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FIRST REPORT OF BRANCHED BROOMRAPE (*PHELIPANCHE RAMOSA* (L.) POMEL) IN RAPESEED (*BRASSICA NAPUS* L.) IN TURKEY

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ABSTRACT

Branched broomrape (*Phelipanche ramosa* (L.) Pomel) is a non-photosynthetic weed that is harmful to many crops around the world and difficult to control. The species was found in some rapeseed (*Brassica napus* L.) fields in the Marmara region, Turkey. A survey was conducted, and branched broomrape was recorded on rapeseed roots at density from 5.4 to 28.9 weeds m^{-2}. The average frequency of branched broomrape was estimated up to 25.6% in the rapeseed fields. The invasion of branched broomrape puts a potential threat to many crops grown in the region, as broomrape causes significant losses in crops in Turkey and worldwide. Hence, control measures must be urgently taken in the study area to prevent the spread of branched broomrape.

KEYWORDS:
Rapeseed, Survey, Density, Frequency Branched broomrape, Turkey.

INTRODUCTION

Invasive species can be harmful by reducing or destroying the diversity of species found in natural vegetation [1, 2]. For example, invasive species affect the nutrient cycle in vegetation with different nutrient acquisition strategies, nutrient uptake and release, and higher nutritional efficiency than native plants. For this reason, it was determined that the invasive species affect their nutrient cycle and their effects on soil processes [2]. One of the most important factors causing global warming and climate change is increase in the amount of CO_2. This factor accelerates the invasive species becoming dominant species in natural and agricultural ecosystems [3]. Therefore, it is predicted that the spread of invasive weed species will continue to increase due to climate changes. Climate change is likely to impact on parasitic plants both through direct effects on the parasite, as well as via indirect effects on the host. Given the central role that parasitic plants can play in mediating community structure and ecosystem functioning [4].

A single individual invasive parasite can affect a large part of the ecosystem due to the multiplicity of host plants. Primarily, Impacts on community presence can also be great. Impacts on host performance change the competitive stability between host species and nonhost species. As a result, the plant community changes. Generally, very heavily parasitized plant species cause non-dominant species to emerge as dominant species in the community [5, 6].

Broomrape species can affect plant communities and ecosystem, especially because of its invasive feature and complete parasite. Broomrape species (*Orobanche* spp. and *Phelipanche* spp.) are holoparasitic flowering plants that are devoid of chlorophyll and completely dependent on their hosts for all nutritional requirements. In nature, interactions between parasitic plants and their hosts begin with the germination of parasites in response to specific chemical signal , the germination stimulants, released by roots of host plants. Generally, broomrape parasitism is harmful and affects many important crops around the world. For example, *Orobanche cumana* Wallr. affects sunflower plants. *Orobanche crenata* Forsk. and *Orobanche foetida* Poir. Inflict legumes. *Phelipanche ramosa* L. Pomel and *Phelipanche aegyptiaca* Pers. affect tomatoes [7].

Notably, The *Orobanche* species were found parasitizing 86 plant species belonging to 24 botanical families. Commpositae (20 species), Solanaceae (11 species), Leguminosae (nine species), Umbelliferae (seven species), Cruciferae (seven species), Cucurbitaceae (four species), Labiatae (four species), and Rosaceae (four species) families were most frequently attacked by *Orobanche* species. Recently, several new hosts have been recorded, including *Prunus armeniaca* L., *Prunus persica* L, *Amygdalus communis* L., *Olea europaea* L. and *Quercus coccifera* L. [8, 9]. In Turkey, 36 species of broomrape have been identified to date [10], but only four species cause significant crop yield losses. Tomato and tobacco are parasitised by *P. ramosa* [11]. Red lentil is parasitised by *Phelipanche aegyptiaca* Pers. [12]. Sunflower is parasitised by *O. cumana* Loefl. [13]. Finally, faba beans are parasitised by *O. crenata* Forsk. [14].

