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RESEARCHES REGARDING THE HISTO-ANATOMY AND FLORAL MORPHOGENESIS IN SOME *OROBANCHE* L. SPECIES

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Abstract: The present paper shows the results of histo-anatomical research studies made on five species of parasitic plants in Romania, species within the *Orobanche* genus: *Orobanche arenaria* Borkh., *O. cernua* Loefl., *O. major* Boissen., *O minor* Sutton and *O. purpurea* Jacq. The authors investigate the structure of vegetative and reproductive organs (haustoria, stem, leaf, flower) of five species, presenting thus a series of common or different traits of the five holoparasitic species. The analysis of the haustorium in holoparasitic plants has allowed the identification of the presence, within the haustorium parenchyma, of woody tissue; there can be observed direct contact between the woody vessels of the haustorium and the ones of the host plant on the sections. These aspects prove the fact that holoparasites extract a large part of the water with mineral nutrients of the host plant, this observation completing the literature data, that states the idea that holoparasites use only the organic solutions from the host plant. The distribution pattern of the vascular tissues, as well as the formation manner of the haustoria and their exogenous origin, prove once more that the haustoria does not represent a root or a metamorphosed stalk, but a specialized organ, perfectly adapted to its absorption function. The *Orobanche* leaves, reduced to scales, have an extremely simple structure; their mesophyll is reduced, and that is strongly correlated with the loss of their photosynthetic capacity. The mechanical tissue is well developed in the *Orobanche* species we have investigated.

Key words: *Orobanche*, anatomy, vegetative and reproductive organs

Bibliographical References

The researches conducted upon the *Orobanche* genus have been various: with monographic character (Vaucher, P., 1823), taxonomical (Beck, G., 1980), morphological (Koch, L., 1887), anatomical (Hovelaque, M., 1888; Privat, G., 1960), embryological (Teriochin, E.S., 1966) as well as physiological (Harborne, J., 1958).

The *Orobanche* genus comprises 22 species in Romania's flora, all being parasites on cultivated or spontaneous plants (Flora R.P.R., vol. VIII).

In Romania, most of the papers deal with the biology and the control against damaging species of the *Orobanche* genus (Grinţescu, I., 1914; Paulian, F., 1973; Racovita, A., 1959; Pârvu, M., 1996), or with only some morphological aspects used in taxonomical purposes (Ungurean, Livia, 1985).

In foreign literature, the interest for studying the ontogenesis of representatives of the *Orobanchaceae* family arose in the middle of the 19-th century, after Schacht (1850) (according to Terehin E., Anisimova G., M., 1978) observed weekly-developed embryos in the mature seeds of some *Orobanche* species. Then, Caspary (1854) (according to Terehin E., Anisimova G., M., 1978) observed some development peculiarities in the plantlet of *Orobanche ramosa* L., parasite on the hemp roots.

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Embryologic researches on orobanchaceae have also been carried by Glišić (1935) and Tiagi (1951, 1952, 1963, 1965) (according to Nikiticeva, E. I., Terëhin, E. S., 1978). Nikiticeva and Terëhin (1978) studied the embryology of *Orobanche pallidiflora* species, that are parasites on *Cirsium oleraceum*, emphasizing at first the germination manner of the seeds. The seeds are stimulated to germinate by the root secretions of the host plants. Consequently, only the seeds that are close to the host plant's roots (approximately 5 mm) will germinate. The germination of the embryo starts with the elongation of the cells from its basal region. As a result of this process the haustoria's primordium is formed, in the shape of a 1-3 mm long tube. The subsequent development of the plantlet depends on the contact established with the root of the host plant. The plantlet tissue grows, at the place of penetration into the root, forming a tuber appearred at the beginning by even parenchymatous cells. Then, at the basis of the tuber, vascular elements are formed, and they make contact with the vascular system of the host plant's roots.The vascular bundles ramify very quickly within the whole tissue of the tuber. When the tuber reaches a certain size (0.7) mm diameter), there starts the formation of initial meristematic areas of the offshoot apex and of secondary haustoria inside it. From the internal part of the meristem, the offshoot apex and the first scales emerge. Unlike autotrophic plants, the organ formation process in the *Orobanche* embryo, that takes place after the plantlet's passing to parasitic feeding, is plastically and energetically ensured by the resources of the host plant.

The particularities of the development of species from this genus are presented also in the work of E. S. Terehin and G. M. Anisimova (1978), who studies the development of *Orobanche cumana*, parasitizing the sun flower. The authors divide the development of *Orobanche* plantlets, until the formation of organs, into 4 stages:

1). The first stage is characterized by the unipolar development and by the plantlet growth, which takes place at the morphologically active basal (root) pole of the reduced embryo. This stage takes place under the influence of the host plant's root secretions.

2). The second stage is characterized by the advancement of the plantlet apex (transformed into haustorium) inside the tissues of the host plant root and by the development of haustoria tissues.

