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Original article

Morpho-Anatomical Characterization of Benguet Lily (*Lilium philippinense* Baker)

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ABSTRACT: This study characterized the morphological and anatomical features of Benguet lily (*Lilium philippinense* Baker) collected from Mt. Jambo, Benguet, Philippines as part of the effort to document the ecologically and culturally important plants in the province. The plant is an endemic annual herb with linear, spiral leaves; white but sometimes purple-tinged, perfect, funnel-shaped, showy flowers; septicidal elongated capsule; and, brown, light, winged seeds. Anatomical features of the plant exhibit structural features common to genus *Lilium* such as indistinct pith in roots, atactostele stem and bifacial leaf with anomocytic stomata. New findings in the study include description of the capsule and seeds, biometric measurements of the different plant organs and the transverse section of contractile roots that showed a suberized layer in the cortex.

KEY WORDS: *Lilium philippinense* Baker, morphological and anatomical features

INTRODUCTION

Benguet, a landlocked province in Luzon, Philippines, harbors a unique floral diversity owing to its high elevation and cool climate. There are already several indigenous plants that were identified but much of these have yet to be fully characterized. One such plant is *Lilium philippinense*, locally known as "Benguet lily or mountain lily". It is commonly observed growing along roads in high-elevated towns of Benguet and noted for its beautiful white flowers. However, there are only a handful of studies on this species particularly on its morpho-anatomical features. Much of the studies on Benguet lily are about its distribution and cultivation requirements (Balangcod *et al.*, 2011; Alipio and Ladilad, 2005; Ampaguey *et al.*, 2002). Yembaturova and Korchagina (2011b) had already made a morpho-anatomical of this species but the plants they used are not from its the natural range, instead they made use of cultivated lilies in Russia. Also, their report is not readily available in English.

Recently, *L. philippinense* populations were reported to have declined due to human activities such as over-collection (Madulid, 2001) and destruction of habitat including land-use conversion and road widening (Balangcod, 2009). From a conservation perspective, it is important to understand many aspects of plant biology, including the ecological and physiological ends of the spectrum. An appreciation of morphology and anatomy is fundamental in understanding these. Plant anatomy, along with "whole plant" physiology and comparative plant morphology, has long formed the core of general botany courses. This is the subject matter at the heart of the study of

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plants at the organismal level. Aside from being a source of characters for taxonomic classification and phylogeny reconstruction, plant morphology and anatomy elucidate the relationship of these structures to their functions or physiology (Pancho and Gruezo, 2012), thus, the continuing need to increase and refine our basic understanding on the internal and morphological structures of plants. Such was the aim of this paper – to document the morphological and anatomical characteristics of Benguet lily (*L. philippinense*) in Benguet Province.

MATERIALS AND METHODS

The plants used in the study were derived from Mt. Jambo, La Trinidad, Benguet. Mt. Jambo, also known as Mt. Yangbew, is located in Barangay Tawang and about 10 kilometers away from Baguio City. It is a series of high-rolling and serrated hills with interesting rock formations but generally covered with herbaceous vegetation such as grasses. The summit which provides a 360° overlooking view of La Trinidad and Baguio City is now being offered as ecotourism site while the slopes are subjected to residential and agricultural activities. Thus, there is an immediate need to document the ecologically and economically important flora in the area as part of conservation and impact assessment.

The study randomly sampled individuals found on the summit and along the slope of the mountain. First, the plants were characterized phytographically. This means coming up with a complete morphological description of the plant and its organs – vegetative organs such as roots, bulb, stems, leaves and reproductive organs such as flowers/inflorescences, fruits and seeds. After that, free hand sections of the roots, stem and leaves were derived. Cross sections of the contractile roots and adventitious roots were taken for comparison. Likewise, cross sections of older stem (located at the basal portion) and younger stem (apical portion) were also derived and compared. For the leaf, epidermal and cross sections of the lamina were taken to observe the stomata, epidermis and mesophyll tissues. Since the plant has a continuous spiral of leaves along the stem axis, cross sections of basal, middle and apical leaves were compared. Same is true with the lamina, cross sections of base, middle and apex were derived and compared. The different cross sections derived were stained with safranin then subjected to light microscopy.

