HAUSTORIAL PARASITISM IN THE ALBANIAN FLORA

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Përmbledhja

Pak është shkruar mbi florën parazitare të Shqipërisë, pavarësisht rëndësisë dhe problemeve që shkaktojnë për bimën "bujtëse". Ky artikull përfaqëson një nga studimet e para të publikuara mbi florën parazitare të Shqipërisë, duke sjell një përmbledhje të plotë të diversitetit të këtij grupi bimësh. Në të njëjtën kohë, ky studim ka bërë një rishikim kritik të volumeve të publikuara "Flora e Shqipërisë" (vol. I-IV), me qëllim identifikimin e ndryshimeve dhe përditësimet që duhen bërë, bazuar në gjetjet e fundit. Të dhënat për këtë studim janë grumbulluar gjatë vizitave në Herbarin Kombëtar, në Qendrën Kërkimore të Florës dhe Faunës dhe nëpërmjet kontrollit të literaturës dhe databazave përkatëse, si: *Flora Europaea*, *MedChecklist*, *Euro+Med Plantbase*. Rezultatet tregojnë për praninë e një diversiteti të madh të florës parazitare, përfshirë specie gjysmë parazite dhe parazite të plota (me një numër në total prej 38 speciesh dhe 8 subspeciesh), pjesë e 4 rendeve dhe 5 familjeve. Rezultatet nga rishikimi i literaturës ekzistuese ("Flora e Shqipërisë") tregojnë për ndryshime brenda familjes Orobanchaceae, si praninë e një gjinie të re – Lathraea, përpos gjinisë Orobanche. Specia *Orobanche crenata*, gjetur vitet e fundit, përfaqëson një specie të re për Shqipërinë. Gjinia Orobanche përfaqësohet nga 23 specie, krahasuar me 11 specie që përshkruhen në Florën e Shqipërisë. Gjithashtu, 2 speciet parazite të plota të rrënjëve, dikur pjesë e rendit Aristolochiales dhe familjes Rafflesiaceae (*Cytinus hypocistis* dhe *Cytinus ruber*), tashmë klasifikohen në rendin Malvales dhe në familjen Cytinaceae.

Fjalëkyçe*:* Parazitmi haustorial, specie të reja, Shqipëri.

Abstract

Little has been written for the parasitic flora of Albania, despite its importance and implications for the "host" plants. This paper represents one of the first published studies on the parasitic flora of Albania, making a complete summary of the diversity of this group of plants for the country. In the meantime, it has realized a critical review of the published volumes of "Flora of Albania" (vol. I-IV), in order to point out the revisions that should be made, based on the last findings. The data have been gathered through visits in the National Herbarium, at the Albanian Research Center of Flora and Fauna and through reviewing relevant literature and databases (such as *Flora Europaea*, *MedChecklist*, *Euro+Med Plantbase*). Results show an interesting diversity of holo-parasitic and semi-parasitic flora of Albania (in total 38 species and 8 subspecies), from 4 different orders and 5 families. Results on the review of the published volumes of "Flora of Albania" show the presence of a new genus – Lathraea, despite the Orobanche

genus, for the Orobanchaceae family. *Orobanche crenata* found in the last years represents a new species for Albania. Orobanche genus has 23 species now, compared to 11 species described in the books "Flora of Albania". Also, two root holo-parasitic species of Aristolochiales order and Rafflesiaceae family (*Cytinus hypocistis* and *Cytinus ruber*) are now classified in the Malvales order and Cytinaceae family.

Keywords: Haustorial parasitism, new species, Albania.

Introduction

A parasitic plant is a plant that derives some or all the nutritional requirements from another plant (which is called the "host plant"), giving no contribute and several time causes extreme damages to the host plant (Henning, 2008). The most determined feature of a parasitic plant are the "haustoria" - modified roots, which penetrate the "host" plant, connecting them to the conductive system – either the xylem, the phloem, or both. This provides them with the ability to extract water and nutrients from the "host". All the parasitic plants are part of Angiosperms group of Spermatophyte plants. Haustorial parasitism has been evolved only in flower plants (dicotyledonous) (Nickrent & Musselman 2004). In the flora of Albania are found different types of parasitism: (i) obligate parasite - a parasite that cannot complete its life cycle without a "host"; (ii) facultative parasite - a parasite that can complete its life cycle independent of a "host"; (iii) stem parasite - a parasite that attaches to the "host" stem; (iv) root parasite - a parasite that attaches to the "host" root; (v) semi-parasite - a plant that is parasitic under natural conditions and is also photosynthetic to some degree. Semi-parasitic plants may just obtain water and mineral nutrients from the host plant. Many obtain at least part of their organic nutrients from the host as well; (vi) holo-parasite - a parasitic plant that derives all of its fixed carbon from the "host" plant (Henning, 2008). Commonly lacking chlorophyll, holo-parasites are often colors other than green. Most of parasitic plants are only considered as curiosity of botany, but some species can cause a real damage to agricultural yield, because can be weed, such as species of *Orobanchaceae* family (Westwood *et al*., 2010). Almost in all cases is very difficult to control the weed growth, that due to the structure and position of the parasite (that can be found underground or inside the "host" plant's body).