3). In the third stage, a protuberance is formed in the shape of a tuber, at the contact area between parasite and host; this is a specific organ for the accumulation of nutritious substances that subsequently ensure the formation of the other organs of the parasite. The formation of the tuber is the result of the change in cellular division orientation and expansion within the tubulous plantlet in the area close to the invasion spot. In the central region of the tuber, certain elements of the vascular system would differentiate; furthermore, the tuber cells start filling with starch.

4). In the fourth stage, the apex of the fruit-baring offshoot and scales would form (which ensures the passing of the plantlet to bipolar development). The offshoot apex is formed from the middle portion of the meristematic area. In parallel, on the lateral sides of this area, the first protective scales differentiate.

The development of the parasite depends greatly on the type of the host it attaches to.

Some data regarding the development, morphology and taxonomy of *Orobanche* species are also found in the paper of Livia Ungurean (1985).

The seeds of *Orobanche* species are characterized by a long latency period and the germination takes place only in the presence of the host plant or of its root secretions. The plantlet shows a simple structure, comprising a haustorium apex and a stalk apex, between which a short hypocotyl develops (Privat, G., 1960, according to Ungurean, Livia, 1985).

The plantlets affix in the hairy areas of the host plant roots through the papillary cells of the haustorium apex that, by repeated divisions, form the main haustorium. The haustoria tissues surround all the central cylinder of the host plant root. The haustoria presents in the sub terminal part a tuberized area, from which lateral roots emerge exogenously. Subsequently, from these roots, secondary haustoria detach and these resemble metamorphosed roots (Ungureanu, Livia, 1985).

The parasite's shoots develop at the soil surface, around the parasitized plants, solitary or in bundles, straight, vigorous, reaching 40 cm height and 2.5 cm thickness, having greenish or yellow-brownish colour, with violet nuances. At the basis, at the place of fixation on the host plant, it has a bulb-like thickening, from which haustoria emerge. At the upper part of the bulb there is the flower-bearing shoot of the parasite, on which capsules with seeds will form (Paulian, F., 1973, according to Ungurean, Livia, 1985).

If it affixes on an annual plant, *Orobanche* flowers at the end of the first year, whereas if it parasitizes a perennial species, it can survive several years (Boullard, B., 1990).

G. Bonnier and Leclerc du Sablon (1905) demonstrate, once more, the role of haustoria in making contact between the host and parasite tissues, by making a longitudinal section through both host and parasite.

As far as the structure of vegetative organs is concerned, some synthetic data can be found in the work of C. R. Metcalfe and L. Chalk (1972), who identified in roots a primary structure, usually diarch, rarely triarch or tetrarch.

In *Orobanche hederae*, the roots are short, without absorbing hairs, made of large amiliferous cells, which surround the vascular tissues placed centrally. The structure resembles the one of a rhizome, but it has reduced xylem and developed phloem (Tate, 1938, according to Metcalfe, C., R., Chalk, L., 1972). The authors believe this structure does not exclude the possibility of water being absorbed directly from soil (Metcalfe, C., R., Chalk, L., 1972).

Livia Ungureanu and Gabriela Şerbănescu – Jitariu identified a series of roots and haustoria of various orders, to finally admit their structure to be very similar. The authors consider that the main haustorium (as well as the lateral roots and the secondary haustoria these form) has as main role the absorbing of nutritious substances. A section through the secondary haustorium demonstrates the existence of a very similar structure with the one of the lateral roots, with the phloem more developed than the xylem (Ungureanu, Livia; Serbanescu-Jitariu, Gabriela, 1973).

R. Gorenflot (1994) considers that the primary haustorium has a relatively simple structure, being represented by a cellular mass crossed in its axis by vascular elements.

Material and Methods

The species analysed in the present paper are: *Orobanche arenaria* Borkh. (collected in June 2004, from the Hanu Conachi reserve – Galati County); *O. cernua* Loefl.

(collected from the Agigea reserve – Constanta County, in June 2004); *O. major* Boissen. (collected from the floristic reserve of Fantanele-Murfatlar – Constanța County in June 2004); *O. minor* Sutton and *O. purpurea* Jacq. (photo 1) (collected from a spontaneous meadow at Potoci – Neamț County in July 2004).

The material was fixed in 70% ethanol, sectioned (transversally and superficially) with hand microtome and cryotome and it was afterwards stained with ruthenium red and iodine green. The sections thus obtained were mounted in glycero-gelatine, analyzed at Novex optical microscope (Holland) and photographed with a Canon camera.