P. ramosa has the widest range of hosts, in-

cluding plants from the Brassicaceae and Solanaceae family as well as legumes [15, 16, 17, 18]. Additionally, *P. ramosa* has caused yield losses of up to 80% in rapeseed crops, which are an important edible oil source. Rapaseed production is one of the important crops for both turkey in the world. Annual worldwide production of rapeseed is approximately 76 million tons [19]. In Turkey, rapeseed production is only around 60,000 tonnes, yet there is great potential for expanding rapeseed production. Rapeseed is an alternative to cereal crops because it can be grown in winter. In particular, the Maramara region accounts for 93% (55,088 tonnes) of rapeseed production in Turkey [20]. The most important problem facing this agricultural crop is weeds and, in particular, the invasion of broomrape transferred from other major crops.

Rapeseed can be grown on an annual or biennial basis [21]. The stalks grow vertically up to 1.5 m tall and are freely branched and sparse. The leaves have a hairless underside and an enlarged base that usually wraps around the stem. The stamens are tetradynamous, with two short and four long stamens in each flower [21, 22, 23].

It is difficult to control broomrape weeds because these weeds produce thousands of small seeds that may remain in the soil for long periods of time and can be easily distributed to new areas. The reduction in crop yield caused by these weeds depends on the crop variety and the severity of the invasion. Yield losses commonly range from 5% to 100%. The average total loss stemming from broomrape species is about 34% [24]. *P. ramosa* causes yield losses in some important crops in Turkey. In this paper, we present the first report of branched broomrape (*P. ramosa*) parasitising rapeseed crops in Turkey.

MATERIALS AND METHODS

This study was carried out mostly in Tekirdağ and Istanbul, two provinces in the Marmara region, where is main area of rapeseed production. A survey was conducted two times in the rapeseed fields during 2016 and 2017. Five districts forming part of the two provinces where rapeseed is intensively cultivated were surveyed. In total, 5% (412.5 ha) of a total area of 8,250 ha was surveyed (Figure 1). This survey were carried out in a total of 56 fields including 16 fields in Silivri and 10 in other districts (Table 1).

Knowledge of the morphology and biology of branched broomrape is important for its identification in the field. It does not contain chlorophyll, has few leaves and is usually branched, with a spike lax and flower calyx formed by triangular teeth that are commonly shorter than the calyx tube (Figure 2c). The corolla can range from white to lavender or purple and is 10–12 mm in size but can grow up to 17 mm (Figure 2b, 2d); the lobes of the lower lip are rounded [10]. Additionally, it has regular flower buds with little variation in the colour and shape of the petals [25]. Its seeds are microscopic and uniform. The colour of the stem is initially light purple, creamy during the first development stage and black or dark brown colour at maturity. Also, *P. ramosa* can be distinguished by its branching. Its stems are yellow-brown in colour, glandular and hairy. Flowers are 15-mm long, two-lipped and tubular; the lower piece is formed by three lobes and the upper piece by two lobes (Figure 2). Its flowers are clustered and shaped as a vertical spike, appearing in the spring and summer [18].

