Available at: https://dergipark.org.tr/tjws

Turkish Journal of Weed Science

Araştırma Makalesi / Research Article

Identity of the *Casuarina* sp. in Turkey

Ian T. RILEY[1]*, Leyla Nur KORKMAZ[1]

[1]Department of Plant Production and Technologies, Faculty of Agricultural Science and Technologies, Niğde Omer Halisdemir University, Niğde, Turkey.
*Corresponding author's E-mail: ian@riley.asia

ABSTRACT

Sheoaks (*Casuarina* sp.) are a common ornamental and amenity trees grown in provinces of Turkey along the Mediterranean and Aegean coasts. In the literature this species is identified as *Casuarina equisetifolia* L., however, recent field observations have brought this into doubt. Qualitative and quantitative characters for 14 specimens (7 female and 7 male) collected from Izmir, Dalaman, Adana and Ceyhan, indicated that the correct determination is *Casuarina cunninghamiana* Miq. This is a new record for Turkey for a species that is considered an invasive woody weed in up to 20 countries. However, as this species has been grown in Turkey of many decades and there is no evidence of naturalization, it is not considered to represent a potential threat and no immediate management action is considered necessary.

Key Words: casual, *Casuarina cunninghamiana*, alien flora, identity, invasiveness, Turkey.

INTRODUCTION

A range of Australian trees are grown in Turkey, mostly as ornamentals, but also for forestry and agricultural uses such as shelter belts. The most common and noticeable is *Eucalyptus camaldulensis* Dehnh. (river red gum). Others include *Acacia* spp. (wattles), *Brachychiton populneus* (Schott & Endl.) R.Br. (kurrajong), *Grevillea robusta* A. Cunn. ex R.Br. (silky oak), *Melia azedarach* L. (white cedar) and *Schefflera actinophylla* (Endl.) Harms (umbrella tree). Uludag *et al.* (2017) lists several Australian *Acacia* spp. as naturalized and *E. camaldulensis* as an exotic casual, but none appear to have become economically or environmentally damaging invasive species at this stage. An important addition to this list is a *Casuarina* sp. (sheoak; locally know as iron tree, or *demir ağacı* in Turkish) that is widely grown as amenity trees in private and public gardens, along city avenues and rural roadsides, and as rural shelter belts in provinces along the Aegean and Mediterranean coasts. In all Turkish sources examined, this sheoak is given the name, *Casuarina equisetifolia* L. (e.g., Birişçi *et al.*, 2017; Sever Mutlu *et al.*, 2017), however, field observations of the senior author indicated that this name is likely to be misapplied.

Even observed from a distance, the sheoaks in Turkey are tall, stately trees more reminiscent of *Casuarina cunninghamiana* Miq. than *C. equisetifolia*; they do not have the open, spreading canopies more typical of the latter. On closer inspection, all specimens examined were dioecious, had relatively small cones and were not particularly pubescencent/tomentose, which further confirmed that they were unlikely to be *C. equisetifolia*. Correct identification of a tree of this significance is intrinsically important, however, given that *C. equisetifolia* is classified as an invasive woody weed in nearly 20 countries (CABI, 2018b) and is subject to official control on Florida, USA (Pernas *et al.*, 2013), misidentification in Turkey might confound efforts to assess the global impact of this species. With sheoaks largely used as urban amenity trees in Turkey, it is important for city planning to have reliable inventories (with known species identity) to underpin assessment of potential benefit and risks (McPherson *et al.*, 2016). Also, trees in the Casuarinaceae are considered to have significant merit for assessment for agroforestry and agroecosystem improvement in Turkey (Riley, 2019), so correct identification of the existing species is an important initial step in such a process.

In order to clarify the identity of the *Casuarina* sp. in Turkey, male and female trees in representative sites in Izmir, Dalaman, Adana and Ceyhan were examined in the field, and samples taken for morphological and morphometric assessment.