RESULTS AND DISCUSSION

Morphological Description

The plants observed in the study are as described in the literatures (Elwes, 1880) with some minor deviation which could be attributed to the plant's plasticity. Two types of roots were observed in the plant – contractile and adventitious. Contractile roots are observed under the bulb which pull the plant deeper into the soil. The contractile roots are more stout and contorted in plants growing in rocky soil. Adventitious roots are observed on the base of the stem that is usually few inches under the soil (see Fig. 1). Several bulbs are located at the base of the stem that are odorless, white with yellow tinge along the conic tip, smooth at the base and widest at the middle. The stem is originally described to be 1-2 feet (30-60 cm) high but could reach up to 200 cm particularly in cultivated plants. The leaves of the specimens observed are narrower from that describe by Baker measuring only about 0.6-1.1 cm wide but the length could be longer reaching up to 24.5 cm (Table 1). The leaf is sessile, glabrous, spiral, entire, apex acute, and linear resembling a grass blade without leaf sheath but more succulent. Basal

leaves are generally broader and longer than apical leaves. The leaves stay through-out majority of the plant's life cycle until the seeds are matured. This could be concluded from the minimal number of leaf scar observed in the stem. However, the plant is only annual.

The flower was observed to be pure white in plants under shade but sun-exposed plants have purple tinge along the mid-vein of the tepals (Fig. 2). The flower has 3 outer and 3 inner tepals arranged in an imbricate-alternate aestivation forming a funnel-shaped perianth. The tepals, if separated, are oblanceolate and have revolute apex with the outer tepals having farther revolute apex about 2 cm while the inner ones only at 1 cm. The purple tinge in sun-exposed flowers is observed in both tepals but it is more scattered on the outer tepal, unlike in the inner ones that form a purple straight line along the mid-vein. This is also the part of the inner tepals that is exposed. The androecium is composed with 6 stamens with greenish white filament and dithecal, versatile dorsifixed anther. The gynoecium is composed of superior elongated ovary, terminal style and 3 fused light green stigma appearing tri-lobed and slightly revolute. In wild lilies, the flower is often solitary, rarely two, but cultivated plants could have up to 10 flowers. The flowers bloomed from March to May and from September to November, different from what Balangcod *et al.* (2011) reported at late May to July. In cultivated plants with multiple flowers, the flower buds arise in bundles as if they arise from a common point but then the internode between the flowers elongated separating them in a spiral fashion. The lowest flower is the first to bloom followed by the succeeding flowers.

