MORPHO-ANATOMICAL FEATURES OF THE VEGETATIVE ORGANS OF *Saponaria pumilio* (L.) FENZL EX A. BRAUN AND THEIR ECOLOGICAL SIGNIFICANCE

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Abstract. For a better understanding of the levels of plant adaptations to alpine environment a study on *Saponaria pumilio* root, stem and leaf morpho-anatomy was performed. Among the morphological adaptations we underline the small size of the plant, the horizontally extended root system, and the leaves arrangement in a acute angle. The structural described adaptations comprise thick cuticle, compact and homogenous mesophyll, and Krantz specific anatomy of leaf. This research recommends *S. pumilio* as an excellent model plant in studies of plant adaptations to alpine environment.

Keywords: *Saponaria pumilio*, morpho-anatomy, adaptation, ecology, alpine environment.

Rezumat. Caracteristicile morfo-anatomice ale organelor vegetative la *Saponaria pumilio* (L.) şi semnificaţia lor ecologică. Pentru o mai bună înţelegere a nivelurilor de adaptare a plantelor la condiţiile mediului alpin au fost efectuate studii privind morfo-anatomia rădăcinii, tulpinii şi frunzei la *Saponaria pumilio*. Dintre adaptările morfologice subliniem dimensiunile reduse ale plantei, sistemul radicular extins pe orizontală şi aranjarea frunzelor în unghi ascuţit. Adaptările structurale descrise se referă la cuticula groasă, mezofilul compact şi omogen şi la anatomia specifică de tip Krantz a frunzei. Acest studiu recomandă specia *S. pumilio* ca fiind un excelent model de studiu al adaptărilor plantelor la mediul alpin.

Cuvinte cheie: *S. pumilio*, morfo-anatomie, adaptare, ecologie, mediu alpin.

INTRODUCTION

Saponaria pumilio (L.) FENZL EX A. BRAUN, the pygmy pink, is a perennial species belonging to the Caryophyllaceae family. It is a cespitose plant forming hummocks on rocky slopes and screes on acid soils. The pygmy pink is known to be an endemic plant species to Europe (JALAS & SUOMINEN, 1988), being native to Eastern Alps and South Carpathian Mountains, Italy, Austria and Romania (TUTIN, 1996). Being mistaken for another taxon, *Saponaria pulvinaris* BOISS. (synonym with *S. pumilio* BOISS), (BOISSIER, 1843, 1849), followed by an incorrect synonymization of this with *S. pumilio* (named *pumilio* by A. Braun after a description of E. Fenzl), the species is also reported from Turkey, Lebanon and Syria. Furthermore, it was mentioned, from North America on the Amanoosuc Ravine Trail of Mount Washington (MAGEE & AHLES, 1999) where it is believed to have been intentionally planted (introduced and naturalized). The species' occurrence in Romania refers to Făgăraş and Iezer Mountains (BELDIE, 1977).

Not only species distribution, but also taxonomic position was the subject of many controversial changes. The species was assigned first to *Cucubalus* genus as *C. pumilio* L., and after to other different genera like *Lychnis* as *L. pumilio* (L.) SCOP. or *Silene* as *S. pumilio* (L.) WULFEN., being finally transferred to *Saponaria* as *Saponaria pumilio* (L.) FENZL EX A. BRAUN, which is presently accepted as the valid botanical name (TUTIN, 1996).

One of the first biologists who systematically study variation in plant morphology along with environmental gradients was Gaston Bonnier. Since the late nineteenth century, Bonnier experimentally showed that alpine climate strongly modified the morphology and the structure of well adapted plant species (BONNIER, 1895). His pioneering research was an open door for many further studies.

The species subject of this study is very well adapted to specific climate condition as proved by the well established and numerous populations. Moreover the plant is successfully cultivated in alpine gardens. These considerations recommend *S. pumilio* as a model plant to investigate the morphological and structural levels of adaptation of herbaceous plant to alpine environments.

