HISTO-ANATOMICAL INVESTIGATIONS ON SOME *CUSCUTA* SPECIES

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The authors investigated the stem and haustoria structure in three *Cuscuta* species parasite on different dicotyledonous species. In all 3 species, the stems have not tector hairs; the vascular bundles are not typical, being collaterally closed, the mechanical tissues are weakly developed or absent. The haustoria penetrate the host plant, especially in the phloem, sometimes arising in the pith. The haustoria xylem contacts the host plant xylem. Rarely, (*C. epithymum*) the haustoria penetrate wholly the thickness of the leaves (of *Inula salicina*).

Key words: Cuscuta, anatomy, stem, haustoria.

INTRODUCTION

The *Cuscuta* genus contains approximately 100 species (Flora României, 1960) of holoparasitic flowering plants with climbing stems, spread all over the world.

Many holoparasitic angiosperms create important damages in crops, orchards and woods. The holoparasitic species are always obligate parasites, having no chlorophyl and with a reduced independent capacity to assimilate carbon. The *Cuscuta* species are dependent on their hosts and their haustorium functions for their attachment, penetration and solute transfer functions (Boullard, 1990; Sallé and Aber, 1986).

Different authors have identified a variable number of *Cuscuta* species in Romania: 18 species (Buia, 1939, 1960), 13 species (Hălălău *et al.*, 1980), 11 species (Ciocârlan, 2000), classified in subgenera *Grammica* (Loyr.) Yunker, *Cuscuta* L. and *Monogyna* (Engelm.) Yunker.

HISTORICAL REFERENCES

The existing literature on the morphology, biology, physiology, embryology and anatomy of holoparasitic flowering plants is quite rich if taking into consideration the studies published since 1986: Sallé and Aber (1986), Buia (1939), Hălălău *et al.* (1980), Boullard (1990), Metcalfe and Chalk (1972). In such publications the authors have analysed especially the biology (Kuijt, 1969), morphology and taxonomy (Smith, 1934), nutrition (Thomson, 1923), morphology and embryology (Tiagi, 1951), morphogenesis (Truscott, 1966), grown and movement (Tronchet, 1961) of *Cuscuta.* Most of the existing literature discusses the structure and development of haustoria.

The stem of parasitic dodders twists around the plant stem and creates a swelling, which will become a prehaustorium (Zender, 1924; Thomson, 1925; Mc Leod, 1961) (cf. Sallé and Aber, 1986). The haustoria cells next to the host vessels become tracheids, which creates continuity between the xylem vessels. Other haustoria cells surround the host phloem vessels (Zender, 1924; Dörr, 1968, 1969; Kollman and Dörr, 1969) (after Sallé and Aber, 1986).

Although the haustoria structure and development has been frequently studied, the stem structure has not been approached in dicotyledonous anatomy studies (Metcalfe and Chalk 1972). As far as we know, *Cuscuta* stem anatomy has never been discussed in Romania until now.

MATERIAL AND METHODS

The present paper analyzes the histo-anatomical aspects of three *Cuscuta* species: *C. epilinum* Weihe, *C. epithymum* (L.) Nath. ssp. *trifolii* (Bab.) Berher var. *prodani* (Buia) Ciocârlan and *C. europaea* L. (Ciocârlan, 2000).

The distribution of these species is very wide; the *Cuscuta* species usually have extremely broad host ranges, and can even be attached to many different hosts at once.The *Cuscuta* species employed for the study have been collected from Potoci (Neamț) in July 2003. The material subject to analysis has been fixed and preserved in 70% alcohol, cross-sectioned with a microtome and colored with ruthenium red and blue methylene. The permanent slides obtained have been photographed on a Novex microscope with a Canon camera.

RESULTS AND DISCUSSION

CUSCUTA EPILINUM WEIHE

The outline of a transverse section through the stem is elliptical and has a few coasts.

The epidermis has a thin cuticle. The cork is thick and made of cellulosic-parenchyma cells arranged in rows; the cells of the middle rows are very flattened (Fig. 1). The central cylinder is elliptical in transverse section and contains two groups of vascular bundles arranged on a circle.

Each vascular bundle contains xylem vessels with lignified and thick walls and peripheric phloem vessels; some bundles contain large aeriferous cavities on the internal face of the xylem. The number of vessels is variable in each bundle (Fig. 2).

