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CONSERVATION STATUS OF THE MADEIRA ISLAND ENDEMIC SPECIES *TEUCRIUM ABUTILOIDES* L'HÈR. (LAMIACEAE)

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With 5 figures and 5 tables

ABSTRACT. The genus *Teucrium* L. is represented in the island of Madeira by 4 species, namely *T. heterophyllum* susbp. *heterophyllum*, *T. abutiloides*, *T. betonicum*, and the recently described *T. francoi*. *T. abutiloides* is the only single species classified under the IUCN categories as CR and needing for a specific recovery plan. Despite of the existing legal instruments that protect natural habitats and plants from human threats, *T. abutiloides* populations are not being able to self recover. This study aims to improve knowledge on geographical distribution and extension of occurrence; habitat; ecology; threats; number, structure and population size. It is expected that data brought here will contribute to better develop a conservation strategy enabling self preservation of this species.

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Field work confirms this species presence in only 4 out of 9 historical sites. Only single individuals were known at each one of these sites. However, field work showed the existence of 8 additional populations. Moreover, two new sites were recorded for the presence of *T. abutiloides* in which 3 populations were observed.

A set of threats affecting the survival of populations in the wild explains the reduction of this species range and area of occupancy. A major threat to habitat integrity and population dynamics are invasive plant species, and in a lesser extent works of management and vegetation cleaning along levadas and paths, and but also pedestrian ecological tourism. Landslides and vegetation dynamics, in ravines and opens canopy areas, respectively, are natural factors that increases the risk of survival extinction.

Control of invasive species and habitat recovery should be considered as primary conservation actions. On the other hand, isolated individuals should be looked at for reinforcements that must be conducted in the short term before extinction occurs with associated loss of genetic variability at the species level.

A number less than 50 adult individuals of *T. abutiloides* meets the IUCN criterion D for classifying this species as critically endangered – CR.

Key words: Madeira, Macaronesia, *Teucrium*, conservation.

RESUMO. O género *Teucrium* L. encontra-se representado na ilha da Madeira por 4 espécies, nomeadamente *T. heterophyllum* susbp. *heterophyllum*, *T. abutiloides*, *T. betonicum*, e a recentemente descrita *T. francoi*. A espécie *T. abutiloides* é a única classificada sob as categorias da IUCN como CR e a necessitar de um plano de recuperação. Apesar da existência dos instrumentos legais que protegem habitats e espécies vegetais de ameaças de origem antrópica, as populações de *T. abutiloides* não tem apresentado quaisquer sinais de recuperação. Este estudo pretende melhorar o conhecimento da distribuição geográfica e extensão da ocorrência desta espécie; habitat; ecologia; ameaças; número, estrutura e tamanho populacional. É esperado que os dados apresentados contribuam para desenvolver uma estratégia de conservação adequada que permita a autosustentação desta espécie.

O trabalho de campo confirma a presença desta espécie em 4 dos 9 locais históricos. Apesar de serem conhecidos apenas indivíduos isolados em cada um destes locais, o trabalho de campo demonstrou a existência de 8 populações adicionais. Por outro lado, foram identificados 2 novos locais nos quais foram observadas 3 populações de *T. abutiloides*.

O conjunto de factores que ameaçam a sobrevivência das populações desta espécie na natureza poderão explicar a redução da extensão de ocorrência desta espécie bem como da sua área de ocupação. A principal ameaça à integridade do habitat e à dinâmica das populações advém das espécies invasoras, e em menor grau da manutenção de levadas e caminhos pedestres, e do turismo ecológico pedestre. As derrocadas e a dinâmica da vegetação características de ravinas e áreas de canópia aberta, constituem factores naturais de risco que afectam a sobrevivência desta espécie.

O controlo das espécies invasoras e a recuperação do habitat devem ser considerados como acções de conservação prioritárias. Em simultâneo, deve ser ponderada a realização de acções de reforço populacional nas populações com indivíduos isolados para evitar a curto prazo a extinção e perda de diversidade genética ao nível da espécie.

O número de indivíduos adultos inferior a 50 determina que esta espécie seja classificada de acordo com o critério D da IUCN como criticamente ameaçada – CR.

Palavras-chave: Madeira, Macaronésia, *Teucrium*, conservação.

INTRODUCTION

The genus *Teucrium* L. is represented in the island of Madeira by 4 species, namely *T. heterophyllum* L'Hér. susbp. *heterophyllum*, *T. abutiloides* L'Hér., *T. betonicum* L'Hér., and the recently described *T. francoi* M. Seq., Capelo, J. C. Costa & R. Jardim (= *T. scorodonia* sensu auct. mad., non L.). The first 3 species are included in the Madeira and Canary Islands endemic section *Teucriopsis* Benth., and the fourth one is included in section *Scorodonia*. *T. heterophyllum* is endemic to Madeira and the Canary Islands, and the remaining taxa are endemic to Madeira (Sequeira *et al.*, 2008; Press & Short, 1994).