Results and Discussions

The haustoria

In typical cross section (photo 2, 3), the haustoria has a circular contour and its structure shows:

- An external layer of cells with the external wall much thicker than the others and with adherences that give the section an irregular, often granular aspect (*O. purpurea*).
- A relatively thick area of cortical parenchyma, with cells tangentially elongated, in which there can be observed, from place to place, anticlinal division walls (*O. purpurea*). At *O. minor*, the cortex ends with a primary type endodermis, with visible Caspary thickenings in the radial walls of the component cells. At *O. cernua* an external cortical area is observed, parenchymatous, with isodiametrical cells to be exfoliated and an internal cortical area, relatively thick, with cells tangentially elongated. The *Orobanche major* species shows a relatively thin cortex differentiated into a one-layer exodermis, made of cells with suberified but thin walls, a cortical parenchyma with 5-6 layers of round cells that leave gas-filled spaces among them and with a primary type endodermis.
- A central area with cylinder value that in *O. purpurea* presents several vascular bundles separated by medullary rays parenchymatous-cellulose, with various widths. These bundles, of different size, comprise xylem vessels irregularly scattered, having thick and intensely lignified walls; the vessels are separated by elements much smaller than the ones of the fundamental parenchyma. We have also observed xylem vessels placed out of the vascular bundles, scattered even in the medullar parenchyma; they were solitary or grouped 2 – 3 in one place, all having the same shape, size and sclerification and lignification degree of the walls as the ones within the vascular bundles. Such elements are also found in *O. arenaria*. The *O. minor* species presents a relatively thick central cylinder, comprising an external secondary phloem area and a central xylem body, relatively compact, mostly of secondary origin. Few large medullar rays, cellulose parenchymatous, that penetrate only partially the secondary xylem, cross both tissues. *O. cernua* presents a formation with intermediate structure between root and stalk, which is confirmed also by sections in which the vascular tissues form typical phloem-xylem vascular bundles, their number varying from 3 to more. However, there can always be observed a few vessels, isolated or grouped 2 – 3, in the parenchymatous axis of the haustoria, rarely along the parenchymatous medullary rays. Such a structure reminds of the one of a rhizome rather than the one of a root, considering the heteronymous position of phloem and xylem in the vascular bundles.

The primary structure of the central cylinder in *O. major* is of diarch type and it starts with a parenchymatous pericycle. In the central cylinder there are two phloem-xylem vascular bundles (as in the stem, only atypical) opposite to each other, joined with the pericycle. The phloem is made of sieve elements and companion cells, with slightly colenchymatous walls, and the xylem forms a central mass made of vessles irregularly dispersed, separated by cellulose parenchyma cells; towards the exterior there are xylem fibers with thick walls, weekly lignified.

On some sections made on *O. major* we have observed the manner of formation and ramification of the haustoria: they are made initially of a parenchymatous mass resulted from the unequal proliferation of cortical cells, in which it occurs subsequently and band of xylem vascular bundles, that will make the contact with the vascular tissues of the parasite with the ones of the host.

This strongly modified structure proves that the haustoria is an altogether special organ, having traits of both stem and root.

The contact of the haustoria with the root of the host plant was shown for *O. purpurea* (photo 4, 5, 6).

The root

The root of the host plant, not penetrated by the haustoria, has a typically secondary structure with regular characters, with a relatively thick ring of secondary phloem and a very thick central cylinder xylem body. At the exterior of the central cylinder there can be observed remainings of the primary and secondary cortex, with most of the cells having suberified walls.

The roots into which the haustoria has already penetrated have an asymmetrical structure. At the contact area with the haustoria, the secondary phloem tissue is missing and even part of the xylem body is destroyed, the whole section taking an irregularly lobed shape. After the haustoria has surrounded the root and has completely penetrated it, the root structure is deeply altered, which means a division into lobes and a visible fragmentation of the secondary vascular tissues, by the complete exfoliation of the tissues from the periphery of the cylinder and by the contact of the xylem vessels from the centre of the root with the ones of the haustoria.

The sections made at this level show the same general structure of the haustoria, that comprises a rich cellulose fundamental parenchyma, in which xylem vessels are dispersed, solitary or grouped, in bundles of various thicknesses; the vessels often have a spiral shape, rarely ring shape and are intensely lignified. In the whole however, the xylem vessels form a thick ring around the host root, ring that sends rays that penetrate deep into the root's vascular system.

At the periphery of the haustoria, the same parenchymatous homogenious cortex is present and the same external layer of cells with the external wall visibly thicker than the others is also present.

We emphasize that in this case as well, all the parenchyma cells between the xylem vessels of the haustoria are large and with extremely thin walls, often with a tendency of division in various planes.

At the contact place between the haustorium vessels and the ones of the host root there can be observed a stratification of all the elements that are organized in radiar overlayed layers that are visibly elongated tangentially.

Thus, the root of the host plant, completely enclosed by the haustoria, keeps still little of the phloem tissue, the structure being extensively altered both at the phloem level and at the secondary xylem level.

The stem

In the upper third (photo 7), the contour of the cross section is irregularly circular, with weekly prominent slopes (*O. arenaria, O. major, O. purpurea*) or slightly wavy due to numerous moats, more or less superficial (*O. cernua*).

The epidermis, face viewed, seems made of polygonal-elongated cells, with thin and straight lateral walls. In cross section, the cells are isodiametrical, of various sizes, with the external wall thicker than the others and covered with a thin cuticle (*O. arenaria, O. cernua, O. major*), or with all the walls very thin (*O. minor*). At all the analyzed species, stomata and relatively long, multiple-celled secretory hairs can be observed, from place to place.