MATERIALS AND METHODS

Fourteen mature *Casuarina* sp. specimens were examined and sampled as detailed below. Field observations were made (and photographs taken) of habit and bark, and evidence of suckering, coppicing and recruitment recorded. Foliage samples were dried in a plant press and cones collected for measurement and seed extraction. About 50 cones from each female tree were frozen on return to the laboratory to allow measurements of unopened cones. Measurements were made with electronic vernier calipers. Data collected were compared primarily to the descriptions in the Flora of Australia (Wilson & Johnson, 1989), and other relevant sources (e.g., Johnson, 1982 and National Herbarium of New South Wales, 2019), and the keys applied.

Material examined;

1 ♂**, 2** ♀: Güzelyurt Mahallesi, Gençlik Berber, 48600 Ortaca, Muğla Province, Turkey, 36° 45’ 25.6” N, 28° 45’ 2.7” E, planted, home garden, 16 Nov 2018, collectors IT Riley & Ferit Turanlı.

3 ♀**, 4** ♂: Fevziye Mahallesi, Fevziye, 48600 Ortaca, Muğla Province, Turkey, 36° 45’ 32.1” N, 28° 45’ 30.1” E, 16 Nov 2018, planted, windbreak planted adjacent citrus orchard, collectors IT Riley & Ferit Turanlı.

5 ♀**, 6** ♂**, 7** ♀**, 8** ♂: Gültepe Mahallesi, Çukurova University, 01250 Sarıçam, Adana Province, Turkey, 37° 03’ 28.4” N, 35° 21’ 24.7” E, planted, university garden, 18 Nov 2018, collector IT Riley.

9 ♂**, 10** ♀: Mithat Paşa Mahallesi, Ceyhan Asri Cemetery, Adnan Menderes Blv., 01920 Ceyhan, Adana Province, Turkey, 37° 01’ 24.1” N, 35° 49’ 55.2” E, 8 Nov 2018, planted, cemetery, collector IT Riley.

11 ♀**, 12** ♂: Erzene Mahallesi, 116/7 Sk., 35040 Bornova, Izmir Province, Turkey, 38° 28’ 8.2” N, 27° 13’ 48.2” E, planted, university garden, 3 Dec 2018, collectors Galip Kaşkavalcı & Ferit Turanlı.

13 ♀**, 14** ♂: Erzene Mahallesi, Istanbul Cd. Yanyolu, 35040 Bornova, Izmir Province, Turkey, 38° 27’ 46.4” N, 27° 13’ 38” E, 3 Dec 2018, planted, university garden, collectors Galip Kaşkavalcı & Ferit Turanlı.

Given that some *Casuarina* spp. are regarded as invasive species and there was little evidence of self propagation, germination of two replicate samples from each female tree was determined; seed was wrapped in moist paper towel, placed in a ziplock bag and incubated at 21°C for at least 2 weeks.

Statistical analysis (ANOVA) was used for indicative purposes only. The data were collected as subsamples of material collected from individual specimens, material which was collected by necessity from lower branches. So the data is not statistically independent or fully representative, so statistical comparison of pairs of means is not considered valid and was not needed to meet the objectives of this study.

RESULTS

Table 1 presents the data collected for the specimens from Turkey in parallel to data for the three most common *Casuarina* spp. that have been actively disseminated worldwide, *viz.*, *C. equisetifolia*, *C. cunninghamiana* and *Casuarina glauca* Sieber. *Casuarina grandis* L.A.S. Johnson, a species from Papua New Guinea is also included as it may have been disseminated as *C. cunninghamiana* before its recognition as a distinct species. The specimens are clearly in the genus *Casuarina*, having cones with thin, protruding bracteoles with no dorsal protuberance and pale colored samaras. However, it is also clear that the specimen from Turkey are not *C. equisetifolia*; they are not monoecious and not sufficiently pubescent, and have too many article teeth (mostly 9, rather than 7-8) and the anthers, cones and samara are too short. Likewise, they are not *C. glauca* having too few article teeth (mostly 9, rather than 12-17) as well as a range of other non-matching characters, including smaller, thinner articles with narrow phyllichnia, cone bracteoles not striated, and there is no evidence of root suckering.

