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Short Communication

Two mistletoes are too many? Interspecific occurrence of mistletoes on the same host tree

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ABSTRACT

Mistletoe can have a major impact on the fitness of the host plant. If there is more than one species of mistletoe on the same host tree, the overall impact might be amplified. We report the occurrence of more than one species of mistletoe on the same host tree. Although it is not a rule in the field, to our knowledge, there have been no studies of this topic. In most cases, two species of mistletoe were recorded on the same host tree, although we recorded three species of mistletoe on one occasion. This demonstrates that different species of mistletoe can be compatible with the same host species. Therefore, compatibility (structural and physiological) might be an important factor for the occurrence of mistletoe. Recent studies have shown that if the mistletoe does not "recognize" the host species, the deposited seeds will germinate but the haustorium will not penetrate the host branch. This is probably the primary mechanism in the establishment of more than one species of mistletoe on the same host, which can trigger a cascade of harmful effects for the host species.

Key words: parasite-host relationship, compatibility, specificity, parasitic plants, Red Queen hypothesis

The first step toward improving our understanding of mistletoe-host interactions is to determine the pattern of host specificity on various spatial scales (Norton & Carpenter 1998; Blick & Burns 2009, Arruda *et al.* 2012). Empirical data show that some species of mistletoe that locally specialize on certain host species (e.g., *Psittacanthus plagiophyllus* on *Anacardium occidentale* L.; Fadini 2011) are generalists on a regional scale (Caires & Proença 2008). Therefore, changes in mistletoe demographics can be expected on the basis of host compatibility, which ultimately affects the spatial pattern of specificity. In addition, the host ranges of many sympatric species of mistletoe can overlap in a given area, and, ultimately, the same host individual can support more than one species of mistletoe.

Here, we present our observations regarding the occurrence of more than one species of mistletoe on individual host trees of various species in the Brazilian savanna (*cerrado*). Although this is not the norm in the field, there is a lack of data on this subject in the literature and our knowledge of the particularities of mistletoe-host interactions is therefore limited. Mistletoe can have a major impact on the development of host plants (Press & Phoenix 2005, Arruda *et al.* 2009; Mourão *et al.* 2009, Arruda *et al.* 2012). Because mistletoe draws nutrition from its host—either by intercepting the xylem, as is the case for *Struthanthus* spp. (Arruda *et al.* 2006; Mourão *et al.* 2006) and *Psittacanthus* spp. (Fadini *et al.* 2009; Teodoro *et al.* 2010), or by intercepting the phloem, as in the case of *Tristerix* spp. (Martínez del Rio *et al.* 1995; Medel

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et al. 2002)—it can have harmful effects on the host, sometimes even causing the death of the parasitized individual.

Through observations at various sites in the Brazilian *cerrado*, we recorded occurrences of two or more species of mistletoe on the same host individual. The host species and the hemiparasites found on it were recorded, as were the geographic coordinates of the sampled location. Although mistletoe occurs in all regions of Brazil, collection efforts are primarily concentrated in the *cerrado*. This can be explained by the ease in sampling material in the *cerrado* when compared with forest habitats like the Amazon, due to the lower canopy in the *cerrado*, which facilitates the detection of mistletoe. The pertinent mistletoe and host species identified in our study are shown in Tab. 1.

We registered an occurrence of two species of mistletoe on the same host individual in the Salto Magessi Environmentally Protected Area (13°34'39.30"S; 55°15'57.73"W), located in the community of Boa Esperança, 200 km from the city of Sinop, in the state of Mato Grosso, where we found *Psittacanthus acinarius* and *Phoradendron mucronatum* on the same branch of the host species *Aspidosperma* sp.1 (Tab. 1 and Fig. 1A). We also recorded mistletoe individuals in the ironstone outcrops area of the Serra do Rola Moça State Park, located 35 km from the city of Belo Horizonte (20°03'60"S; 44°02'00"W), in the northwestern portion of the Iron Quadrangle, in the state of Minas Gerais. We found *Tripodanthus acutifolius* and *Struthanthus flexicaulis* simultaneously on the host *Mimosa calodendron* (Tab. 1). We made another record at the edge of a forest fragment of tropical semideciduous forest near the city of Lavras (ca. 21°14'43"S; 44°59'59"W), in the state of Minas Gerais. In this record, two *Phoradendron* species (*P. perrottetii* and *Phoradendron* sp.) were found on the host *Tapirira obtusa* (Tab. 1).