The cortex is thick, made of approximately 15 layers of round cells, which leave gas-filled spaces among them; in the cortex there can be observed several of the large vascular bundles, that abandon their typical circular position (*O. cernua*). The cortex does not end with a special type endodermis, just as the central cylinder does not start with a pericycle.

The central cylinder is very thick and it presents a large number (30 – 35 in *O. arenaria, O. minor, O. purpurea* and over 60 in *O. cernua*) of xylem-phloem vascular bundles of various sizes, separated by medullary rays moderately sclerified and intensely lignified. In *O. arenaria*, all the vascular bundles have, at the extremity of the phloem, a very thick cord of sclerenchymatous elements with the walls sclerified and lignified. The wood shows, towards the interior, few primary vessels, separated by cellulose parenchyma cells; towards the interior there is a large number of vessels of secondary origin and libriform elements with thickened and strongly lignified walls. The phloem appears as isles made of sieve elements and companion cells, completely surrounded by lignified tissue: secondary xylem at the internal side, sclerified medullary rays between them and sclerenchyma at the external side. The largest vascular bundles penetrate deep into the pith full of elements with sclerified walls that, in fact, continue the medullary rays made of elements of the same type.

In all the analysed species, the pith is very thick of cellulose-parenchyma, spongy type; the cells from the central area of the pith are disorganizing, resulting in numerous air spaces with irregular shape that can come together, resulting in a unique central air cavity.

In the middle third (photo 8), the general structure of the stem is the same, with the difference that the sclerified tissues have cells with more lignified walls. From place to place, there can be observed leaf scales into which the vascular bundles from the central cylinder penetrate. *O. minor* has, at this level, a continuous ring, intensely lignified, made of xylem bundles, the rays being between them and the area around the pith. Some pith cells from the central area of the stalk disorganize, resulting in a small air cavity, with irregular shape (*O. purpurea*).

In the lower third (photo 9, 10), the structure maintains the same as in the ones analyzed previously, with the following differences:

- the secretory hairs are very rare;
- the cortex is relatively thinner; in *O. cernua*, in its thickness there can be observed 2 – 3 concentric areas with cells radialy flattened and tangentially elongated, that are separated by just as many parenchyma areas made of round cells, that leave gas-filled spaces among them;
- the cords of vascular elements around the phloem are much thinner; in *O. cernua*, there cannot be observed any sclerification and lignification of such cords;
- the phloem in the vascular bundles has much more component elements;
- the wood is completely lignified, except the species *O. minor*, at which in every woody bundle, among vessels, there can also be observed few elements of cellulose woody parenchyma. In *O. purpurea*, the wood of all the bundles (having all elements sclerified and lignified), together with the medullary rays, sclerified and lignified too, form a continuous sinuous ring; the general structure of the stem remains only of primary type (even if the last woody elements remind of libriform fibers found in the secondary xylem of most dicotyledonous);
- the vascular bundles do not penetrate deeply into the pith in *O. arenaria*, and in *O. cernua* there can be observed few large, composed cortical vascular bundles, which have the medullary rays and central parenchyma slightly sclerified and lignified, taking the general aspect of hadrocentric type vascular bundles; in *O. major*, the vascular bundles protrude visibly in the cortex, some of them completely detaching from the central cylinder;
- the pith is perforated by several air cavities with irregular contour (*O. arenaria*, *O. major*) or it disorganizes and is completely reabsorbed, its place being taken by a much larger air cavity (*O. minor*).

The base of the stem (photo 11, 12) is bulb-like thickened, and in its structure several elements can be found:

- a very thick, cellulose parenchyma cortex, with cells tangentially elongated; the external layers have cells with the walls slightly thickened;
- a fundamental parenchyma of the central cylinder, which in *O. cernua* shows numerous vascular bundles irregularly spread and having different positions, so that on cross section some of them appear longitudinally or obliquely sectioned and that is why the wood seems surrounded by phloemic tissue. Often, the phloem disorganizes, a cavity resulting in the middle of which the xylem with vessels and cellulose parenchyma cells persist. *O. minor* exhibits, besides the typical xylem vessels, groups of big, parenchymatous cells, with lignified walls, often forming arches at the internal side of the vessels groups. In this species all the bundles are disposed on a circle, being extensively elongated radially, within them being few xylem vessels, which continue with a radiar band of lignified parenchyma cells. *O. purpurea* is characterized at this level by a very

thick central cylinder, with a sinuous ring of vascular bundles (of various sizes and separated by medullar rays of various widths). All the vascular bundles show the xylem almost completely lignified; only from place to place there remain cells of cellulose woody parenchyma. Unlike the rest of the stalk, at this level all the parenchyma between the bundles remains of cellulose, amiliferous type;

- in the analysed species, all the cortical parenchyma, phloem and pith, has cells rich in starch grains.