The specimens from Turkey are closest to *C. cunninghamiana* with only two obvious, non-diagnostic differences (Table 1). The article teeth length was measured as being slightly outside the range for *C. cunninghamiana*, but this measure is subject to the errors in defining the exact position of the tooth base and tip. Article teeth wither in *C. cunninghamiana*, so the exact length might depend on the status of the specimen collected. The larger difference was in cone diameter; 8.3 mm for the specimens from Turkey, but 4-6 mm as described for *C. cunninghamiana*. This character might also subject to measurement errors. Measurements were made on fresh cones from Turkey, actively sampling mature well developed cones, whereas, the published descriptions are most likely to be of dried herbarium

specimens with cones that may have shrunk on drying (although significant shrinkage on drying was not apparent for the material from Turkey when dry specimens were measured). Therefore, this difference cannot be considered diagnostic or precluding a determination of the *Casuarina* sp. in Turkey as *C. cunninghamiana*.

The ratio of cone diameter to samara length was calculated to test the proposition that cones measured for the published description had shrunk with drying. On the assumptions that samara within the cone lie perpendicular to the cone peduncle and that samara length does not change significantly as the cone dries, the cone radius must be greater than the samara length so that the samara is fully inclosed within the carpel. The ratio of cone diameter and samara length in the specimens from Turkey was 2.1 with minimal variation (Table 1). Whereas, for the described species, it is less than 2 and only 1.5 for *C. cunninghamiana* (Table 1). Therefore, the published cone dimensions should be interpreted with some caution, and not considered diagnostic unless the differences are substantial, as is the case for *Casuarina cristata* Miq. (Wilson & Johnson, 1989).

Results of analysis of the quantitative data collected for the specimens from Turkey are given in Table 2. Overall variation in the data was low but most measures showed some differences, largely due one to three specimens. There was no particular specimens that were consistently different to the extent that if fell outside the range for *C. cunninghamiana*. Therefore, the variation was likely to have been mostly phenotypic rather than arising from the material containing more than one species or the segregating progeny of hybrids. However, for male spike length, two specimens (6 at 71 mm and 8 at 57 mm) were longer than any *Casuarina* sp. described, but within the range for *Allocasuarina* (Wilson & Johnson, 1989), which indicates that this character is not of great diagnostic value.

Given the apparently weak diagnostic value of cone data, verbatim cone descriptions from non-Australian sources for the three common *Casuarina* spp. are provided in Table 3. From these descriptions it is clear that there is considerable overlap in both qualitative and quantitative characters, and that cone descriptions are not definitively diagnostic for this group of species. Although it is noteworthy in this context that Woodall and Geary (1985) gave the *C. cunninghamiana* cone diameter as 6-10 mm (indicating they are as long as they are wide), which fits well with the data for the specimens from Turkey (Table 1, with the local specimens have a mean size ratio of about 1.2). In their description, Woodall and Geary (1985) used new observations in conjunction with published descriptions, so it is possible they also measured undried cones. If representative reference material was to hand, it is likely that cones of the three species could be distinguishable for an experienced field botanist, however, Castle and Andreu (2017) did not indicate that cones are diagnostically useful for field determination.

Table 1. Qualitative and quantitive (measured and derived) characters for 14 (7 female and 7 male) *Casuarina* sp. specimens from Turkey and equivalent values for four described species with data sourced from Johnson (1982), Wilson and Johnson (1989) and the National Herbarium of New South Wales (2019).