Our investigations confirm the results of Metcalfe and Chalk (1972) who consider that "there are minute groups of vessels accompanied by phloem strands,

which are sometimes so closely packed that they almost constitute a closed ring, but in other cases they are rather more widely separated".

No trace of interxylary phloem has been detected in any species. Metcalfe and Chalk (1972) identified secretory cells in the primary cortex, pericycle and pith of the axis, although in the material subject to analysis no secretory cells have been found out.

The haustoria cells migrate through the epidermis and cork and invade the central cylinder of another *Cuscuta* stem; again, as far as we know, this aspect has never been discussed in literature until now. All haustoria cells are intensely radially elongated (Fig. 3).

CUSCUTA EPILINUM (HOST PLANT: *URTICA DIOICA*)

The outline of the transverse section through a host plant stem is approximately square, with coasts.

The haustoria responsible for the infection of the host plant stem migrates through the cork and phloem vessels of the bundles (Fig. 4), which is followed by the contact between the xylem vessels of the haustoria and the host (Fig. 5, 6).

The haustoria terminal cells are intensely elongated and swollen, in contact with the host stem epidermis (Fig. 7). Some of the *Cuscuta* stems send haustoria in other *Cuscuta* stems (Fig. 8).

CUSCUTA EPILINUM (HOST PLANT: *LAMIUM MACULATUM*)

The haustoria enter all over the host stem, even wander through the periphloemic sclerenchyma and angular collenchyma.

The haustoria are formed of radiary elongated cells with thin and still unsuberified walls. These elongated cells destroy the phloem and realise the connection with the xylem of host stem (Figs. 9, 10). The elongated cells of the haustoria have got absorbent hairs.

CUSCUTA EUROPAEA L.

The outline of transverse section through a dodder stem is elliptical. The epidermis has quadratic cells with slighly thick external walls and a very thin cuticle.

The cork contains cellulosic parenchyma cells. The central cylinder is a atypical comparatively with other dicotyledons, containing strands of xylem and phloem that may be in direct contact or not. These types of strands or isolated vessels are spread in the pith of the axis. Rarely, the bundles are of the collateral type (Figs. 12, 13).

CUSCUTA EUROPAEA (HOST PLANT: *INULA SALICINA*)

The outline of transverse section through a host stem is almost circular. The haustoria (nail shaped) migrate through the cork, rarely to the bundles, but often to the parenchyma between the bundles (Fig. 14).

Sometimes the haustoria penetrate the periphloemic fibres and enter the phloem; this haustoria contains xylemic vessels (Fig. 15).

CUSCUTA EUROPAEA (HOST PLANT: *GALIUM VERUM*)

The haustoria contain an adhesion disc fixed on the host stem; the cells in contact with the epidermis are radially elongated and with the external walls with cuticle. The haustoria cells penetrate through the epidermis and the colenchymatised hypoderm and destroy the phloem, making in this way the contact with the xylem. The haustoria contain belts of xylemic vessels (Figs. 16, 17).

CUSCUTA EPITHYMUM L. NATH. SSP. *TRIFOLII* (BAB.) BERHER VAR. *PRODANI* (BUIA) CIOCÂRLAN

Stem epidermis has small quadratic cells with moderately-thickened internal and external walls; the external wall is covered by a thin cuticle (Fig. 18).

The cork contains 4–7 rows; the endodermis and the pericycle are absent (Fig. 19).

The central cylinder contains a meatic-type parenchyma in which the vascular tissues do not form bundles; the xylary vessels are spread in the parenchyma, being sometimes in contact with the phloem vessels (Fig. 20).

CUSCUTA EPITHYMUM VAR. *PRODANI* PARASITING *INULA SALICINA* LEAF

The outline of transverse section through the leaf takes a curly shape and the vascular bundles show different sizes.

The haustoria cells penetrate through the epidermis and invade the mesophyll between the vascular bundles. When contacted with the host epidermis, the haustoria cells set elongated and moderately-suberified. Rarely, the haustoria enter the vascular bundle because of the perifascicular sclerenchyma (Fig. 21, 22).

CUSCUTA EPITHYMUM VAR. *PRODANI* (HOST PLANT: *RHINANTUS RUMELICUS*)

The outline of transverse section through the host plant stem (hemiparasitic plant) is approximately square, with coasts.