The conservation status of *Teucrium* in Madeira, as defined by IUCN (2001) varies from non-threatened to critically-endangered. In this matter, *T. abutiloides* is the only single species that falls clearly under the latter category of threat by meeting the criterion of less than 50 adult individuals in the wild (Jardim *et al.*, 2006; Sequeira *et al.*, 2008). Futhermore, this is the only species in need for a specific plan that would enable it to recover from the present situation of very high risk of extinction (Jardim *et al.*, 2006). More recently, *T. abutiloides* was included in the top 100 macaronesian endangered species prioritised for management based on its category of threat, effort needed for conservation and management as well as for its social importance, among other criteria (Martín *et al.*, 2008).

T. abutiloides is a shrub up to 1.5 m, pubescent or villous, leaves ovate-cordate, crenate to serrate, and villous; flowers brownish-orange and grouped in dense inflorescences (Press & Short, 1994). Its populations are highly dispersed and fragmented within laurel forest in the north of the island of Madeira (Jardim & J. A. Carvalho, 2008).

T. abutiloides and its natural habitat are under European and pan-European protective scope of the Directive Habitats and the Convention on Wild Life and Natural Habitats in Europe (Bern Convention), respectively. Moreover, the international recognition by UNESCO of madeiran laurel forest ('Laurissilva da Madeira') as Natural World Heritage increases the responsibility of local authorities for protection and conservation of laurel forest ecosystem and species such as *T. abutiloides*. At the regional level there are several legal instruments directed towards the protection and implementation of conservation actions, namely the classification of areas of laurel forest as natural park and forest reserves, but also legislation that protects plants and habitats outside those areas. Despite of the existing legislation and protection measures to natural habitats and plants, populations of *T. abutiloides* are not being able to self recover.

This study aims to improve the knowledge on geographical distribution and extension of occurrence; habitat; ecology; threats; population size, number and structure of *T. abutiloides*. It is expected that the data brought here will contribute to better develop a conservation strategy that will enable the self preservation of this species.

MATERIALS AND METHODS

The location of most *T. abutiloides* natural populations was already known by the authors of this paper. However, other locations were obtained through personal communication by different authors (F. Fernandes, *pers. com.*; O. Baeta, *pers. com.*) and from existing information in herbarium specimens held in MADJ.

The field work was conducted during 2008, in the flowering and fruiting season, making possible the evaluation of seed production per plant.

The evaluation of seed production was conducted only in populations with adult individuals. The largest plant in each population studied was chosen. From this set of largest plants, the biggest and the smallest one were chosen; the number of inflorescences counted; on each plant a medium size inflorescence was chosen and the number of flowers counted; 5 flowers were chosen randomly on each inflorescence and the number of capsules counted; in each capsule the number of seeds was counted. The maximum and minimum values for seeds per plant presented in this study were obtained.

The most aggressive invasive species affecting the survival of each population of *T. abutiloides* were recorded and classified according to their degree of influence in the habitat

and on the species. A minimum of presence and influence was given a plus (+); a maximum of presence and influence was given four plus (++++). Intermediate degrees of presence and influence were given an intermediate number of plus (+), *i. e*. (++) and (+++).

In order to specicify location of populations of *T. abutiloides* we used the Universal Transverse Mercator (UTM) coordinate system which is a grid-based method of specifying locations on the surface of the Earth. UTM coordinates for herbarium specimens were obtained with approximation by consulting a military map of Portugal. Geographical coordinates for populations visited in the field were obtained using a GPS 60CSx GARMINI. In this paper we have chosen to present populations' cartographic information using a U. T. M. grid of 2 km^2 to keep confidentiality on their precise location.

RESULTS

This species has its populations recorded within the Natural Park of Madeira (Figs. 1 and 2), but outside the limits of forest reserves. The area of occurrence and species range for historical sites was 18 km^2 and 162.87 km^2 respectively (Fig. 1). The area of occurrence and species range for present day distribution is 18 km^2 and 108.61 km^2, respectively (Fig. 2).