Studies concerning morpho-anatomical features of *Saponaria* genus are very few and refer to other species (ATAŞLAR, 2004; ÇINBINGEL et al., 2007) none of them from alpine environment. In Romania there are some references but from other related genera like *Silene* (TOMA, 1969; AIFTIMIE-PĂUNESCU, 2000).

MATERIAL AND METHODS

Plant samples were collected in late July 2012 from populations in flowering stage, naturally growing in Iezer Mountains (N 45^0 27'36.354"/ E 24^0 57'41.011"), at 2161 m high.

Fresh samples from the vegetative organs were fixed in a mixture (3:1) of ethanol and glacial acetic acid for at least 7 days and after in ethanol 70^0 until processed. Transverse cuttings from root, stem and leaves were made using a hand microtome and a botanical razor blade. Sections between 10-15 µm thick were double stained with 1 % w/v light green and 1 % w/v safranin and finally mounted in synthetic resin (Entallan). For surface view of the epidermis, peelings from the adaxial and abaxial surface of the leaf were coloured with 1 % w/v safranin and also mounted in Entallan. The used double coloration is applied for general plant tissues where lignified and cutinized walls appear bright red, cellulose walls green, and meristems light blue.

Histological observations were made with bright field microscopy, under a Nikon Eclipse E200 microscope, and micrographs were recorded with a Nikon Coolpix 5400 digital camera.

RESULTS AND DISCUSSIONS

As general morphology the plant is very dwarf forming hummocks up to 40 cm across but only a few (1-8) centimetres high (Figs. 1a, b).

Figure 1. *S. pumilio* habitus - a. general view, b. detail. (photo original)

Root

S. pumilo has a perennial and well developed root system, with slender and branched tap roots ranging from 0.5 to 4mm thick. In cross section the distal end of the root (Fig. 2a) shows an early secondary structure being covered by a thin periderm originated from pericycle and made by 3-4 layers of cells with suberized walls, whereas rhizodermis (epiblem), cortical parenchyma and endodermis are exfoliated. Under the periderm the ring of pericycle with bundles of primary phloem are visible.

The central part of the root is filled by primary xylem and in peripheral position a few secondary xylem vessels. At this level the rays are not distinguishable. The cross-section through the middle part of the root shows an advanced secondary structure with more peridermal layers, obvious secondary phloem and xylem, and parenchymatous rays with starch deposits (Fig. 2b).

Stem

The stem is short, measuring 5-7 mm (the sterile shoots), with very shorts (0.5-1.5 mm) internodes. Flowering stems are up to 20 mm long and bear a solitary flower. In cross section the stem has a typically caryophyllaceous structure (METCALFE & CHALK, 1965): epidermis with almost isodiametric cells with cutinized external walls (Fig. 3a), cortical assimilatory parenchyma (2-3 layers of cells at the basal level, and up to 5 layers in flowering stems), and central cylinder with a partially sclerified pericycle, vascular tissues (external phloem and internal xylem) and a central parenchymatous pith, complete not disorganized, even in fertile shoots.

The pith, mostly in sterile shoots, has big cells with numerous crystals of calcium oxalate and also smaller parenchymatous cells with starch deposits. (Figs. 3b, c). The structure of the basal node is more complex showing the leaf sheath of mature leaves, leaf primordia, and stem primary tissues (Figs. 4a, b, c).

Leaves

The leaves are opposite to each node and with grown together sheaths (Fig. 4a), linear, small, up to 2 mm wide, 3-10 mm long onto floral stem and 10-20 mm onto sterile shoots. Leaf margins shows some papillose cells (Figs. 5b,c) and the sheaths at node level bear trichomes (Fig. 5a). In cross section through the lamina (Figs. 6a, b), the upper and the lower epidermis comprise slightly tangentially elongated, to isodiametric cells with external walls covered by a thick cuticle.