On its whole , the structure is extensively altered, resembling the one of the bulbs of several monocotyledonous.

The scales

The subterranean scales (photo 13) (that cover the portion bulb-like thickened of the stalk) have a simple structure in all the analyzed species, with half-moon shape in cross section.

The epidermis cells from the upper side are always larger, with the external wall thicker than the others; on this side of the scales neither stomata nor secretory hairs can be observed.

In the homogeneous parenchyma mesophyll, with isodiametric cells, there is one very small median vascular bundle, with only few xylem and phloem vessels (*O. arenaria*), or 3 bundles (*O. purpurea*), the median one being the largest.

The scales at the base of the aerial stem show an epidermis (front view) made of isodiametric cells, with polygonal contour, with straight lateral walls (*O. arenaria*), or made of polygonal elongated cells (*O. cernua, O. major, O. purpurea*). At the level of the epidermis neither stomata nor any secretory hairs can be observed. At the upper part of the scales most of the cells are polygonal elongated. *O. purpurea* shows on the edge of the scales secretory hairs similar in structure with the ones mentioned at the stalk.

The mesophyll is parenchyma homogeneous (the scales have a bifacial-isofacial structure), with isodiametric cells and with a various number of xylem-phloem vascular bundles: 1, placed medianly in *O. arenaria*, or numerous (15-17), relatively small, that don't stick out over the level of the epidermis; all of them have the phloem made of sieve elements and companion cells, and the xylem made of vessels with irregular positioning, separated by very few woody cellulose parenchyma in *O. purpurea*. The bundles towards the edges of the lamina are very large, reduced only to few xylem and phloem vessels.

The scales on the aerial stem (photo 14) are wider, in the shape of the letter V in cross section, with strongly diverging arms, delimitating in *O. arenaria* a very wide adaxial but superficial ditch.

On both sides of the scales, the epidermis cells, frontally viewed, are polligonal elongated, more on the upper side, with straight lateral walls. The stomatae are missing in *O. arenaria* and are present in the inferior epidermis of *O. cernua*, *O. major* and *O. purpurea*. The secretory hairs are either absent in *O. arenaria*, or are few in the inferior epidermis of *O. major* and have different length and unicellular gland in *O. minor* and *O. purpurea*.

The mesophyll is parenchyma homogeneous, of aeriferous type, except for *O. purpurea* where it is made of 5-7 layers of slightly tangentially elongated cells; thus, the structure of the scales is bifacial isofacial in this species. Into the mesophyll there are several (9 – *O. arenaria*; 15 – *O. major*; 11 – *O. purpurea*) xylem-phloem vascular bundles, the ones in the median area being slightly larger, all of them having however few xylem and phloem vessels. The smallest bundles have only phloem elements.

Brief Flower Morphogenesis Elements in *O. purpurea* (photo 15)

The flowers are protected by glandular bracts, which have numerous secretory hairs, especially on the inferior epidermis.

The sepals are short, grown together at the base, with multiple celled secretory hairs (single series, multiple celled pedicle and multiple celled gland).

The petals are made of the upper epidermis, 2-3 layered mesophyll and inferior epidermis. In both epidermis layers, but especially in the inferior one, secretory hairs can be observed.

The stamens are large, with thick filaments, inserted in the corolla tube. The anther wall is made of epidermis, mechanical layer, transitory layers and tapetum layer; this structure is not constant along the anther and the transitory layers can be missing. The pollen grains are small and numerous. At the analysed material we have observed both the tetrade stage, as well as the mature separated pollen grains.

The ovary is tetra-carpelary, unilocular, with parietal placentation. The ovules, orthotropous type, are numerous but of small dimensions, presenting a single integument, and the nucellus is very reduced (they are thus tenuinucellate ovules).

Conclusions

The analysis of the haustoria structure in the holoparasite plants has allowed us to distinguish the presence in the haustoria parenchyma mass of woody tissue; on the slides made, we have observed the direct contact between the xylem vessels of the haustoria and the ones of the host. These aspects demonstrate that holoparasite plants also extract part of the water with mineral nutrients of the host plant and this finding completes the literature data, that affirms that holoparasites use only the organic solutions from the host plant.

The *Orobanche* species we analysed have a main haustorium, that ramifies giving numerous secondary haustoria, that will invade the root of the host plant. The structure of these haustoria is relatively simple, being represented by a parenchyma mass crossed in the middle by vascular elements. The disposition of the vascular tissues is various; in some cases (*O. arenaria*) it is similar with the one of an aerial stem, or with the one of a rhizome (*O. cernua*). This pattern of the vascular bundles, the haustoria manner of formation, as well as their exogenous origin, demonstrate once more that the haustoria is not a metamorphosed root or stem, but a special organ, perfectly adapted to its absorbtion function.

The leaves of the *Orobanche* species are reduced to scales and they have an extremely simple structure, their mesophyll being thin, homogeneous; this is strongly related with the loss of their photosynthetic function. The mechanical tissue is well developed at all *Orobanche* species.

