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A Bird's Eye View of Parasitic Angiosperms in Rajasthan, India

Khushboo Sharma and Aparna Pareek

Department of Botany, University of Rajasthan, Jaipur, Rajasthan, 302004

Abstract:

Parasitic plants may be harmful or beneficial. They are mainly viewed as pests because many plant species of angiospermic parasites cause serious damage to agriculture and forestry. Some parasitic plants exert positive effects on natural ecosystems and human society. Parasitic flowering plants intensify nutrient cycling and provide assets for other organisms thus contributing to facilitation cascades in ecosystems. Many parasitic plants have medicinal importance against a broad range of diseases. These plants are generally used in both folk and modern medicines. They have been cultivated for their products and aesthetic values. Harmful effects of parasitic angiosperms on individual hosts suppress community dominants that include invasive species, reducing competitive pressure that may increase biodiversity. An effort has been made to review the parasitic angiosperms of India in general and Rajasthan in particular.

Introduction:

Generally plants are photoautotrophic organisms, which need only fundamental abiotic resources for their essential vital processes but there is an exception to this i.e the parasitic plants, which acquire resources by parasitizing other plants via a specialized organ known as the haustorium. Haustoria are developed as root or stem modifications which secure unidirectional connections between the vascular systems of the host and parasite, enabling resource flow and freeing parasitic plants from many constraints to growth parameters. In parasitism, parasites are always benefited while it exerts moderate to strong negative effects on host growth and/or reproductive output.

Forms of plant parasites:

Obligate parasites are parasites that cannot complete their life cycle without the help of host, while facultative parasites can complete their life cycle independent of their host. Parasitic angiosperms are also sub divided as either root or stem parasites. Parasites can be further subdivided as holoparasites or hemiparasites with respect to the presence or absence of functional chloroplasts. Some holoparasites are – Broomrape (*Orobanche*), Dodder (*Cuscuta*), *Rafflesia*, *Hydnora* etc. Holoparasites are the type of obligate parasites, while Hemiparasites may be facultative or obligate, they can contain chlorophyll e.g *Striga* species and mistletoes.

Review of Literature:

International status

According to Kujit et.al, 1969; Yoshida et.al 2016 and Bouwmeester et.al 2003, a parasitic angiosperm is a plant that directly attaches to another plant through a haustorium. A specific structure is formed between the parasite and host that forms a morphological and physiological link between host and parasite called a haustorium. Some plants like *Monotrapa* (IndianPipe), does not contain chlorophyll and they are mycoheterotrophs (means parasites of mycorrhizal fungi), therefore these plants parasitize the trees indirectly on which the mycorrhizal fungi are found. (Nickrent et al., 2004; Nickrent, 2020; Musselman, 1987; Musselman & Press,1995). Parasitic plants are an important component of the worldwide vegetation that influence the structure and function of the ecosystem (Bardgett et.al, 2006; Li & Dong, 2011; Tesitel et.al, 2016). According to Poulin, 2011, parasitic plants are a particular functional species group, which form haustoria that obtain water, nutrients and carbohydrates, partially or completely from their hosts.

Due to the differences in plant traits like leaf flower, fruit phenology and property with their hosts, parasitic plants also confer profound effects on population dynamics across different trophic levels (Hartley et.al, 2015; Molau, 1995).

Extensive studies have been done on phylogenetic evolution of parasitic plants, interactions between host and parasite and possible harmful effects on crop production by parasitic angiosperms (Brohman, Cowman & Lanfear , 2013;; Brown & Tellier, 2011;Calatayud et.al , 2016 ; Dueholm et.al , 2017 ; Grewell , 2008 ; Fernandez – Aparicio , Reboud & Gibot – Leclerc , 2016 ; Sauerborn , Mullerstover & Hershenhorn, 2007 ; Zwanenburg , Mwakaboko & Kannan , 2016; Bouwmeester, Li, Thiombiano, Rahimi & Dong, 2021; Bouwmeester, Sinha & Scholes, 2021; Stewart et.al, 1990; Zhang, Li, Sun,2018). Parasitic species have evolved independently at least twelve times, they are not derived from a monophyletic group (Bellot & Renner, 2014; Westwood, Yoder, Timko & Depemphills, 2010; Pennings et.al, 1996), indicating that parasitic plants could be varied both evolutionally and ecologically.