Character	***Casuarina* sp. ex Turkey[1]**	***C. equisetifolia*[2]**	***C. cunninghamiana*[2]**	***C. glauca*[2]**	***C. grandis*[2]**
Habit	tree (heights not measured, but estimated at commonly >12 m), not suckering	tree 6-12 m high	tree 15-35(-50) m high	tree 8-20 (-35) m high, frequently producing root suckers	tree to 50-60 m tall
Dioecious/monoecious	dioecious	monoecious	dioecious	dioecious	dioecious
Bark	finely fissured and scaly, grey-brown	scaly, grey-brown to black	finely fissured and scaly, grey-brown	finely fissured and scaly, grey-brown	n/a
Branchlet pubescence	glabrous	densely hairy at least when young on ridges as well as in furrows	mostly glabrous	glabrous	n/a
Branchlet orientation	drooping	drooping	drooping in vigorous specimens, erect in depauperate specimens	spreading to drooping	spreading or possibly pendulous
Branchlet length (mm)	150 (81-261)	to 300	n/a	to 380	n/a
Branchlet tips	non-pungent (13) subpungent (1)	as genus: non-pungent	as genus: non-pungent	as genus: non-pungent	n/a
Article number/branchlet	29 (13-58)	n/a	n/a	n/a	n/a
Article length (mm)	6.3 (4.4-12.7)	5-13	4-9	8-20	6-11
Article diameter	0.5 (0.36-0.65)	0.5-1.0	0.4-0.7	0.9-1.2	c. 0.4
Article teeth/whorl	8.7 (7.6-9.2), mostly 9	7 or 8, occasionally 6	6-10	12-17, rarely to 20	8-10
Article teeth length (mm)	0.6 (0.4-1.0)[3]	0.3-0.8	0.3-0.5	0.6-0.9	0.3-1.0
Article teeth	eject, yellow at base with brown band one-third down from the tip, tip cells withered (dry but not particularly shrivelled) and unpigmented	erect, densely and obviously pubescent, relatively large and light green to light yellow, not withering	yellow at base, darker brown towards apex, (or greyish with an obvious transverse brown band), withering	erect, usually withering	deltoid, with dark brown base, the apex withering pale
Article phyllichnia	angular (with slight median rib), narrow	narrow and prominently angular, occasionally flattish in older growth	angular to flat with a median rib	flat to slightly rounded, broad	angular, the angle more prominent than *C. cunninghamiana*
Article furrows	closed, deep, not densely pubescent	furrows usually densely pubescent	edges of furrows often marked (when dry) by a slight ridge	n/a	furrows with protruding hairs
Young persistent shoots	different to branchlets with shorter articles, teeth recurved	different to branchlets with shorter articles; teeth not recorded	different to branchlets with shorter articles; teeth not recorded	different to branchlets with shorter articles, long-recurved	n/a

Character	*Casuarina* sp. ex Turkey[1]	*C. equisetifolia*[2]	*C. cunninghamiana*[2]	*C. glauca*[2]	*C. grandis*[2]
Male flower branchlets	same as vegetative branchlets	as genus: same as vegetative branchlets	as genus: same as vegetative branchlets	as genus: same as vegetative branchlets	unknown
Male flower bracteoles	persistent	as genus: persistent	as genus: persistent	as genus: persistent	unknown
Male spike length (mm)	34 (7-71)[3]	7-40	4-40	12-40	unknown
Male flower whorls/spike	34 (10-77); i.e., 1.1 (0.8-1.6) whorls/mm	10-35; based on 0.7-1.15 whorls/mm	3-35; based on 1.1-1.3 whorls/mm	17-40; based on 0.7-1.0 whorls/mm	unknown
Anther length (mm)	0.49 (0.34-0.64)	0.6-0.8	0.4-0.7	0.8	unknown
Cones	globose-cylindrical with both ends truncate, slightly pubescent, white, bracteoles broadly acute	pubescent, bracteoles acute	sparsely pubescent, bracteoles broadly acute to acute	pubescent (ferruginous to white), becoming glabrous, bracteoles broadly acute	globose-cylindrical with both ends truncate, bracteoles glabrous, brown
Cone peduncle length (mm)	4.6 (3.7-6.3)	3-13	2-9	3-12	6-10
Cone body length (mm)	10 (9-12)	10-24	7-14	9-18	6-11
Cone diameter (mm)	8.3 (7.7-9.0)	9-13	4-6	7-9	9-11
Cone size ratio[4]	1.22 (1.11-1.58)	1.5	2.1	1.7	0.85
Cone carpel members	8 (7.5-8.5) i.e., 16-(14-18-)stichous	n/a	n/a	n/a	14-18-stichous
Cone carpel whorls	7.7 (6.6-9.9)	n/a	n/a	n/a	n/a
Cone bracteoles	thin, no dorsal protuberance, no striation	as genus:never greatly thickened and always lacking a dorsal protuberance	as genus:never greatly thickened and always lacking a dorsal protuberance	striation obvious, otherwise as genus:never greatly thickened and always lacking a dorsal protuberance	n/a
Cone bracteole width (mm)	1.6 (1.4-1.8)	n/a	n/a	n/a	1.0-2.0
Samara	glabrous, pale yellow-brown	as genus: glabrous, pale yellow-brown or grayish, dull	as genus: glabrous, pale yellow-brown or grayish, dull	as genus: glabrous, pale yellow-brown or grayish, dull	n/a
Samara length (mm)	4 (3.8-4.3)	6-8	3-4	3.5-5	n/a
Cone diameter/samara length[4]	2.1 (1.9-2.2)	1.57	1.43	1.88	n/a