The mesophyll appears relatively homogenous with palisade tissue towards both epidermis but more compact and with more elongated cells towards adaxial surface. A cross section of the midrib exhibits one main vascular bundle accompanied by 3-4 smaller ones. Vascular bundles are collateral made by adaxial xylem and abaxial phloem and surrounded by a one-layered sheath of enlarged parenchymatous cells with chloroplasts. The cells from palisade extend radially from the bundle sheath cells. This distinctive leaf structure is known as **Kranz anatomy** and characterizes the C4 plants. Some cells from the mesophyll contain big crystals of calcium oxalate. The crystals are big enough to be visible thorough leaves transparency (Figs. 5b, c).

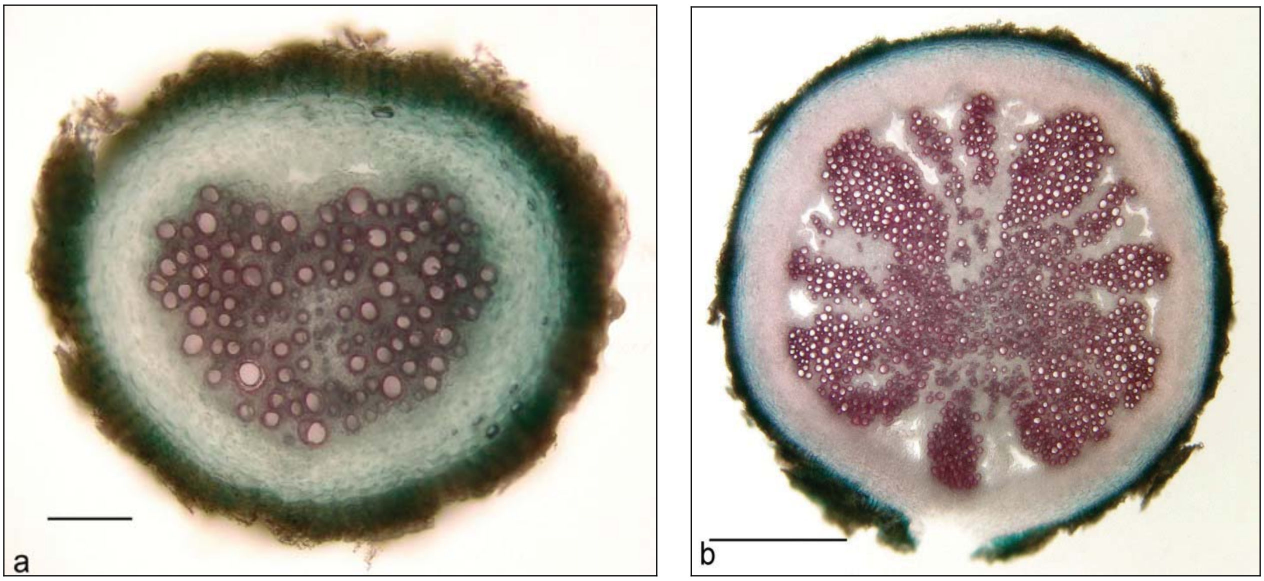

Figure 2. Root cross section. a - distal end (bar: 100µm);
b - middle part (bar: 500µm) (photo original).

