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Host Specificity of *Cassytha filiformis* and *C. pergracilis* (Lauraceae) in the Ryukyu Archipelago

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Abstract Host plants of two parasitic *Cassytha* species in the Ryukyu Archipelago, namely the pantropic *Cassytha filiformis* and the Ryukyu endemic *C. pergracilis*, were investigated in the present study. Twenty-six vascular species of pteridophytes and spermatophytes were recognized as host plants of *C. filiformis*. On the other hand, two monocotyledonous species *Aristida takeoi* (Poaceae) and *Rhynchospora rubra* (Cyperaceae), specifically occurring in a certain special environment in the Ryukyus, were recognized as host plants of *C. pergracilis*. *Rhynchospora rubra* is reported for the first time as a host plant of *C. pergracilis*. The present study implies that rarity of the Zwischenmoor vegetation in the Ryukyus and high habitat specificity of the two host species could be the cause of the narrow-distribution range of *C. pergracilis*.

Key words: *Cassytha*, host specificity, parasitic plant, Ryukyus.

Introduction

Parasitic plants derive some or all of their energy from other plants, and about 4100 species of parasitic flowering plants in 270 genera are known (Nickrent and Musselman, 2010). There are four major types of parasitic plants based on whether they can photosynthesize (hemiparasite) or not (holoparasite); and whether the parasite is attached to the host plant aboveground or belowground (Heide-Jorgensen, 2008). The genus *Cassytha* (Lauraceae) is a perennial hemiparasitic vine that attaches to the stems of host plants (Heide-Jorgensen, 2008). This genus is the only parasitic taxon in the Lauraceae, and comprises 23 species in the Old and New World tropics and subtropics, primarily in Australia (Weber, 2007). Mature plants of *Cassytha* have twining stems without roots or developed leaves (e.g., Weber, 1981). Soon after germination, *Cassytha* plants develop radicles that grow into the soil, and produce a few short lateral roots using nutrients stored in the cotyledons. Once the first haustorium forms, the radicles disappear and the plant becomes independent of soil contact (Heide-Jorgensen, 2008).

At least, two *Cassytha* species occur in the Ryukyu Archipelago (the Ryukyus) of Japan: the pantropical species *C. filiformis* L. (Fig. 1A) and the endemic species *C. pergracilis* Hatus. (Fig. 1B) (Hatusima, 1975). *Cassytha filiformis* is relatively abundant on seashores and in coastal environments on most of the Ryukyu Islands (Hatusima, 1975) (Fig. 1C). In contrast, *C. pergracilis* is very rare and has been recorded only from the Islands Kume-jima and Izena in the central Ryukyus (Fig. 1D) (e.g. Hatusima, 1975). It is a component species of the *Rhynchospora rubra-Aristida takeoi*-Gesellschaft, which is a Zwischenmoor vegetation that occurs on argillaceous soil, and is usually dry but poorly-drained after rain (Okuda, 1989). However, no popula-