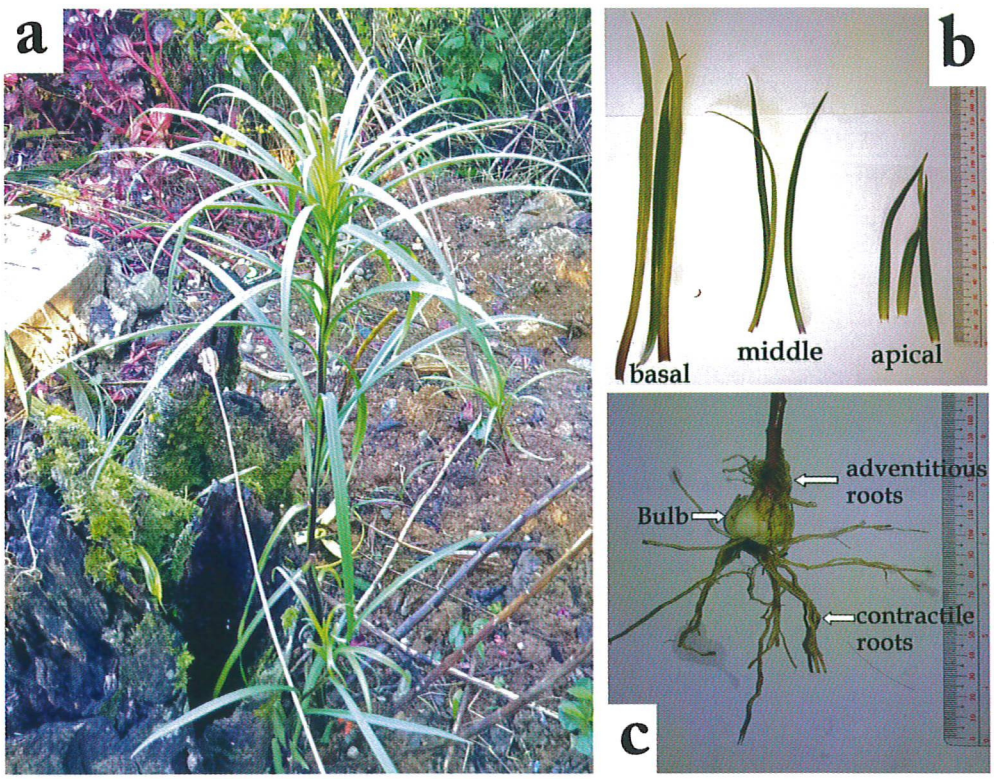


Figure 1. Vegetative organs of Benguet lily (a – plant habit; b – leaves; c – roots)

Table 1 Biometric measurements of Benguet lily (*Lilium philippinense* Baker)

Part of plant /parameter		Minimum	Maximum	Mean	Standard deviation
Bulb	Length (cm)	1.80	4.00	2.78	±0.75
	Width (cm)	2.00	4.50	3.10	±0.96
Stem	Length (cm)	39.60	190.00	93.91	±52.98
	Diameter (cm)	0.30	1.00	0.58	±0.21
Leaves	Length (cm)	6.00	24.50	15.39	±4.66
	Width (cm)	0.40	1.10	0.69	±0.17
Pedicel	Length (cm)	3.00	16.50	8.64	±4.25
Outer tepal	Length (cm)	14.30	14.90	14.67	±0.21
	Width (cm)*	2.80	3.10	2.97	±0.10
Inner tepal	Length (cm)	14.10	14.90	14.48	±0.29
	Width (cm)*	4.00	4.90	4.42	±0.25
Anther	Length (cm)	0.50	1.40	0.82	±0.35
Filament	Length (cm)	10.80	11.70	11.32	±0.31
Ovary	Length (cm)	3.90	4.50	4.14	±0.18
Style	Length(cm)	7.30	8.60	8.06	±0.33
Capsule (Fruit)	Length (cm)	4.00	10.10	7.56	±1.87
	Diameter (cm)	1.80	2.50	2.11	±0.24
Seed	Length (cm)	0.70	0.90	0.78	±0.08
	Width(cm)	0.50	0.50	0.50	±0.00

*widest portion

Fruit and Seeds. Baker was not able to describe the capsule and seed of this species. Fruit is a septicidal capsule from compound ovary of 3 carpels with axile placentation. After fertilization and senescence of the perianth and stamens, the capsule is visibly linear and green. The locule of the capsule broadens as the ovules mature making the involute septa more prominent. The septa are deeper, midway into the capsule, at every other interval making the capsule look like trilobed (see Fig. 3). The length of the capsule varies from 4 to 10 cm but the diameter is relatively stable at around 2 cm. At maturity, the capsule dries, turns brown along with the entire plant, then dehiscence starting from apex downward releasing the seeds. Numerous seeds are contained in the capsule ranging from few hundreds to a thousand. The seeds are oblong, brown and light-weight sorrounded by thin brown film indicating wind dispersal.

Anatomical Features of Benguet Lily

The roots. As mentioned above, the plants have adventitious roots and contractile roots. Cross sections of adventitious roots showed a typical monocotyledon roots (Fig. 4A). The epidermis, consisting of single layer of rectangular cells, forms the outermost covering followed by a wide cortex then the vascular cylinder. Unicellular roots hairs were also observed arising from the epidermis of varying height. The cortex consists of generally circular, large

