

SOME PARASITIC FLOWERING PLANTS OF SASKATCHEWAN

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Parasites, in general, are organisms that live on or in other individuals and draw their nourishment from their hosts. Most plants, on the other hand, are autotrophic, and can manufacture their own complex nutrients independently from simple naturally occurring substances. But even here in the green (with chlorophyll), self-sustaining plant kingdom, evolution has perhaps been diverted several times to produce a small number of saprophytes and parasites. The saprophytes are those that survive on a wide variety of complex organic substances without depending on other plants. Their aerial parts are non-green (lacking chlorophyll) and the underground roots become variously modified by showing very irregular branching. Often these irregularly branched roots morphologically resemble corals, and hence they are called coralloid roots, as in some plants such as Pine Sap or Indian-pipe (*Monotropa*) of the family Monotropaceae, or Coralroot Orchid (*Corallorhiza*) of the family Orchidaceae. Their roots are usually associated externally and/or internally with fungi, and such an association is called mycorrhiza.

Unlike the saprophytes, parasites depend directly on other plants for their growth, development and reproduction. The parasites can be classified into two types — a) complete or holo-parasites and b) semi- or hemi-

parasites. The complete parasites are those that depend on autotrophic plants for their living. They are non-green and can not photosynthesize. The semiparasites do contain chlorophyll but depend on other living plants for water and other simple nutrients. Some semiparasites in nature may or may not depend on hosts for their living. The former are called obligate semiparasites; the latter, facultative or circumstantial semiparasites. In all parasites, the roots, usually the lateral roots, become modified to form haustoria (the part of the fungus that penetrates the host), which help in the uptake of water and other nutrients. The facultative semiparasites, under favourable growth conditions, may not produce haustoria; they may remain as autotrophic plants.

Details of parasitism in some local species of Clustered Broom-rape (*Orobanche fasciculata*) and Bastard Toadflax (*Comandra umbellata*) have been investigated and are here described. In addition, other parasitic species which occur in Saskatchewan are also listed with a brief account of the nature of parasitism in each of them.

Orobanchaceae (Broom-rape family) — *Orobanche fasciculata* Nutt. (Clustered Broom-rape): Roots of this complete parasite are associated with roots of other host plants,

