseudoctenis* was emended by Harris (1964) without knowledge of the cuticle of the type. Epidermal characters of the type material (specimen V. 12202) *P. eathiensis* were published later by Van Konijnenburg- van Cittert & Van der Burg (1989: 23, pl. 7, fig. 1) who re-emended the diagnosis of the genus.

Pseudoctenis babinensis sp. nov.

Pl. 1, figs 1-7, Pl. 2, figs 1-6

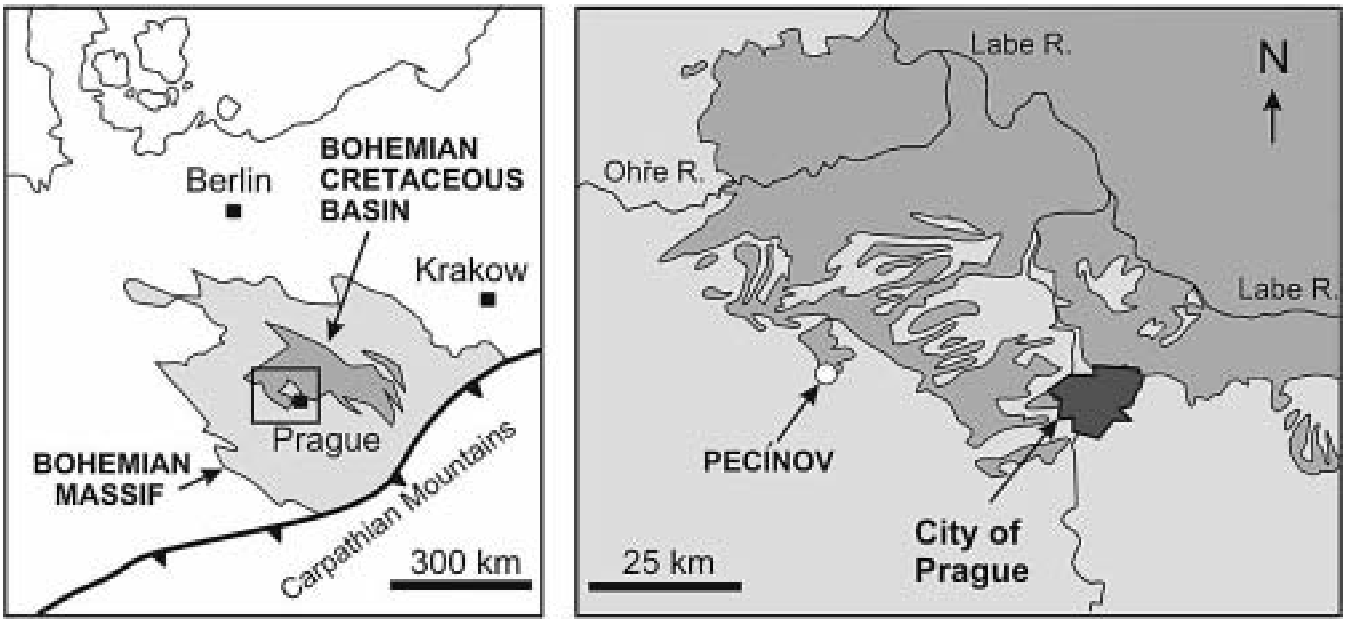
Etymology: The name of the species is derived from the name of the part of the Pecínov Quarry – the pit Babín.

Holotype: F 2448, designated here, housed in the National Museum, Praha.

Paratype: F 2318, designated here, housed in the National Museum, Praha.

Type locality: Babín north open pit, Pecínov quarry.

Type horizon: Cretaceous, Cenomanian, Peruc-Korycany Formation, unit 2 (according to Uličný and Špičáková 1996).



Text-fig. 1. Location of the Bohemian Cretaceous Basin in Central Europe (left) and location of the fossil site mentioned in this paper (right). Dark grey area indicates the Cretaceous Basin; light grey area indicates the Bohemian Massif (after Uličný et al. 1997).

D i a g n o s i s : Bipinnate fronds; rachis robust with numerous longitudinal ridges. Pinnae linear – lanceolate, entire-margined; apex attenuate, apex rather blunt; margins in the base running straight. Veins parallel-sided simple or forking once in the basal region; many veins ending in margins. Pinnae arising at a sharp angle of about 50–60°. Leaves hypostomatic; adaxial cuticle showing quadrangular, isodiametric cells forming short rows, some cells slightly more cutinized. Abaxial cuticle bearing nearly isodiametric cells forming rows in costal areas and numerous trichome bases. Haplocheilic stomata sunken in pits surrounded by 8 subsidiary cells forming a rounded or elliptical rim. Stomata irregularly orientated, scattered with tendency to avoid costal areas.

