Parasitic Flowering Plants on Postal Stamps: Vehicles for Learning

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Abstract. *It is proposed that philately and the study of parasitic plants can be conflated for educational purposes. Of the 12 lineages of parasitic flowering plants, eight are currently represented on postal stamps. The most frequent genus seen on stamps is* Rafflesia*, closely followed by* Viscum*. These stamps convey messages about the history and importance of parasitic plants such as witchweed* (Striga)*, sandalwood, and mistletoes. Some of these parasitic plants are beautiful wildflowers such as* Castilleja, Euphrasia*, and* Pedicularis *whereas many mistletoes in Loranthaceae have flowers that rival orchids. Countries with rich parasitic floras that currently do not have stamps featuring these plants should consider them as worthy subjects.*

Keywords: parasitic angiosperm, philately

Introduction

As stated by Raven [1], "we need to find ways to pay more attention to plants." To combat "plant blindness" and increase the connections humans feel with plants, activities such as gardening, participation in outdoor activities, and anthropomorphization have been recommended [2]. One way to promote appreciation of plants that has not been widely discussed is the seemingly unlikely conflation of botany with another popular human endeavor: the collection and study of postage stamps (philately). It is here proposed that collecting stamps is an activity that can provide a gateway for young and old to explore botanical diversity.

Images of stamps featuring parasitic flowering plants (angiosperms) were first posted on the Parasitic Plant Connection website [3] decades ago. Since then, it has become increasingly evident that philately can be used as an educational vehicle. Philatelic organizations are international with thousands of members who often specialize in particular themes. For the biological world, a rich inventory of stamps exist depicting animals [4,5] and fungi [6] as well many botanical themes. Indeed the journal Biophilately represents an international cooperative society dedicated to the study of biological postal stamps. Although the study of parasitic plants is a specialized botanical subdiscipline, research in this area spans a myriad of fields including agriculture, forestry, ecology, physiology, anatomy, phytopathology, biotechnology, molecular biology, biochemistry, taxonomy, and phylogenetics.

Parasitic plants are referred to as heterotrophic, i.e. "different feeding" because they obtain at least some of their water and nutrients from another vascular plant. The parasite attaches to the host plant through a structure called the haustorium that connects to the xylem and, in some cases, the phloem of the host. Parasites that obtain water and minerals from the host but are green and retain photosynthetic activity are called hemiparasites. These parasites attach to the

xylem but not the phloem. In contrast, parasitic angiosperms that attach to both xylem and phloem and have lost the ability to photosynthesize are called called holoparasites They also have highly altered morphologies, often with leaves reduced to scales, or in some cases, where stems and leaves are missing altogether. Mycoheterotrophs are another type of heterotrophic angiosperm that rely on mycorrhizal fungi to obtain nutrients but do not attach directly to tree roots.

The question "how many angiosperm parasite lineages exist?" was recently reviewed [7] and it appears that this nutritional mode has evolved independently 12 times. Holoparasites exist in 10 of the 12 lineages, and seven of these are composed entirely of holoparasites. In 11 of the 12 orders, the parasitic members are present in one family, whereas, in the sandalwood order (Santalales), about 20 families can be recognized. Finding the closest photosynthetic, non-parasitic relatives of the holoparasites has proven to be challenging, but molecular analyses have provided definitive answers.

The purpose of this paper is to tabulate the parasitic angiosperms that occur on stamps and discuss their importance to human endeavors as well as their role in natural ecosystems. We also wish to promote future production of additional parasitic plant stamps that are scientifically relevant, of economic or humanistic importance, or simply beautiful.