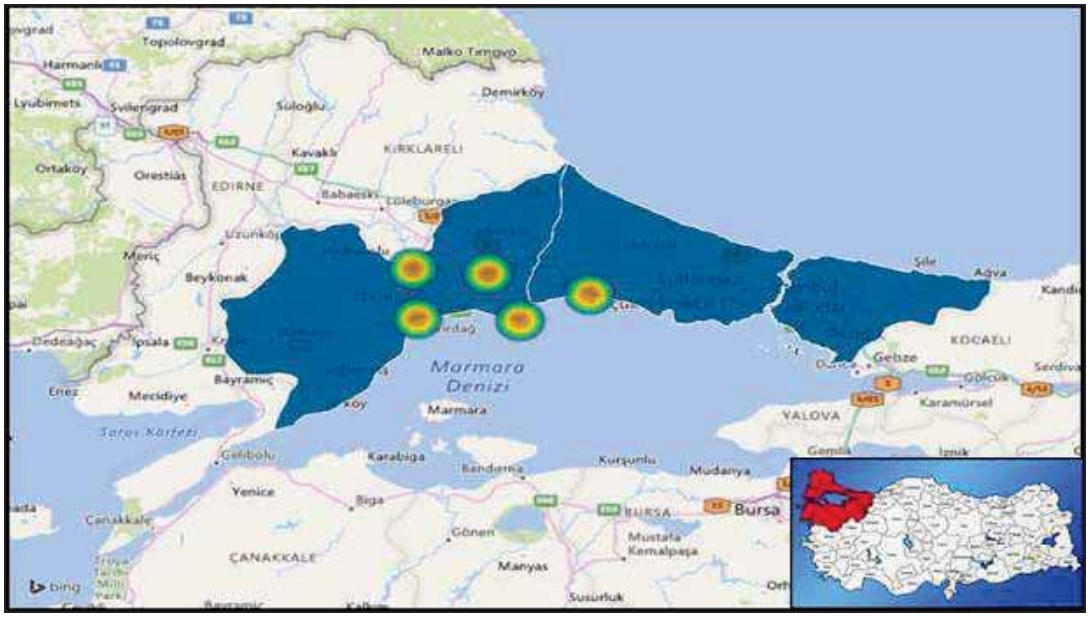

FIGURE 1
Frequency and density of branched broomrape in the surveyed districts of Marmara Region

TABLE 1
Details of the rapaseed zones under study

Year of survey	Rapeseed zone	District	Latitude Longitude Altitude	Min Max Mean temperature (°C)	Number of fields surveyed
2016-2017	Istanbul	Silivri	N 41°04′31.98″	5.4	16
			E 28°14′52.47″	16. 5	
			8 m	10.75	
2016-2017	Tekirdag	Çorlu	N 41°09′21.72″	4.3	10
			E 27°48′49.66″	17.6	
			183 m	13.0	
2016-2017	Tekirdag	Süleymanpaşa	N 40°58′47.11″	8.9	10
			E 27°30′42.56″	16.4	
			51 m	13.7	
2016-2017	Tekirdag	Marmaraereğlisi	N 40°58′18.52″	6.5	10
			E 27°57′11.23″	19.1	
			4 m	14.8	
2016-2017	Tekirdag	Muratlı	N 41°10′19.65″	7.5	10
			E 27°29′40.25″	15.8	
			82 m	15.2	
Total					56

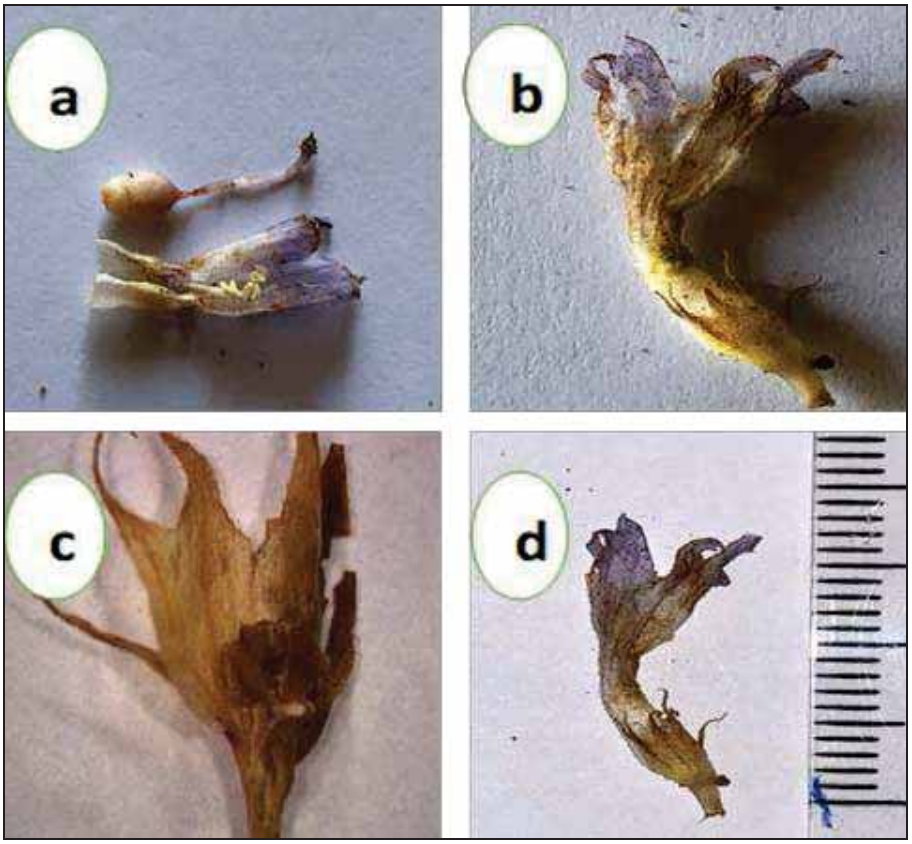

FIGURE 2
branched broomrape stamen and stigma (a), flowers (b, d) and calyx (c).

