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*LILPOPIA POLONICA* LIPIARSKI FROM THE KARNIOWICE  
TRAVERTINE (LOWER AUTUNIAN) NEAR CRACOW, POLAND

*Lilpopia polonica* Lipiarski z martwicy karniowickiej (dolny oten) koło  
Krakowa

ABSTRACT

The paper contains a description of the fossil plant species *Lilpopia polonica* Lipiarski occurring in the travertine of Karniowice near Cracow. The diagnostic features of *L. polonica* are compared with these of two other species of the genus *Lilpopia* Conert et Schaarschmidt, i. e. *Lilpopia raciborskii* (Lilpop) Con. et Schaar., and *L. crockensis* (R. et W. Remy) Con. et Schaar.

INTRODUCTION

This paper presents a full description, drawings and photographs of the third species of the genus *Lilpopia* Conert et Schaarschmidt 1970. Previously, the genus *Lilpopia* Con. et Schaar. 1970 was called *Tristachya* Lilpop 1937, but the latter name appeared to be a homonym of a name already introduced. Impressions and casts of *Lilpopia polonica* occur in a freshwater limestone called Karniowice travertine. This rock is outcropped in the villages Karniowice and Filipowice some 35 km to the West of Cracow. Its age is considered to be Lower Autunian (Lipiarski 1969, 1971).

The type species of *Lilpopia* Con. et Schaar. is *Lilpopia raciborskii* (Lilpop) Con. et Schaar., also from the Karniowice travertine (Lilpop 1937).

The second described species of this genus was *Lilpopia crockensis* (R. et W. Remy) Con. et Schaar., found in argillaceous rocks of the Autunian at Crock in Thuringia (R. et W. Remy 1961).

Recent researches on *Lilpopia raciborskii* allowed to revise its description and to modify the reconstruction (Lipiarski 1972). It appeared that in fertile verticils the cones occur between leaves, and not above the leaves, as presumed by Lilpop (1937).

During the present study, the late Professor W. Szafer most kindly showed his interest in it and made helpful suggestions. The author also gratefully acknowledges the help he received from Professor S. Z. Stopa, who read the manuscript, and from Dr J. Małeckı who made the drawing of the reconstruction of the species.

#### FAMILY: LILPOPIACEAE

Genus: *Lilpopia* Conert et Schaarschmidt 1970 (= *Tristachya* Lilpop, non Nees v. Esenb.)

Type species *Lilpopia raciborskii* (Lilpop) Con. et Schaar. (= *Tristachya raciborskii* Lilpop 1937)

#### *Lilpopia polonica* Lipiarski

Pl. I—V

1971 *Lilpopia polonica* Lip., p. 31, Pl. V, Figs. 6—21

Holotype nr MK-1 is deposited in the collections at the Laboratory of Coal of the Institute of Regional Geology and Coal Deposits of Academy of Mining and Metallurgy in Cracow.

#### DIAGNOSIS

Leaves triangular, six in each verticil, 3 to 29 mm long and 2 to 13 mm wide. In sterile verticils the smaller leaves convex, their anterior margin dentate, curved in an arch, more or less rounded at the corners, distinctly directed upwards; larger leaves with dentate or fimbriate anterior margin; veins bifurcating several times reaching each tooth of margin.

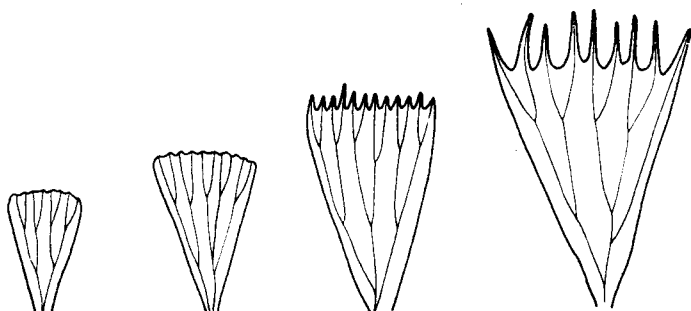


Fig. 1. Types of leaves of *Lilpopia polonica* Lip.,  $\times 1.5$

Ryc. 1. Typy listków *Lilpopia polonica* Lip.,  $\times 1.5$

In the fertile verticils there are always three cones and six leaves similar to those in sterile verticils. Cones occur between pairs of leaves and are bent obliquely downwards in relation to the stem axis. Cones consist of five peltate rounded sporangiophores joined by stalks with the cone axis: there is one greater apical peltate head and four smaller lateral ones. The apical peltate head occurs at the end of the cone axis; the lateral peltate heads depart from a distinctly thickened node, in a plane perpendicular to the axis, one opposite another. At the lower side of the peltate heads there occur sporangia (only concavities in under side of head observed).

#### MATERIAL

The present species is represented by more than three hundred impressions and casts, mostly found in the outcrops of the Karniowice travertine. The specimens commonly form accumulations in the rock. The leaf bearing stems are preserved in different positions in relation to the bedding planes, but are mostly perpendicular. This is their natural position of growth. The travertine containing the specimens is usually cavernous and porous. Therefore, it is difficult to obtain large specimens. The length of fragments of stems usually obtained was four to eight cm; it was possible, however, to obtain some specimens two or three times longer. Most specimens are excellently preserved, and even small morphological features are well visible. The specimens are mostly external impressions surrounding cavities which remained after the oxidation of the plant. In some cases, the surface of the impressions is covered by fine calcite crystals, but usually it is irregularly covered by a brown substance. The irregularity of covering causes an apparent deformation of some organs, mostly leaves (Pl. I, figs. 3, 4; Pl. II, figs. 1, 3, 4, 5; Pl. III, fig. 3).