We recorded six occurrences of multiple mistletoe species on the same host in the Federal District of Brasília:

Passovia ovata and *Dendrophthora warmingii* on the host species *Vochysia pyramidalis* (ca. 15°31'09"S; 48°01'08"W)

Phoradendron mucronatum and *Passovia ovata* on the host species *Aspidosperma subincanum* (ca. 15°33'05"S; 48°11'07"W)

Phoradendron mucronatum and *Passovia stelis* on the host species *Aspidosperma subincanum* (ca. 15°33'05"S; 48°11'07"W)

Phoradendron tunaeforme and *Phoradendron andersonii* on the host species *Myrcia tomentosa* (ca. 15°56'08"S; 47°58'09"W)

Phoradendron apiciflorum and *Phoradendron mucronatum* on the host species *Senegalia polyphylla* (ca. 15°31'09"S; 48°06'07"W)

Phoradendron crassifolium, Dendrophthora warmingii and *Phoradendron strongyloclados* on the host species *Miconia ferruginata* (ca. 15°30'07"S; 48°10'08"W)

We registered three occurrences in the state of Mato Grosso do Sul:

Psittacanthus acinarius and *Phoradendron affine* on the host species *Guazuma ulmifolia* (ca. 20°13'57"S, 56°28'59"W)

Psittacanthus cordatus and *Phoradendron bathyoryctum* on the host species *Anadenanthera* sp.1 (ca. 20°14'25"S; 56°23'39"W)

Psittacanthus cordatus and *Psittacanthus acinarius* on an unidentified species of the family Malpighiaceae (ca. 20°14'51"S; 56°22'56"W)

In the state of Mato Grosso, we recorded the joint occurrence of *Oryctanthus florulentus* and *Passovia pyrifolia* on the host species *Citrus* sp.1 (ca. 09°14'02"S; 56°59'24"W). In the community of Cáceres, also in the state of Mato Grosso, *Psittacanthus acinarius* and *Struthanthus* sp. were recorded on the host *Triplaris* sp. (Fig. 1B), although the geographic coordinates of the location were not recorded.

To our knowledge, this is the first study to present records of multiple species of mistletoe on the same host individual. Most of the cases involved the simultaneous occurrence of two species of mistletoe, although three species of mistletoe were involved on one occasion. The activity of these hemiparasites can have harmful effects on the host, including changes to the anatomy, physiology and behavior of the host, as well as altering their role in the community (Press & Phoenix 2005; Wood *et al.* 2007; Arruda *et al.* 2009; Mourão *et al.* 2009; Cuevas-Reyes *et al.* 2011; Milanello do Amaral & Ceccantini 2011; Arruda *et al.* 2012). Recent results show that mistletoe can affect the reproductive success of its host, because parasitized individuals produce less fruit and present reduced seed weight (Mourão *et al.* 2009). In addition to the physiological effects, significant host mortality has been observed (Mourão *et al.* 2009; Teodoro 2010). Mistletoe drains water from its host, the former having high rates of transpiration, which might be related to the increased availability of nutrients, provided by the host (Glatzel & Geils 2009). At lower mistletoe densities, it is unlikely that mortality will occur, because there is no competition for water and nutrients between the mistletoe and the host. However, a higher density of a given species of mistletoe, or even increased density due to the occurrence of more than one mistletoe species, can be expected to diminish the fitness of the host individual, which may be reflected in both the competitive and reproductive ability of the hosts.