S p e c i m e n s s t u d i e d : F 2318, F 2448 – F 2450, F 2790.

O c c u r r e n c e : Pecínov Quarry, Babín Pit, unit 2.

D e s c r i p t i o n : The holotype (Pl. 1, fig. 1) represents a part of the bipinnate leaf. Basal parts of 14 pinnae arising at angles of 50-60°. Although the frond displays only basal and medial parts of the pinnae it has been selected as the holotype as it also shows the ribbed rachis. The paratype F 2318 (Pl. 1, fig. 3) shows well preserved entire pinna bearing 15 veins running parallel with the leaf margins. The veins frequently end in the margin. The best preserved cuticle has been obtained from the specimens F 2449 (Pl. 1, fig. 6) and F 2450 – fragments of pinnae.

Adaxial cuticle is considerably thick without stomata (Pl. 1, fig. 4) showing ordinary cells (10-30 x 25-50 μm) and trichome bases (25–30 μm in diameter, Pl. 2, figs 1, 3). Anticlinal walls of the cells are straight or bent, 4–5 μm thick. Cells form short rows running parallel to the venation. The periclinal wall of some cells is more cutinized. The slightly thinner abaxial cuticle shows cells slightly divided into costal and intercostal files (Pl. 1, fig. 7). The epidermal surface is more cutinized and probably it also has different physical features than anticlinal walls. Due to this fact anticlinal walls are split from the periclinal walls (Pl. 2, fig. 2) and caused difficulties in SEM observation (Pl. 2, fig. 5). Ordinary abaxial cells (15–50 x 40–60 μm) are isodiametric, quadrangular, in costal areas slightly elongate where they form 2–5 rows. Stomata (Pl. 1, fig. 2) are surrounded by 6–10, typically 8, slightly more strongly cutinized subsidiary cells (10–35 x 40–70 μm) forming a shallow oval or elliptical stomatal pit (Pl. 2, fig. 6, Pl. 1, fig. 5). SEM observation of the inner part of the abaxial cuticle was complicated because the cuticle did not have entirely preserved anticlinal walls (Pl. 2, fig. 5). Stomata are irregularly orientated and scattered over the leaf lamina with a slight tendency to avoid costal areas (Pl. 1, fig. 7).

D i s c u s s i o n : *Pseudoctenis babinensis* sp. nov. differs from *Jirusia jirusii* (BAYER) DOMIN (Kvaček 1995), a most similar cycad foliage morpho-species from the Bohemian Cenomanian, in the lack of teeth, in having stomata irregularly oriented and having a higher number of subsidiary cells.

Species described by Watson and Cusack (2005) from the Lower Cretaceous English Wealden are rather weakly defined. Three species are based on three single specimens, one even without cuticle (*P. risehomaridae* WATSON et CUSACK). *Pseudoctenis babinensis* differs from *P. foljambeae* WATSON et CUSACK, 2005 in absence of strongly decurrent pinnae and having them arranged at a wider angle to the rachis. *P. babinensis* differs from *P. divana* WATSON et CUSACK, 2005 in having pinnae shortly decurrent and having a lower number of subsidiary cells per stoma. *P. risehomaridae* WATSON et CUSACK, 2005 is represented by a single pinna impression (Watson and Cusack 2005, text-fig. 49D) without any cuticular details described, so it is considered here as doubtful, lacking clear diagnostic characters of Cycadales.

P. crassa S. ARCHANGELSKY et BALDONI, 1972 and *P. ornata* S. ARCHANGELSKY et al., 1995 from the Lower Cretaceous of Patagonia differs from *P. babinensis* in having smaller ordinary cells and large papillae on both subsidiary and ordinary cells. *P. dentata* S. ARCHANGELSKY et BALDONI, 1972 from the Lower Cretaceous of Patagonia differs from *P. babinensis* in having toothed pinnae and amphistomatic leaves.