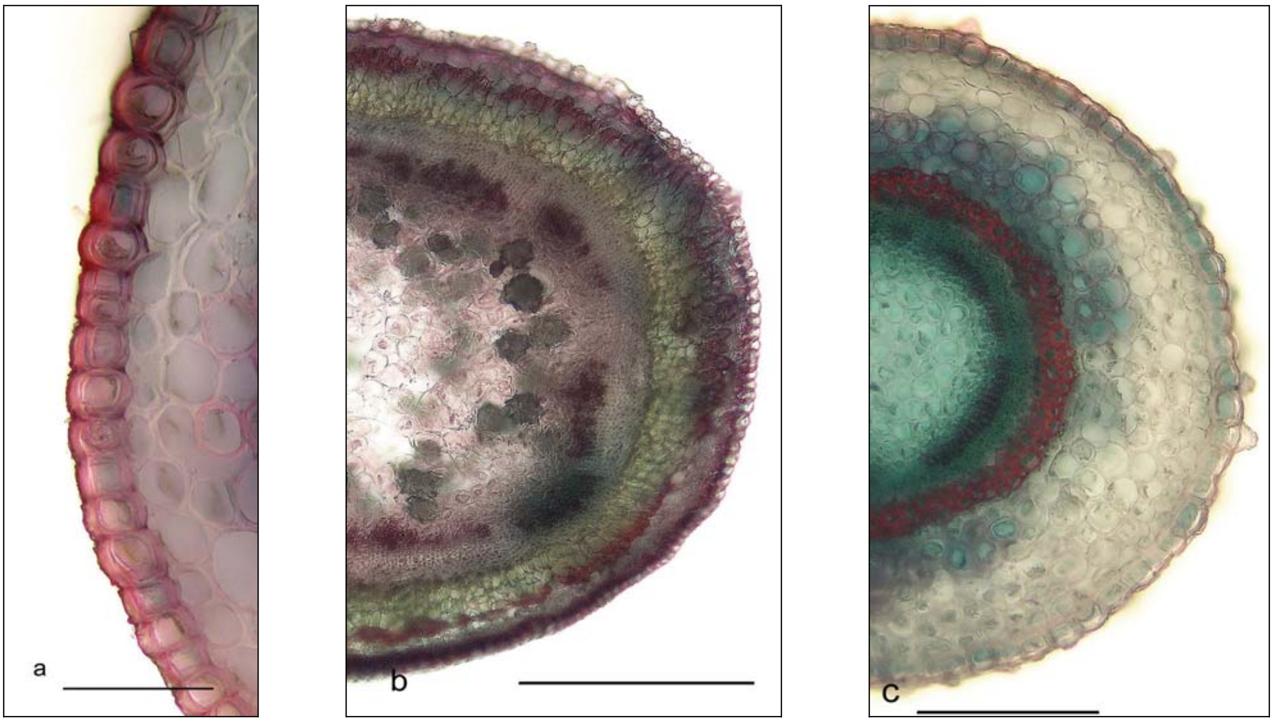

Figure 3. Stem cross section (internode). a – epidermis detail (bar: 50 µm);
b - sterile stem (bar: 250µm);
c - flowering stem (bar: 250µm) (photo original).