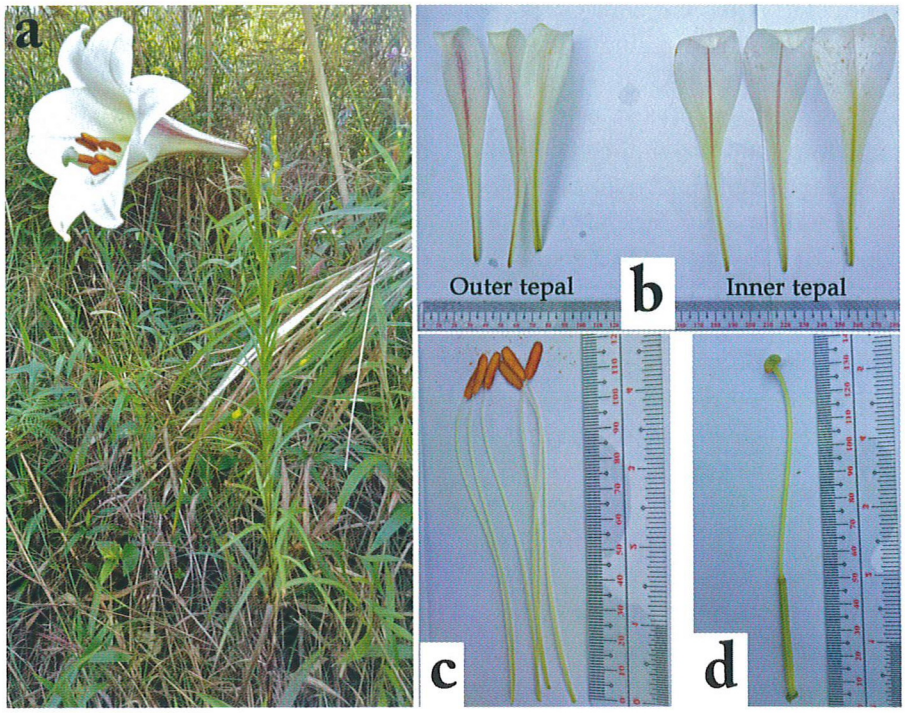


Figure 2. The flower of Benguet lily (a – overview showing the funnel-shaped perianth; b – the tepals; c – stamens; d - carpel)

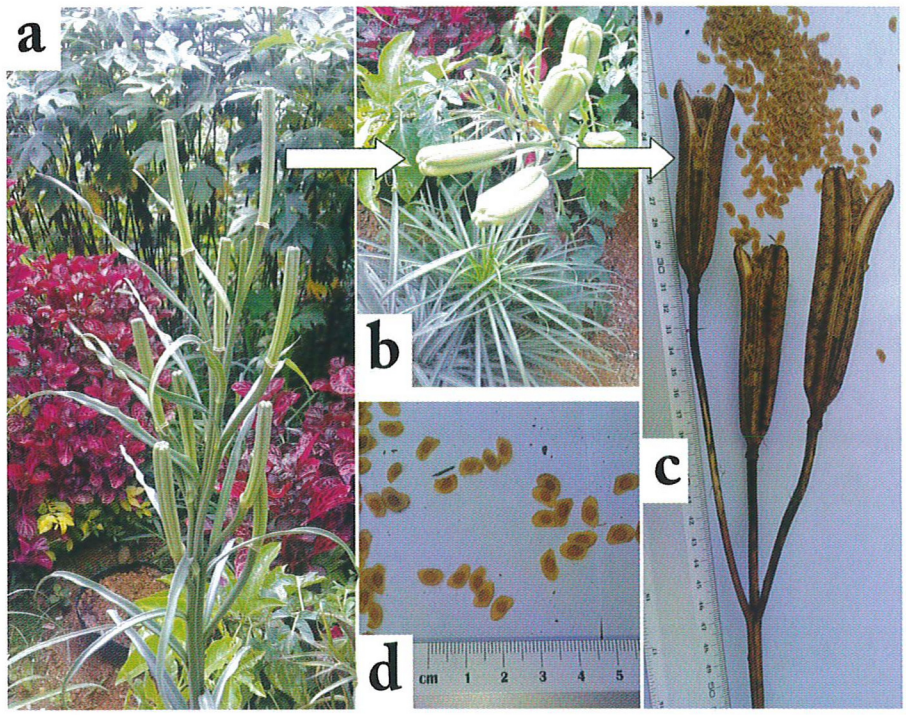


Figure 3. The septicidal capsule and seeds of Benguet lily (a to c – development of the capsule from fertilization to dehiscence; d – seeds)

parenchyma cells. After the cortex lies the endodermis, composed of a single layer of well shaped cells lined with Casparian strip. This is followed by the pericycle which is composed of thin, single layer of cells. There was no well-defined parenchymatic core or pith in the vascular cylinder, instead, the centre is dominated by metaxylem elements. The xylem is exarch with 8 to 11 arms and the phloem located in between these xylem arms. These findings on roots of *L. philippinense* are consisted with other species of *Lilium* like *L. candidum* (Özen *et al.*, 2012) and *L. polyphyllum* (Dhyani *et al.*, 2009).