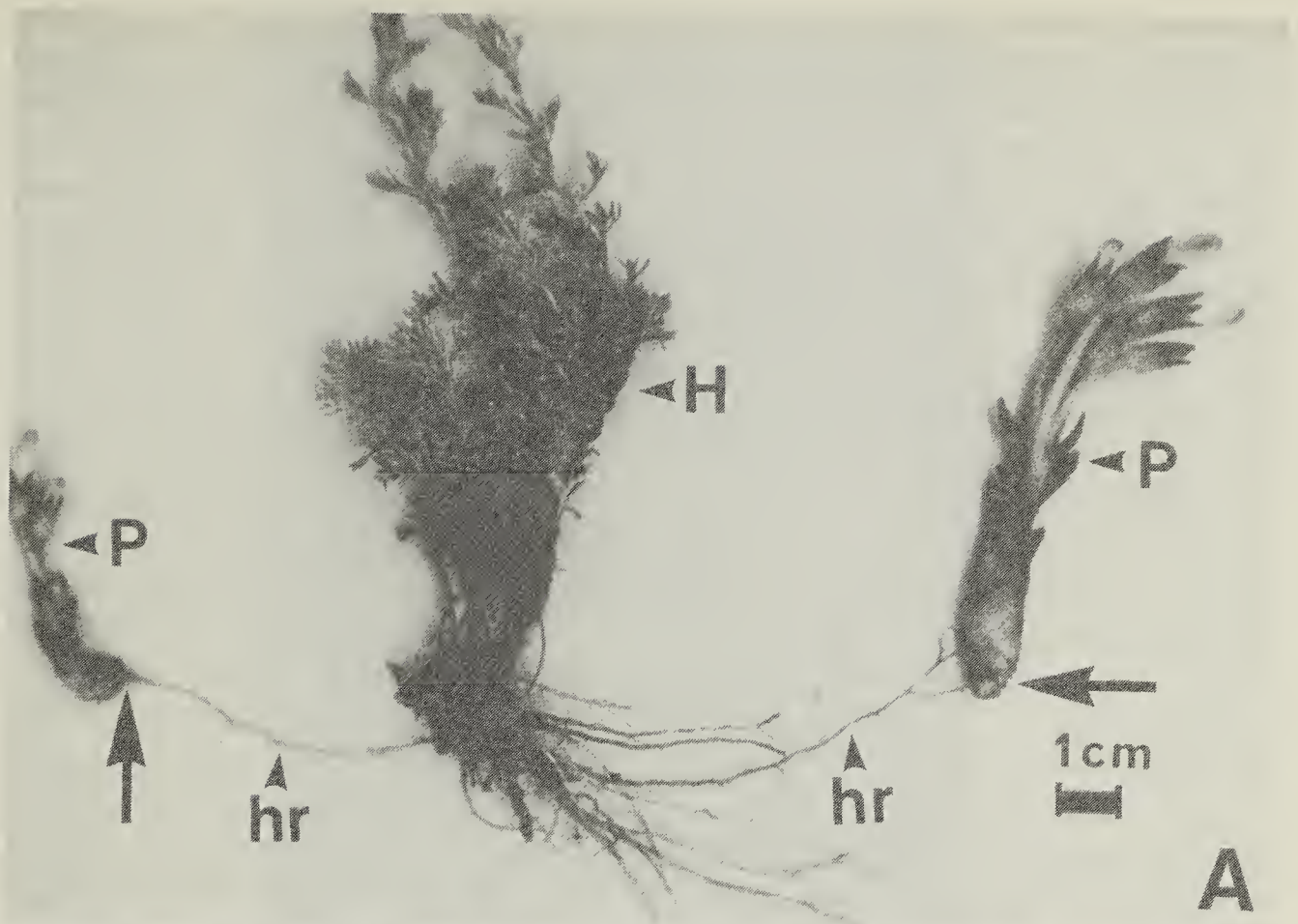


Figure 1. Pictures of *Orobanche fasciculata* and *Comandra umbellata*.

A. *O. fasciculata* collected from field to show the basal attachment of the shoot to roots of *Artemisia frigida* (Prairie Sage). Arrows indicate the region of attachment. Note the flower buds in the parasite.

B. *C. umbellata* in the field to show the flowering shoots (white arrows). Centimetre ruler at the bottom. (H, host plant; hr, host root; P, parasite)

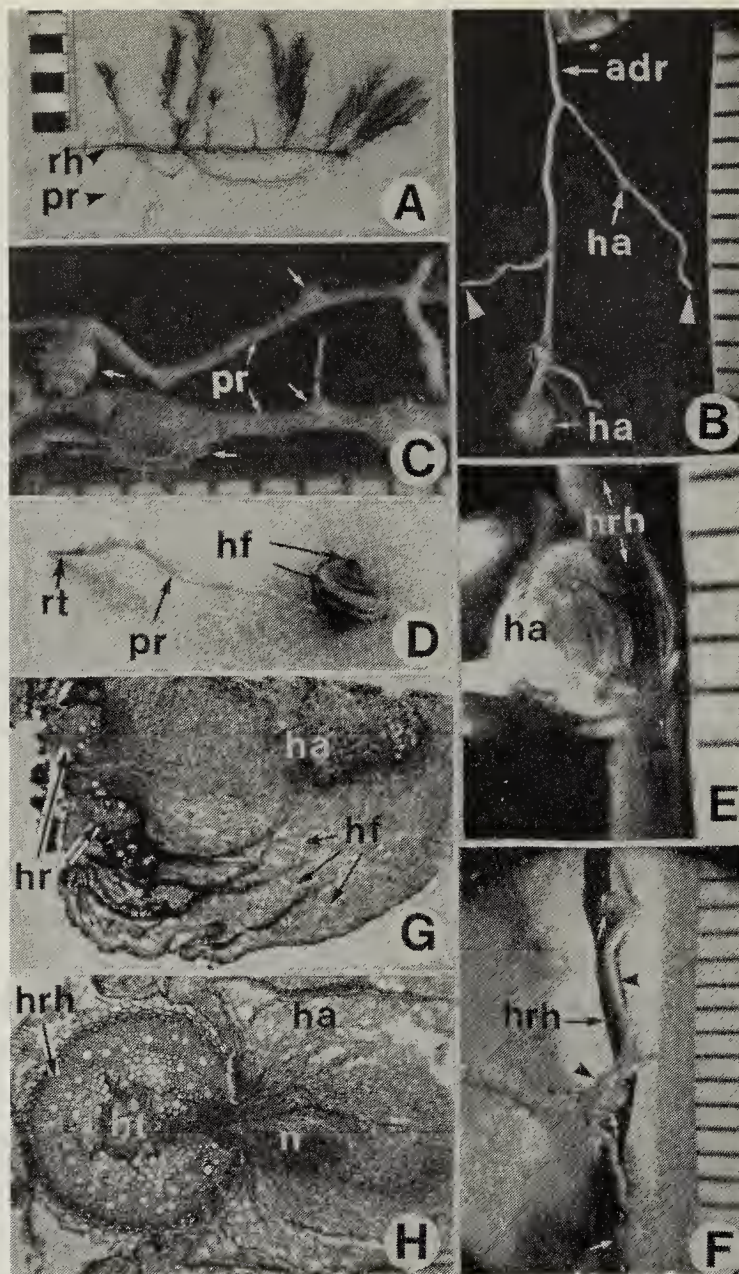


Figure 2. Pictures of *Comandra umbellata* to show its habit, roots and haustoria.