Parasitic Plants: The Good, The Bad, and The Ugly

The term "parasite" often provokes a negative first impression, leading to the idea that these plants are killing their hosts. That this is not true is supported by the fact that only about 25 of the 280 genera of parasitic angiospermsare pathogens that negatively impact plants cultivated by humans [8]. Two genera are particularly damaging to crops: *Striga* (witchweed) and *Orobanche*

(broomrape). Witchweed derives its name from the observation that it "bewitches" its host. Even before the parasite emerges from the soil, the host shows physical symptoms of parasitism, such as stunted growth and loss of reproduction. *Striga asiatica* and *S. hermonthica* cause major crop damage in Subsaharan Africa and have thus been the focus of intense research to mitigate these losses [9]. The broomrapes are problematic in the Middle East, Europe, and Asia [10]. Some stem parasites (mistletoes) in Santalales can cause damage to fruit trees. The dwarf mistletoes (*Arceuthobium* spp.) are major pathogens of coniferous trees grown in agroforestry settings [11]. Human alteration of the forest ecosystem, such as planting monocultures, encourages the spread and damage caused by these native components of the flora.

The above examples highlighted some of the "bad" players, but what about the "good" parasitic plants? That expression may sound like a non sequitur, but indeed the vast majority of parasitic angiosperms are benign and even integral components of their ecosystems [12]. Work in Australia showed that removal of mistletoes negatively affected the nesting behavior of several bird species, thus they are keystone resources in these woodland habitats [13]. Similarly, root parasites such as *Rhinanthus* may lower host plant biomass, thus allowing increased diversity. At high density they enhance the number of invertebrates and affect herbivores, predators, and detritivores [14]. Parasitic plants can even alter the physical environment around them, such as soil water and nutrients, atmospheric CO_2, and temperature [15]. Many parasitic plant species are rare and, being dependent upon their hosts, are particularly susceptible to population decline, thus they merit conservation and restoration efforts [16]. These organisms represent a large proportion of biodiversity and therefore their importance should be recognized [17]. Finally, what about "ugly" parasites? Like troll dolls, whether any parasite species is ugly or beautiful is probably in

the eye of the beholder. As shown below, some parasitic angiosperms are as beautiful as orchids and thus fully deserve showcasing on postal stamps.

Parasitic Plants on Stamps

Of the 12 lineages (orders) containing parasitic angiosperms, eight have been represented on postal stamps. These groups and the full taxonomic names of the species included are listed in Table 1. At least 95 different stamps show parasitic angiosperms representing 52 species in 29 genera. Indonesia has the highest number of parasitic plant stamps (seven) followed by Malaysia (six). These two countries achieved high numbers because *Rafflesia* is a popular subject to represent on stamps. Like the rhinoceros and panda, *Rafflesia* is "charismatic mega*flora*" because members have the largest flowers in existence! The next most popular subject is *Viscum* owing to its symbolism during the Christmas season (see below).

Although this paper is focused on haustorial angiosperm parasites, we would be remiss to not mention the New Caledonian endemic *Parasitaxus usta* (Podocarpaceae), the only parasitic gymnosperm. *Parasitaxus* is a physiological chimera mixing haustorial parasitism with mycoheterotrophy [18]. This amazing plant was featured on a commemorative postal stamp issued in 1989.

Lamiales – Orobanchaceae

One-third of all stamps bearing images of parasitic plants (10 genera, 23 species) show members of the broomrape family, Orobanchaceae (Figure 1). This is the largest family among parasitic angiosperms with 101 genera and over 2100 species[8]. *Striga asiatica* is a major pathogen on maize, sorghum, rice, and sugarcane [19]. In response to its accidental introduction

into the United States in the 1950s, the US Department of Agriculture initiated a control program. This species is shown on stamps from British Indian Ocean Territory (Fig. 1K) and Saudi Arabia. *Striga elegans*, a close relative of *S. asiatica,* was depicted on two stamps, one from Lesotho and another from Togo (Fig. 1L). Given their morphological similarity, it has been suggested that these species share a recent common ancestor. *Striga asiatica* is agrestal, meaning it is only known from agricultural fields, whereas *S. elegans* is only known from native grasslands [20], thus human activities may have provided the conditions necessary for the evolution of this crop pathogen. Another major crop pest in Africa is *S. hermonthica* which is shown parasitizing maize on a stamp issued in 1989 from Burkina Faso.,