Contractile roots, on the other hand, are larger than the annual adventitious roots and are perennial as the bulb. Its cross-sections exhibit a generally similar structure like that of the adventitious roots with few distinctions. The cortex has a suberized layer a few layers below the epidermis creating a circular line (Fig. 4B). This suberized layer protects the cortex from dehydration during dry season and is more defined in plants growing in shallow soil found on rock crevices common on the mountain's summit. Some cells in the cortex are irregularly shaped with contorted cell walls particularly along the periphery while the rest are rectangular to hexagonal.

The stem. Cross-sections of the stem exhibits atactostele arrangement, common on monocot stem. The single-layer epidermis covered by cuticle forms the outermost covering, followed by ground tissues and the intersperse vascular bundles. On young (apical) stem, the ground tissues are predominantly parenchymatous but on mature (middle) stem, collenchymatous layers developed then became schlenchymatic on older (basal) stem (Fig. 5A-C). These schleranchymatic cells formed by secondary

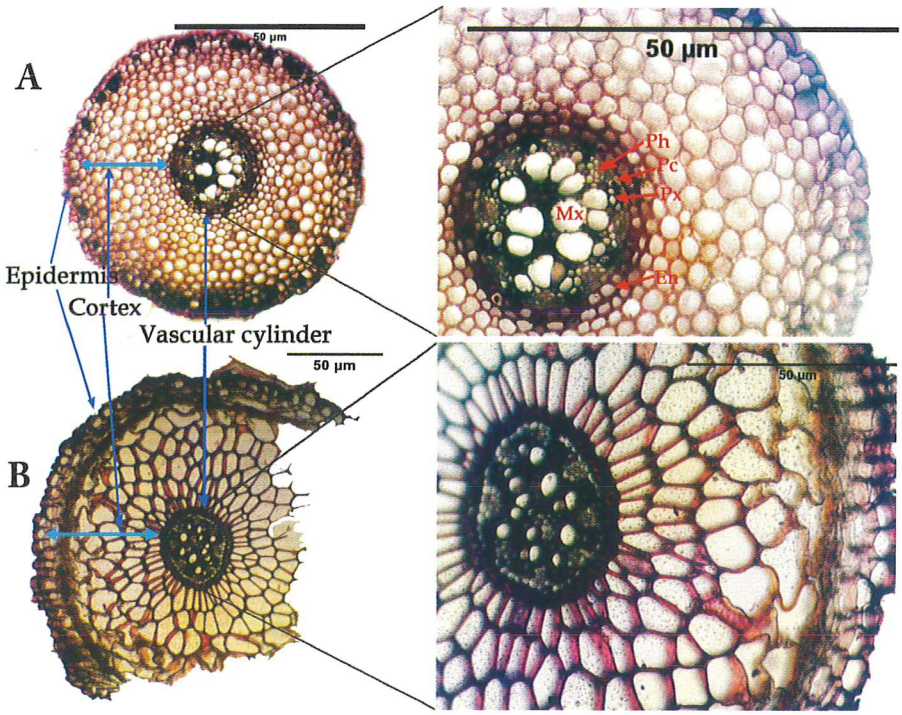


Figure 4 A and B. Cross-section of the adventitious roots (A) and contractile root (B) showing the different tissues (En – endodermis; Mx – metaxylem; Pc –pericycle; Ph – phloem; Px – protoxylem)

wall development help plant organs for bending, folding and give support for weight and pressure (Fahn, 1990; Vardar, 1982; Yentür, 1995). The metaxylem elements are also wider and the vascular bundles more developed on mature stem. The cross-sections of the mature and old stem of *L. philippinense* are similar with those of *L. candidum* described by Özen *et al.* (2012).

The leaf. Epidermal sections on both upper and lower epidermis show generally elongated tapering cells (Fig. 6A-B, unstained) with slanted anticlinal walls. The periclinal wall is generally straight but some abaxial epidermal cells are curved particularly those located in between stomata. Also the adaxial epidermal cells are longer than its abaxial counterpart. The stomata of Benguet lily are of anomocytic type, where stomata are surrounded by limited number of subsidiary cells which are quite alike the remaining cells. Anomocytic type was also reported in other species of Lilium and in families Boraginaceae, Ranunculaceae and Geraniaceae. The stomata are mostly concentrated in the abaxial epidermis but few are noted sporadically in adaxial epidermis but only in the lamina base of middle and basal leaves. This contradicts the general notion that monocot have uniform distribution of stomata in the abaxial and adaxial epidermis. This also contradicts the findings of Zarinkamar (2006) that there are equal or more stomata in adaxial epidermis than abaxial in other species of Liliaceae such as *Allium atroviolaceum*, *Allium rubellum*, *Asparagus officinalis*, *Asphodeline dendroides* and others. However, these species are no longer under Liliaceae but transferred to other related families under same order Liliales.