[1] Measurements give as mean (min-max) based on 5 to 10 measurements per specimen, with minimum and maximum the means for individual specimens consisting of 7 females and 7 males.

[2] Shading within the column indicates key/obvious differences between the described species and the specimens from Turkey.

[3] Two specimens from Turkey had male spikes longer than described for any *Casuarina* spp.

[4] Ratio calculated individually for each specimen from Turkey, and from mid-range values for the described species.

Table 2. Standard errors, statistical significance and the main differences for quantitive characters for 14 (7 female and 7 male) *Casuarina* sp. specimens from Turkey. Means and ranges are given in Table 1.

Character	Specimens	n[1]	SE[2]	*p*[3]	Main differences[4]
Branchlet length (mm)	14	5	16	***	1 longer (7) 1 shorter (14)
Articles/branchlet (no)	14	5	3.6	***	1 longer (7)
Article length (mm)	14	5	0.57	***	1 longer (6)
Article diameter (mm)	14	5	0.03	***	2 larger (6 and 8)
Article teeth length (mm)	14	5	0.08	***	continuous range
Article teeth/whorl (no)	14	5	0.33	**	1 fewer, 8 vs 9 (10)
Male spike length (mm)	7♂	5	7.0	***	2 longer (6 and 8) 1 shorter (14)
Male flowers whorls/spike (no)	7♂	5	8.3	***	2 greater (6 and 8)
Male flower whorls/mm (no)	7♂	5	0.26	ns	-
Anther length (mm)	7♂	5	0.06	***	2 shorter (12 and 14)
Cone peduncle length (mm)	7♀	10	0.82	*	1 longer (7)
Cone body length (mm)	7♀	10	0.47	***	continuous range
Cone diameter (mm)	7♀	10	0.29	**	continuous range
Cone size ratio	7♀	10	0.05	***	1 smaller (3) 1 larger (7)
Cone carpel members (no)	7♀	10	0.25	**	1 greater (2)
Cone carpel whorls (no)	7♀	10	0.38	***	1 greater (7)
Cone bracteole width (mm)	7♀	10	0.22	ns	-
Samara length (mm)	7♀	10	0.22	ns	-

[1] n, number of subsamples.
[2] SE, standard error of differences in means; means given in Table 1.
[3] ns, not significant; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.
[4] Numbers in parentheses are the specimen numbers given in the text.

Table 3. Cone descriptions for *Casuarina equisetifolia*, *C. cunninghamiana* and *C. glauca* verbatim from four non-Australian sources (i.e., not those used in Table 1).

