Biology of aerial parasitic vines in Brunei Darussalam: *Cuscuta* and *Cassytha*

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Abstract

Plants of the genus *Cuscuta* (Convolvulaceae) have often been mistaken as *Cassytha filiformis*, an unrelated genus in the family Lauraceae in Brunei Darussalam. Large majority of *Cuscuta* species are holoparasitic and all species of *Cassytha* are obligate stem hemiparasites. Also, *Cassytha* is perennial, whilst *Cuscuta* is annual. The chlorophyll content in *Cassytha* is generally influenced by the physiology of host, passive /dormant hosts usually increase the greening of *Cassytha*. Field observations conducted over 7 years have revealed that a novel method of *Cuscuta* infestation exist in Brunei Darussalam where a large majority of *Cuscuta* populations produce seeds vary rarely, and the infestations and spread are more often due to perennating structures. The nastic movements that allow both these parasitic species to "forage" hosts are still not totally understood, but there is strong evidence to suggest the involvement of chemical cues released by host plants trigger parasite's growth and attachment to the host. Both *Cuscuta* and *Cassytha* species have shown extremely broad host ranges in Brunei where a single parasite can even attach to many different hosts. Studies on the impacts of both these parasitic angiosperms on the community structure, diversity and vegetation cycling under both natural and agricultural systems will be useful to assess the impacts the parasitic plants on agricultural crops and native plants in tropical Brunei Darussalam.

Index Terms: parasitic plants, convergent evolution, parallelism, haustoria

1. Introduction

Have you seen a mass of orange spaghetti rashly thrown over shrubs and herbs? This can well be the parasitic plant dodder (*Cuscuta* spp. of the morning glory family - Convolvulaceace) or woe vine (*Cassytha* spp. of the laurel family - Lauraceae). Species of both these genera are commonly known as *Cuscuta* and *Cassytha* species ("love vines") and look similar with haphazard appearance in nature. In Brunei, both parasitic vines are generally referred to as "akar janjang", directly translates to 'stringy roots'. However, they are highly ordered and taxonomically different. Thus, these species cause confusion to many naturalists[1] but provide an excellent example of convergent evolution in parasitic plants[2]. It is one of the most remarkable examples of a phenomenon known as parallelism as shown in ***Figure 1*** - the development of similar structures in entirely unrelated organisms existing in tropical Brunei Darussalam.

Genus *Cuscuta* Yuncker includes about 170 species[3], while genus *Cassytha* L. is composed of 20 species with a worldwide distribution[4]. Both genera have thin, light greenish yellow stems, with scaly leaves and are virtually rootless as shown in ***Figure 1a*** and ***Figure 1b***. Young *Cassytha* stem is often green (photosynthetic) and turns yellowish when mature. However *Cuscuta* spp.

Figure 1. General habit of (a) *Cuscuta* (Cu) and (b) *Cassytha* (Ca) *parasitizing* host plants. One of the most convenient methods of correct identification of these two species showing parallelism in the field is by close examination of the vegetative body. Stem appearance of *Cuscuta* is smooth (c), while *Cassytha* has a coarse stem due to the presence of waxy plates (d).

have smooth, shiny appearance whereas *Cassytha* spp. have coarse and ridged stems due to the presence of numerous waxy plates as shown in ***Figure 1c*** and ***Figure 1d***. When stems are crushed, while *Cuscuta* is generally odourless, most *Cassytha* spp. release a pungent odour due to the presence of a range of essential oils, which is a characteristic feature of family Lauraceae.

Confusion has been infused to all species of "love vines" because sometimes in literature both genera are introduced as stem holoparasites (completely dependent on host plants for their water and nutritional requirements). In reality, large majority of *Cuscuta* species are holoparasitic and all species of *Cassytha* are obligate stem hemiparasites (only some of its sustenance derives from the host as it has chlorophyll for synthesis of some of its carbon requirements). Visser (1981)[5] has suggested that the chlorophyll content in *Cassytha* is generally influenced by the physiology of host *viz*. dormant hosts increase the greening of *Cassytha*. It is worthwhile to mention the fact that even though most dodders are holoparasitic, some *Cuscuta* species (ie. *C. reflexa*) have retained little chloroplast plastid genome and functional RUBISCO activity to become hemiparasitic to some extent. [6, 7]

Here we summarise some unusual field discoveries that we have made over the past six years when trying to unravel the biological and behavioural mystiques of love wines in Brunei Darussalam. In this research note, one of our main aims is to bring attention of a wider scientific community about this novel group of tropical parasitic plants least investigated in Borneo.