#### DESCRIPTION OF SPECIES

Articulated stems, triangular in cross section, often branching (Pl. III, fig. 1; Pl. V, figs. 1, 4). Branches beginning at nodes, somewhat elevated, alternating, not always lying in a single plane. Stems of the last order reaching a width of 1 to 3 mm, usually 2 mm, are clearly thickened in the nodes. Stems of penultimate order, thicker and stronger, are up to 5 mm in diameter. Locally they are devoid of leaves, and nodes are less clearly marked. The length of internodes is 2 to 20 mm, mean 6 to 8 mm, 8 mm in the holotype.

Leaves variable in size and form, occurring in groups of six both in sterile and fertile verticils, in successive verticils superposed. The leaves are triangular, 3 to 20 mm long and 2 to 3 mm wide at the anterior margin (Pl. I, figs. 3, 4, 5; Pl. II, figs. 1—6; Pl. III, figs. 3—6; Fig. 2). The value

of the relation: width of leaves to length of leaves, is 1 : 1.5 to 1 : 1.8. The smaller leaves, convex, clearly directed upwards, possess an anterior margin curved in an arch, and the corners are more or less rounded, depending on the size of the leaf (Fig. 2). The corners of some leaves appear more rounded than they really are, because the brown iron compounds did not reach there. The anterior margin of the larger leaves, commonly

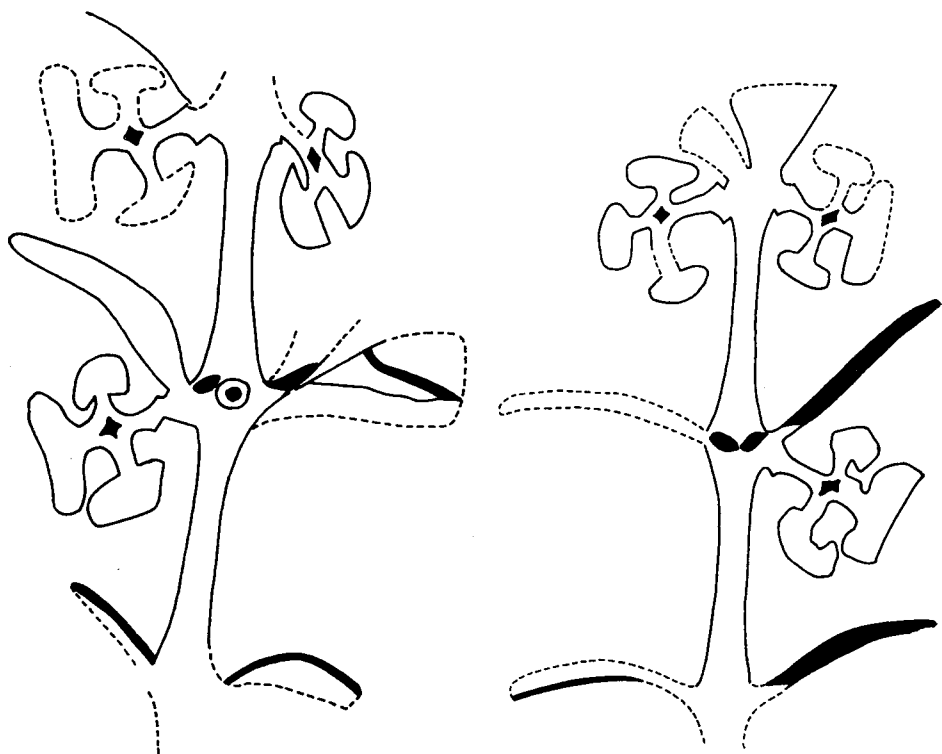


Fig. 2. Part and counterpart of holotype shown in Pl I, figs 1, 2,  $\times$ ca. 4

Ryc. 2. Dwie części okazu holotypu przedstawione na Tabl. I, fig. 1, 2,  $\times$ ca. 4

drooping, is either dentate or fimbriate with teeth attaining a length of 5 mm. In some cases the teeth are partly lacking; they were probably broken during preparation and remained in the rock (Pl. II, figs. 3, 5, 6; Pl. IV, fig. 1). Large leaves possess up to 15 teeth. Each leaf is reached by a vein situated in a furrow. In the leaf, the vein bifurcates several times, in such a way that at the anterior margin the number of veins is equal to that of teeth.

On about twenty specimens the cones were found in connection with leaf bearing stems and therefore this connection is certain. The reproductive organs occur most frequently on medium sized stems of the last order (Pl. I, figs. 1, 2; Pl. II, fig. 7; Pl. III, fig. 1), but they are not un-

common on the stems of the penultimate order. There is no clear difference between the stems possessing both leaves and reproductive organs and those possessing leaves alone. It appeared only that small stems with small strongly elevated leaves are usually devoid of cones.