In parasite-host relationships, the Red Queen hypothesis proposes that parasites affect certain genotypes of the hosts and, because the hosts can make rapid evolutionary adjustments, sexual reproduction in hosts would guarantee that future generations become resistant to parasites (Van Valen 1973). If the presence of only one species of mistletoe can cause deleterious effects in various biological attributes of hosts, the synergistic effects of two or more species can increase the scale of negative impacts on the host. Therefore, multiple species of mistletoe could break the co-evolutionary cycle predicted by the Red Queen hypothesis and, in

Table 1. Host species found to harbor more than one species of mistletoe in the Brazilian *cerrado*. To minimize spelling errors and problems related to synonymy, plant species data were verified with the web tool Plantminer (Carvalho *et al.* 2010).

Host	Mistletoe species																
	Loranthaceae							Viscaceae									
	Tripodanthus acutifolius (Ruiz & Pav.) Tiegh.	*Struthanthus flexicaulis* (Mart. ex Schult. f.) Mart.	*Psittacanthus cordatus* (Hoffmanns. ex Schult. f.) Blume	*Psittacanthus acinarius* (Mart.) Mart.	*Passovia stelis* (L.) Kuijt	*Passovia ovata* (Pohl ex DC.) Tiegh.	*Oryctanthus florulentus* (Rich.) Tiegh.	*Phoradendron* Nutt. sp.1	*Phoradendron tunaeforme* (DC.) Eichler	*Phoradendron strongyloclados* Eichler	*Phoradendron perrottetii* (DC.) Eichler	*Phoradendron mucronatum* (DC.) Krug & Urb.	*Phoradendron crassifolium* (Pohl ex DC.) Eichler	*Phoradendron bathyoryctum* Eichler	*Phoradendron apiciflorum* Rizzini	*Phoradendron andersonii* Rizzini	*Phoradendron affine* (Pohl ex DC.) Engl. & K. Krause	*Dendrophthora warmingii* (Eichler) Kuijt
Family																	
Species																	
Anacardiaceae																	
Tapirira obtusa (Benth.) J.D.Mitch.								X			X						
Apocynaceae																	
Aspidosperma subincanum Mart. ex A.DC.						X						X					
Aspidosperma Mart. & Zucc. sp.1				X								X					
Fabaceae																	
Mimosa calodendron Mart.	X	X															
Senegalia polyphylla (DC.) Britton & Rose												X			X		
Anadenanthera Speg. sp.1			X											X			
Malpighiaceae																	
Malpighiaceae sp.1			X	X													
Malvaceae																	
Guazuma ulmifolia Lam.				X												X	
Melastomataceae																	
Miconia ferruginata DC.										X			X				X
Myrtaceae																	
Myrcia tomentosa (Aubl.) DC.									X							X	
Rutaceae																	
Citrus L. sp.1					X		X										
Vochysiaceae																	
Vochysia pyramidalis Mart.						X											X

the long term, increase the mortality of the host species or add a new host in the range of potential hosts of a particular species of mistletoe. However, compared with traditional parasite-host relationships, the mistletoe-host interaction does not yet have any clear general patterns in Brazil, where the collection effort for this group is still incipient (Arruda *et al.* 2009; Arruda *et al.* 2012; Fadini, Caires & Arruda, unpublished data).

The occurrence of mistletoe species can be determined by their compatibility with their hosts. If any one species of host is compatible with more than one species of mistletoe, the tendency would be to increase the density at the local level (individual host) and at the regional level (host species). Our results show that various host species support more than one species of mistletoe, suggesting that, if we increase the sampling effort, we will find more examples of multiple mis-