Description source	***C. equisetifolia***	***C. cunninghamiana****	***C. glauca***
Identity of *Casuarina* in Florida; Woodall & Geary, 1985	usually abundant, 10-20 (mostly 16) mn in diameter, slightly longer than wide, covered while green with usually continuous mat of white hairs that turn rusty with age	small (6-10 mm diameter), as long as wide, with thin, glabrous bracteoles.	not confirmed in Florida; in Australia, 10-20 (mostly 12) mm diameter, slightly longer than wide, and often pubescent when young.
Flora of China; Xia et al., 1999	ellipsoid, 1.2-2.5 cm, grayish green or yellowish brown tomentose when young, glabrous at maturity, base and apex truncate to obtuse; apex of bracteoles slightly obtuse or acute	ellipsoid or subglobose, 7-12 mm, truncate at both ends; apex of bracteoles acute	broadly ellipsoid to subglobose, 1.2-2 cm, truncate at both ends; apex of bracteoles broadly acute to obtuse
Manual of the flowering plants of Hawaii; Wagner *et al.*, 1999	subglobose to elongate and oblong-globose, 1.2-2.2 cm long, ca. 1.1-1.4 cm in diameter, the valves broadly ovate, protruding ca. 2 mm, pubescent, apex obtuse.	n/a	subglobose, flat-topped, ca. 0.7-1.3 cm in diameter, the valves prominent, protruding ca. 1-1.5 mm, pubescent, apex obtuse
World Agroforestry Centre; Orwa *et al.*, 2009	cylindrical, cone-shaped or globose, 10-24 x 9-13 mm; bracteoles more acute, more or less protruding from the surface of the cone	small, subglobose, about 7-14 x 4-6 mm	subglobose to shortly cylindrical, 9-18 x 7-9 mm, bracteoles broadly acute
Invasive Species Compendium; CABI, 2018a,b,c	globose to short- to long-cylindrical, 10-35 mm long, 9-15 mm diameter, with acute bracteoles more or less protruding from the surface of the cone	small, sparsely pubescent, subglobose, about 7-14 mm long and 4-6 mm diameter, bracteoles broadly acute to acute	as Orwa et al., 2009

* Larger cone diameter of "0.7-1.3 cm (0.3-0.5 in)" is given by Whistler and Elevitch (2006) and Potgieter *et al.* (2014) for *C. cunninghamiana*, but neither give cone length, so this is potentially erroneous, possibly derived from a source such as the Flora of China that does not indicate if the dimension is length or diameter. Alternatively, this has been mistakenly duplicated by Whistler and Elevitch (2006) from *C. glauca*, as they give the same dimension for both species. Only the dimensions given by Orwa *et al.* (2009) closely match those in the Flora of Australia (Wilson & Johnson, 1989; see Table 1).

Table 1 also includes *C. grandis* for comparison with specimens from Turkey. Although *C. grandis* similar to *C. cunninghamiana* there are a couple of characters that indicate that it is not the species in Turkey; different colouration of the article teeth and presence of furrow hairs. However, there is insufficient information on the characters the diagnostically distinguish *C. cunninghamiana* and *C. grandis*. Johnson (1982) noted that this was a complex matter and promised more information would be published, but this does not appear to have eventuated. However, it is worth noting that Johnson (1982) had previously determined *C. grandis* as *C. cunninghamiana*, with the larger cone diameter of the former not apparently precluding this.

Mean germination of samara from the specimens from Turkey was 71% ranging from 60-77%. The cone samples used for seed extraction were not specifically collected at an optimal maturity stage or dried under conditions designed to maximize seed viability. Although, no root-sucking was observed, self propagation does not appear to be limited by seed viability. However, natural recruitment was not observed in the areas where specimens were collected. Three *Casuarina* sp. saplings were observed growing on a weed-covered rubble pile about 30 m from a single mature female tree that had be planted in a former school yard in Narlık Village, Ceyhan, Adana.