The reproductive organs are developed as cones occurring in the verticils together with leaves. In a fertile verticil there are always six leaves and three cones (Fig. 4). Leaves in fertile verticils are commonly distributed in pairs and even cover one another. Thus, in a verticil there appear three small gaps between the three pairs of leaves.

The axes of cones beginning in a verticil together with the leaves are not perpendicular to the stem axis, but are directed obliquely downwards (Pl. I, figs. 1, 2; Figs. 2a, 2b). Transverse section of the cone axis and the relation of the cone axes to the leaves in the area where they grow from the stem may be seen in an external non deformed empty impression (Pl. I, figs. 1, 2; Pl. II, fig. 7; Pl. IV, figs. 3, 4). In cross sections, the leaves at the base are oval approaching lenticular, while the cross section of the axis of a cone is circular (Pl. IV, figs. 3, 4; Fig. 2), and they are therefore easily distinguishable. The cone grows slightly below the beginnings of the two leaves situated on its sides. The leaves are as a rule directed upwards, while the cones are directed downwards. The angle

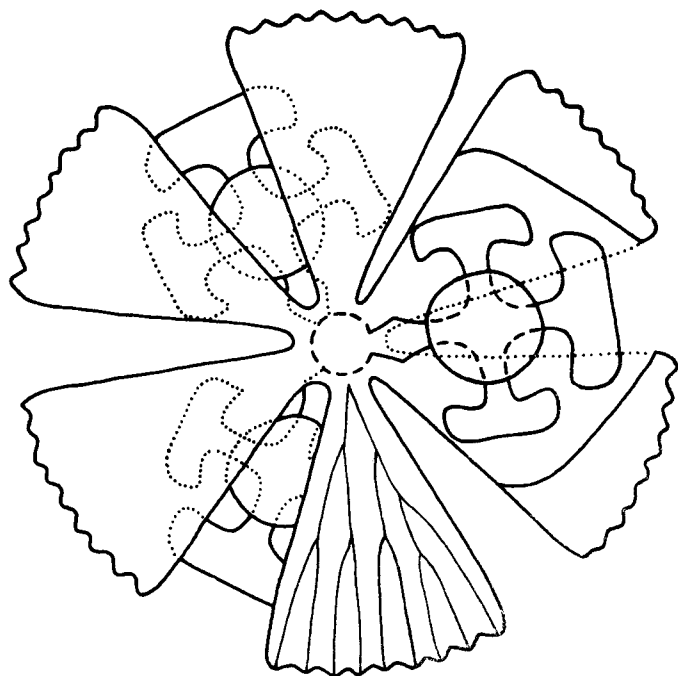


Fig. 3. Schematic representation of fertile verticil based on holotype and paratype,  $\times 5$

Ryc. 3. Schemat budowy okółka owocującego, na podstawie holotypu i parotypu,  $\times 5$

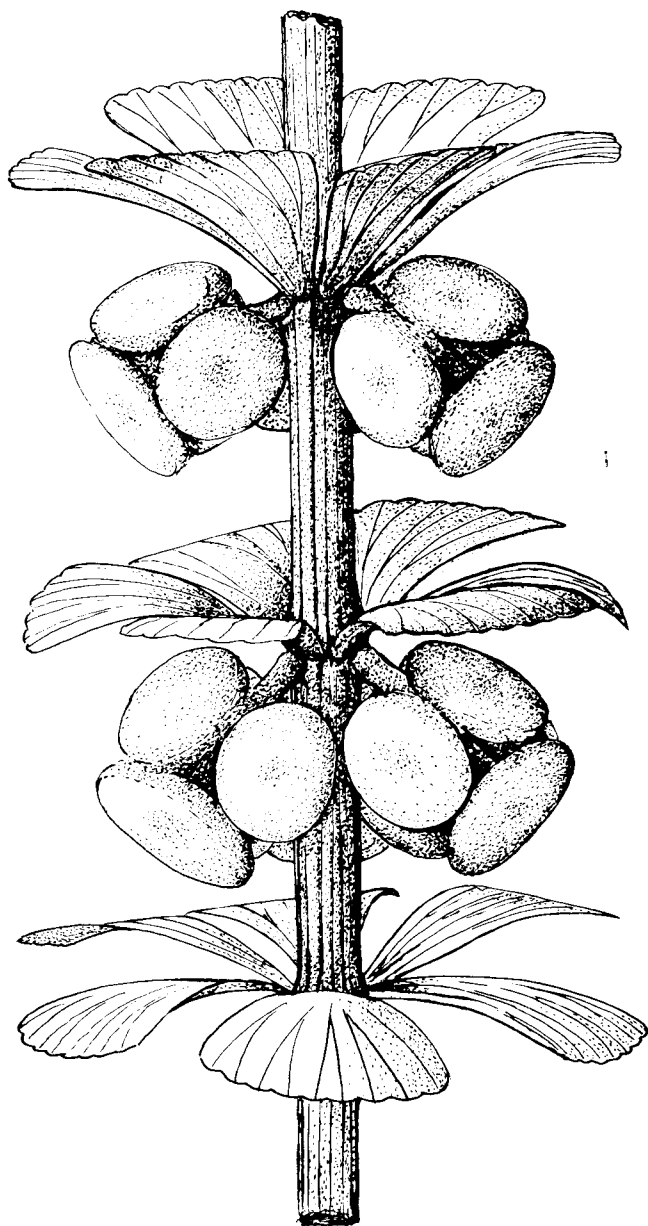


Fig. 4. Reconstruction of a part o stem of *Lipopia polonica* Lip.  $\times$  ca 5  
Ryc. 4. Rekonstrukcja części pędu *Lilpopia polonica* Lip.  $\times$  ca 5