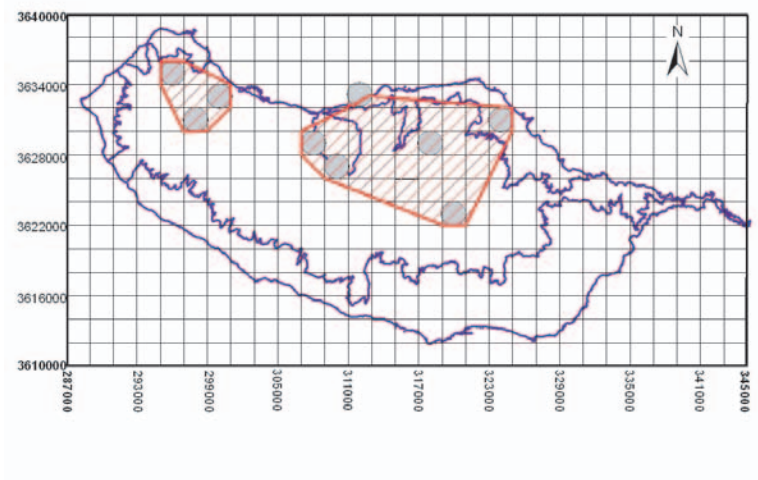

Fig. 1 - Geographical distribution and range of herbarium specimens of *T. abutiloides* held in MADJ (Jardim Botânico da Madeira) on the island of Madeira using a U. T. M. 2 km^2 grid. Inner outline refers to natural park bounderies.

Herbarium specimens

Range

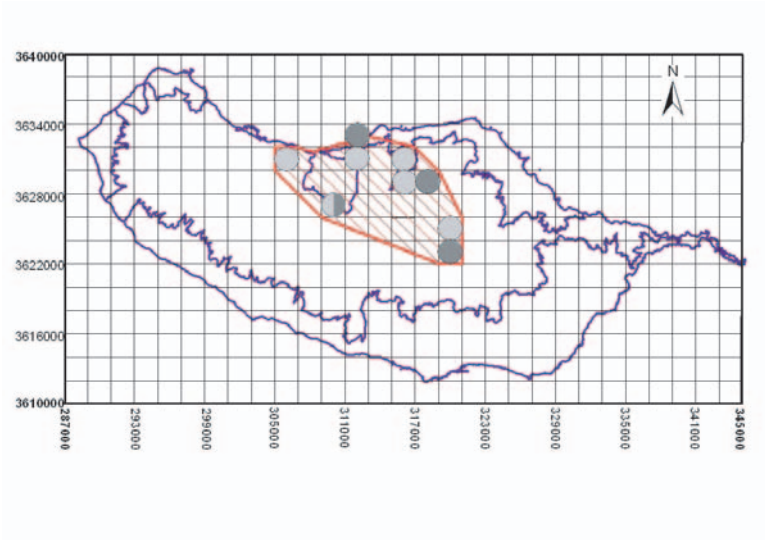

Fig. 2 - Present day geographical distribution and range of *T. abutiloides* on the island of Madeira using a U. T. M. 2 km^2 grid. Inner outline refers to natural park bounderies.

Herbarium locations confirmed

New populations

Range

Field work showed the presence of *T. abutiloides* in 6 sites (Table 1). This species presence is confirmed only in 4 sites out of 9 sites recorded in the herbarium MADJ (Table 2). Historically, only single individuals were known at each one of these sites. However, field work showed the existence of 8 additional populations on confirmed historical sites (Table 3). Moreover, two new sites were recorded for presence of *T. abutiloides* (Table 1) in which 3 populations were observed (Table 3).

The four historical populations visited during the field work counted for 4 plants, of which 2 adults and 2 young individuals. The 11 new populations counted for 93 plants, of which 18 adults, 41 young individuals and 34 seedlings. The total number of populations observed is 15, with 97 plants, of which 20 adults, 43 young individuals and 34 seedlings (Table 3).

Habitat

T. abutiloides grows typically in the laurel forest on the north of the island of Madeira, between 400 and 1000 m a. s. l.. Populations occur preferably nearby small water

streams, levadas, and small ravines (Fig. 3). These habitats are open canopy areas within laurel forest with a set of plant species (Table 4) characteristic of two vegetation types, *i. e*. *Rhamno glandulosi-Sambucetum lanceolati* Rivas-Martinez, Capelo, J. C. Costa, Jardim, Sequeira, Aguiar, Fontinha & Lousã (Capelo *et al*., 2003) e *Diplazio caudati-Perseetum indici* Jardim, Sequeira, Capelo, J. C. Costa, Aguiar & Lousã (Capelo *et al.*, 2003). Both vegetation types are humid to hyper humid woods with high water soil content (Costa *et al.*, 2004).

Fig. 3 - Plant of *Teucrium abutiloides*.