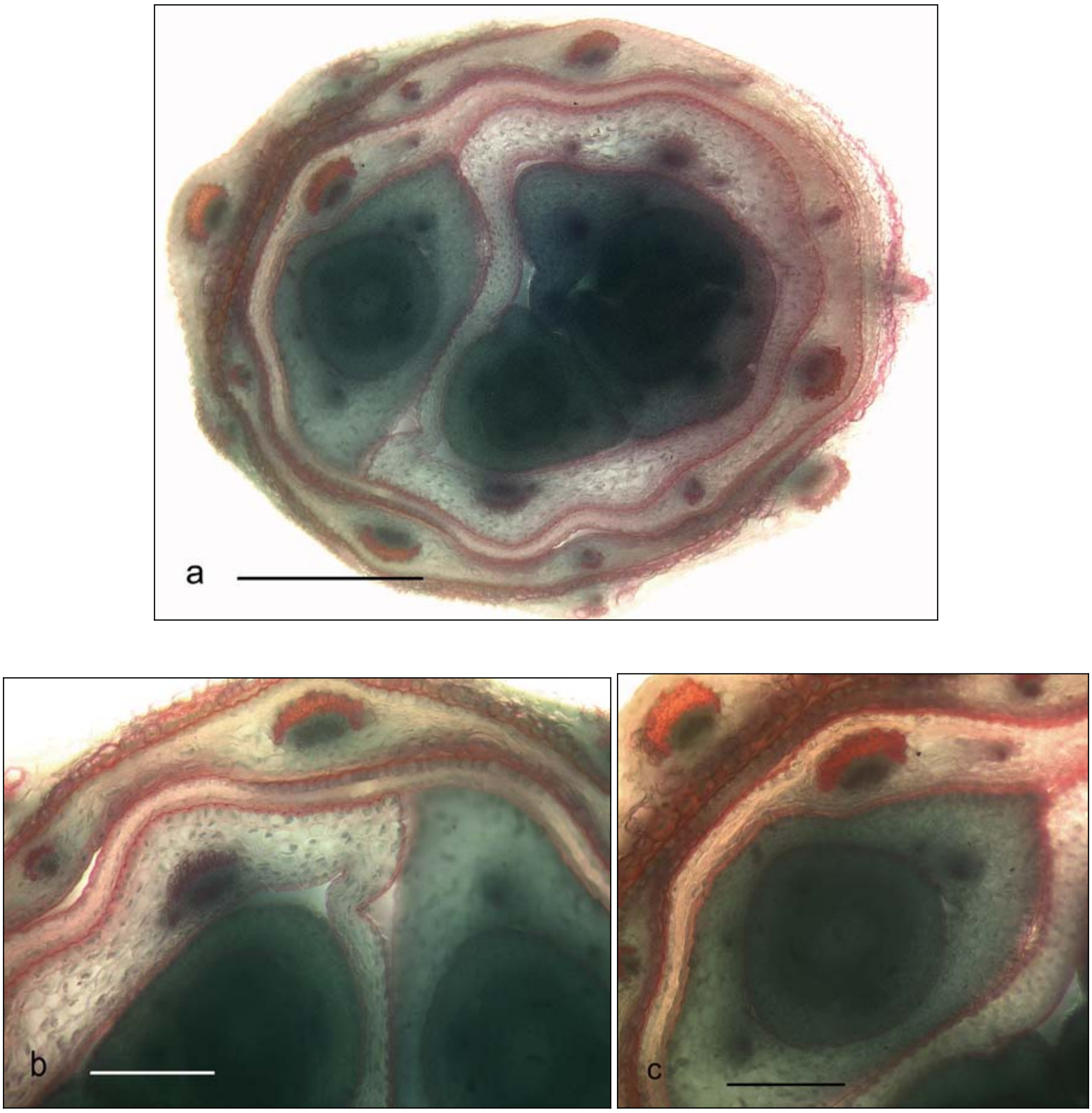

Figure 4. Stem cross section (basal node). a - general view (bar: 600 µm); b , c - details (bar: 150 µm) (photo original).

Figure 5. Leaf: a - trichomes on sheaths (bar: 400 µm);
b , c - lamina with crystals of calcium oxalate (250 µm) (photo original).

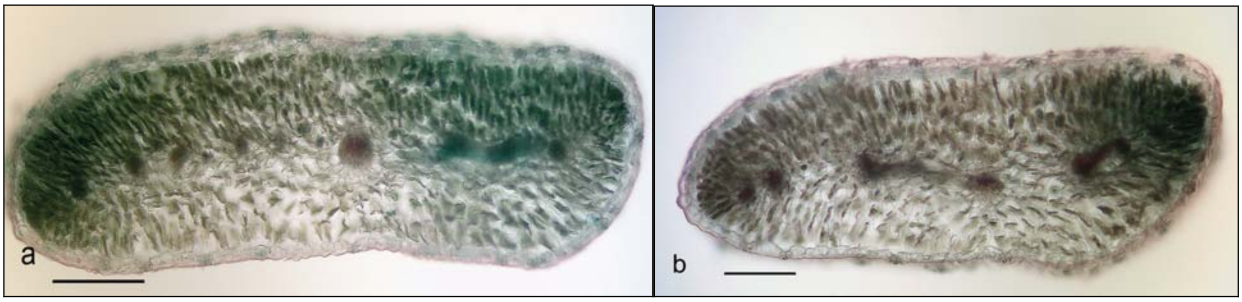

Figure 6. Leaf cross section: a - middle lamina (bar: 150 µm); b - base of lamina (bar: 150 µm) (photo original).