In recent years the genus *Orobanche* has undergone taxonomic revision owing to DNA sequence data analysis. *Orobanche* contains 117 species whereas its segregates are *Phelipanche* (62 species) and the New World *Aphyllon* (20 species). Two of these holoparasites are featured on stamps, *Orobanche rapum-genistae* (Fig. 1H) and *Phelipanche purpurea* (Fig. 1J). In contrast to the stamps with *Striga*, none of the ex-*Orobanche* crop pests such as *Phelipanche aegyptiaca*, *P. cernua*, and *P. ramosa*, are featured on stamps. A stamp showing *Cistanche* was issued in 1959 from French West Africa (8 former French colonies, dissolved in 1960), possibly the first parasitic flowering plant stamp. This species was also featured on a stamp from Bahrain in 1993 (Fig. 1D) as well as stamps from Jordan, Oman, and Saudi Arabia (Table 1).

Except for *Alectra*, the remaining hemiparasitic plants shown on stamps are non-pathogenic species. Indeed, some of these are beautiful wildflowers that are admired and cherished, at least by some. Wyoming adopted *Castilleja linariifolia* as its state wildflower in 1917, but not without objection by botanist Aven Nelson. He argued that only experts could distinguish among the more than 200 species of Indian paintbrush (the common name for *Castilleja*). He also asked,

"who would want to plant a parasitic plant in a garden?" Despite these objections, Wyoming retained paintbrush as its state flower and it was featured on a stamp in 1982 along with the western meadowlark (Fig. 1C). With ca. 600 species, *Pedicularis* (lousewort) is the most speciose genus in Orobanchaceae followed by *Euphrasia* (eyebright, Fig. 1F) with 246 species [8]. *Pedicularis* has been chosen as a subject for stamps by seven different political entities. Greenland chose *P. hirsuta* which notably occurs at the highest latitude on earth for any parasitic flowering plant. Except for *P. apodochila* of Japan (Fig. 1I), the remaining five *Pedicularis* species are rare and/or endangered and require conservation efforts for their preservation.

Santalales – Six Families

The sandalwoods (Santalales) have 179 genera and 2428 species [8], of which 11 genera and 16 species are represented on stamps. Six stamps commemorate the sandalwood of commerce, *Santalum album*. This root parasitic tree has been utilized for centuries because of its aromatic heartwood that contains the essential oil santalol, the source of odor in incense [21]. Various themes are depicted on these stamps such as the tree's woody trunk (Indonesia), an elephant harvesting sandalwood trees (India 2006), and perfume (India 2019, Fig. 2F). Indeed, the Indian sandalwood stamps were infused with the fragrance of the plant, possibly the first and only time this has been done. The 150th anniversary of the arrival of Captain Robert Clark Morgan and his "santaliers" in New Caledonia in 1841 are commemorated on a 1991 stamp. The "boom and bust" history of exploiting sandalwood in Hawaii is well documented; however, such commercial operations were also taking place in other regions as early as the 16th century. The stamp from 2015 showing a woman bearing baskets with sandalwood commemorates the 500th anniversary since Portugal colonized East Timor. Other sandalwood species besides *S. album*

were also harvested and two of these are shown on stamps: *S. insulare var. hendersonense* from Pitcairn Islands in 1992 and *S. yasi* from Fiji in 1990 (Fig. 2G).

Three African countries (Botswana, Malawi, and Mozambique) have all produced stamps with images of the root parasite *Ximenia caffra* (Fig. 2L) commonly known as sour plum for its edible fruits. In Africa the leaves and roots are used medicinally to treat several diseases and ailments [22]. In a wild fruit series of stamps issued by Upper Volta (now Burkina Faso) in 1977, *Opilia amentacea* was shown (as *O. celtidifolia*, a synonym; Fig. 2H). This root parasite is a woody vine that is widely distributed from tropical Africa to Australia.