- A.** A portion of the perennial plant to show the rhizome with many aerial shoots attached to it. Roots are adventitious developed from the rhizome. (centimetre ruler).
- B.** An adventitious root developed from rhizome showing three lateral roots. A lateral root almost at the tip is modified into haustorium. White arrow heads point at lateral root tips. (millimetre ruler).
- C.** Mature roots of the parasite to show haustoria (arrows). Roots indicate self-parasitism (haustoria attached to parasite roots). (millimetre ruler).
- D.** A root of the parasite showing the face view of a well developed haustorium, which shows characteristic haustorial (clasp) folds. Note the dead root tip. x 4.
- E.** Haustorium with its haustorial folds clasp the underground host rhizome of a grass (Northern Wheatgrass) (millimetre ruler).
- F.** Parasite root (black arrow heads) with its haustoria (white darts) attached to host (grass) rhizome. (millimetre ruler).
- G.** Long section of a haustorium showing haustorial or clasp folds in the periphery. The core (nucleus) or the central part of the haustorium has penetrated the host root to break it. x 90.
- H.** Long section of a haustorium showing the central core or nucleus has penetrated the rhizome of a grass (Northern Wheatgrass). Note the central tissue of the host rhizome is replaced by the haustorial tissue. x 90.
- (adr, adventitious root; ha, haustorium; hf, haustorial or clasp folds; hr, host root; hrh, host rhizome; n, nucleus or central core; pr, parasite root; rh, rhizome)

especially Pasture Sage (*Artemisia frigida*). The plant occurs in open prairies and ranches, close to aspen groves and seems to prefer dry sandy soils. An unbranched shoot emerging from shallow depths of soil terminates in an inflorescence of a few stalked flowers (Fig. 1A). The entire axis is covered by short bract-like leaves which are pinkish or purplish in colour indicating a lack of chlorophyll. Fruit capsules (fruits), on dehiscing (spontaneous opening), release numerous seeds. Seeds become buried in the ground and most of them remain dormant. Although some seeds germinate and produce seedlings, only a few, that are in contact with the roots of adjacent host plants, will survive.^{4,13} In *O. fasciculata*, the primary root of a young seedling in contact with the host root becomes modified into a primary haustorium and remains attached to the host root (Fig. 1A). The central core of this haustorium establishes vascular connection with that of the host root.^{4,13} The young seedling, thus attached to the host root, develops into a reproductive axis which emerges above ground to produce flowers (Fig. 1A). This species is an annual and does not develop an extensive root system of its own, nor does it develop secondary haustoria from lateral roots.

Louisiana Broom-rape (*Orobanche ludoviciana* Nutt.) and Small Broom-rape (*O. uniflora* L.) of the family Orobanchaceae are occasionally seen on the prairies. The habitat, habit and mode of parasitism of these species are similar to *O. fasciculata*.

Santalaceae (Sandalwood family) — (*Comandra umbellata* (L.) Nutt.) (Bastard Toadflax): This is a perennial root parasite occurring throughout the prairies, parkland areas and

boreal forest of Saskatchewan. It survives predominantly by vegetative propagation, producing many new shoots from underground rhizomes (underground stems) to form small clones (Fig. 1B, 2A) and also to colonize new areas by the vigorous spread of rhizomes. It is a semi-parasite with photosynthetic aerial shoots. Rhizomes produce new roots, called the adventitious roots (roots developed from stems); such roots (Fig. 2B, D-F) eventually develop lateral roots, some of which get modified into haustoria especially when they come in contact with the roots or rhizomes of adjacent plants (Fig. 2B-F). In this investigation, two species, *Artemisia frigida* (Pasture Sage) (Family Asteraceae) and *Agropyron dasystachyum* (Northern Wheatgrass) (Family Poaceae), have been identified as hosts. The haustoria have been collected at various stages of development and sectioned for microscopic study. Each haustorium develops from a young lateral root and on coming in contact with the host root produces a series of peripheral or haustorial or clasping folds, which help in the firm attachment of the haustorium to the host root or rhizome (Fig. 2D-G). Meanwhile, the central core, which is called the nucleus, can penetrate the host and mechanically destroy the host root (Fig. 2G) or rhizome (Fig. 2H) and absorb the nutrients available in them. In some instances, the haustoria of the parasite become attached to its own root, causing some destruction (Fig. 2C). This phenomenon is called self-parasitism, which is not uncommon in parasites, especially in semiparasites.