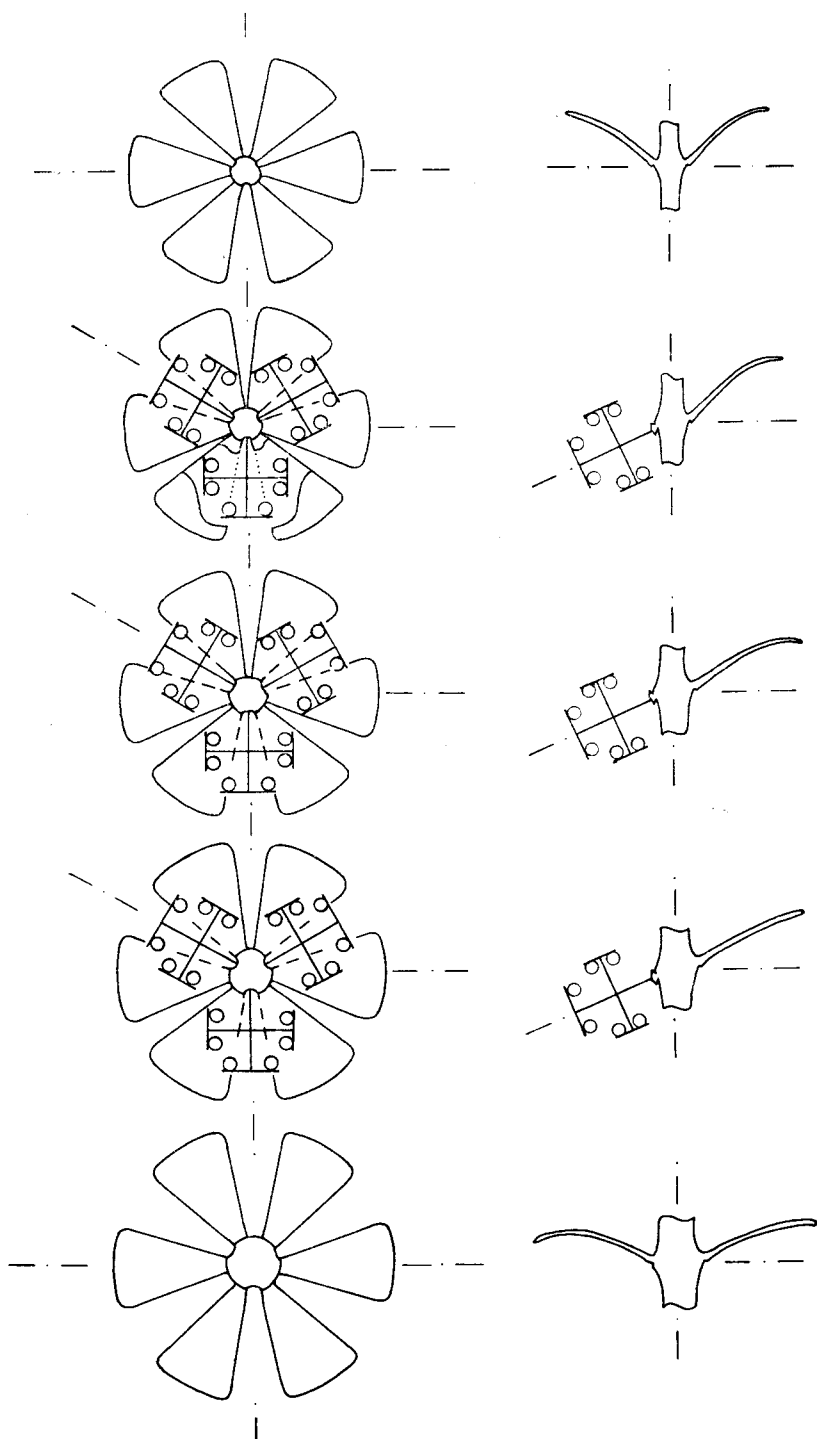


Fig. 5. Schematized structure of stem of *Lilpopia polonica* Lip. 1'5  
 Ryc. 5. Schemat budowy pędu *Lilpopia polonica* Lip. 1'5

between the leaf and the axis of cone commonly approaches or even is greater than  $90^\circ$ .

Cones possess an axis 4 to 5 mm long and 0.5 to 1 mm in diameter departing from a node of the stem. Towards the area of attachment the axis gradually becomes thicker, and just (about 0.5 mm) before this area it thins abruptly. At the area of attachment, the diameter of the axis is almost half of that in the thickened area (Figs. 3, 4). About the middle of the axis there occurs a thick node, and the greatest sporangiophore continuing the axis forms a circular anterior peltate head up to 5 mm in diameter. The remaining four smaller sporangiophores, forming also circular peltate heads about 3 mm in diameter, are attached to the node by short stalks forming one verticil. The four sporangiophores occurring in this verticil are situated opposite one another. Thus, in one cone there are five sporangiophores. The margins of the peltate heads of the sporangiophores are curved downwards. At the internal surfaces of the peltate heads in some cases very poorly preserved elliptical concavities may be seen, probably corresponding to sporangia. Also some cones separated from the plant were found (Pl. III, fig. 1).