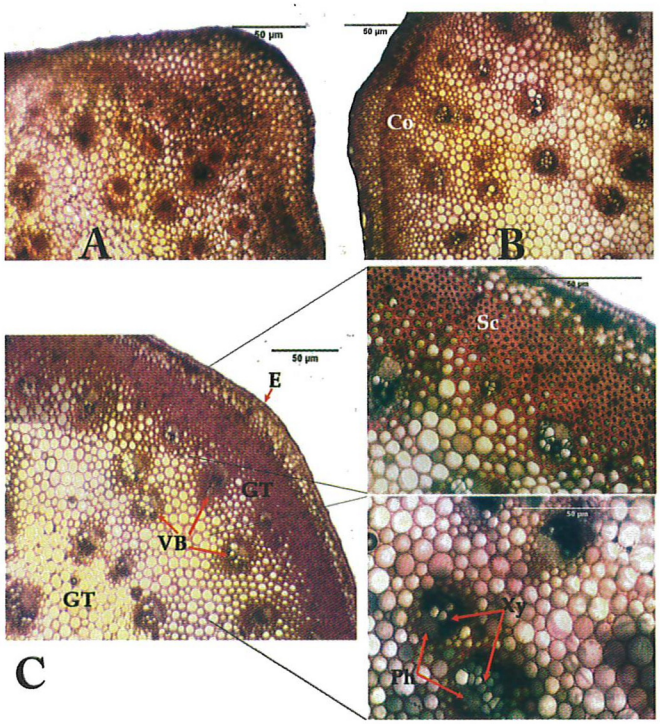


Figure 5 A to C. Cross-sections of stem showing the development of ground tissues from predominantly parenchymatous of young stem (A) to appearance of collenchymatous layer in middle stem (B) and schlenrenchymatous in old stem (C) (Co – collenchyma; E – epidermis; GT – ground tissues; Ph –phoem; Sc – Schlerenchyma; VB – vascular bundles; Xy – xylem)