To account the nonrandom distribution pattern of parasitic plants, “the host- quality hypothesis” was proposed by Watson (2009). Most of the parasites had a wide host range,that was mainly affected by host geographical distribution and ecological relationships. (Joel et.al)

Casadesus and Munne-Bosch (2021) and Tesitel et al. (2021) studied the role of parasitic angiosperms in natural ecosystems. For providing the shape to natural mediterranean ecosystems, Bosch (2021) describe the role of holoparasitic plant- host interactions (like in between *Cytinus hypocystis* and various shrubs of the genus *Cistus*). Discussion on how parasitic plants can positively affect the growth and/or reproductive output of their host or non- host organisms and how they can have positive effects on community structure and ecosystem processes, was done by Tesitel et al. (2020, 2021) and also reviewed that parasitic flowering plants play a role as food or medicinal uses or for aesthetics and cultural purposes. Masumoto et.al (2021) reported a three - dimensional reconstruction of the haustorium of the obligate parasite *Striga hermonthica* and the facultative parasite *Phtheirospermum japonicum* and also revealed the spatial arrangements of multiple cell types inside haustoria and their interaction with the host root, and also highlight the differences between the two parasites, specifically with regard to the xylem connection with the host, through the

combination of three - dimensional reconstruction method and field emission scanning electron microscopy.

Masanga et al. (2021) illustrated the negative impact of some parasitic angiosperms (like *Cuscuta*) on agricultural crops in their research article. They revealed the presence of field dodder (*Cuscuta campestris*) and *C. kilimanjari* both are either naturalized or endemic to east Africa and reveal the presence of the giant dodder (*C.reflexa*) for the first time in continental America (a South Asian species). They explained the potential risk of *C.reflexa* expanding its host range to important woody cash crops such as tea, coffee and mango and revealed successful parasitism, followed by haustorial formation and vascular bundle connections in all these crops.

Jamil et al. (2021) explain how our growing knowledge can be used to improve the control of parasites, both through (modern) breeding and through smart agricultural practices and agrochemistry. Albert et al. (2021) and Teixeira et.al (2021) have reviewed many examples of hosts that have developed defense strategies to avoid infection or protect themselves actively after attack of parasites that often leads to complete or partial resistance. They discussed the defense strategies used by host plants like active molecular resistance mechanisms against the parasitic plants to make the host plants resistant to infection. These discussions outline the perspectives and the potential of future studies needed to develop the breed-resistant crops (Nelson, 2021). According to Press and Phoenix (2005) and Watson (2009), the ecological impact of parasitic plants extends beyond individual hosts and plant communities, having a range of effects that resonate across entire ecosytems and involve higher trophic levels than primary producers. According to Cullings et.al (2005) trees that were infected with dwarf mistletoes like *Arceuthobium spp*, were characterized by greater fungal biomass in their root zone, with consequent effects on decomposition and soil structure. From earlier times, parasitic plants have been exploited for human use, including food, medicine and cultural purposes in human communities worldwide (Kujit, 1969; Brand-Miller and Holt, 1998; Bussing, 2004, O'Neill et al., 2016; Muche et al.,2022). According to Brand-Miller and Holt (1998); Clarke (2008), first nation people of Australia, have sustained their life for some 50-65000 years on a diet rich in indigenous flora that includes a wide range of parasitic plants , especially from the families Santalaceae , Loranthaceae and Lauraceae. Bussing (2004) discussed the cultural value of parasitic plants in Europe, where religious use of the mistletoe *Viscum album* has a long history dating back to ancient Greece and Celtic period. According to Paine and Harrison (2018) the origin of the modern mistletoe tradition relates to Celtic Pegan rites of the winter solstice.

A new species of parasitic angiosperm has been discovered in honour of the Konyak tribe of Nagas,that has no chlorophyll, and survives by feeding on another species of plant that does, named *Gleadovia konyakianorum*. This plant was identified during a botanical exploration in year 2022 near Tobu town of Mon district in Eastern Nagaland.

National status

According to Nickrent and Musselman (2004), about 4100 species of angiospermic plants belonging to 277 genera are reported to be parasitic on different host plants, out of which 25 genera can cause negative impacts on host plants. According to Mathur (1949), a parasitic angiosperm *Dendrophthoe falcata var. coccinia* (Loranthaceae) is called as Mistletoe and *Cassytha filiformis* (Lauraceae) is also called as dodder,

cause serious problems for the host plants(Pandian et al.2017). Mukhtar et al. (2010), Kokubugata and Yokota (2012) reported that dodder infests woody plants and damages certain economically important crops. *Cassytha filiformis* has a wide range of host such as grasses, broad leaved angiosperms, ferns and gymnosperms.

The list of parasitic angiosperms reviewed in the literature are: (A) Root parasites- Orobanchaceae (*Orobanche, Christisonia, Lathraea, Aeginetia, Cistanche*), Balanophoraceae (*Balanophora*), Hydnoraceae (*Hydnora*), Scrophulariaceae (*Rhinanthus, Castilleja, Striga, Euphrasia, Bartsia, Pedicularis, Melampyrum, Buchnera, Cordylanthus, Sopubia, Tozzia)*, Lennoaceae (*Lennoa*) and Krameriaceae (*Krameria*), Santalaceae (*Tesium, Exocarpos, Santalum album*)

(B) Stem parasites- Loranthaceae (*Loranthus, Dendrophthoe, Viscum*), and Cuscutaceae (*Cuscuta*), Santalaceae (*Caldomyza, Dendromyza*). (Yadav, 2009)