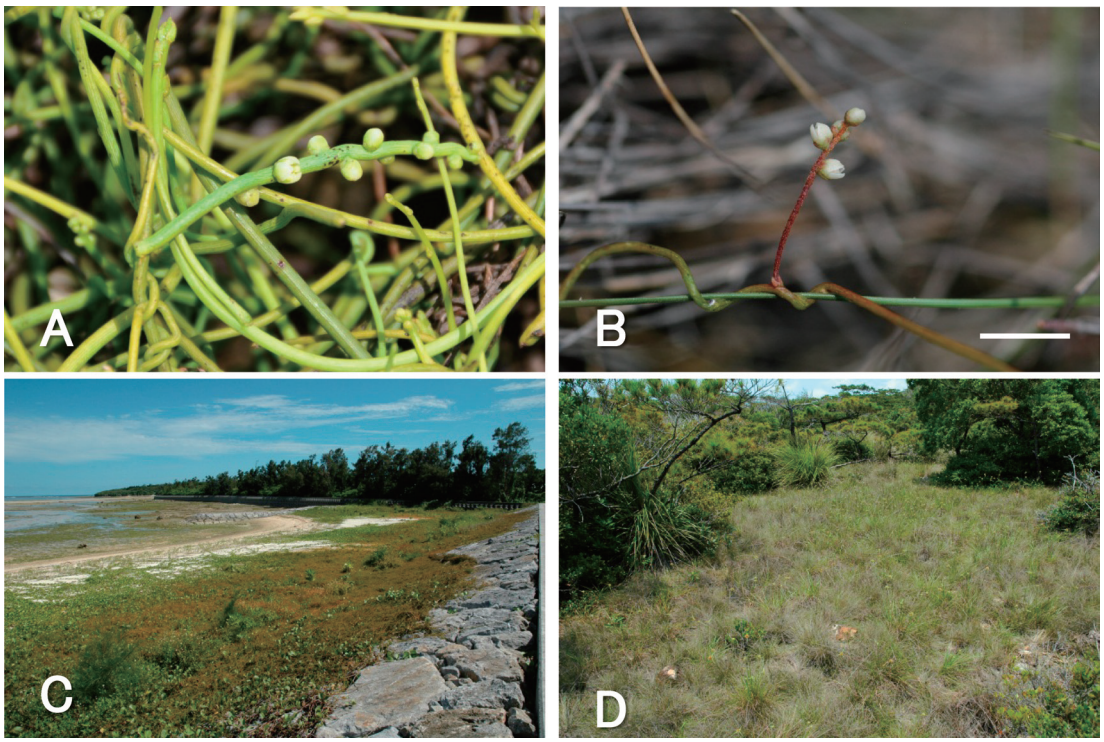

Fig. 1. Two *Cassytha* species and their habitats. A & C. *C. filiformis* (Ishigaki Isl., Ohama; GK6785). B & D. *C. pergracilis* (Izena Isl.; GK6553). Bar in B represents 3 mm for both A and B.

tions have been found recently on Kume-jima, and only a few populations are presently known on Izena Island (Yokota and Shinzato, 2006). Therefore, *C. pergracilis* is considered a threatened species in Japan (Japanese Ministry of Environment, 2007).

Host-specificity of parasitic plants has been studied in several fields, including ecology (Cuevas-Reyes *et al.*, 2011), evolutionary biology (Thorogood *et al.*, 2009) and physiology (Fernández-Aparicio *et al.*, 2011). However, host specificity has been poorly investigated for the two *Cassytha* species in the Ryukyus. In this study, we investigated the host plants of *C. filiformis* and *C. pergracilis*, and discuss relationships between host specificity and the narrow distribution of *C. pergracilis*.

Materials and Methods

We examined the host plants of *Cassytha filiformis* and *C. pergracilis* using dried specimens from our collection. Plant specimens that had *Cassytha* haustoria attached to the leaves or stems were considered as host species. If two or more host species were found for a specimen, every host species was recorded. Duplicate records of the same host species collected on the same day from the same population were excluded. We examined 49 specimens of *C. filiformis* from 36 locations on fourteen islands in the Ryukyus and five specimens of *C. pergracilis* from three locations on Izena Island (Table 1). Voucher specimens were deposited in the herbaria of the National Museum of Nature and Science (TNS) and the University of the Ryukyus (RYU).