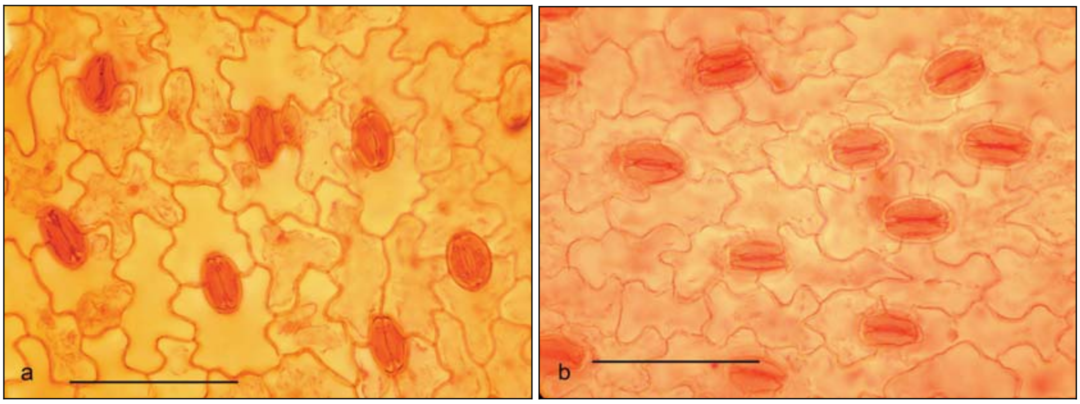

Figure 7. Leaf - surface view of epidermis: a - adaxial (bar: 100 µm); b - abaxial (bar: 100 µm) (photo original).

The transverse sections of different levels of lamina (middle, Fig. 6a and base, Fig. 6b) do not reveal significant structural modifications. In surface view, the epidermis is composed of cells with undulating walls with stomata mostly of anomocytic type and rare typically diacytic (caryophyllaceous). There are no notable differences in the epidermal cells between abaxial and adaxial surfaces (Figs. 7a, b).

CONCLUSIONS

The study on morpho-anatomical features of *S. pumilio* vegetative organs showed a series of adaptations specific to alpine plants. From the morphological ones the most obvious are: shorter stems, shorter internodes, and smaller leaves compare with other *Saponaria* species from lower altitude. Also, the well developed mainly horizontally extended root system that ensures plant fixation and an optimal water supply (especially pluvial). Leaves are orientated in a acute angle with the stem and this arrangement prevents heatstroke.

From the structural adaptation, at root and stem level we have noted the starch deposits which will ensure plant survival under harsh conditions.

At stem and leaves level there are also some notable adaptations as follows:

- thick cuticle that reduces water loss and plays a role in controlling surface temperatures by reflecting the incoming radiation;
- the arrangement of palisade tissue maximizes the efficiency rate of photosynthesis by placing cells at the optimum angle to the incoming sun rays;
- the relative homogenous and compact mesophyll is an adaptive response to high levels of incident light;
- leaf specific anatomy (**Krantz anatomy**) confers a greater photosynthetic efficiency by using the double-carbon fixation pathway.

Another structural adaptation to local conditions (substrate) is calcium deposits in form of calcium oxalate crystals (mainly in stem pith and leaf mesophyll) *S. pumilio* being a calcifuge species.

All these complex adaptation make *S. pumilio* an excellent candidate for a model plant in researches of mechanisms of plant adaptation to alpine climate.

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