Underground stems are thin tubes ca. 0.5 mm in diameter, branching several times (Pl. III, fig. 4).

#### SYSTEMATIC POSITION

The presence of cones similar to those of *Equisetum* and of leaves of a *Sphenophyllum* type indicate that, according to Lilpop's (1937) definition, the present species should be included to the family *Lilpopiaceae*.

The following diagnostic features (Lilpop 1937, Lipiarski 1972) indicate that this species belongs to the genus *Lilpopia*:

1. in the fertile verticils there occur leaves and three cones;
2. cones are attached to nodes between leaves.

#### SIMILARITIES AND DIFFERENCES

As may be seen in the above description, the species *Lilpopia polonica* possesses some morphological features common with the two remaining species of the genus *Lilpopia* Con. et Schaar. and also with some species of the genus *Sphenophyllum* Koenig.

*Lilpopia polonica* is a plant smaller than *L. raciborskii*, the internodes are shorter and the leaves are proportionately smaller.

The structure of cones of *L. polonica* is clearly different from those of the other species of this genus. Cones of *L. polonica* consist always of five sporangiophores, while in *L. raciborskii* there are 18 to 24 peltate



heads, and in *L. crockensis*, about ten peltate heads. The low number of peltate heads in the present species is not due to, e.g., immaturity of specimens collected. There are five peltate heads in the cones on stems both of the ultimate and penultimate order. In the fertile verticils of *L. polonica* there are six leaves besides three cones, a character which by itself would allow to distinguish this species from the remaining ones, where in the fertile verticils there are only three leaves.

The anterior margin of leaves of *Lilpopia polonica* is straight or slightly arched with rounded corners, while medium sized leaves of *L. raciborskii* are as a rule more rounded at the corners and characteristically dentate at the anterior margin. Larger leaves of both species are dentate at the anterior margin, and the largest leaves are fimbriate. However, the leaves of *L. raciborskii* are dissected and are characterized by the rounded corners.

The leaves of *L. crockensis* are comparable only to the large leaves of *L. polonica*; they are more elongate and possess longer teeth. It should be stressed that the leaves of *L. crockensis* with long teeth occur in the fertile verticils, while in *L. raciborskii* and *L. polonica* such leaves occur mostly in sterile verticils and in the lowest parts of stems.

The leaves of *L. polonica* are somewhat similar to those of *Sphenophyllum emarginatum* Brongniart and *S. verticillatum* Schlotheim. The medium sized leaves of *L. polonica* are broader than those of *S. emarginatum*, their bases are wider, the teeth at the anterior margin are sharper and their shape is different; the anterior margin itself is slightly arched. The larger leaves are characterized by fimbriate margins, and the small leaves — by rounded corners.

It is difficult to distinguish between the small leaves of *Lilpopia polonica* and those of *Sphenophyllum verticillatum* with poorly preserved veins. The leaves of *L. polonica* seem to be somewhat broader. The larger leaves of this species with teeth still not developed, possess more rounded corners than in *S. verticillatum*.

The leaves of *L. polonica* resemble, by the presence of teeth, those of *S. longifolium* Germar, differing from them by the general outline, and those of *S. thonii* Mahr, from which they differ by the distribution of veins.

#### OCCURRENCE

The specimens of *Lilpopia polonica* occur in the Karniowice travertine together with the species *Callipteris conferta*, *C. naumanni*, *Sphenopteris obongifolia*, *Odontopteris lingulata*, *Taeniopteris multinervis*, *Lilpopia raciborskii* and other fossils, on which basis the age of the rock was established as the lower part of the Autunian (Lipiański 1971).

Numerous specimens were found in situ at Karniowice, where this species is locally very abundant. Fewer specimens were found in outcrops of the Karniowice travertine in other areas.

Kraków, October 1970

Academy of Mining and Metallurgy in Kraków

Laboratory of Coal Deposits of the Institute of Regional Geology and Coal Deposits

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## STRESZCZENIE

### LILPOPIA POLONICA LIPIARSKI Z MARTWICY KARNIOWICKIEJ (DOLNY OTEN) KOŁO KRAKOWA

W niniejszej pracy podano opis oraz rysunkową i fotograficzną dokumentację gatunku kopalnej rośliny *Lilpopia polonica* Lipiarski, z rodzaju *Lilpopia* Conert et Schaarschmidt 1970. Poprzednio rodzaj *Lilpopia* Con. et Schaar. 1970 znany był pod nazwą *Tristachya* Lilpop 1937, która okazała się homonimem nazwy wcześniej użytej dla określenia rodzaju innej rośliny.

Skamieliny gatunku *Lilpopia polonica* występują w wapieniu słodkowodnym zwanym martwicą karniowicką. Skala ta odsłania się na powierzchni na terenie wsi Karniowice i Filipowice, około 35 km na zachód od Krakowa. Wiek tej skały określono jako dolny otén (Lipiarski 1969, 1971).