Results and Discussion

Host plants of two Cassytha *species in the Ryukyus*

Table 1. Plant materials of two *Cassytha* species and their host plants

Parasitic species	Collection locality	Voucher no.	Host species
C. filiformis	Japan, Ryukyus, Amami Isl., Ushuku.	GK12332	*Ischaemum aristatum* L. (Poaceae)
	Japan, Ryukyus, Amami Isl., Sotoganeku.	GK12457	*Bidens pilosa* L. var. *minor* (Blume) Sherff (Asteraceae)
	Japan, Ryukyus, Amami Isl., Ushuku.	GK13000	*Ipomoea pes-caprae* (L.) Sweet (Convolvulaceae)
	Japan, Ryukyus, Amami Isl., Yo.	GK13009	*Spinifex littoreus* (Burm.f.) Merr. (Poaceae)
	Japan, Ryukyus, Amami Isl., Taira.	GK13016	*Casuarina stricta* Ait. (Casuarinaceae)
	Japan, Ryukyus, Kikai Isl., Araki.	GK12321	*Scaevola taccada* (Gaertn.) Roxb. (Goodeniaceae)
	Japan, Ryukyus, Kikai Isl., Nakazato.	GK12310	*Bidens pilosa* var. *minor*
	Japan, Ryukyus, Tokunoshima Isl., Kanehisa.	GK12168	*Chrysanthemum crassum* (Kitam.) Kitam. (Asteraceae) *Peucedanum japonicum* Thunb. var. *japonicum* (Apiaceae) *Heterosmilax japonica* Kunth (Smilacaceae)
	Japan, Ryukyus, Tokunoshima Isl., Kametsu.	GK12156	*Melanthera biflora* (L.) Wild (Asteraceae)
	Japan, Ryukyus, Tokunoshima Isl., Yonama.	GK12137	*Zoysia pacifica* (Goudswaard) M.Hotta et Kuroki (Poaceae)
		GK12136	*Peucedanum japonicum* Thunb. var. *japonicum* (Apiaceae)
	Japan, Ryukyus, Tokunoshima Isl., Kanami.	GK12178	*Dodonaea viscosa* Jacq. (Sapindaceae) *Pandanus odoratissimus* L.f. (Pandanaceae)
	Japan, Ryukyus, Iyeha Isl., Dana.	GK10729	*Bidens pilosa* var. *radiata* Sch. Bip. (Asteraceae)
	Japan, Ryukyus, Izena Isl., Serikyaku	GK6526	*Melanthera biflora*
	Japan, Ryukyus, Izena Isl., Izena Beach.	GK6492	*Thuarea involuta* (G.Forst.) R.Br. ex Sm. (Poaceae) *Zanthoxylum beecheyanum* K. Koc. var. *alatum* (Nakai) H.Hara. (Rutaceae)
	Japan, Ryukyus, Okinawa Isl., Ada.	GK6954	*Thuarea involuta*
	Japan, Ryukyus, Okinawa Isl., Kijoka.	GK6547	*Thuarea involuta*
		GK6546	*Ipomoea pes-caprae*
		GK6548	*Vitex rotundifolia* L.f. (Verbenaceae)
	Japan, Ryukyus, Ikei Isl.	GK12893	*Thuarea involuta*
		GK12894	*Vitex rotundifolia*
		GK12892	*Lysimachia mauritiana* Lam. (Myrsinaceae)
	Japan, Ryukyus, Tokashiki Isl., Aharen.	GK13020	*Cinnamomum doederleinii* Engl. (Lauraceae) *Dicranopteris linearis* (Burm.f.) Underw. (Gleicheniaceae)
	Japan, Ryukyus, Tonaki Isl., population 1.	GK13065	*Pandanus odoratissimus*
	Japan, Ryukyus, Tonaki Isl., population 2.	GK13087	*Thuarea involuta*
	Japan, Ryukyus, Tonaki Isl., population 3.	GK13092	*Zanthoxylum beecheyanum* var. *alatum*
	Japan, Ryukyus, Zamami Isl., Asa, population1.	GK12257	*Bidens pilosa* var. *minor*
	Japan, Ryukyus, Zamami Isl., Asa, population 2.	GK12267	*Dodonaea viscosa*
	Japan, Ryukyus, Zamami Isl., Asa, population 3.	GK12271	*Zanthoxylum beecheyanum* var. *alatum*
		GK12274	*Pandanus odoratissimus*
	Japan, Ryukyus, Kume Isl., Aka.	GK7003	*Ischaemum aristatum* L. (Poaceae)
	Japan, Ryukyus, Kume Isl., Shimajiri, population 1.	GK7016	*Casuarina stricta*
	Japan, Ryukyus, Kume Isl., Shimajiri, population 2.	GK7026	*Lysimachia mauritiana*
	Japan, Ryukyus, Kume Isl., Nakandakari.	GK12745	*Ipomoea pes-caprae*
	Japan, Ryukyus, Kume Isl., Gima.	GK12752	*Bidens pilosa* var. *minor*
	Japan, Ryukyus, Ishigaki Isl., Ohama.	GK6785	*Ipomoea pes-caprae*
	Japan, Ryukyus, Ishigaki Isl., Hoshino.	GK14500	*Scaevola taccada*
		GK14502	*Breynia vitis-idaea* (Burm.f.) C.E.C.Fisch. (Euphorbiaceae)
	Japan, Ryukyus, Ishigaki Isl., Ohzato.	GK14503	*Clerodendrum inerme* (L.) Gaertn. (Verbenaceae)
		GK14504	*Ipomoea pes-caprae*
		GK14505	*Scaevola taccada*