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Photo 1

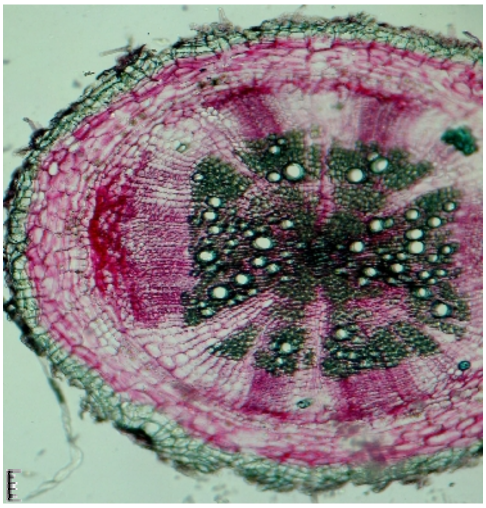


Photo 2

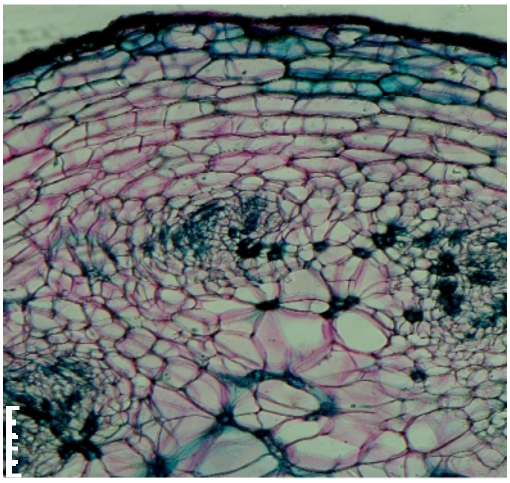


Photo 3

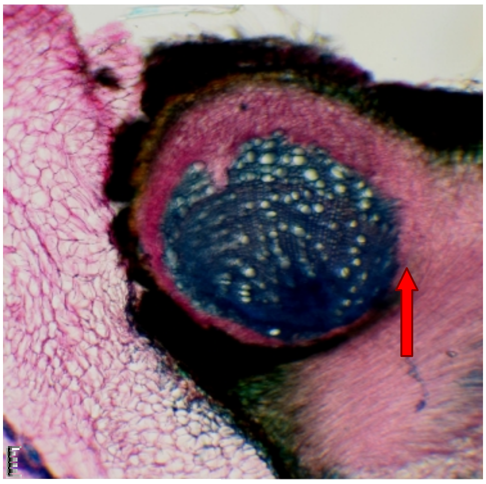


Photo 4

Photo 1 – *Orobanche purpurea*: macroscopic aspect (orig.)
Photo 2 – *Orobanche major*: main haustoria (cross section) (orig.)
Photo 3 - *Orobanche purpurea*: the haustoria(cross section) (orig.)
Photo 4 – *Orobanche purpurea*: the contact of the haustoria with the root of the host plant (cross section) (orig.)