Several varieties of *Comandra umbellata*, including *livida*, *angustifolia*, and *pallida* have been recognized in Saskatchewan; they are very similar in their habit and

parasitism to *C. umbellata*. See Kuijt⁴ and Piehl¹¹ for more details on root parasitism.

The following are a few other parasites commonly found in Saskatchewan. Some of these plants appear normal (autotrophic) and it is rather difficult to recognize them as parasites unless their roots are carefully examined for haustoria under a microscope. Others, of course, can easily be recognized as complete parasites by their complete lack of green colour. Many published books on local floras, which deal with these species taxonomically, do not indicate that they are parasites. Because of this lack of information we have given some details relevant to the type of parasitism in the following species which form important components of the flora of Saskatchewan. We have also confirmed that the following species are indeed parasites by carefully examining herbarium specimens deposited in the George Ledingham Herbarium of the University of Regina, checking wild plants, and gathering information from published literature. Appropriate references have been provided in support of our observations of the following dicotyledonous species.

Loranthaceae (Mistletoe family) — *Arceuthobium americanum* Nutt. (American or Dwarf Mistletoe): This perennial species is a complete parasite, occurring as a stem epiphytic parasite most commonly on *Pinus banksiana* (Jack Pine). Its distribution includes the Cypress Hills and the boreal forests of northern Saskatchewan east to Ontario.

Arceuthobium pusillum Peck (Dwarf Mistletoe) (Family Loranthaceae): It is a perennial semiparasite, distributed commonly in the pine-spruce forests in northern Saskatchewan

and in the Cypress Hills. This epiphytic stem parasite is commonly seen on *Picea mariana* (Black Spruce) in midwestern Saskatchewan. It is a smaller species and the habit and mode of parasitism are very similar to *A. americanum*. For more details see Kuijt⁴ and Raju and Steeves.¹²

Convolvulaceae (Convolvulus family) — *Cuscuta gronovii* Willd. (Dodder): It is a complete stem parasite of the aerial parts of the host. This annual species occurs on different angiospermous (or flowering plant) hosts in the parklands and open moist woods in the prairies. It is also found in the Qu'Appelle Valley near Crooked Lake in southern Saskatchewan. The seeds germinate and produce small seedlings which very soon establish contact with the neighbouring autotrophic host plants. The primary root of the parasite soon dies and the stem parts of it wrap around the host stem. At the region of contact, the parasite stem produces small haustoria, which become attached to the host stem. Eventually, the central core or nucleus of each haustorium penetrates and establishes vascular connections with the internal tissues of the host stem. Such haustorial connections allow the parasite to have access to nutrients and water. For more details about haustorium in *Cuscuta*, see Kuijt.⁴

Scrophulariaceae (Figwort family) — *Castilleja miniata* Dougl. ex Hook. (Common Red Paint Brush): It is a semiparasite occurring commonly in the parklands, Cypress Hills and northern Saskatchewan. This perennial species is a root parasite, and its lateral roots become modified into haustoria, which are found attached to roots of a variety of flowering plants. It seems to depend on host

roots for simple nutrients and water. The core or nucleus of the haustorium penetrates the host root, establishing vascular connection in it.

Castilleja coccinea (L.) Spreng. (Scarlet Paint Brush): It is a perennial semiparasite, commonly found in moist meadows and ditches in eastern Saskatchewan and in the parklands area. The habitat, habit and mode of parasitism are similar to those of *C. miniata*. For details of the haustorium in *Castilleja*, see Heckard,³ Dobbins and Kuijt,² and Lytton et al.⁶

Melampyrum lineare Desr. (Cow-wheat): This semiparasitic annual species grows commonly in moist woodlands on sandy soils. It occurs along the Saskatchewan River banks and in pine-spruce woods in northern Saskatchewan. The roots of the parasite are usually attached to fine roots of grasses and other flowering plants. See Kuijt⁴ and Lytton et al.⁶ for more details.