Materials and methods

Most of the data about the holo-parasitic and semi-parasitic taxa of Albanian flora is gathered through visiting the National Herbarium of Albania at the Research Center of Flora and Fauna, where a total number of 450 samples have been consulted. Additionally, the rest of the information has been extracted from literature such as the four volumes of "Flora of Albania" (Paparisto *et al*., 1988, Qosja *et al*., 1992, Qosja *et al.*, 1996, Vangjeli *et al*., 2000); the five volumes of

the "Flora Europaea" (Tutin *et al*., 1964-1980); the MedChecklist (Greuter *et al*., 1984-1989) and the Euro + Med Plantbase

(http://ww2.bgbm.org/euroPlusMed/query.asp). Furthermore, also unpublished data from few Albanian researchers have been included. As a reference for the names of the species, MedChecklist and Euro + Med Plantbase have been selected. The conservation status at national, European and global level has been defined based on the Albanian Red List of Vascular Plants, (Decision of Ministries Council, 2013), Annex II, IV of Habitats Directive (Council Directive 92/43/ EEC) and the IUCN Red List of Endangered Species (IUCN 2016) respectively.

Results

A list of semi and holo-parasitic plants, or haustorial parasitism (Table 2) has been prepared by the analysis of the entire Albanian vascular flora. A total number of 38 species and 8 subspecies, belonging to 4 different orders, 5 families and 7 genera are present in Albania. Orobanchaceae is the most common and dominant family with 24 species, followed by Convolvulaceae family with 8 species, Santalaceae family with 3 species and Cytinaceae family with 2 species. The last family represented only by one species is Loranthaceae.

1. **Lamiales Order:**

Orobanchaceae family: Annual plants, with no chlorophyll, parasite of Spermatophyte roots, mostly in dicotyledonous herbaceous plants. This family has the biggest number of parasitic plants: 90 genera and around 1800 species (APG 2009). In the past, the semi-parasitic individuals were divided from the holo-parasitic ones, and were part of Scrophulariaceae family, while the holo-parasitic individuals part of Orobanchaceae family. Recent molecular and phyllo-genetic studies involve the both divisions as part of Orobanchaceae family and thus show that this family is monophyletic (Nickrent & Musselman, 2004). Orobanche genus includes around 150 species of obligate and holo-parasitic of plants roots in Europe and America. The highest diversity of this genus is recorded in Mediterranean region and Western Asia (Nickrent & Musselman, 2004). In the 3rd volume of the books "Flora of Albania" (Qosja *et al*., 1996), Orobanchaceae family includes 1 genus, 11 species and 3 subspecies, a total of 14 taxa. But, since the last publishing of these books (year 2000) till nowadays, a lot of changes have been recorded by both, Albanians and foreigners. Actually, this family is represented by 2 genera: *Orobanche* and *Lathraea*. Lathraea genus is represented by *Lathraea squamaria* - a new species for Albania (Rakaj 2006). Also changes are recorded within the Orobanche genus.

Table 1: Composition of Orobanchaceae family and their status for Albanian Flora

Family	**Genera**	**Species**	**Status for Albanian Flora**
Orobanchaceae	Orobanche	*Orobanche nana* (Reut.) Beck	New for the Albanian Flora
		Orobanche ramosa L.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche alba Stephan ex Willd	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche reticulata Wallr.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche pancicii G. Beck.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche amethystea Thuill.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche loricata Rchb.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche minor Sm.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche caryophyllacea Sm.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche lutea Baumg.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche elatior Sutton	Present in the 3rd volume of the books "Flora of