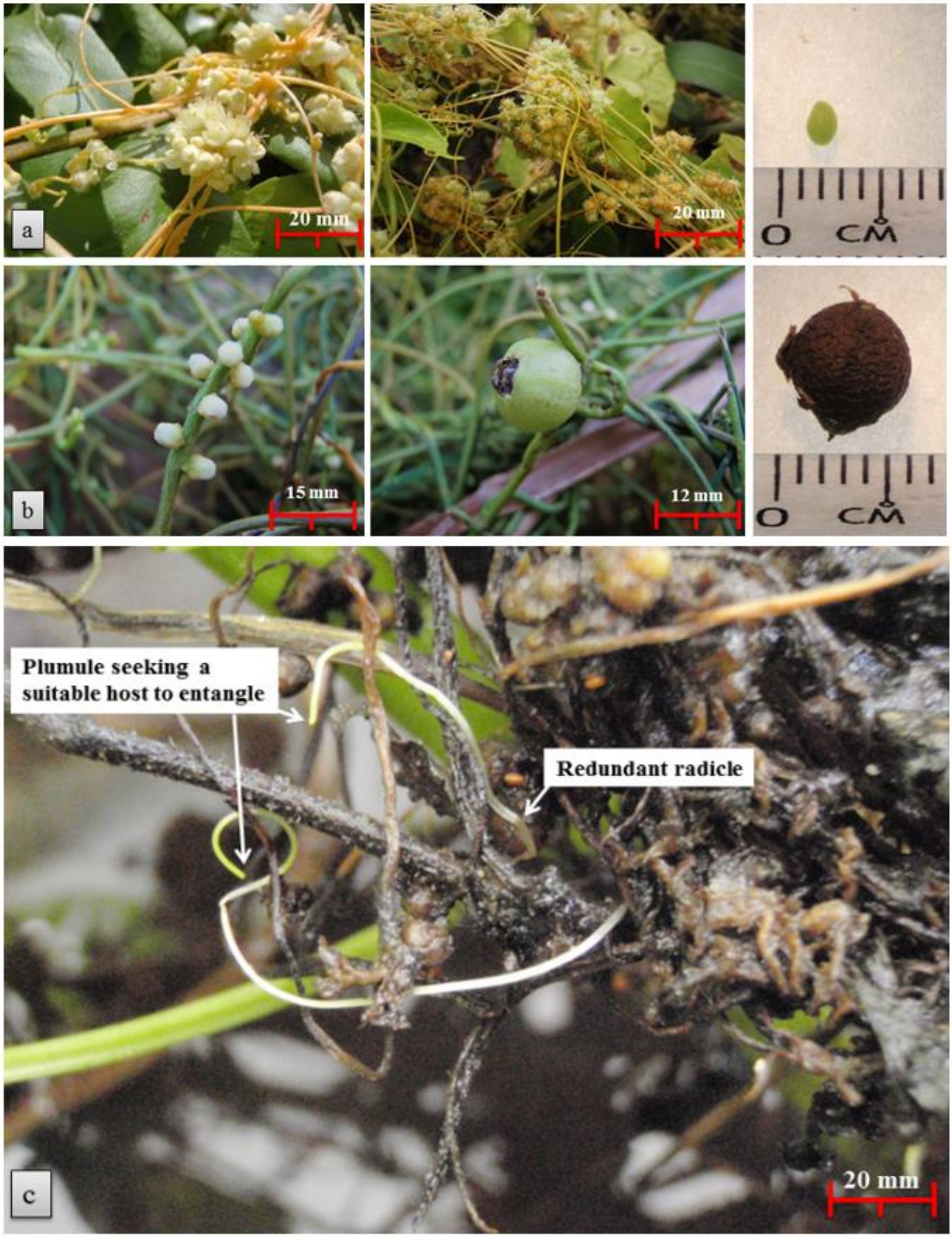

Figure 2. Distinguishable flower, fruit and seed characters of (a) *Cuscuta* spp., (b) *Cassytha filiformis and* (c) Geminating *Cuscuta* seeds – note the lack of development of radicle and the elongating plumule in search of a suitable host plant for immediate attachment.