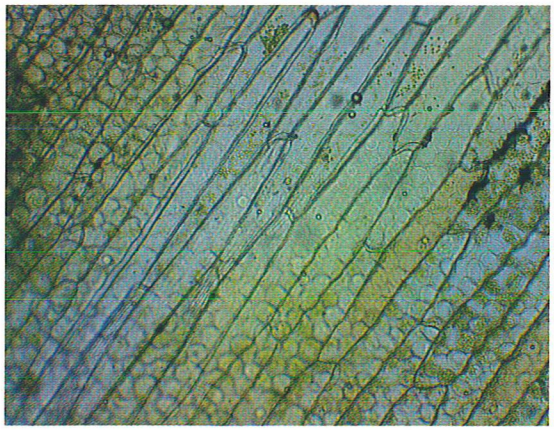


Figure 6A. Highly elongated epidermal cells in the adaxial epidermis

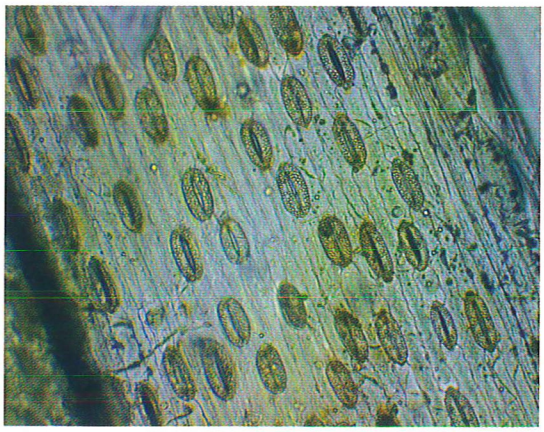


Figure 6B. Stomata and elongated epidermal cells in the abaxial epidermis

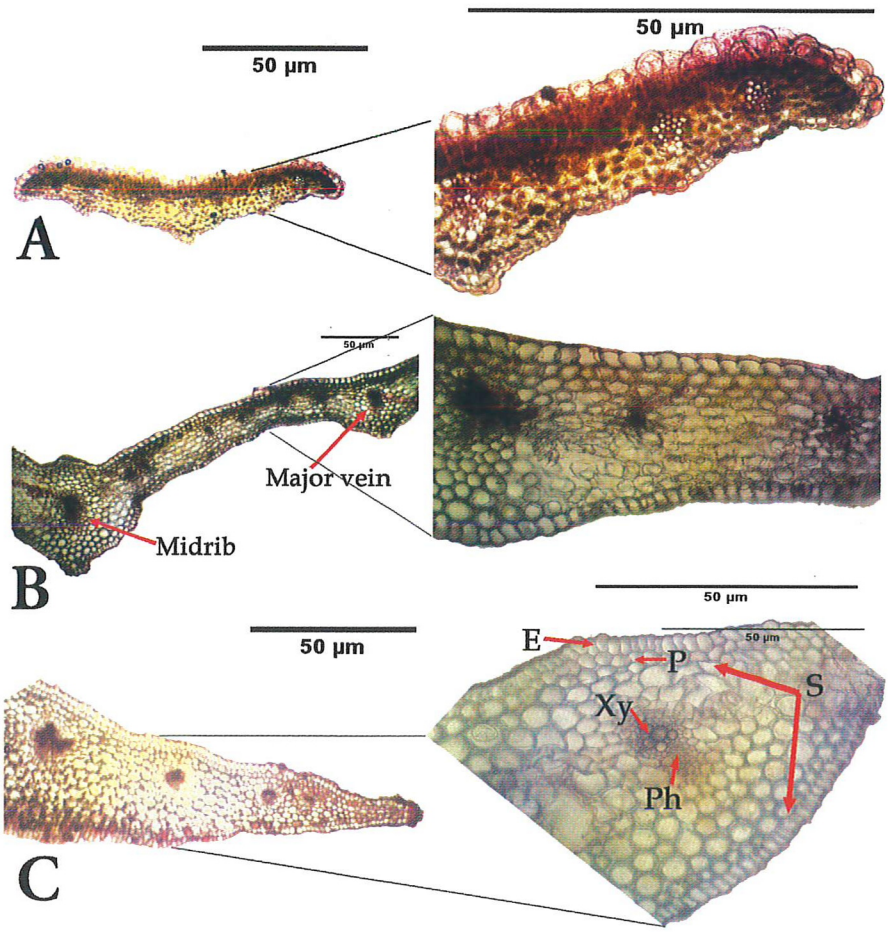


Figure 7 A to C. Leaf cross sections from base (A) to middle (B) and apical portion (C) of the lamina (E – epidermis; P – Palisade; Ph –phoem; S – Spongy; Xy – xylem)

Cross-sections of the leaf show both upper and lower epidermises enclosing the mesophyll and regularly spaced vascular bundles (Fig. 7A-C). The upper and lower epidermis are both uniseriate and composed of transparent cells. The upper epidermal cells are generally larger with thicker cuticle. The mesophyll is divided into palisade and spongy layer. This mesophyll structure is quite different from the common monocot leaves which have undivided mesophyll. The palisade layer resembles a brick-like layer of rectangular cells, not elongated, which make it distinct from the spongy layer that is composed of generally larger cuboidal cells with larger air spaces. This finding supports the previous reports that mesophyll of genus *Lilium* is bifacial with a single layer palisade (Yembaturova and Korchagina, 2011a). Same bifacial mesophyll was also documented in *L. candidum* (Özen *et al.*, 2012) but no lobed or branching palisade cells were observed. Among parts of the lamina, basal cells contain lesser chloroplast as compared with the middle and apical part. The vascular tissues are regularly spaced as consequence of the parallel venation with xylem at the upper portion and the phloem beneath. The superficially distinct 2 major veins flanking the midrib are also conspicuous in the cross-section, being more prominent and larger than the other veins. These results are consistent with the earlier report of Yembaturova and Korchagina (2011b) on *L. philippinense*. Lastly, there were no structural difference observed between basal (older) leaves with middle and apical (younger) leaves along the leaf spiral of the plant.

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