P. pecinovensis differs from the type of the genus *Pseudoctenis eathiensis* (RICHARDS) SEWARD, 1911 from Culgower (Jurassic of Scotland) in having stomata surrounded by a higher number of subsidiary cells, in lacking cuticle striation and poorly differentiated costal and intercostal zones (Van Konijnenburg-van Cittert & Van der Burgh 1989). Both species *P. spectabilis* HARRIS, 1932 and *P. depressa* HARRIS, 1932, described from the Rhaeto-Liassic of Greenland, differ in appearance of the frond which consists of broad segments. *P. spectabilis* is very similar in cuticle anatomy to *P. babinensis*, from which it differs in fewer (typically 6) subsidiary cells, presence of trichome bases and absence of a stomatal rim. *P. depressa* differs from *P. babinensis* in the presence of striation on the abaxial cuticle and well-exposed guard-cells. *P. herriesii* HARRIS, 1964 from the Jurassic of Yorkshire differs from *P. babinensis* in the expanded pinna base and slightly sunken stomata lacking the stomatal rim. *P. locusta* HARRIS, 1949 from the Jurassic of Yorkshire differs from *P. babinensis* in having short elliptical pinnae showing thick forked veins, in the presence of trichomes and in having stomata orientated mostly parallel to the veins. *P. oleosa* HARRIS from the same locality (Harris 1964) differs from *P. babinensis* in the adaxial cuticle possessing striation and in having stomata longitudinally orientated to the veins. *P. lanei* THOMAS, another species from the same locality, differs from *P. babinensis* in uniformity of costal and intercostal areas of the abaxial cuticle, in having stomata orientated parallel to the veins and numerous papillae. *P. latus* DOLUDENKO et SVANIDZE from the Upper Jurassic of Georgia (Doludenko and Svanidze 1969, pl. 29, figs 1-4, pl. 30, figs 1-5) differs from *P. babinensis* in the contracted bases of pinnae and in having stomata longitudinally orientated to the veins. *P. barulensis* DOLUDENKO et SVANIDZE from the Upper Jurassic of Georgia (Doludenko & Svanidze 1969, pl. 26, figs 1-6, pl. 27, figs 1-6) differs from *P. babinensis* in the presence of papillae that are scattered on the abaxial cuticle and surround stomatal pits, and in slightly sunken guard cells. *P. creysensis* BARALE, 1981 from the Jurassic of Creys, France differs from *P. babinensis* in a smaller number of subsidiary cells and in stomata longitudinally orientated to the veins. *Pseudoctenis* sp. described by Carpentier

(1939, pl. 8, figs 1-10, pl. 9, figs 1-9) shows differences in having stomata confined to well-defined costal zones and in extremely thickly cutinized subsidiary cells. *P. cteniformis* (NATHORST) HARRIS from the Rhaetic of Bjuf in Sweden (Harris 1950) differs from *P. babinensis* in having numerous papillae on the adaxial cuticle and a lower number (4-6) of subsidiary cells (compare Florin 1933, pl. 9, figs 1-7, text-figs 28, 29). *Pseudoctenis florinii* LUNDBLAD, 1950 differs from *P. babinensis* in having decurrent pinnae and stomata scattered on the complete abaxial surface of the pinnae (not avoiding veins). *P. ensiformis* HALLE (1913) lacks cuticles and therefore it is difficult to compare, it differs from *P. babinensis* in macromorphology of its pinnae which always show expanded bases (Gee 1989). *P. cornelii* POTT recently described from the Triassic of Lunz (Pott et al. 2007, pl. 1-3) differs from *P. babinensis* in having decurrent pinnae and well developed papillae on subsidiary and some ordinary cells.

Conclusions

This is the first report of the genus *Pseudoctenis* from the Bohemian Cenomanian showing a rather higher diversity of cycads there than previously thought. *Pseudoctenis babinensis* has quite thick cuticles, stomata surrounded by a thickly cutinized rim and sunken in stomatal chambers. These characters suggest it could grow on well drained parts of the flood plan and slopes of the river valley (unit 2 as defined by Uličný and Špičáková 1996 and Uličný et al. 1997).

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Explanation to the plates

PLATE 1

Pseudoctenis babinensis sp. nov.