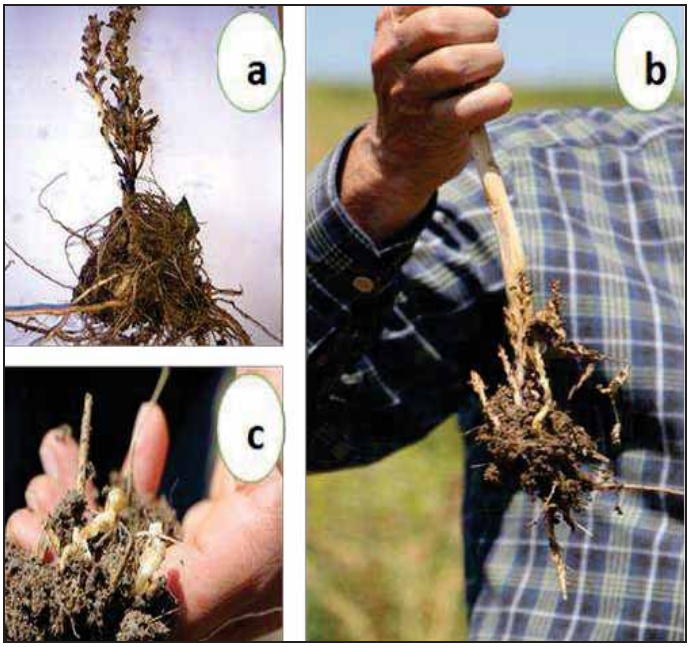

FIGURE 3
Rapeseed roots infested with branched broomrape (a, b, c)

TABLE 2
Frequency and density of branched broomrape (*Phelipanche ramose* (L.) Pomel.) in the Marmara Region, Turkey

Province	District	Rapeseed growing area (ha^{-1})	Survey area (ha^{-1})
Istanbul	Silivri	3200	160.0
Tekirdag	Çorlu	1300	65.0
Tekirdag	Süleymanpaşa	1650	82.5
Tekirdag	Marmaraereğlisi	1400	70.0
Tekirdag	Muratlı	700	35.0
Total		8250	412.5

To confirm that the parasitic plant was attached to the host roots, the encountered rapeseed plants were carefully removed by digging, and the root systems were washed (Figure 3). *Phelipanche ramosa* attachments were then observed.,

To evaluate the degree of infestation of branched broomrape, weed counts were made based on the size of the surveyed rapeseed field. A specific number of frame (1 m^{-2}) was surveyed depending on the size of the rapeseed field: 10, 15, 20 and 25 times were surveyed in rapeseed fields of 0.1–0.5, 0.6–1, 1.1–2 and 2.1+ ha, respectively. The species of broomrape was determined using The Flora of Turkey (volume 7) guide [10].

The frequency of broomrape in the evaluated rapeseed fields was calculated by dividing the number of rapeseed plants infested with branched broomrape by the total number of surveyed rapeseed fields according to Odum [26]. The overall density of branched broomrape (plants m^{-2}) was calculated by dividing the total number of broomrape plants by the total number of frame containing the weed. The data were calculated annually and the averages of two years were used for statistical analysis.

Statistical Analysis Method. SPSS 20 for Windows Standard Version package was used for statistical analysis. One way variance analysis (General Linear Model, Univariate) was used in SPSS 22 package program to determine the differences in control and application groups. For this purpose, Duncan comparison tests were performed at 0.05 significance level [27].