Reproduction

This species flowers from April to June and produces seeds from July to October. Each capsule holds 4 seeds; each inflorescence holds in average 50 capsules, *i. e*. 200 seeds per inflorescence; each plant holds 6 to 8 inflorescences, which gives an estimation of 1,200 to 1,600 seeds per plant per year.

Invasive species

T. abutoloides populations are mostly threatened by three invasive species (Figs. 4 and 5), namely *Rubus* sp., *Hedychium gardnerianum* e *Fuchsia arborescens* (Table 5).

TABLE 1 - Location of new populations of *T. abutiloides* in historical sites (MADJ herbarium) and in new sites (*), dates of observation and U. T. M. coordinates.

GENERAL SITE NAME (MADJ HERBARIUM)	**SPECIFIC SITE NAME**	**DATE**	**U.T.M.[1]**	***CONCELHO***	***FREGUESIA***
-	Levada da Achada Grande (*)	05-03-08	CB1528	São Vicente	Boaventura
Fajã do Penedo	Levada dos Tornos	07-03-08	CB1529	São Vicente	Boaventura
Abaixo do Chão dos Louros	Cova do Lanço	11-03-08	CB0926	São Vicente	S. Vicente
Lombada da Ponta Delgada	Vereda do Pombo da Rocha	18-03-08	CB1132	São Vicente	Ponta Delgada
Fajã da Nogueira	Levada da Serra do Faial	28-03-08	CB1924	Santana	São Roque do Faial
-	Montado dos Pessegueiros (*)	26-10-08	CB0530	Porto Moniz	Seixal

[1] CB and BB refers to the 100 000 km square identified by numeral 3 and 2, respectively, i.e. the first numeral in U.T.M. horizontal geographical coordinates shown in Figures 1 and 2.

TABLE 2 - Data on herbarium specimens, namely location, herbarium number, dates of collection and *in situ* confirmation for the presence of *T. abutiloides* obtained during field work in 2008.

HERBARIUM No.	SITE	DATE	U.T.M. [1]	*CONCELHO*	*FREGUESIA*	*IN SITU* OBSERVATION		
						DATE	YES	NO
4717	Fajã do Penedo	13-06-1957	CB1728	São Vicente	Boaventura	09-01-08	√	
7418	Santana	07-06-1962	CB2330	Santana	Santana	17-01-08		√
4725	Abaixo do Chão dos Louros	13-06-1963	CB0928	São Vicente	São Vicente	09-11-07	√	
4721	Levada da Central Ribeira da Janela	28-06-1984	BB9534	Porto Moniz	Santa	22-01-08		√
4722	Galhano	19-08-1986	BB9730	Calheta	Fajã da Ovelha	14-03-08		√
4723	Levada da Fajã d'Ama	26-08-1986	CB0728	São Vicente	São Vicente	29-01-08		√
4724	Lombada da Ponta Delgada	28-04-1987	CB1132	São Vicente	Ponta Delgada	07-02-08	√	
4726	Ribeira Funda	30-06-1987	BB9932	Porto Moniz	Seixal	12-02-08		√
9937	Fajã da Nogueira	15-05-1993	CB1922	Santana	São Roque do Faial	14-11-07	√	

[1] CB and BB refers to the 100 000 km square identified by numeral 3 and 2, respectively, i.e. the first numeral in U.T.M. horizontal geographical coordinates shown in Figures 1 and 2.

TABLE 3 - Number of historical and new populations, number of historical and new sites (*), dates of observation, number of individuals, and population structure of *T. abutiloides* obtained during field work in 2008.

	SITE	DATE	NO. POP.	NO. INDIV.	ADULT PLANTS	YOUNG PLANTS	SEEDLINGS
HISTORICAL	Fajã do Penedo	09-01-08	1	1	0	1	0
POPULATIONS	Abaixo dos Chão dos Louros	09-11-07	1	1	1	0	0
(MADJ	Lombada da Ponta Delgada	01-02-08	1	1	1	0	0
HERBARIUM)	Levada da Fajã da Nogueira	12-02-08	1	1	0	1	0
	TOTAL		**4**	**4**	**2**	**2**	**0**
NEW	Levada da Achada Grande (*)	05-03-08	2	53	9	14	30
POPULATIONS	Fajã do Penedo (Levada dos Tornos)	07-03-08	1	2	0	2	0
	Abaixo do Chão dos Louros (Cova do Lanço)	11-03-08	2	20	4	12	4
	Lombada da Ponta Delgada (Vereda do Pombo da Rocha)	18-03-08	1	10	3	7	0
	Levada da Fajã da Nogueira (Levada da Serra do Faial)	28-03-08	4	7	2	5	0
	Montado dos Pessegueiros (*)	26-10-08	1	1	0	1	0
	TOTAL		**11**	**93**	**18**	**41**	**34**
TOTAL			**15**	**97**	**20**	**43**	**34**

TABLE 4 - Most dominant plant species present in *T. abutiloides*' populations per political-administrative locality.