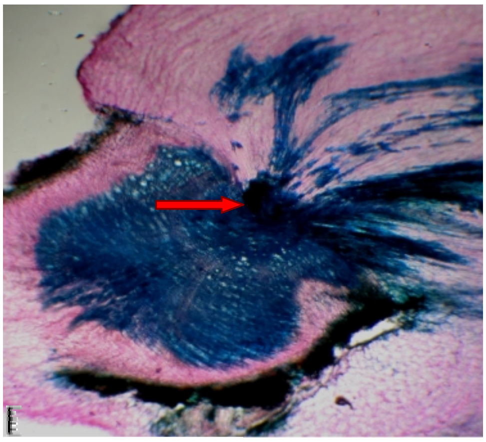


Photo 5

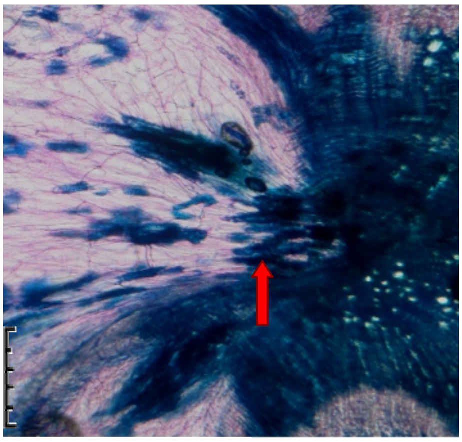


Photo 6

Photo 7

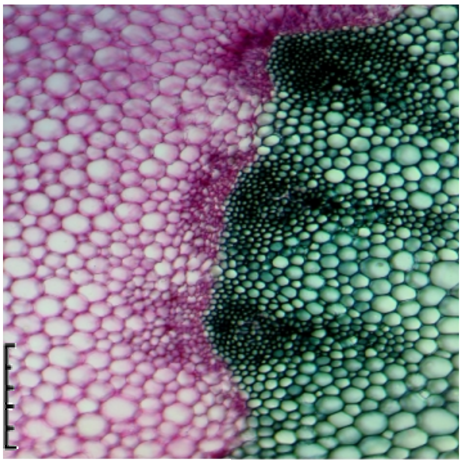
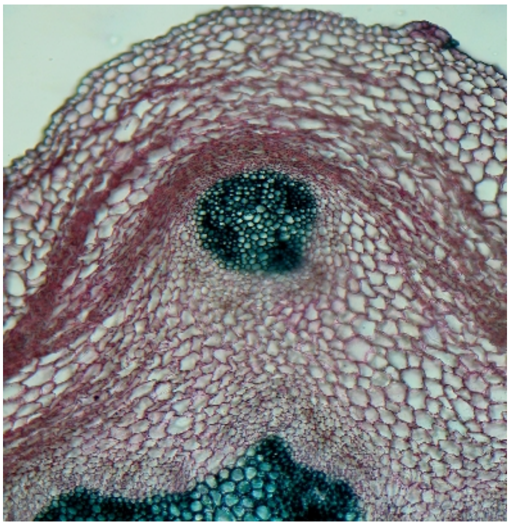


Photo 8

Photo 5 - *Orobanche purpurea*: penetration of the haustoria into the root of the host plant (cross section) (orig.)
Photo 6 - *Orobanche purpurea*: contact of the wood tissue of the haustoria with the wood tissue of the host plant (cross section) (orig.)
Photo 7 – *Orobanche arenaria*: cross section through stem (upper third) (orig.)
Photo 8 - *Orobanche minor*: middle third of the stem (cross section) (orig.)



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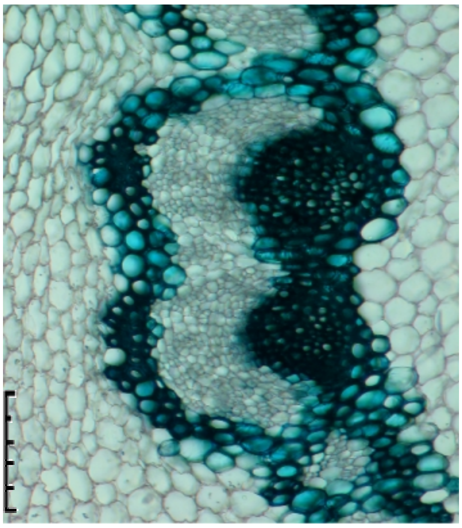

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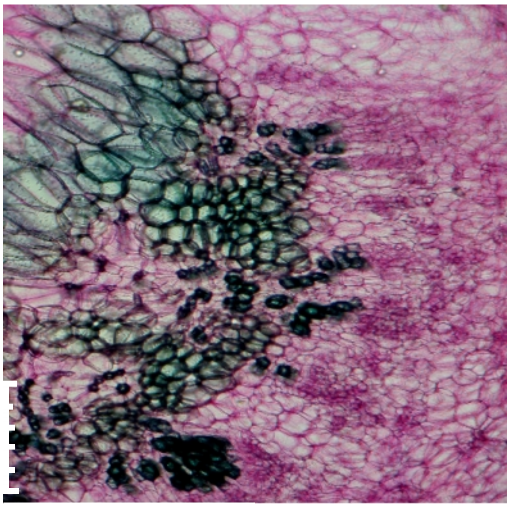


Photo 11

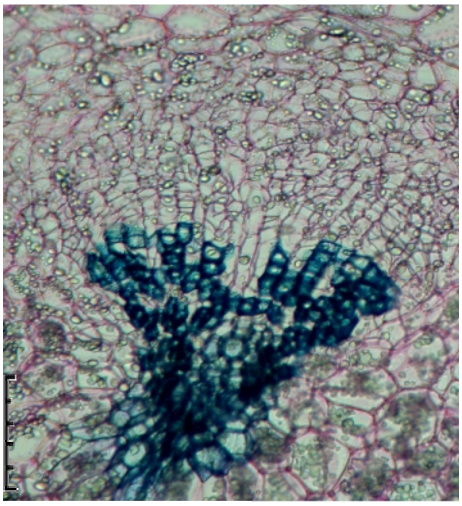


Photo 12

Photo 9 - *Orobanche cernua*: lower third of the stem (cross section) (orig.)
Photo 10 - *Orobanche arenaria*: the stem in the lower third (cross section) (orig.)
Photo 11 - *Orobanche minor*: the bulb – like thickened area of the stem (cross section) (orig.)
Photo 12 - *Orobanche purpurea*: vascular tissues of the bulb – like thickened stem (cross section) (orig.)