One holoparasite in Santalales has been illustrated on stamps: *Thonningia sanguinea* (Balanophoraceae), another plant utilized in traditional medicine. This family, with 14 genera and 42 species, contains some of the most unusual holoparasites in the angiosperms. The plants are highly modified to the point some resemble fungi. The Democratic Republic of Congo (Kinshasa) issued its stamp with *Thonningia* in 1960 (Fig. 2I) followed by the Ivory Coast in 2013 that also showed a mistletoe (*Tapinanthus belvisii*).

The mistletoe family Loranthaceae includes members with large, showy flowers, thus they have often been chosen as subjects for stamps. Eight species are listed in Table 1, however, in some cases, the species were misidentified or the taxonomy has changed since the stamp was issued. A stamp from Rwanda shows *Agelanthus brunneus* (Fig. 2A) or possibly *A. krausii* that also occurs in this country. Another stamp from Rwanda shows a brush fire juxtaposed with a painting of a mistletoe labeled *Tapinanthus prunifolius* (Fig. 2B). According to Polhill and Wiens [23], that species (now in *Agelanthus*) does not occur in Rwanda, thus the painting may depict *A. muzozensis* that is native to that country. A stamp issued in 1983 from Fiji shows the mistletoe *Decaisnina forsteriana* (as *Amylotheca insularum*), which is widely distributed in the

south Pacific. Although not specifically identified, the stamp from the Federated States of Micronesia shows *Macrosolen melintangensis*, a species that occurs in Southeast Asia but not Micronesia. Stamps with correctly identified Loranthaceae include *Amyema scandens* from New Caledonia (Fig. 2C), *A. incarnatiflora* from the Philippines (Fig. 2D), *Tapinanthus belvisii* from Ivory Coast (Fig. 2E), and *T. globiferus* from Chad.

The mistletoe family Viscaceae contains seven genera, two of which are featured on stamps: *Phoradendron* and *Viscum*. Although displaying these plants during the Christmas season originated in Europe, North Americans continued the custom, substituting *Phoradendron* for *Viscum*. In 1964 the US Postal Service circulated a Christmas theme group of four stamps, one of which was *P. leucarpum*. In 1893 this mistletoe was chosen as the state floral emblem for the Oklahoma Territory in the USA. Soon after Oklahoma became a state in 1907 controversy about mistletoe ensued and the Indian blanket (*Gaillardia pulchella*, Asteraceae) became their state wildflower. That mistletoe could not be a state flower or wildflower stems from the common misunderstanding that mistletoe is not a flowering plant. In 1982 Oklahoma issued a beautiful stamp featuring the scissor-tailed flycatcher (its state bird) and *P. leucarpum* whose seeds could be dispersed by this bird (Fig. 2J).

The European mistletoe, *Viscum album* is a very frequent parasitic plant subject for stamps, again owing to its Christmas symbolism. The two stamps issued by Hungary in 1963 were apparently the first to show this species, in both cases associating it with good luck. In 1974 Switzerland issued a mistletoe stamp beautifully illustrating *V. album* in fruit as part of its "Poisonous Plants of the Forest" series, highlighting the fact that mistletoe fruits and seeds contain viscotoxins. European political entities that have produced *V. album* stamps include England, the Bailiwicks of Guernsey and Jersey (Fig. 2K), Sweden, Yugoslavia, and the

Netherlands. The latter country issued a stamp in 2014 depicting the Yuletide custom of kissing under the mistletoe.