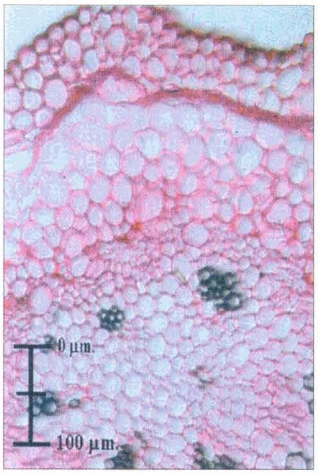


Fig. 1

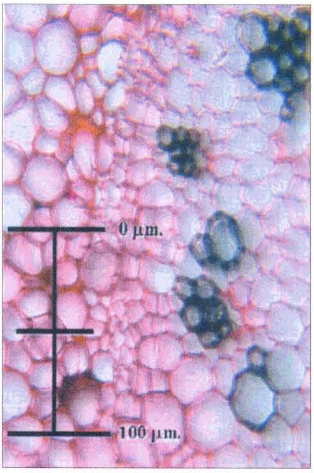


Fig. 2

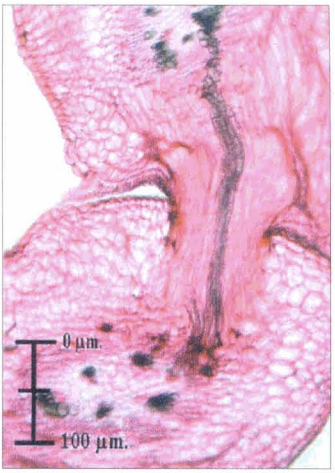


Fig. 3

Fig. 4

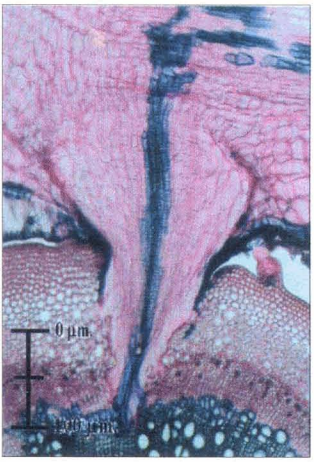


Fig. 5

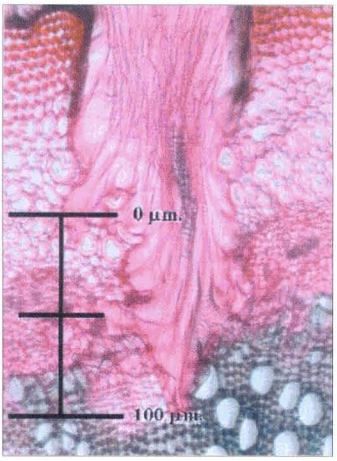


Fig. 6

Fig. 1. *Cuscuta epilinum* – transverse section through the stem.
Fig. 2. *Cuscuta epilinum* – transverse section through the stem.
Fig. 3. *Cuscuta epilinum* – parasiting another *Cuscuta* stem.
Fig. 4. *Cuscuta epilinum* – parasiting on *Urtica* stem.
Fig. 5. *Cuscuta epilinum* – parasiting on *Urtica* stem.
Fig. 6. *Cuscuta epilinum* – parasiting on *Urtica* stem.

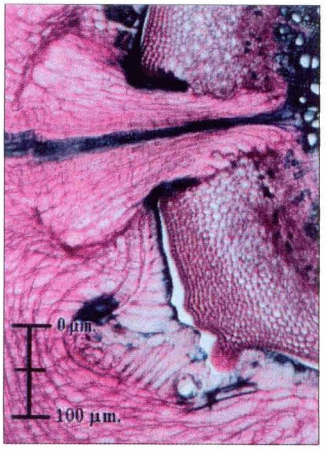


Fig. 7

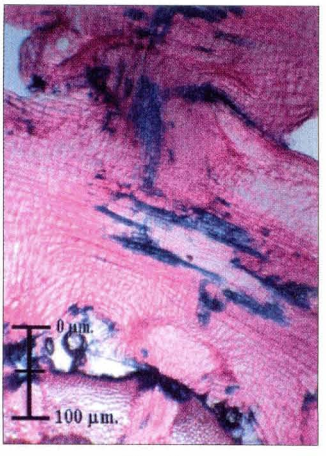
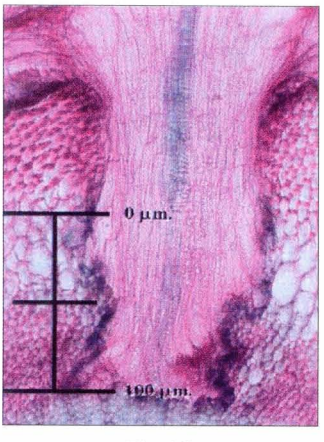