Photo 13

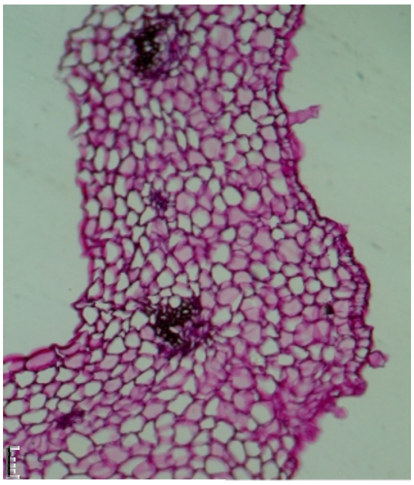


Photo 14

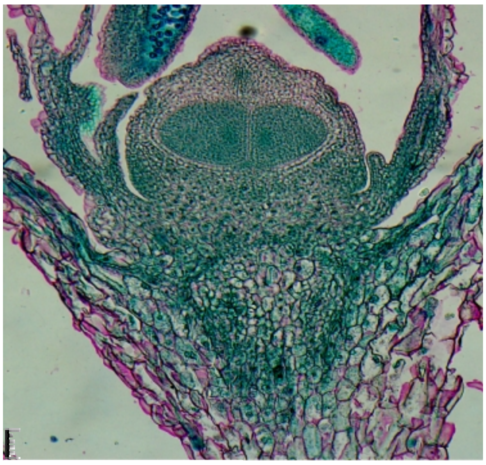


Photo 15

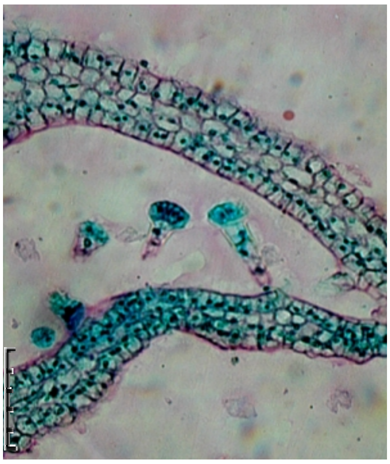


Photo 16

Photo 13 - *Orobanche major*: base scale (cross section) (orig.)
Photo 14 - *Orobanche minor*: aerial stem scale (cross section) (orig.)
Photo 15 – *Orobanche purpurea*: flower (longitudinal section) (orig.)
Photo 16 - *Orobanche purpurea*: flower - petal (longitudinal section) (orig.)

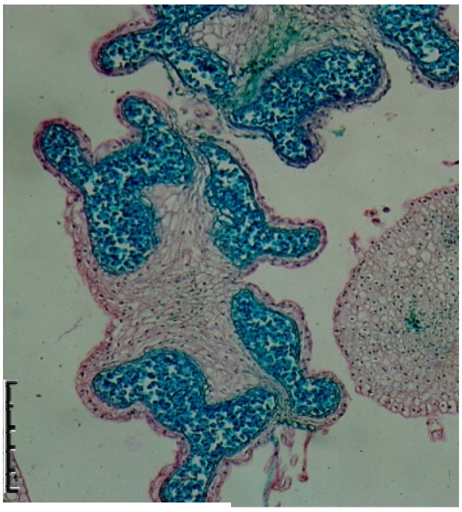
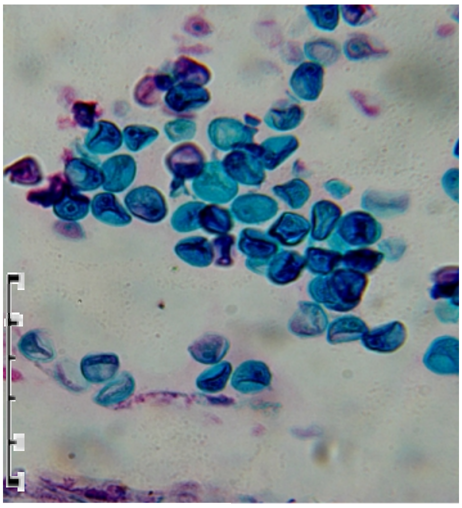


Photo 17



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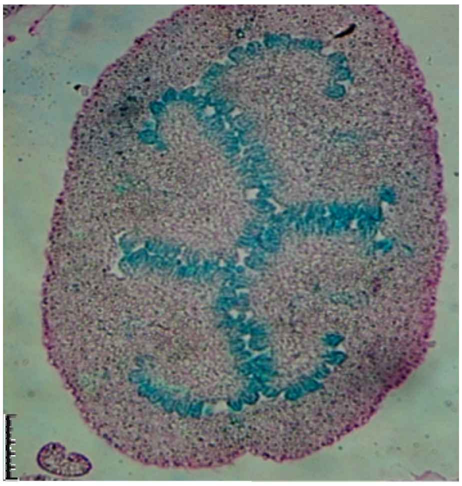

Photo 19

Photo 20

Photo 17 – *Orobanche purpurea*: anther (cross section) (orig.)
Photo 18 - *Orobanche purpurea*: pollen grains (cross section) (orig.)
Photo 19 - *Orobanche purpurea*: ovary (cross section) (orig.)
Photo 20 - *Orobanche purpurea*: flower (longitudinal section) (orig.)