Typem rodzaju *Lilpopia* Con. et Schaar. jest gatunek *Lilpopia raciborskii* (Lilpop) Con. et Schaar., który występuje w martwicy karniowickiej (Lilpop 1937). Oprócz wymienionych znany jest jeszcze jeden gatunek z omawianego rodzaju, *Lilpopia crockenensis* (R. et W. Remy) Con. et Schaar., pochodzący ze skał ilastych otenu z Crock w Turyngii (R. et W. Remy 1961).

Omawiany gatunek posiada szereg cech morfologicznych, którymi wyodrębnia się spośród innych podobnych mu gatunków *Sphenopsida*. Najważniejsze cechy morfologiczne, będące równocześnie jego diagnostycznymi cechami gatunku, dotyczą budowy kłosów zarodniowych, liści oraz stosunku przestrzennego kłosów do liści (diagnozę gatunku, w językach: polskim, rosyjskim i francuskim, oraz opis gatunku w języku polskim podano w pracy autora z 1971 roku).

## Plates

All specimens represent *Lilpopia polonica* Lipiarski and derive from the Karniowice travertine (Lower Autunian) near Cracow, Poland.

## Tablice

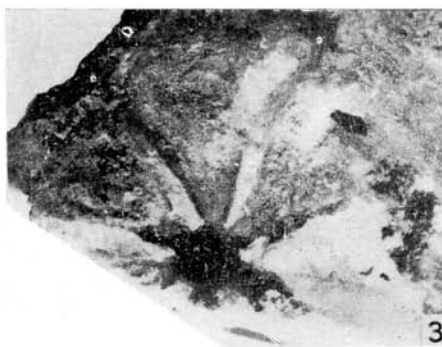
Wszystkie okazy przedstawiają gatunek *Lilpopia polonica* Lipiarski i pochodzą z marmrowicy karniowickiej (górny oten) koło Krakowa

### Plate I

- 1, 2. Fragment of fertile stem. Cones occur in two verticils. Part and counterpart of the longitudinally cracked holotype. Impression,  $\times 1$ . Respectively, 1a, 2a —  $\times$  ca. 3
- 3, 4, 5. Leaves occurring in verticils; some leaves appear to be deformed due to discontinuous colouring. 3, 4 — impressions, 5 — cast,  $\times 2$

### Tablica I

- 1, 2. Fragment owocującego pędu. Kłosa zarodniowe występują w dwóch okółkach; dwie części pękniętego podłużnie okazu holotypu. Odcisk,  $\times 1$ . Odpowiednio 1a, 2a —  $\times$  ok. 3
- 3, 4, 5. Listki występujące w okółkach; kształt niektórych listków jest zdeformowany na skutek niepełnego zabarwienia ich blaszek. 3, 4 — odciski, 5 — odlew,  $\times 2$

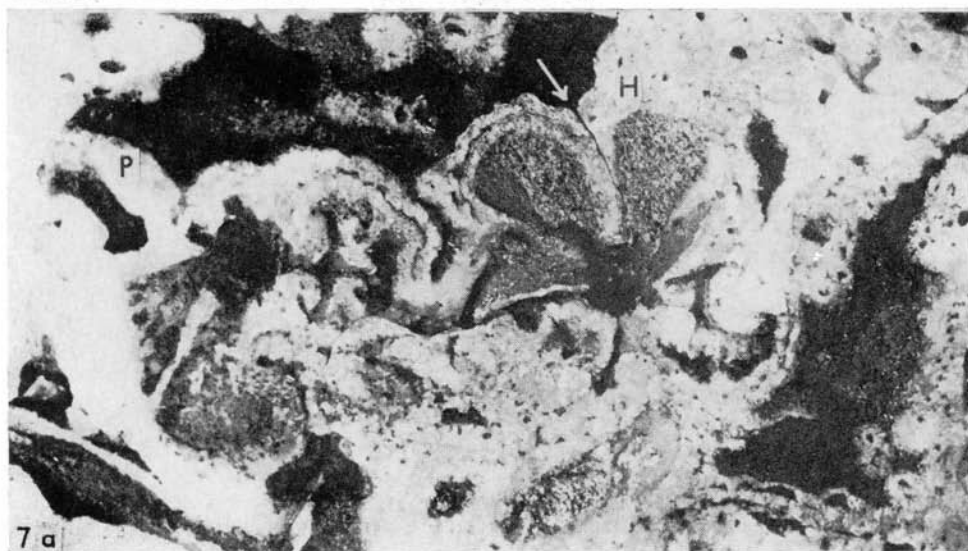
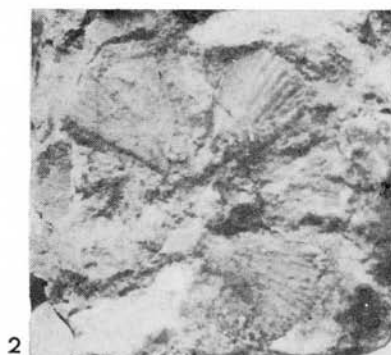
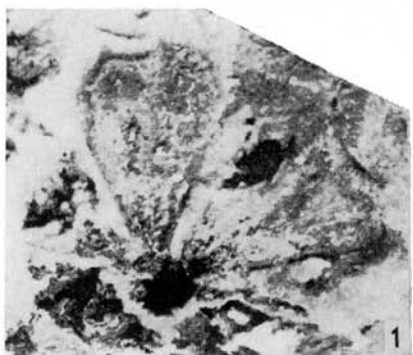