Table 1. (Continued)

Parasitic species	Collection locality	Voucher no.	Host species
	Japan, Ryukyus, Ishigaki Isl., Shiraho.	GK14507	*Vigna marina* (Burm.) Merr. (Fabaceae)
			Chamaesyce atoto (G.Forst.) Croizat (Euphorbiaceae)
		GK14508	*Canavalia lineata* (Thunb.) DC.
		GK14509	*Ischaemum aristatum*
	Japan, Ryukyus, Iriomote Isl., Haemi.	GK6766	*Ipomoea pes-caprae*
			Thuarea involuta
	Japan, Ryukyus, Iriomote Isl., Takana	GK14474	*Ipomoea pes-caprae*
		GK14475	*Vitex rotundifolia*
		GK14476	*Canavalia lineata*
	Japan, Ryukyus, Yonaguni Isl., Higawa.	GK14043	*Gymnosporia diversifolia* Maxim. (Celastraceae)
			Scaevola taccada
C. pergracilis	Japan, Ryukyus, Izena Isl., population 1.	GK6483	*Aristida takeoi* Ohwi (Poaceae)
		GK6553	*Aristida takeoi*
	Japan, Ryukyus, Izena Isl., population 2.	GK12212	*Rhynchospora rubra* (Lour.) Makino (Cyperacea)
	Japan, Ryukyus, Izena Isl., population 3.	GK12195	*Aristida takeoi*
			Rhynchospora rubra
		GK12197	*Rhynchospora rubra*

For *C. filiformis*, 26 vascular plant species of 17 families, including one pteridophyte, six monocots (three families), and 19 dicots (13 families), were recognized as host plants (Table 2). The host plants included not only native species but also naturalized species, namely *Bidens pilosa* L. var. *minor* (Blume) Sherff and var. *radiata* Sch. Bip. (Asteraceae), and *Casuarina stricta* Ait. (Casuarinaceae). Among the host species of *C. filiformis*, *Ipomoea pes-caprae* (L.) Sweet (Convolvulaceae; Fig. 2A) had the highest frequency of observation (seven records), followed by *Thuarea involuta* (G. Forst.) R. Br. ex Sm. (Poaceae; six records; Fig. 2B), *Scaevola taccada* (Gaertn.) Roxb. (Goodeniaceae; four records), *Bidens pilosa* var. *minor* (four records), *Ischaemum aristatum* L. (Poaceae; three records), *Pandanus odoratissimus* L.f. (Pandanaceae; three records; Fig. 2C), *Zanthoxylum beecheyanum* K.Koch var. *alatum* (Nakai) H. Hara (Rutaceae; three records), and *Vitex rotundifolia* L.f. (Verbenaceae; three records) (Table 2). These eight host plants are abundant on sandy beaches, rocky seaside slopes, and grasslands in the Ryukyus. The other 18 species (e.g., *Melanthera biflora* (L.) Wild; Table 2), which were observed less often, are less abundant on sandy beaches compared to the above species (e.g., Okuda,1989).

For *C. pergracilis*, two monocotyledonous species were recognized as host species: *Aristida takeoi* Ohwi (Poaceae; three records; Fig. 2E) and *Rhynchospora rubra* (Lour.) Makino (Cyperaceae; three records; Fig. 2F). *Aristida takeoi* is endemic to the central Ryukyus (Hatusima, 1975), and *R. rubra* is widely distributed from Japan to Australia (Hatusima, 1975). Parasitism of *A. takeoi* by *C. pergracilis* has been previously reported by Hatusima (1971) and Yokota and Shinzato (2006), but this is the first record of *R. rubra* as a host species for *C. pergracilis*. We also confirmed the occurrence of several other grass and sedge species in the same habitat on Izena Island that were not parasitized by *C. pergracilis*. The observed Poaceae species were *Apludamutica* L., *Eriachne armittii* F. Muell. and *Miscanthus sinensis* Anderss; and the Cyperaceae species observed were *Gahnia tristis* Nees, *Cyperus polystachyos* Rottb., *Schoenus calostachyus* (R.Br.) Poir. and *Scleria levis* Retz. These results suggest that *C. pergracilis* does not parasitize all Cyperaceae and Poaceae species.