Orthocarpus luteus Nutt. (Owl's-clover) (Family Scrophulariaceae): This semiparasitic annual species is a common root parasite in the dry prairies in sandy soil. It occurs on native prairies and also on ranches. Occasionally it is seen in disturbed roadside ditches or sloughs. See Cannon,¹ Kuijt,⁴ and Lytton et al.⁶

Pedicularis macrodonta Richards (Lousewort) (synonymous with *P. parviflora* Smith): This semiparasitic root parasite occurs in eastern Saskatchewan parklands and boreal forest. The roots of this perennial species produce short haustoria, which become attached to the host roots.

P. groenlandica Retz. (Elephant's Head) and *P. labradorica* Wirsing (Labrador Lousewort): Both species

are rare in Saskatchewan. They are found in eastern parts extending to northern Saskatchewan. These two perennial species are root parasites, and their habit and parasitism are similar to *P. macrodonta*. For details about haustoria, see Kuijt,⁴ Lytton et al.,⁶ Maybrook⁸ and Piehl.¹⁰

Agalinis (*Agalinis*) (three species) and *Besseyia* (*Kittentail*) (one species): These two genera are rare in Saskatchewan. Three species of *Agalinis* (synonymous with *Gerardia*) are known to occur in southeastern parklands and in southeastern boreal forest, and one species of *Besseyia* occurs in the Cypress Hills.⁵ The three species of *Agalinis* are annuals and reported to be semi-root parasites. The one species of *Besseyia* is perennial and it is also a semi-root parasite. For more details, see Lytton et al.⁶

The members of the Scrophulariaceae are interesting with respect to their parasitic behaviour. They are facultative hemiparasites. In nature, the roots of these plants produce haustoria when they come in contact with the host roots. However, under experimental conditions they can also survive and complete their life cycle without the host plants. Similar parasitic behaviour has been demonstrated in some related species.^{3,9}

The parasitic plants form a very small proportion of the entire angiosperms and show no evidence of evolutionary progress. However, they are still highly significant for they, especially the obligate parasites, represent an evolutionary dead end. They depend on other host plants in nature, and if the host plants are in any way threatened, it is obvious that the parasites are also threatened. A good ecological understanding of the host/parasite relationship of the parasitic plant species is

ship of the parasitic plant species is necessary to monitor and predict their future population status.

General Suggestion Next time you see or collect plants belonging to the Figwort family (Scrophulariaceae), make it a point to check their roots carefully for root haustoria.

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Literature Cited

1. CANNON, W.A. 1909. The parasitism of *Orthocarpus purpurascens* Benth. *Plant World* 12:259-261.
2. DOBBINS, D.R. and J. KUIJT. 1973. Studies on the haustorium of *Castilleja* (Scrophulariaceae). I. The upper haustorium. *Can. Jour. Bot.* 51:917-922.
3. HECKARD, L.R. 1962. Root parasitism in *Castilleja*. *Bot. Gaz.* 124:21-29.
4. KUIJT, J. 1969. The biology of parasitic flowering plants. University of California Press, Berkeley and Los Angeles, USA.
5. LOOMAN, J. and K.F. BEST. 1979. Budd's flora of the Canadian prairie provinces. Supply and Services Canada, Hull, Quebec.
6. LYTTON, J., F.L.S. MUSSELMAN and W.C. DICKISON. 1975. The structure and development of the haustorium in parasitic Scrophulariaceae. *Bot. Jour. Linn. Soc.* 70:183-212.
7. MALCOLM, W.H. 1966. Root parasitism in *Castilleja*. *Ecology* 47:179-186.
8. MAYBROOK, A.C. 1917. On the haustoria of *Pedicularis vulgaris*. *Ann. Bot.* 31:499-511.
9. NWOKE, F.I.O. and S.N.C. OKONKWO. 1974. Facultative hemiparasitism in *Buchnera hispida* Buch.-Ham ex D.Don. *Ann. Bot.* 38:993-1002.
10. PIEHL, M.A. 1963. Mode of attachment, haustorium structure and hosts of *Pedicularis canadensis*. *Amer. Jour. Bot.* 50:978-85.
11. ——. 1965. The natural history and taxonomy of *Comandra* (Santalaceae). *Mem. Torrey Bot. Club* 22:1-97.
12. RAJU, M.V.S. and T.A. STEEVES. 1962. The Dwarf Mistletoe, A plant parasite. *Blue Jay* 20:82-84.
13. SAUERBORN, J. 1991. Parasitic flowering plants — ecology and management. Scientific Books, Verlag Josef Margraf, Weikersheim, Germany.
14. SHOSTECK, R. 1974. Flowers and plants — an international lexicon with bibliographical notes. The New York Times Book Company, New York.



A gentle breeze of just over 2 miles an hour will carry a female Gypsy Moth's scent almost 3 miles. *The Marvels of Animal Behavior*. National Geographic Society.