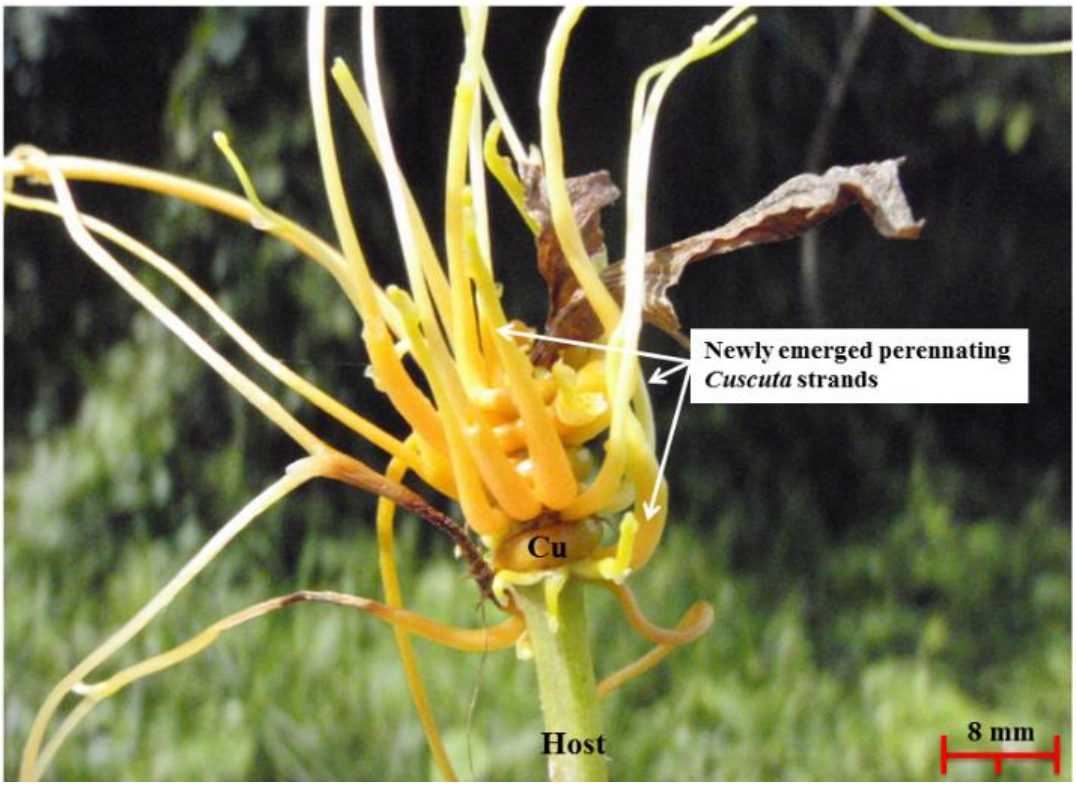

Figure 3. Perennating structures emerging from a mature strand of *Cuscuta* vegetative body (Cu) that has remained alive on a host found in Brunei Darussalam where flowering has not being recorded for over 4 years continuously.

2. Experimental approach

Field observations of *Cuscuta* and *Cassytha* spp. were conducted in Brunei-Muara, Tutong and Belait districts of Brunei Darussalam between January 2010 and January 2016, with localities recorded using a Global Positioning System (Garmin GPSMap 60CSx, Taiwan). Descriptions of study sites are elaborated recent studies.[8,9,10,11] The branching patterns, stem colours, haustorial developmental stages, emergence of new shoots from perennating tissues and flowers of both species were recorded for each site at least once in three months over the six year observation period.

3. Results and Discussion

Cassytha is perennial, whilst *Cuscuta* is annual. Both genera are twining parasites and both species have the ability to overwinter on host tissue or debris and re-emerge.[8] However, the most obvious mode of dispersal of both these love vines is by seeds (***Figure 2c***). *Cuscuta* produces a dehiscent capsule carrying four seeds with very hard seed coat, requiring mechanical or chemical scarification to induce germination. *Cassytha* fruit is a drupe with pulp, brightly coloured when mature to attract fruit eating birds as dispersal agents. Each drupe carries a solitary seed with hard seed coat. Seeds can remain dormant on soil for a long duration until it is scarified.[4,11,12,13]

A novel method of *Cuscuta* infestation has been reported in Brunei Darussalam[8], where a large majority of *Cuscuta* populations produce seeds vary rarely, and the continuation of *Cuscuta* infestations is more often due to perennating structures. After the entire *Cuscuta* population completely disappears at the end of its life cycle, few swollen fully mature *Cuscuta* strands that remain alive give rise to a number of new *Cuscuta* shoots early in the next growing season to continue its existence (***Figure 3***).

Stems of both genera actively move to find its host. Even though the stem movement is not evident to casual observer, if you mark the location of the dodder or woe vine stem tip of any species of these two genera and return the next day, you will find that stem has moved noticeably.