			Albania"
		Orobanche gracilis Sm.	Present in the 3rd volume of the books "Flora of Albania"
		Orobanche crenata Forssk.	New for the Albanian Flora
		Orobanche nowackiana Markgr.	New for the Albanian Flora
		Orobanche krylovii Beck	New for the Albanian Flora
		Orobanche lavandulacea Rchb.	New for the Albanian Flora
		Orobanche hederae Duby	New for the Albanian Flora
		Orobanche pubescens d'Urv.	New for the Albanian Flora
		Orobanche purpurea Jacq.	New for the Albanian Flora
		Orobanche teucrii Holandre	New for the Albanian Flora
		Orobanche oxyloba (Reut.) Beck	New for the Albanian Flora
		Orobanche rapum-genistae Thuill.	New for the Albanian Flora
		Orobanche artemisae-campestris Vaucher ex Gaudin	New for the Albanian Flora
	Lathraea	*Lathraea squamaria* L.	New for the Albanian Flora

Figure. 1: a) *Orobanche nowackiana* Markgr. nearby Dushku lake, Gramsh, Albania, b) *Orobanche crenata* Forssk. nearby Soda Forest, Vlorë, Albania (*Photo: A.Mullaj*)

Figure 2: *Lathraea squamaria* L., Qytezë, Devoll, Albania (*Photo: A.Mullaj*)

2. Santanales order:

Loranthaceae family: Shrubs containing chlorophyll, semi-parasitic plants of trees. This family is represented by 75 genera and 1000 species of trees parasite, most of them semi-parasite (Barlow 2018). In 1st volume of the books "Flora of Albania" (Paparisto *et al*., 1988) this family is represented by three genera: Loranthus, Viscum and Arceuthobium. Recent genetic studies of Angiosperm phyllo-genesis (APG 2009) has shown that actually this family includes only Loranthus genus, while Viscum and Arceuthobium genus belongs to Santalaceae

family. Loranthus genus is represented only by one species in the flora of Albania – *Loranthus europaeus* Jacq. Referring to Hegi (1981) this species is a parasite of oaks, such as; *Quercus pubescens*, *Quercus cerris*, *Quercus robur*, *Quercus petraea* and of chestnuts (*Castanea sativa*).

Santalaceae family:

A) Viscum genus: Part of this genus are classified 70-100 species, distributed worldwide, native in temperate and tropical climate areas of Europe, Africa, Asia and Australia (Nickrent, 1997). In Albania this genus is represented only by one species: *Viscum album* L., which is a semi-parasitic shrub of trees stem. Recent studies have shown the presence of some subspecies (Bean, 1980; Blamey & Grey-Wilson, 1989) such as; subsp. *album*, subsp. *abietis*, subsp. *austriacum. Viscum album* is widely used in modern and alternative medicine.

B) Arceuthobium genus: This is a genus, whose plants are parasite of Pinaceae and Cupressaceae family, in North America, Central America, Europe and Africa (Nickrent, 1997). Recently, based to genetic studies, the number of species within the genus is reduced to 26. In Albania this genus is represented by 2 species: *Arceuthobium oxycedri* (DC.) M.Bieb. and *Arceuthobium minutissimum* (new for Albanian flora - unpublished information).

3. Malvales order:

Cytinaceae family: this family includes 2 genera: *Bdallophytum* Eichler. and *Cytinus* L., distributed in Europe (Mediterranean), Lesser Asia, Southern Africa, Madagascar and Central America (Nickrent, 1997). In 1894, Solms-Laubach classified these genera in Rafflesiaceae family. But, recent molecular studies prove that these genera belong to Malvales order and Cytinaceae family (Nickrent *et al*., 2004). Plants species of Cytinus genus are parasites of Cistus and Halimium genus (both part of Cistaceae family). In 1st volume of the books "Flora of Albania" (Paparisto *et al*., 1988) this family is represented only by one genus (Cytinus) and 2 species *Cytinus hyposcistis* and *Cytinus ruber*, and belongs to Rafflesiaceae family (Aristolochiales order). But, as mentioned above, recent studies (Nicrent *et al*., 2004) put it in Malvales order and Cytinaceae family (accepted also by MedChecklist data and Euro+Med Plantbase) (*Angiosperm Phylogeny Group, 2009*).