High host specificity has been reported in some parasitic plants. For example, *Rafflesia* species (Rafflesiaceae) specifically parasitize only one or two of ca. 95 *Tetrastigma* species (Vitaceae) in Southeast Asia (Nais, 2001). In contrast, it has been thought that most *Cassytha* species generally do not have high host specificity (Weber, 1981; Heide-Jorgensen, 2008). This

Table 2. Summary of host plants of two *Cassytha* species

Parasitic species	Host plant		Frequency of observation
	Family	Species	
C. filiformis	Convolvulaceae	*Ipomoea pes-caprae*	7
	Poaceae	*Thuarea involuta*	6
	Asteraceae	*Bidens pilosa* var. *minor*	4
	Goodeniaceae	*Scaevola taccada*	4
	Poaceae	*Ischaemum aristatum*	3
	Pandanaceae	*Pandanus odoratissimus*	3
	Rutaceae	*Zanthoxylum beecheyanum* var. *alatum*	3
	Verbenaceae	*Vitex rotundifolia*	3
	Apiaceae	*Peucedanum japonicum* var. *japonicum*	2
	Asteraceae	*Melanthera biflora*	2
	Fabaceae	*Canavalia lineata*	2
	Casuarinaceae	*Casuarina stricta*	2
	Myrsinaceae	*Lysimachia mauritiana*	2
	Sapindaceae	*Dodonaea viscosa*	2
	Poaceae	*Spinifex littoreus*	1
	Smilacaceae	*Heterosmilax japonica*	1
	Poaceae	*Zoysia pacifica*	1
	Asteraceae	*Bidens pilosa* var. *radiata*	1
	Asteraceae	*Chrysanthemum crassum*	1
	Celastraceae	*Gymnosporia diversifolia*	1
	Euphorbiaceae	*Breynia vitis-idaea*	1
	Euphorbiaceae	*Chamaesyce atoto*	1
	Fabaceae	*Vigna marina*	1
	Gleicheniaceae	*Dicranopteris linearis*	1
	Lauraceae	*Cinnamomum doederleinii*	1
	Verbenaceae	*Clerodendrum inerme*	1
C. pergracilis	Cyperaceae	*Rhynchospora rubra*	3
	Poaceae	*Aristida takeoi*	3

study revealed a wide-range of host specificity in *C. filiformis*, but much greater host specificity for *C. pergracilis,* unlike most other *Cassytha* species.

High host specificity of Cassytha pergracilis *and its narrow distribution*

The habitat of *C. pergracilis* is restricted to environments characterised by the *Rhynchospora rubra-Aristida takeoi*-Gesellschaftin the Ryukyus (Okada, 1989). The environments are occasionally observed in the Ryukyus, andareprimarily found in some islands of Amami and Okinawa island groups in the central Ryukyus. Therefore we consider that the rarity of these environment allowing and the high habitat specificity of the two host species could be the cause of the narrow distributional range of *C. pergracilis*. *Aristida takeoi* and *R. rubra* also occur on other islands of the central Ryukyus, and it is not clear why *C. pergracilis* is distributed only on Kume-jima and Izena in the central Ryukyus. To clarify this issue, more studies are needed of other possible factors limiting the distribution of *C. pergracilis*, such as chemical properties of soils that may influence the germination of this species.

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Fig. 2. Host plants of two *Cassytha species*. A. *Ipomoea pes-caprae* parasitized by *C. filiformis* (Ishigaki Isl., Ohama; GK6785). B. *Ipomoea pes-caprae* parasitized by *C. filiformis* (Izena Isl.; GK6942). C. *Pandanus odoratissimus* parasitized by *C. filiformis* (Tonaki Isl.; GK13065). D. *Melanthera biflora* parasitized by *C. filiformis* (Tonaki Isl.; GK6526). E. *Aristida takeoi* parasitized by *C. pergracilis* (Izena Isl.; GK6553). F. *Rhynchospora rubra* parasitized by *C. pergracilis* (Izena Isl.; GK12197).

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