TAXA	*CONCELHO*		
	Porto Moniz	São Vicente	Santana
Ageratina adenophora (Spreng.) R. King & H. Rob	√	√	
Apollonias barbujana (Cav.) Bornm.	√	√	
Arachniodes webbianum (A. Braun) Schelpe	√	√	
Clethra arborea Aiton		√	
Diplazium caudatum (Cav.) Jermy	√	√	
Euphorbia mellifera Aiton	√	√	√
Geranium palmatum Cav.			√
Hedera maderensis K. Koch		√	
Laurus novocanariensis Rivas-Mart., Lousã, Fern. Prieto, E. Dias, J.C. Costa & C. Aguiar	√	√	√
Myrica faya Aiton	√	√	
Persea indica (L.) K. Spreng.		√	√
Phyllis nobla L.	√		√
Ranunculus cortusifolius Willd.			√
Rubia agostinhoi Dans. & P. Silva		√	
Rubus sp.	√	√	√
Rumex maderensis Lowe		√	√
Sambucus lanceolata R. Br.		√	
Semele androgyna (L.) Kunth	√		√
Sonchus fruticosus L.f.			√

TABLE 5 - Invasive plant species observed in *T. abutiloides*' populations during field work in 2008.

Sites	*Freguesia*	*Concelho*	Taxa		
			Rubus sp.	*Hedychium gardneranum* Sheppard ex Ker Gawl.	*Fuchsia arborescens* Sims
Abaixo do Chão dos Louros (Cova do Lanço)	Rosário	São Vicente	++++		
Fajã da Nogueira (Levada da Serra do Faial)	São Roque do Faial	Santana	+++	+	
Levada da Achada Grande	Boaventura	São Vicente		++++	+
Fajã do Penedo (Levada dos Tornos)	Boaventura	São Vicente		+++	

(++++) maximum influence and presence

(+) minimum influence and presence

Fig. 4 - Habitat of *T. abutiloides* weakly altered by invasive plant species.

Fig. 5 - Habitat of *T. abutiloides* extremely altered by invasive plant species.

DISCUSSION AND CONCLUSIONS

Threats

Our field work confirmed Jardim *et al.* (2006) and Carvalho *et al.* (2008) set of threats affecting the survival of this species in the wild. This work shows the massive presence of invasive species in many populations. Their impact on habitat and populations of *T. abutiloides* seems to indicate the important role this factor might have had in the probable extinction of this species in 5 historical sites. In addition, herbarium records indicate that extinct populations occurred in small ravines or just below them and along levadas, which makes this species also susceptible to natural factors such as landslides as referred by Carvalho *et al.* (2008); and to threats such as works of management and vegetation cleaning, and pedestrian ecological tourism. This species' preference for forest clearings or ephemeral open canopy habitats makes it also vulnerable to an additional natural factor, *i. e*. vegetation dynamics.

These set of threats and natural factors increase the risk and interact negatively in the survival of populations of *T. abutiloides* and could explain the strong reduction of this species range.

Conservation and management

Populations and potential habitat of *T. abutiloides* are under legal protection of a natural park which brings together the necessary conditions for implementing habitat and species directed conservation and management plans.

Conservation actions referred by Carvalho *et al*. (2008) are basically directed towards reintroduction or population reinforcement. However, our data shows that the influence of invasive species on populations and habitat is very high. Therefore, control of invasive species and habitat recovery should be looked at as primary conservation actions for wild populations of this species. Thus, actions of reintroduction or populations reinforcement should be conducted only in face of unsuccessful population' recovery or if populations show evidence of inbreeding depression as a result of isolation. Simultaneously, isolated individuals should be looked at for possible reinforcement actions that must precede extinction and loss of genetic variability at the species level.

On the overall, as referred by Carvalho *et al*. (2008), reduced sized populations may result in a set of genetic processes, *e. g*. inbreeding depression, that act as an additional limiting factor for the recovery of this species.

Conservation status

Herbarium records and present day distribution indicate a decrease in species range that along with severely fragmented populations and isolated individuals puts this species in the fringe of meeting the IUCN criterion B (2001) for critically endangered. On the other hand, and despite of the increase of known populations and individuals in the wild, the number of adult individuals is still below 50. This number of adult individuals of *T. abutiloides* meets the IUCN criterion D (2001) for critically endangered, *i. e*. a species that faces still a very high risk of extinction in the wild.

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