Fig. 8

Fig. 9



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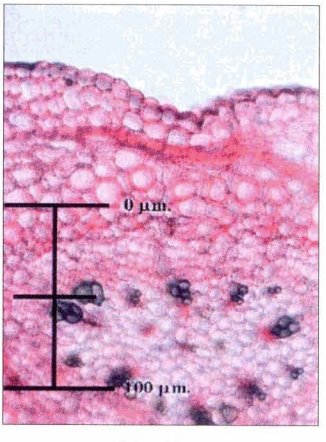


Fig. 11

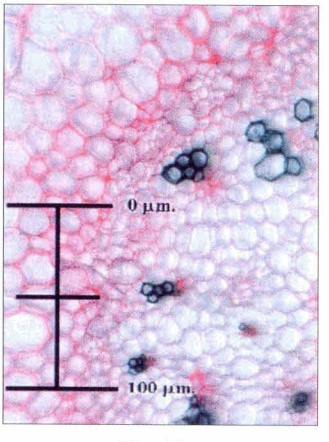


Fig. 12

Fig. 7. *Cuscuta epilinum* – parasiting on *Urtica* stem..
Fig. 8. *Cuscuta epilinum* – parasiting on *Cuscuta* stem which is parasiting on *Urtica* stem.
Fig. 9. *Cuscuta epilinum* – parasiting on *Lamium* stem.
Fig. 10. *Cuscuta epilinum* – parasiting on *Lamium* stem.
Fig. 11. *Cuscuta europaea* – transverse section through the stem.
Fig. 12. *Cuscuta europaea* – transverse section through the stem.