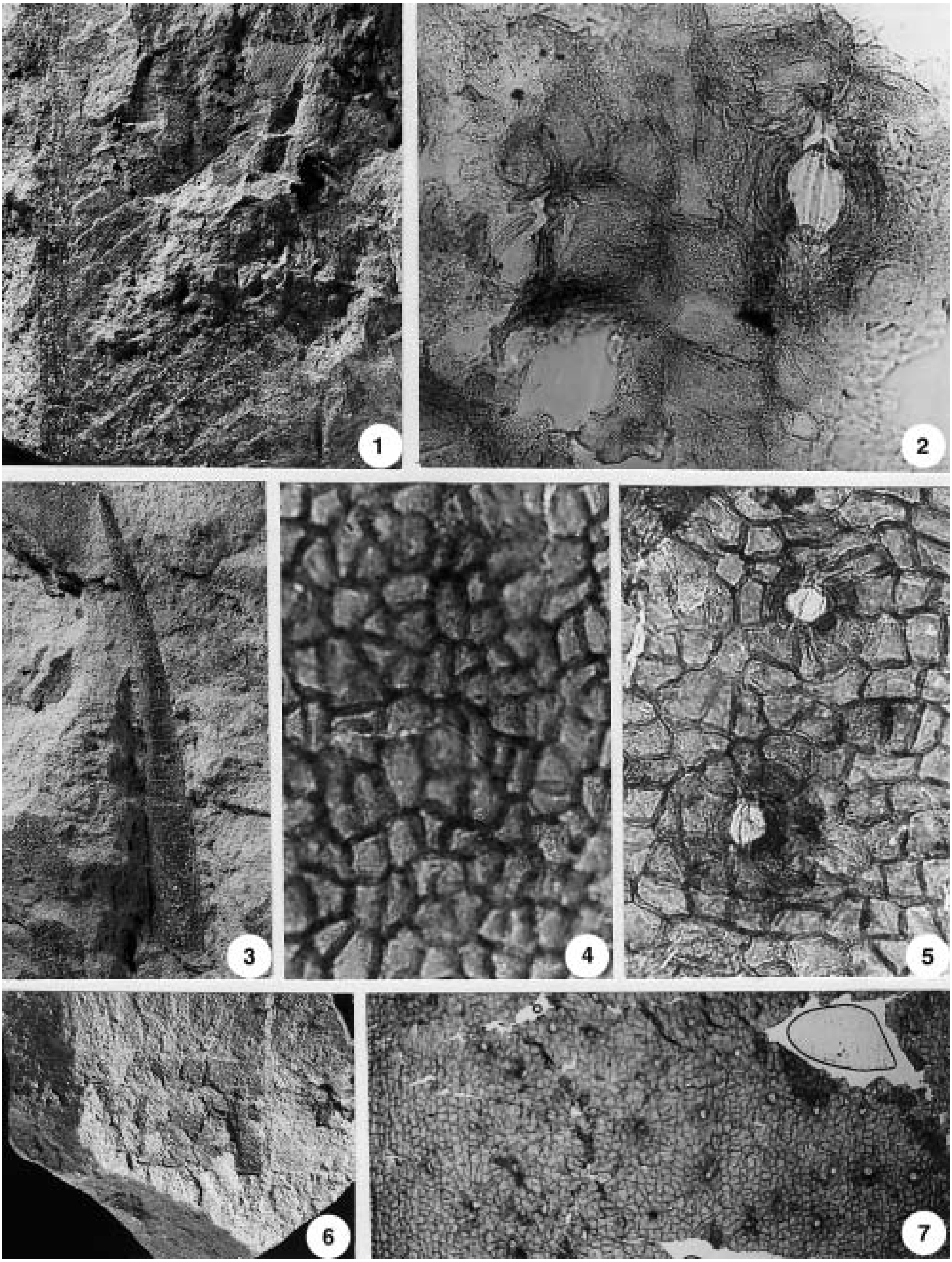
1. Holotype, simply pinnate leaf, Pecínov; F 2448, × 1.
2. Holotype, light microscope preparation of abaxial cuticle, stoma, Pecínov; F 2448b, × 400.
3. Paratype, isolated pinnula, Pecínov; F 2318, × 1.
4. Light microscope preparation of adaxial cuticle, note isodiametric cells, Pecínov; F 2449b, × 200.
5. Light microscope preparation of abaxial cuticle showing two stomata, Pecínov; F 2449b, × 200.
6. Fragment of pinna compression, Pecínov; F 2449, × 2.
7. Light microscope preparation of abaxial cuticle, view of costal (to right) and intercostal rows, Pecínov; F 2449b, × 40.