4. Solanales order:

Convolvulaceae family - Cuscuta genus: Parasitic herbaceous plant, usually annual. In this genus are included 200 species and are worldwide distributed, but most of them (~ 150 *spp*, 75%) are recorded in America (Yuncker, 1932; Hunziker, 1950; Mabberley, 1997; Stefanović *et al*., 2007). Species of this genus are parasite of a diversity host plants (especially agriculture ones), such as; potatoes, alfalfa, clover, etc. In the past, this genus belonged to Cuscutaceae

family, but nowadays it belongs to Convolvulaceae family (Stefanovic ' S, 2004). In the 3rd volume of the books "Flora of Albania" (Qosja *et al*., 1996) are included 7 species and 3 subspecies, as below:

1. *Cuscuta australis* R. Br.

subsp. *tinei* (Insenga) Feinbrun

2. *Cuscuta campestris* Juncher

3. *Cuscuta europaea* L.

4. *Cuscuta epithymum* (L.) L.

subsp. *epithymum*

subsp. *kotschyi* (Desmoulins) Archangeli

5. *Cuscuta brevistyla* A.Braun

6. *Cuscuta planiflora* Ten.

7. *Cuscuta approximata* Bab.

According to recent publications (Barina *et al.,* 2017, Pils 2016) another species of Cuscuta is present in Albania – *Cuscuta monogyna* Vahl., found mostly on serpentine substrate.

Conclusions and discussions

After a critical review of parasitic plants in the flora of Albania and based to recent studies of holo-parasitic and semi-parasitic plants, the results show that in Albania are present 38 species and 8 subspecies of haustorial parasitism (Table 2). From the taxonomy point of view, haustorial parasitic plants of the Albanian Flora are classified in 4 different orders, such as: Lamiales, Santanales, Malvales and Solananles and 5 families: Orobanchaceae, Loranthaceae, Santalaceae, Cytinaceae and Convolvulaceae. The critical revision of Orobanchaceae family shows the presence of a new genus – Lathraea, except the Orobanche genus. *Lathraea squamaria* is a new species for the flora of Albania. Changes have been noticed also within Orobanche genus. This study reveals that this genus is represented in Albania by 23 species, **12** of them are new for the flora of Albania. *Orobanche nana* has passed from the status of subspecies to the status of species. The three genus: Loranthus, Viscum and Arceuthobium – stem and semi-parasite plants, in the present volumes of the books "Flora of Albania" are classified in the Loranthaceae family, but actually, referred to recent studies, these genus belongs to 2 different families: Loranthaceae and Santalaceae. For Viscum genus can be accepted also 3 subspecies for the flora of Albania; subsp.*album*, subsp.*abietis* and subs.*austriacum*. *Cytinus hypocistis* and *Cytinus ruber* - root and holo-parasite plants are put in a new family: Cytinaceae family

and Malvales order, while in the present books ("Flora of Albania") they are classified in the Rafflesiaceae family and Aristolochiales order. Cuscuta genus, recorded as the only genus of Cuscutaceae family, is now accepted that belongs to Convolvulaceae family. Most of the species from this group are invasive aliens, coming mainly from Australia and America. *Orobanche teucrii* (Pils, 2016) and *Arceuthobium minutissimum* are two species that need more confirmation because are seen just once in Albania. Parasitic plants can have both impacts: negative and positive. Some of them cause real damages to agriculture yield (Orobanchaceae family and Cuscuta genus), but others, such as: *Viscum album,* can be used in modern and alternative medicine (Westwood *et al*. 2010).

Table 2: Holo-parasitic and semi-parasitic flora of Albania (haustorial parasitism)

Order	**Family**	**Genera**	**Species**	**Subspecies**	**Type of parasitism**	**"Host" Plant**
Lamiales	Orobanchaceae	Orobanche	*Orobanche nana*		Root-parasite, holo-parasite	Genera: Trifolium, Vicia, Lotus
			Orobanche ramosa	subsp.*ramosa*	Root-parasite, holo-parasite	*Cannabis sativa* *Nicotiana tabacum* *Solanum lycopersicum* *Solanum tuberosum* *Humulus lupulus* *Daucus carota* *Xanthium strumarium* *Lamium maculatum* *Geranium pusillum* *Melilotus officinalis*
			Orobanche alba		Root-parasite, holo-parasite	Lamiaceae family (Thymus, Satureia, Origanum, Salvia, Mellisa, Teucrium)
			Orobanche reticulata		Root-parasite, holo-parasite	Genera: Carduus, Cirsium, Centaurea (all of the family Asteraceae), and Knautia (family Dipsacaceae)
			Orobanche pancicii		Root-parasite, holo-parasite	Genera: Ligustrum, Scabiosa
			Orobanche amethystea	subsp.*amethystea*	Root-parasite, holo-parasite	*Eryngium campestre* and some species of the genus Evonymus
			Orobanche loricata		Root-parasite, holo-parasite	*Artemisia campestris* and some species of the genus Achillea (family Asteraceae)