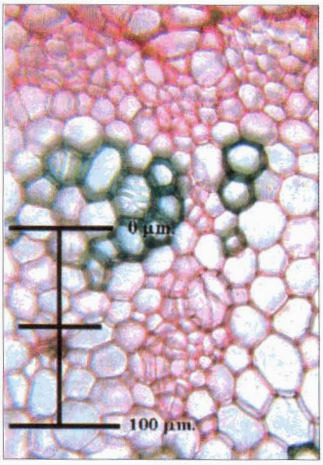


Fig. 13

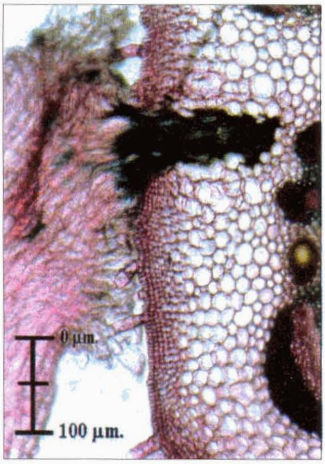


Fig. 14

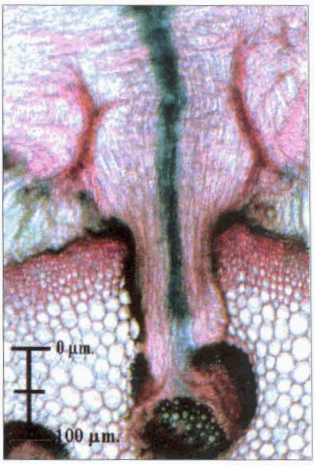


Fig. 15

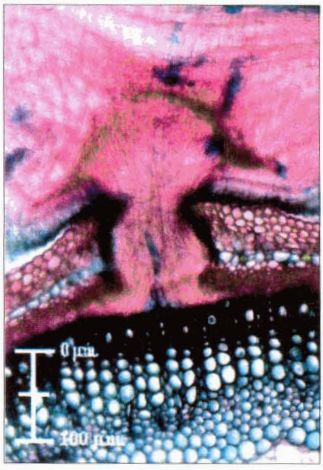


Fig. 16

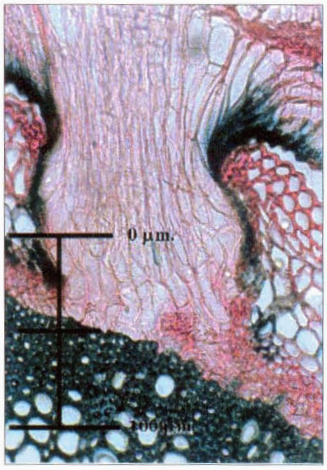


Fig. 17

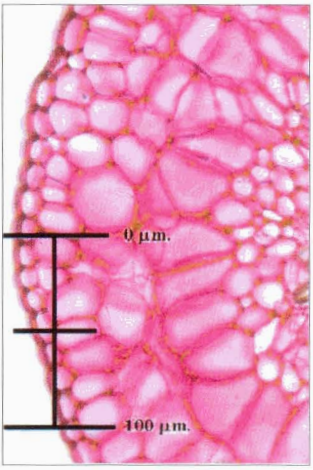


Fig. 18

Fig. 13. *Cuscuta europaea* – transverse section through the stem.
Fig. 14. *Cuscuta europaea* – parasiting on *Inula* stem.
Fig. 15. *Cuscuta europaea* – parasiting on *Inula* stem.
Fig. 16. *Cuscuta europaea* – parasiting on *Galium* stem.
Fig. 17. *Cuscuta europaea* – parasiting on *Galium* stem.
Fig. 18. *Cuscuta prodani* – transverse section through the stem.

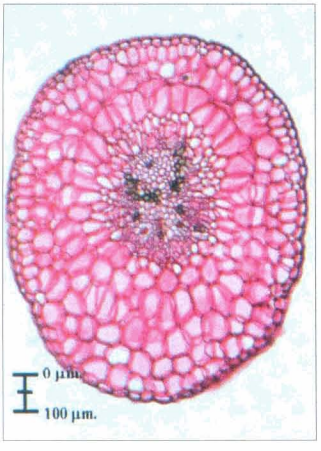


Fig. 19

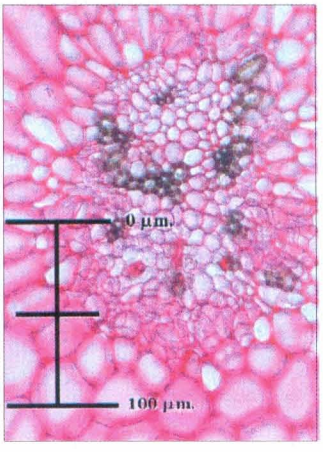
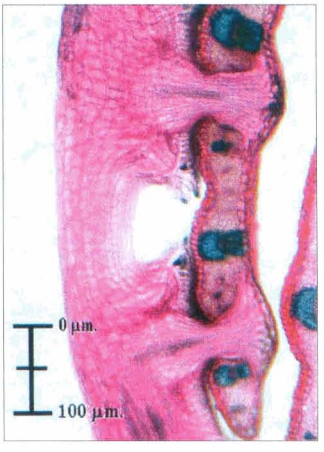


Fig. 20



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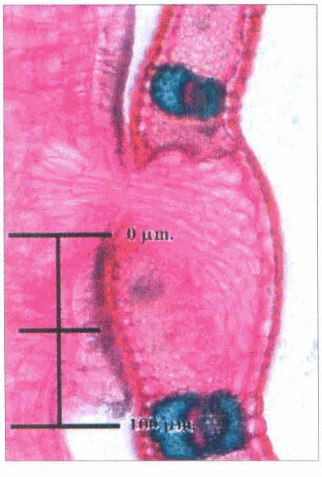

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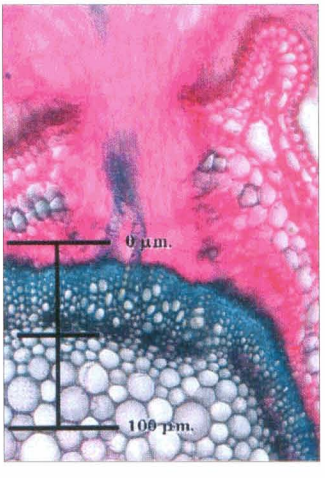