## Plate II

- 1—6. Leaves in verticils; the shape of the leaf in fig. 5 appears somewhat modified due to the discontinuous colouring (see the text). 1, 4, 5, 6 — impressions; 2 and 3 casts;  $\times 2$
7. Fragments of two fertile verticils: holotype (H) to the right and paratype (P) to the left, seen from above. Arrow indicates cracking of holotype. Impressions; 7 —  $\times 1$ , 7a —  $\times$  ca. 3

## Tablica II

- 1—6. Listki w okółkach; kształt listka na fig. 5 jest nieco zmieniony na skutek niepełnego zabarwienia jego blaszki (zobacz tekst). 1, 4, 5, 6 — odciski, 2, 3 — odlewy;  $\times 2$
7. Fragmenty dwóch okółków owocujących: holotypu (po prawej stronie — H) i parotypu (po lewej stronie — P), widzianych od góry. Strzałka wskazuje miejsce pęknięcia okazu holotypu. Odciski; 7 —  $\times 1$ , 7a —  $\times$  ok. 3



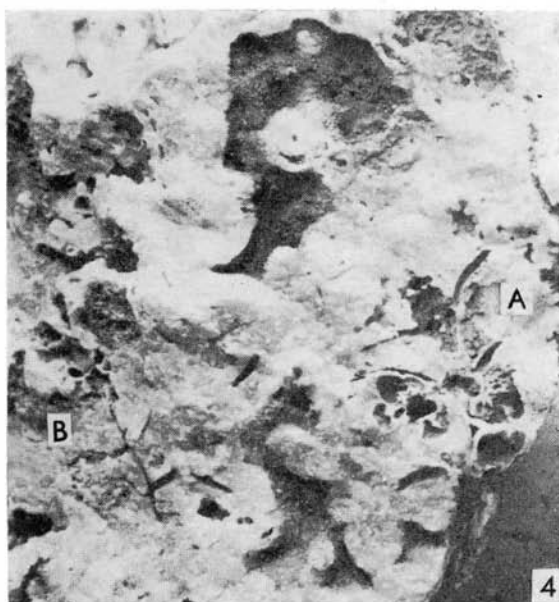
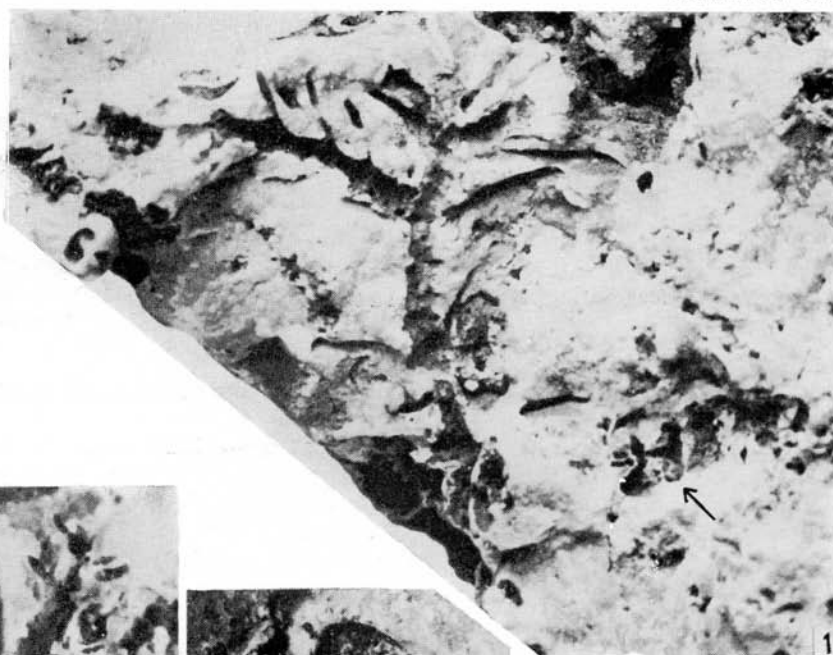
### Plate III

1. Fragment of stem of penultimate order branching in its upper part and with a fragment of cone without frontal peltate head of apical sporangiophore in its lower part. Arrow indicates a cone occurring separately in the rock. Impression,  $\times 2$
2. Fragment of upper part of a sterile stem of ultimate order. Impression,  $\times 2$
3. Leaf in verticil. Shape of the leaf appears to be modified due to the discontinuous colouring of its blade. Impression,  $\times 2$
4. Fragment of fertile stem (A) and underground organs (B). Impression,  $\times 2$

### Tablica III

1. Fragment pędu przedostatniego rzędu rozgałęziającego się w górnej części, zaś w dolnej części z fragmentem kłosa zarodniowego bez zachowanej tarczki czołowej sporofila wierzchołkowego. Strzałka wskazuje kłos zarodniowy występujący oddzielnie w skale. Odcisk,  $\times 2$
2. Fragment górnej części płonnego pędu ostatniego rzędu. Odcisk,  $\times 2$
3. Listek występujący w okółku; kształt jednego listka jest zdeformowany na skutek niepełnego zabarwienia jego blaszki. Odcisk,  $\times 2$
4. Fragment owocującego pędu (A) i organy podziemne badanego gatunku (B). Odcisk,  $\times 2$