			Orobanche minor		Root-parasite, holo-parasite	Fabaceae family Asteraceafamily Apiaceae family
			Orobanche caryophyllacea		Root-parasite, holo-parasite	Genera: Galium, Asperula, all of the Rubiaceae family
			Orobanche lutea		Root-parasite, holo-parasite	Fabaceae family (Genera: Medicago, Trifolium, Melilotus, Lotus)
			Orobanche elatior		Root-parasite, holo-parasite	*Cirsium spp*., *Cardus spp*., and *Thalictrum minus*
			Orobanche gracilis		Root-parasite, holo-parasite	Genera: Cytisus, Doricnium, Genista, Lotus, Lathyrus, Melilotus, Onobrychis, Trifolium, Ononis and Coronilla
			Orobanche crenata		Root-parasite, holo-parasite	*Vicia faba* *Pisum sativum*
			Orobanche nowackiana		Root-parasite, holo-parasite	*Alyssum* spp.
			Orabanche krylovii		Root-parasite, holo-parasite	*Thalictrum minus*
			Orobanche lavandulacea		Root-parasite, holo-parasite	*Psoralea bituminosa*
			Orobanche hederae		Root-parasite, holo-parasite	*Hedera helix*
			Orobanche pubescens		Root-parasite, holo-parasite	Apiaceae taxa
			Orobanche		Root-parasite,	Asteraceae taxa

			purpurea		holo-parasite	
			Orobanche teucrii		Root-parasite, holo-parasite	Genera: Teucrium, Thymus and Satureia
			Orobanche oxyloba		Root-parasite, holo-parasite	Asteraceae taxa
			Orobanche rapum-genistae		Root-parasite, holo-parasite	Genera: Genista and Cytisus
			Orobanche artemisae-campestris		Root-parasite, holo-parasite	*Artemisia spp*., Asteraceae and Apiaceae taxa
		Lathraea	*Lathraea squamaria*		Root-parasite, holo-parasite	Alnus genus (rarely)
Santalales	Loranthaceae	*Loranthus*	*Loranthus europaeus*		Stem-parasite, semi-parasite	Chestnut trees
	Santalaceae	*Viscum*	*Viscum album*	subsp. *album*	Stem-parasite, semi-parasite	Dicotyledonous trees
				subsp. *abietis*	Stem-parasite, semi-parasite	*Abies sp*., *Pinus halepensis*
				subsp. *austriacum*	Stem-parasite, semi-parasite	*Pinus nigra*
		Arceuthobium	*Arceuthobium oxycedri*		Stem-parasite, semi-parasite	*Juniperus oxycedrus*
			Arceuthobium		Stem-parasite,	*Pinus brutia*

			minutissimum		semi-parasite	
Malvales	Cytinaceae	*Cytinus*	*Cytinus hypocisitis*		Root-parasite, holo-parasite	Cistaceae family *(Cistus sp*., *Halimium sp*.)
			Cytinus ruber		Root-parasite, holo-parasite	Cistaceae family (*Cistus sp*., *Halimium sp*.)
Solanales	Convolvulaceae	Cuscuta	*Cuscuta australis*	*subsp. tinei*	Stem-parasite, holo-parasite	Genera*:* Polygonum, Beta, Ocimum,etc.
			Cuscuta campestris		Stem-parasite, holo-parasite	Genera: Trifolim, Medicago, etc.
			Cuscuta europaea		Stem-parasite, holo-parasite	*Urtica dioica, Humulus lupulus*
			Cuscuta epithymum	subsp. *epithymum*	Stem-parasite, holo-parasite	Various herbaceous plants and shrubs
				subsp. *kotschyi*	Stem-parasite, holo-parasite	Various herbaceous plants and shrubs
			Cuscuta brevistyla		Stem-parasite, holo-parasite	Mainly herbaceous plant
			Cuscuta planiflora		Stem-parasite, holo-parasite	Shrubs and annual herbaceous plants
			Cuscuta approximata		Stem-parasite, holo-parasite	Shrubs
			Cuscuta monogyna		Stem-parasite, holo-parasite	*Cotinus coggygria*

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