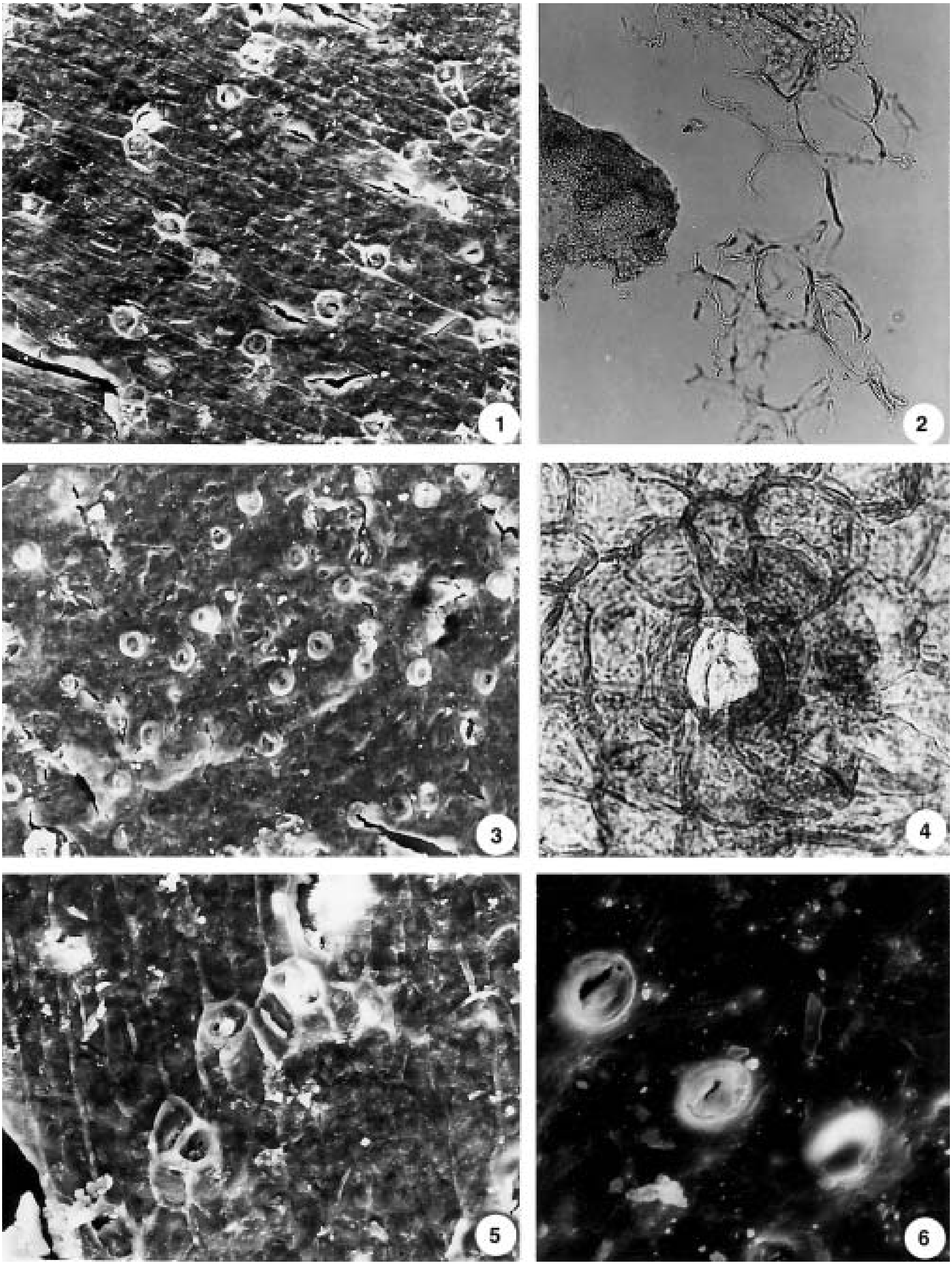
PLATE 2

Pseudoctenis babinensis sp. nov.

1. SEM of adaxial cuticle, inner surface showing rounded trichome bases; Pecínov F 2449c, × 150.
2. Holotype, light microscope preparation of abaxial cuticle showing fragment of hypodermis; Pecínov, F 2448b, × 400.
3. SEM of adaxial cuticle, outer surface showing trichome bases ; Pecínov F 2449c, × 150.
4. Light microscope preparation of abaxial cuticle showing stoma, Pecínov; F 2449b, × 400.
5. SEM of abaxial cuticle, inner surface, stomata are difficult to observe; Pecínov F 2449c, × 300.
6. SEM of abaxial cuticle, outer surface showing three stomata with a rim; Pecínov F 2449c, × 600.

PLATE 1

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