Of the known parasitic flowering plants, about 25 genera put negative impact on host plants cultivated by humans and out of these *Striga, Orobanche, Loranthus, Dendrophthoe, Viscum* and *Cuscuta* are considered agronomically important and much research has been undertaken on these parasitic genera.(Calder et.al, 1983; Muche et.al, 2022) The parasitic plant families, that are agronomically important, are Lauraceae, Orobanchaceae, Loranthaceae, Santalaceae, Viscaceae, Balanophoraceae, Hydnoraceae, Lennoaceae, Rafflesiaceae, Scrophulariaceae, Cuscutaceae. *Cuscuta* species are well known for their medicinal value and used as a herbal remedy for thousands of years, in India. (Sharma & Kapoor, 2014)

An unexplored genus of a parasitic flowering plant has recently been discovered from the Nicobar group of islands, named as *Septemeranthus*. The host plant of the genus *Septemeranthus* is *Horsefieldia glabra* (Blume) Warb. This genus is partially host dependent because it has leaves that are photosynthetic. This genus is endemic only to the Nicobar group of Islands. It belongs to the family –Loranthaceae, a hemi-parasite under the sandalwood order Santalales.

Status in Rajasthan

Rajasthan is located in the north-western part of the country, Rajasthan covers an area of 3,42,239 sq km, that is 10.40% of the geographical area of the country. The geographical extent of the state is bounded by 23º4'N to 30º11'N latitude and 69º29'E to 78º17'E longitude. There are four distinct regions in the state namely, Western desert with barren hills, level rocky and sandy plains, the Aravalli hills and South-eastern plateau. The climate of the state differ from semi -arid to arid. The Western part of the state includes Thar Desert (which is also known as the Great Indian Desert) is relatively dry and infertile whereas in the South-western part, the land is wetter, hilly and more fertile. The average annual temperature varies between 0ºC to 50ºC and the average annual rainfall in the range of 500 mm to about 750 mm. According to geographical area, Rajasthan is the largest state of India, but it ranks 15th in terms of the RFA (Recorded Forest Area), It is a forest deficient state. As per Champion & Seth classification of Forest type (1968), there are two type groups of forests in Rajasthan i.e. Tropical dry deciduous and Tropical thorn forests which are further divided into 20 forest types. According to Indian state of forest report 2021 the forests of Rajasthan cover approximately an area of 32,863 Sq km which is 9.60%of the total geographical area of the state, of which

12,475 Sq km is reserved forest, 18,217 Sq km is protected forest and 2,045 Sq km as unclassified forests. Five National parks, 25 wildlife sanctuaries and 11 conservation reserves constitute the Protected Area Network of the state covering 2.92% of its geographical area. There are three project tiger (Ranthambore, Sariska and Mukundra hills) and two Ramsar sites (Keoladeo Ghana sanctuary and Sambharlake). The state has teak forests,which is Northern most limit of teak zone in India.

The forests of Rajasthan are spread unequally in Northern, Southern, Eastern and South-Eastern parts, and the Western region of Rajasthan is devoid of any forest cover. Most of the forests are in hilly regions of Udaipur, Rajasamand, Kota, Baran, Sawai Madhopur, Chittorgarh, Alwar, Sirohi, Bundi, Jhalawar and Banswara districts. The extent of Natural Forests in Rajasthan is not only one of the lowest in the country but also in terms of productivity of forest, it is the lowest. On the contrary, the state is endowed with the largest chunk of wasteland which is about 20% of the total wastelands of the country. From the literature reviewed,the most common parasitic angiospermic plants in Rajasthan are *Cuscuta reflexa* Roxb., *Orobanche aegyptica* Pers., *Orobanche cernua* Loefl., *Striga angustifolia*(D.Don.) Saldhana., *Striga asiatica*(L.)Ktze., *Dendrophthoe falcata* var. coccinia (in desert areas), *Cistanche tubulosa.*(Sharma,2022; Yadav, 2009)

Parasitic plants are diverse group of flowering plants rely on host plants for growth and development. They depend partially or completely on host for carbon, nutrients and water which they require by attaching to it by special multicellular structures known as haustoria. Parasitic plants are common in many ecosystems from tropical rain forests to the high arctic and even in desert areas. It has been reported that about 1%of the flowering plants, approximately 3000 species in total, are parasitic. In the Thar Desert, four genera of parasitic plants namely *Orobanche*, *Cuscuta*, *Striga* and *Cistanche* which belong to the families Cuscataceae and Orobanchaceae of the dicotyledons are present. *Cistanche tubulosa* (Schenk)R.Wight is able to tolerate saline environment. It is a rare and endangered plant species but mostly found in arid and semi-arid regions of Rajasthan (India), China and Pakistan. In western parts of Thar Desert it mostly grows on the roots of *Salvadora* tree in saline affected arid area. (Agarwal et.al, 2021)

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