Figure 4. Nastic movement of *Cuscuta* stems in search of potential hosts; (inset) Young vegetative stems of *Cuscuta* inadvertently entangling among themselves when foraging towards the preferred host plants for establishing successful parasitic connections via numerous haustoria.

Field observations have revealed that dodders appear mostly along the banks of streams, degraded watersheds and wastelands while woe vines distribute mainly in coastal vegetation. Dodders also grow at a much faster rate than woe vines in search of host plants.[9] It was reported that dodders usually make the attachments with hosts within 3 days upon germination. The movement of parasite stem is from side to side to facilitate contact with vertically growing hosts.

The nastic movements (in response to a host stimulus) that allow these parasitic species to "forage" (move towards) hosts are still not totally understood (***Figure 4***). Albert et al. (2008) and Runyon et al. (2006) have suggested the involvement of chemical cues released by host plants trigger parasite growth and attachment to the host[14,15]. *Cuscuta* and *Cassytha* both studiously avoid parasitizing some of the monocotyledonous plants (especially grasses), even though they may only twine about as supporting structures to reach neighbouring (potential) host plants with their growing tips.

Both *Cuscuta and Cassytha* species usually have extremely broad host ranges (total number of different species that can be parasitized), and can even be attached to many different hosts at once. But in nature, the host preference (choice of the most desirable host for optimal growth) typically is much narrower and the parasite can often be located by first finding the preferred host. Similar patterns are observed for both genera in Brunei.[8,10,16] If a suitable host stem is not available within reachable distance, *Cuscuta* and *Cassytha* will inadvertently twine about an intimate object. Due to the parasitic nature of both genera, seedlings will die if a suitable host is not found within a few days.

Upon successful contact with a suitable host, both parasites coil indiscriminately around the host stem and penetrate into host tissues (mostly the stems) by a specialized structure known as the haustorium (***Figure 5***). After the initial host-parasite connection (adhere) phase is completed, haustorium penetrates into host tissue and intimate connections are made with both xylem (mostly direct lumen - lumen connections) and phloem

(from absorbing hyphae abutting host phloem sieve tubes) tissues of host.[17,18]

Figure 5. Successful haustorial establishment of (a) *Cuscuta* (Cu) and (b) *Cassytha* (Ca). (c) Longitudinal sections at the haustorial interface clearly show the orderly tissue contacts made by the haustorium (ha) to tap nutrients and waters from the host vascular tissue.

Absorption system of all species of "love vines" for host substance appears to be very efficient. Albert et al. (2008) and Wolswinkel (1984) have reported that during host plant fruit development, dodders compete for assimilates and act as a much stronger sink than the host plants fruits itself.[14,19] Both *Cuscuta* and *Cassytha* species usually have extremely broad host ranges (total number of different species that can be parasitized), and can even be attached to many different hosts at once. But in nature, the host preference (choice of the most desirable host for optimal growth) typically is much narrower and the parasite can often be located by first finding the preferred host. Similar patterns are observed for both genera in Brunei.[8,10,16]

In natural communities, love vines are capable of affecting the community composition by influencing the host growth, biomass allocation, and reproductive output, thus changing the ability of a range of host plants to successfully compete with neighbours. Due to its ability of reducing host performance, love vines clearly affect the community structure, diversity and vegetation cycling. Furthermore, they perform a valuable role in natural ecosystems by attracting birds and other seed dispersing agents to communities they inhabit.[10,11]

4. Conclusion

In spite of its fascinating biology, physiology and scientific interest, *Cuscuta* species (especially *C. australis* and *C. campestris* found in Brunei Darussalam) often considered as one of the most damaging pests in agriculture. It is widely reported that *Cuscuta* parasitism can reduce the production of a range of cash crops such as tomato, chilli, onion, cowpea, beans, corn and a range of other leafy vegetables by more than 50%.[20] *Cuscuta* is listed as one of the top ten weeds by the United States Department of Agriculture. However there has not been many reports on the detrimental effects of *Cassytha* on agricultural crop production, especially in Brunei Darussalam.[11]

In spite of their parasitic behaviour, many biological aspects of the love vines are yet to be unravelled. New research frontiers related to

bioprospecting (both genera of love vine seeds reported here are commonly used in traditional herbal medicines for various ailments), ability of these plants used as biological control of noxious weeds and a tool to transfer pathogens and genetic material from plant to plant will no doubt provide more prominence to this special group of nature's scroungers in the future.

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