Malpighiales – Rafflesiaceae

The "Queen of Parasites" is *Rafflesia*, some species of which have flowers over one meter in diameter, the largest among all angiosperms[4]. The plants lack stems, leaves, and roots and exist within the host vine (*Tetrastigma*) as a filamentous endophyte. Their presence is only revealed when the flower buds emerge and later open. It is no wonder that these unusual and record-breaking plants have been the subject of stamps for Thailand, Malaysia, Brunei, Indonesia, and the Philippines. *Rafflesia arnoldii* is one of three national flowers of Indonesia.

Species misidentifications have occurred frequently with *Rafflesia* stamps. In some cases, a generalized image is shown with just the genus *Rafflesia* indicated. In other cases the *Rafflesia* illustration suggests a species, such as Malaysia (2007) where *R. arnoldii* is shown with a hornbill bird. Similarly, the stamp issued by Indonesia in 1989 clearly shows *R. micropylora* from Sumatra (Fig. 3E). In 1979 Malaysia released a series of *Rafflesia* stamps, each individualized for one of its 13 states. Unfortunately, the name on the stamp was *R. hasseltii* but the image shows either *R. arnoldii* or *R. gadutensis* (two similar species). Indonesia erred in the opposite direction on its 2012 stamps. The grouping of four stamps each shows a quarter of a *Rafflesia* flower, identified as *R. arnoldii*, when in fact it is *R. pricei* from Kalimantan (Fig. 3F). Fortunately, *R. arnoldii* was properly illustrated and identified on other stamps from Indonesia in 1992 (Fig. 3A), 1993, and 2008. Other correct identifications are of *R. azlanii* (Malaysia 2013; Fig. 3B), *R. kerii* (Thailand 2006; Fig. 3 C), *R. micropylora* (Indonesia 2002), and *R. pricei* (Brunei Darussalam 2000). At the time the Philippine *Rafflesia* stamp was issued (2007), this

species was known as *R. manillana*, but later taxonomic work [24] showed it should be called *R. lagascae* (Fig. 3D). Both of the other genera in Rafflesiaceae have also been featured on stamps. *Rhizanthes lowii*, whose bizarre flower is fringed with worm-like appendages, was showcased on the 2000 stamp from Brunei Darussalam (Fig. 3G). Finally, an accurate and strikingly beautiful painting of *Sapria poilanei* was presented by Thailand in 2006 (Fig. 3H).

Laurales – Lauraceae

Cassytha, popularly known as love-vine, is a genus of about 20 species, most of which occur in Australia. One species, *C. filiformis*, is pantropical, often reaching remote islands where it forms dense masses of stems that indiscriminately parasitize many different plant species. Under its medicinal plant series, the Marshall Islands issued a stamp in 1985 that nicely illustrated *C. filiformis* (Fig. 4A). Tea made from this species is considered an aphrodisiac in the Bahamas.

Piperales – Hydnoraceae

Hydnoraceae includes *Hydnora* of the Old World and *Prosopanche* of the New World. *Hydnora* has been described as "the strangest plant in the world" [25], and its vegetative and floral morphology bear this out. These holoparasites form angular pilot roots and haustorial roots that attach to host roots. No stems or leaves are formed, only a fleshy flower with a brown, rough exterior and a pink or orange smooth interior, the part of the flower visited by pollinating beetles. In its parasitic plant series in 1991, the Republic of Transkei (now part of South Africa) issued a stamp (Fig. 4B) showing the flower of *Hydnora africana* with its *Euphorbia* host plants in the background.

Saxifragales – Cynomoriaceae

Cynomorium coccineum (Cynomoriaceae) has been known for thousands of years by ancient people who used it for food, medicine, and even for dyeing. Arabs call the plant "tarthuth" and Bedouins ate the interior portions of fresh young stems, prepared infusions of older stems to treat colic or stomach ulcers, or dried and pulverized the plant for use as a condiment with meat dishes [26]. Following the Crusades, the Knights Hospitaller from Jerusalem relocated to Malta where they continued the medicinal use of *Cynomorium* that they learned from the Muslims. The site called Fungus Rock where the "Maltese Mushroom" grew was thereafter vigorously guarded. Despite its appearance, *Cynomorium* is certainly not a mushroom as its position within the angiosperm phylogeny was confirmed using DNA sequencing [27]. Under a mushroom theme, *Cynomorium* was featured on a 1993 stamp by Bahrain (Fig. 4C).