#### Plate IV

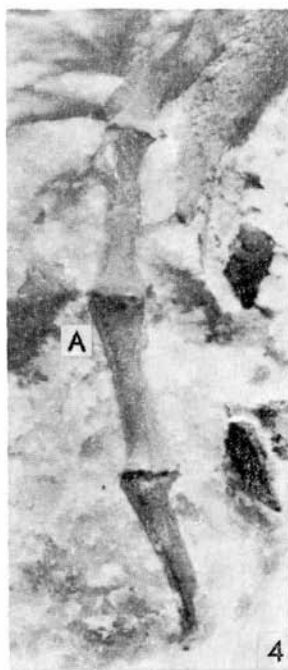
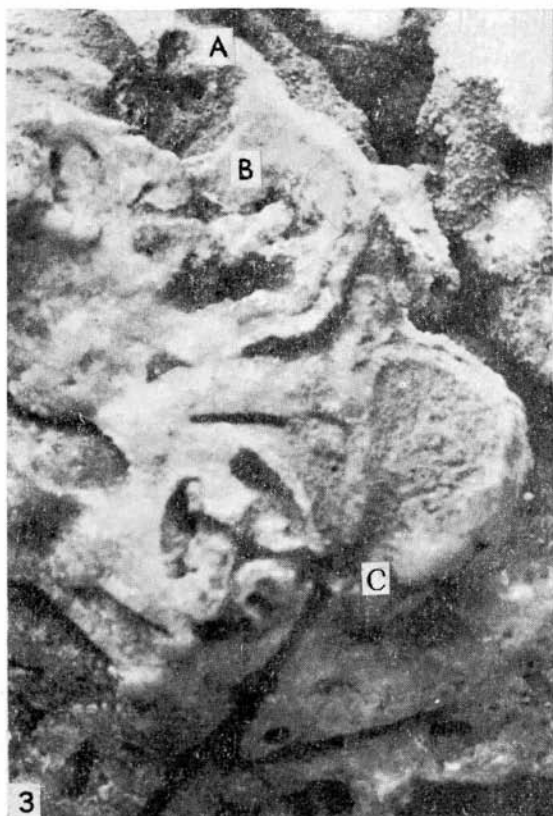
1. Leaf partly without teeth. Impression,  $\times 2$
2. Fragment of upper part of stem of ultimate order. Probably fertile specimen. Impression,  $\times 2$
3. Fragment of stem with the attachment of cone visible from the inner side of stem (A) and from above, in longitudinal section of the cone (B) in paratype; lateral view of the same in holotype (C);  $\times 4$ . Other views of this part of the holotype and paratype are shown in Pl. II, fig. 1
4. Fragment of stem of ultimate order with characteristic shape of surface of stem with leaves extending into the rock and with the area of attachment of cone visible (A). Impression,  $\times 2$

Remarks: the specimen was photographed lighted in such a way that the originally concave part of specimen appeared convex in the impression. Turn this photograph  $180^\circ$

#### Tablica IV

1. Listek pozbawiony części ząbków. Odcisk,  $\times 2$
2. Fragment górnej części pędu ostatniego rzędu. Okaz prawdopodobnie owocuający. Odcisk,  $\times 2$
3. Fragment łodygi z miejscem przyczepu kłosa zarodniowego widzianym od wewnętrznej strony łodygi (A) oraz widzianym z góry na przekroju podłużnym kłosa (B) — na okazie parotypu; to samo widziane z boku na okazie holotypu (C);  $\times 4$  (inne ujęcie tej części okazu holotypu i parotypu przedstawiono już na tabl. II, fig. 1)
4. Fragment pędu ostatniego rzędu o charakterystycznej morfologii powierzchni łodygi z listkami sięgającymi w głąb skały oraz z dostrzegalnym miejscem przyczepu kłosa zarodniowego (A). Odcisk,  $\times 2$

U w a g a: przy fotografowaniu zastosowano oświetlenie uwidoczniające faktycznie wklęsły odcisk okazu w formie wypukłej. Porównaj tę fotografię obróconą o  $180^\circ$



## Plate V

1. Fragment of stem of penultimate order. Impression,  $\times 2$
2. Fragment of stem of ultimate order. Impression,  $\times 2$ . Same remarks as in Pl. IV, fig. 4
3. Fragment of stem of ultimate order. Impression,  $\times 2$ . Same remarks as in Pl. IV, fig. 4
4. Fragment of stem of penultimate order. Impression,  $\times 2$

## Tablica V

1. Fragment pędu przedostatniego rzędu. Odcisk,  $\times 2$
2. Fragment pędu ostatniego rzędu. Odcisk,  $\times 2$ . Uwaga jak do Tabl. IV, fig. 4
3. Fragment pędu ostatniego rzędu. Odcisk,  $\times 2$ . Uwaga jak do Tabl. IV, fig. 4
4. Fragment pędu przedostatniego rzędu. Odcisk,  $\times 2$