Fig. 23

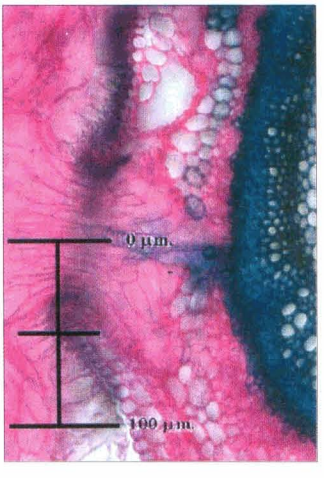

Fig. 24

Fig. 19. *Cuscuta prodani* – transverse section through the stem.
Fig. 20. *Cuscuta prodani* – transverse section through the stem.
Fig. 21. *Cuscuta prodani* – parasiting on *Inula* stem.
Fig. 22. *Cuscuta prodani* – parasiting on *Inula* stem.
Fig. 23. *Cuscuta prodani* – parasiting on *Rhinanthus* stem.
Fig. 24. *Cuscuta prodani* – parasiting on *Rhinanthus* stem.

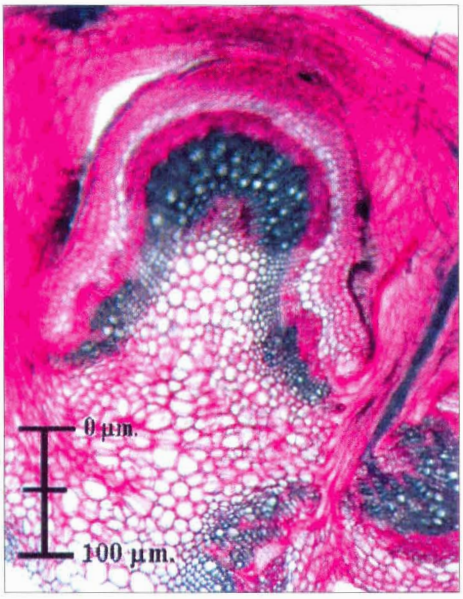

Fig. 25

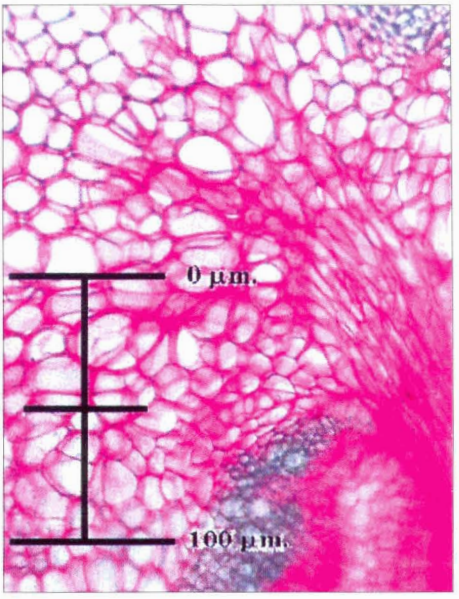

Fig. 26

Fig. 25. *Cuscuta prodani* – parasiting on *Nepeta* stem.
Fig. 26. *Cuscuta prodani* – parasiting on *Nepeta* stem.

The haustoria cells penetrate through the epidermis, cork-parenchyma, endodermis and the phloem ring; then the contact between the xylem vessels of the haustoria and the host occurs (Fig. 23). The haustoria cells are radially elongated, with thin and cellulosic walls (Fig. 24).

CUSCUTA EPITHYMUM VAR. *PRODANI*
(HOST PLANT: *NEPETA NUDA*)

The parasitic stem surrounds almost half of the host plant stem, the haustoria enter between the coasts and penetrates through the epidermis, cork and cambium ring to the medullar parenchyma.

All haustoria cells are elongated, with thin walls. Some of the haustoria cells have a branched aspect at the contact with the host medullar cells (Fig. 25, 26).

CONCLUSIONS

The stem of the three investigated *Cuscuta* species shows the following characteristics:

- epidermis with a thin cuticle and without any type of hairs;
- cork with cellulosic parenchyma (chlorophyll absent);
- irregular vascular bundles dispersed in the parenchyma;
- mechanical tissues undeveloped or absent.

The haustoria cells are perpendicularly elongated, and with swollen extremities. The haustoria contain cellulosic parenchyma and belts of xylem vessels which assure the contact with the host xylem.

The haustoria enter different levels, sometimes the medullar paranchyma or leaf mesophyll (*eg. Cuscuta epithymum* var. *prodani* parasiting *Inula salicina* leaf).

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