RESULTS

The surveys conducted in 2016 and 2017 confirmed that a branched broomrape infestation had seriously affected rapeseed crops in the Marmara Region of Turkey (Figure 4). Samples were removed from the soil by digging to confirm that rapeseed roots were parasitised (Figure 3).

The broomrape plants in the rapeseed fields of the Marmara Region were identified and confirmed to be branched broomrape (Figure 4). The survey areas determined by the size of rapeseed production fields are shown in Table 2.

When the results obtained from the survey are examined, it was determined that the differences in districts (Sig; 0.000) were significant when the

average weed frequency of all districts were compared statistically. In the same way, it was determined that the differences between weed desities (Sig; 0.000) were significant. As a result of the statistical analysis, when compared to branched broomrape frequency, The frequency of branched broomrape in the silivri district was at least 1.44 times higher than the other districts. The density of branched broomrape in the district of silivri was also 1.4 times higher than in other districts (Table 3).

The average frequency of branched broomrape was 25.6%. Four out of 5 of the districts in the study region were invaded by branched broomrape. The Silivri district had the highest frequency (58.36%) of branched broomrape, followed by the Çorlu (35.23%), Süleymanpaşa (24.36%) and Marmaraereğlisi (10.21%) districts (Figure 5).

TABLE 3
Statistical comparison of frequency and density of branched broomrape (*Phelipanche ramose* (L.) Pomel.) according to districts

Districts	Weed frequency (%)		Weed density (weeds m^{-2})	
Muratlı	0	E	0	C
Marmaraereğlisi	10.21	D	5.48	B
Süleymanpaşa	24.36	C	10.32	BC
Çorlu	35.23	B	14.26	B
Silivri	58.36	A	29.98	A
Sig.		0.000		0.000

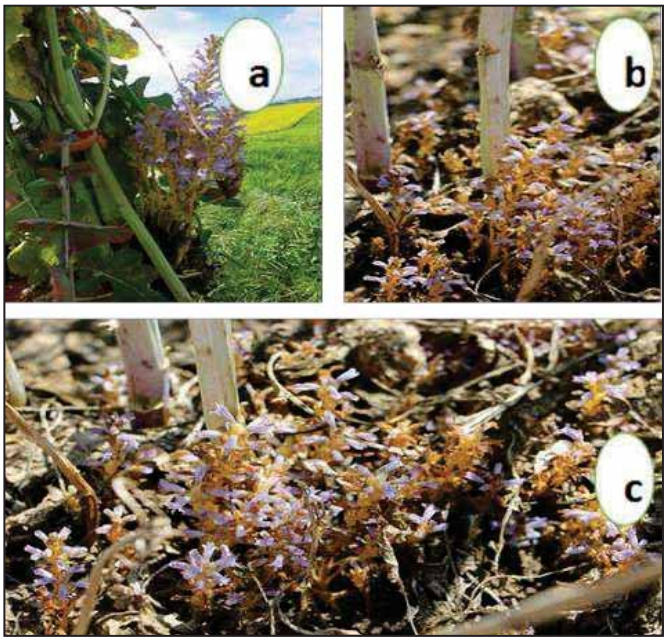

FIGURE 4
Rapeseed infected with branched broomrape (a), *Phelipanche ramosa* flowers (b) branched broomrape in rapeseed field (c)

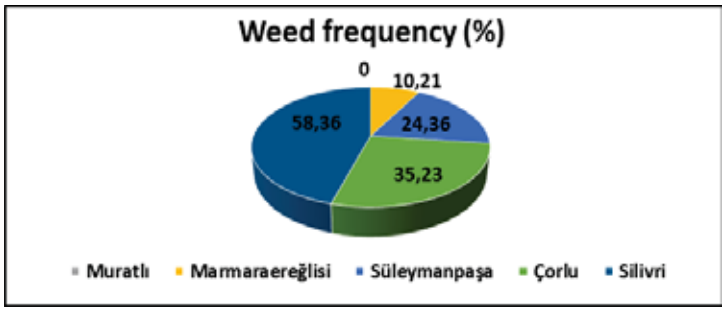

FIGURE 5
The frequency of branched broomrape in districts.