Zygophyllales – Krameriaceae

At the end of the alphabet for angiosperm orders is Zygophyllales, containing two families: Zygophyllaceae and Krameriaceae. The former includes lignum vitae (*Guaiacum*) notable for having one of the densest woods in the world, and creosote bush (*Larrea tridentata*) which produces ring clones over 11,000 years old. Krameriaceae contains the genus *Krameria* with about 23 species commonly called rhatany. The flowers of *Krameria* have showy sepals and some petals are modified into glands. The fruit is globose and covered with spines. The Federated States of Micronesia produced a group of ten stamps of plants used in traditional medicine, none of which are native to Micronesia. One of these was *K. lappacea* (Fig. 4D).

(synonym *K triandra*) that constitutes the true rhatany of commerce [28]. This plant has been used by Andean people to stanch blood flow, clean the teeth, combat diarrhea, treat mouth ulcers, etc.

Solanales – Convolvulaceae

Within the large family Convolvulaceae, which includes morning glory vines, a lineage of parasitic plants exists that is commonly called dodder. The genus *Cuscuta* contains over 200 species [8] of vines which may be hemiparasitic or holoparasitic. Although the vast majority of species are not problems on crop plants, some such as *C. campestris* can attack diverse crops, particularly legumes [29]. The Bailiwick of Guernsey is the only political entity that has shown a dodder species on a stamp (Fig. 4E). In 1994 they issued a stamp with a beautiful painting of *C. epithymum* parasitic on *Ulex europaeus* (Fabaceae) along with the Dartford Warbler (*Sylvia undata*). As the name implies, this dodder usually uses thyme (*Thymus*) as its host plant, but other hosts can also be parasitized.

Parasitic Plants Not on Stamps

Four orders and families of holoparasites are not currently represented on stamps (Fig. 4F-I). Three of these families were once thought to be related to Rafflesiaceae, but molecular phylogenetic work [30] showed they were all in different orders. The first is Apodanthaceae (Cucurbitales) which includes the genus *Pilostyles* (Fig. 4F). These holoparasites have tiny flowers that emerge from the branches of legume host trees and shrubs. The genus is widely distributed with species in North and South America, Africa, the Middle East, and Australia. The next ex-Rafflesiaceae family is Cytinaceae (Malvales) which includes the genus *Cytinus* (Fig. 4G) in the Old World and *Bdallophytum* in the New World. The third ex-Rafflesiaceae family is

Mitrastemonaceae (Ericales) which includes only the genus *Mitrastema* (Fig. 4H) with two disjunct species, *M. yamamotoi* in East Asia and *M. matudae* in Mexico. Who could have guessed that these three lineages were related, respectively, to cucumbers, okra, and blueberries! The order Boraginales contains the family Lennoaceae with just two genera, *Lennoa* and *Pholisma* (Fig. 4I), distributed in the western US and Mexico. The inflorescences of these holoparasites emerge from the desert sand and display a tight cluster of tubular flowers. *Pholisma sonorae*, an endangered plant species in the southwestern US, is called "sand food" because native Americans consumed it. Parasitic plants from all four of these lineages would make fascinating and informative stamps that highlight the unique biodiversity of their respective regions.

In conclusion, approximately 46 political units have issued parasitic plant stamps, with the highest numbers coming from Indonesia (seven) and Malaysia (six). Interestingly, the African country of Burkina Faso also has six. And the very small territory Baliwick of Guernsey has five stamps. Large regions that have rich parasite floras, such as central Asia, South America, and Australia have no parasitic plant stamps. We hope that this article will encourage more representation of these incredible organisms on stamps.

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