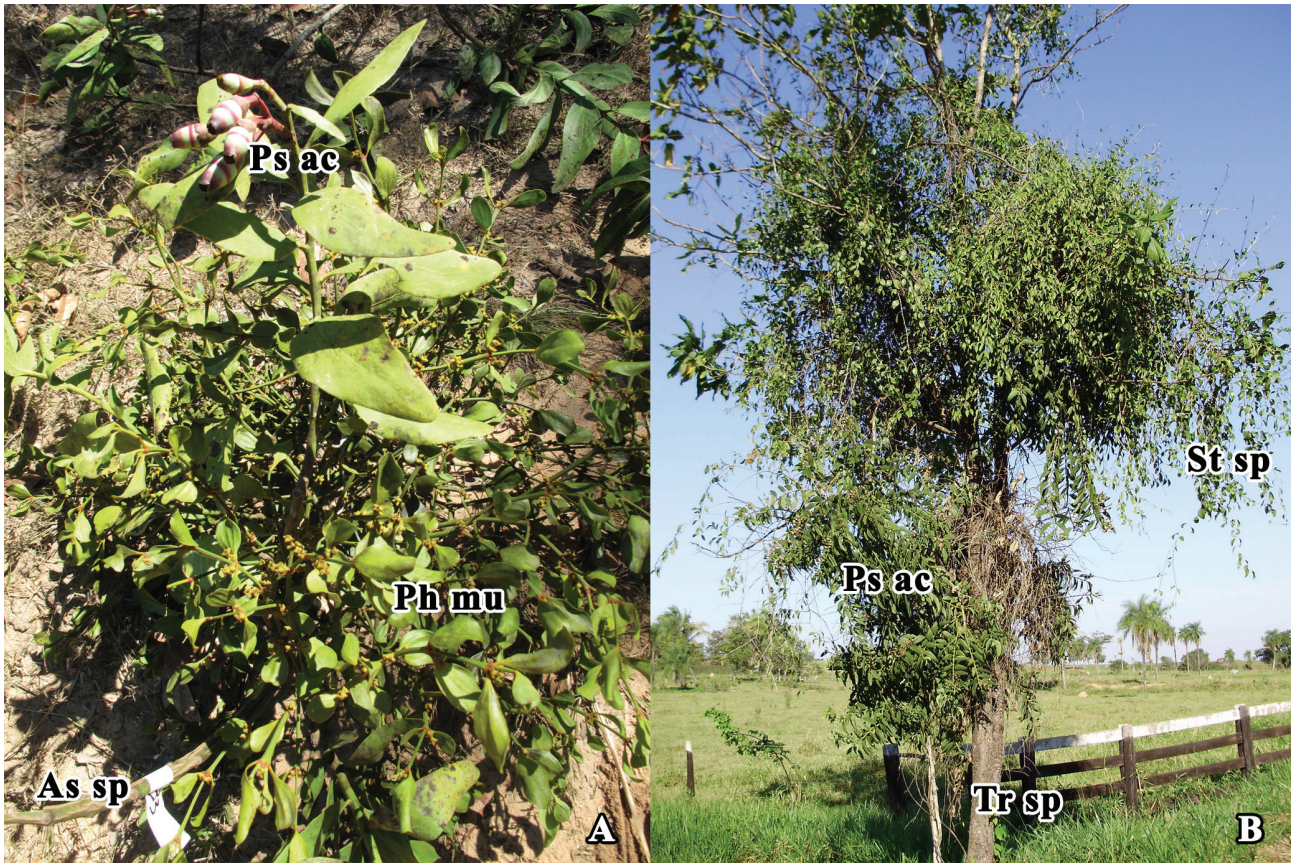

Figure 1. Examples of the occurrence of multiple mistletoe species on the same host in the Brazilian *cerrado*. A. *Psittacanthus acinarius* (Ps ac) and *Phoradendron mucronatum* (Ph mu) found on the same branch of the host species *Aspidosperma* sp.1 (As sp). B. *Psittacanthus acinarius* (Ps ac) and *Struthanthus* sp (St sp) found on the host *Triplaris* sp (Tr sp).

tletoe species sharing a host tree (Arruda & Carvalho 2004; Arruda *et al.* 2006; Mourão *et al.* 2006; Caires & Proença 2008; Fadini 2011; Arruda *et al.* 2012). Consequently, compatibility (structural and physiological) is perhaps an important factor for the occurrence of multiple mistletoe species on a single host. This is probably the primary mechanism that favors the establishment of more than one species of mistletoe and also determines the degree of specificity, which can trigger a cascade of harmful effects for the host species, such as reduced reproductive fitness and increased mortality.

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