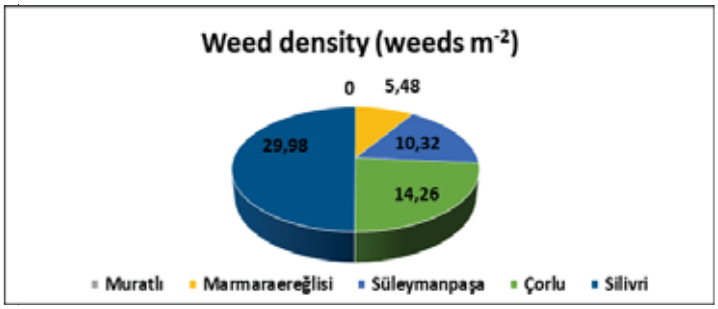

FIGURE 6
The density of branched broomrape in districts.

FIGURE 7
Branched broomrape seeds (The distance between each digit is 1 cm).

The average density of branched broomrape was 11.76 weeds m^{-2} (Figure 6). The most intense infestation of branched broomrape was found in the Silivri district (28.98 weeds m^{-2}) in İstanbul province. The other districts of Çorlu, Marmaraereğlisi and Süleymanpaşa had differing densities of 14.26, 10.32 and 5.48 weeds m^{-2}, respectively (Table 3).

DISCUSSION

According to the results of the survey conducted on 8.5 ha of rapeseed fields, branched broomrapes were present at an average frequency of 26.78% and an average density of 11.76 weeds m^{-2}. Unforunately, the control of this holoparasitic weed is difficult because it produces thousands of tiny seeds that can survive for many years in the ground (Figure 7).

The germination of *P. ramosa* seeds and the penetration of its haustoria in crops only occurs underground, so it is very difficult to detect from outside observation. In addition, the presence of *P. ramosa* parasitism in rapeseed plants can only be identified when *P. ramosa* reaches maturity and a stem emerge from the soil.

Other less obvious symptoms include the slow development of rapeseed plants, leaf chlorosis and low fruit production [28]. Also, by developing on the host roots, the parasite competes with the host plant for water, minerals and sugars. Sometimes, the reduction in host biomass is not fully explained by the parasite biomass [29]. In this latter case, photosynthetic protein distraction probably prevents the host from continuing its normal level of photosynthesis [30].

The present study confirmed that *P. ramosa* infected the roots of rapeseed plants. Thus, this is the first report of *P. ramosa* attached to rapeseed plants in Turkey. It is estimated that the yield losses caused by *P. ramosa* in rapeseed crops range from 40% to 70%. However, if we also consider the effects of crop quality, the results may be even more significant. For example, *P. ramosa* infestation may cause rapeseed plants to produce a low number of seeds. Also, the invasion of broomrape is a threat to potential host crops in the Marmara Region of Turkey considering that the host spectrum of broomrape affects many major crops from the Solanaceae, Fabaceae, Apiaceae, Brassicaceae and Asteraceae families [18, 31, 32] including tomatoes, red lentils, faba beans, sunflower plants, tobacco, hemp, eggplant, peppers, cabbage, radishes, cucumbers, carrots, squash and potatoes.

Several reports previously indicated that broomrapes attack crops in Turkey [11, 12, 14, 34]. However, this report represents the first record of broomrape parasitism on rapeseed plants in Turkey. *P. ramosa* was first reported on rapeseed plants in Greece [33] where the researchers identified yield

losses 30% to 60%.

Finally, no information is available on the control or dispersal of broomrape. However, if control measures are not attempted and growers are not immediately informed, it is likely that the problem will expand throughout the area.

CONCLUSION

The present study was conducted to determine the extent of the branched broomrape (*Phelipanche ramose*) problem in rapeseed crops in the Tekirdag and Istanbul provinces of the Marmara region of Turkey. This parasitic plant was detected in the study area in 2016 and 2017 and was found to represent a high threat to crops. It has the potential to spread to large agricultural areas, and crop yields in the region may inevitably decrease as a result. For farmers with limited resources, the associated crop losses may be high and also affect other farming or processing facilities. Finally, no information is available on the control and dispersal of broomrape in the region. However, if control measures are attempted and growers are immediately informed, a more destructive invasion of branched broomrape may be avoided.

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