DISCUSSION

The key finding of this investigation is that the common *Casuarina* sp. grown in the Turkish provinces sampled is *C. cunninghamiana* not *C. equisetifolia*. Although the collections (and other observations of the author) were made across wide geographic range, this finding does not preclude the possibility *C. equisetifolia* occurs elsewhere in Turkey. Given that *C. equisetifolia* can prosper within close proximity to the sea, tolerant of salt and high wind exposure, it is recommended that sheoaks growing in any such context in Turkey be identified to species. Effectively, therefore, this is the first report of *C. cunninghamiana* in Turkey, and in such a situation for a species that is regarded as an important invasive elsewhere in the world (CABI, 2018a) a logical next step would be to undertake a weed risk assessment. However, *C. cunninghamiana* is likely to be have been in Turkey for many decades (given the size of some mature trees), and perhaps even introduced during the Ottoman period with the enthusiastic European introduction of plants from Australia during 1772 to 1820 (Groves, 1991), without becoming naturalized, so it seems most unlikely it will become invasive and no immediate management action is considered necessary. Indeed, the counter position that this species represents an underutilized economic resource for agroforestry in Turkey could be argued (Riley, 2019).

The observations made during this study support the inclusion of the *Casuarina* sp. in Turkey (here determined as *C. cunninghamiana*) as an exotic casual (Uludag et al., 2017). No suckering was observed, viable seed is produced in large quantities, but naturalization has not occurred and unplanted specimens are uncommon. This supports the suggestion above that *C. cunninghamiana* does not represent a threat and is unlikely to become an invasive woody weed in Turkey.

Johnson (1982) indicted that hybridization between the common *Casuarina* spp. occurs freely when grown in close proximity and that this can frustrate species identification. Hybrids are recorded in Florida but not in the native range of the species (Woodall & Geary, 1985). However, the characters of the species in Turkey are not suggestive of it being a hybrid, and determination as *C. cunninghamiana* is made with reasonable confidence. Although this seems a justified determination, the specimens were mostly growing under horticultural conditions, and were healthy and vigorous, so it would be reasonable to expect some deviation (e.g., cone size) from specimens growing in natural stands in Australia. In a molecular study of 527 *Casuarina* accessions (Gaskin et al., 2009), hybridization between *C. equisetifolia* and *C. glauca* was relatively common in Florida, but *C. cunninghamiana* hybridization was only found at a single site and no hybridization was found among 341 accessions from Australia. Given that Turkey appears to only have one of these three taxa, the probability of it being a hybrid is quite low, nevertheless, a future study to confirm its molecular identity would have merit.

Another observation from this study is the apparent ambiguity of some cone data. Cone diameters as published seem to be inconsistent with reported samara length. It is conceivable that cone and bracteole shrinkage during drying is substantial and a process that could advantage samara release. Such shrinkage would explain this inconsistency. So examination of the degree of cone shrinkage, both longitudinal and radial, comparing a range of *Casuarina* and *Allocasuarina* species, and its relationship to samara release would be a worthy undertaking.

CONCLUSIONS

Both *C. cunninghamiana* and/or *C. equisetifolia* are reported in nearly all Mediterranean countries, and although many reports seem reliable, there is a distinct possibility that some are not. Clearly there is a risk of inaccurate or presumptive field identification of these species and *C. glauca*, a situation that prompted the publication of the early work of Woodall and Geary (1985) and the recent field guide of Castle and Andreu (2017). Given the differing global importance of these *Casuarina* spp., both positive and negative, it is incumbent on researchers reporting on invasive woody species, agroforestry, amenity horticultural and allergenic pollens to ensure their species determinations are based on sound botanical practice. Also, given that the common *Casuarina* spp. can hybridize, molecular investigation of *Casuarina* within the Mediterranean Basin would be useful, not only to confirm species identities but also to provide information on their history of introduction and subsequent distribution.

ACKNOWLEDGEMENTS

The logistical support and assistance with sample collection provided by Galip Kaşkavalcı and Ferit Turanlı (Ege University, Izmir), and Sedat Serçe (Niğde Omer Halisdemir University, Niğde) is gratefully acknowledged.

REFERENCES

Birişçi T., Turel H., Ozeren Alkan M. (2017). Kültürpark'ın ağaç, ağaççık ve çalıları - Bitki tanıtım kitabı. Department of Landscape Architecture, Ege University Faculty of Agriculture and Metropolitan Municipality of Izmir, Izmir, Turkey. In Turkish.

CABI (2018a). *Casuarina cunninghamiana*. Invasive species compendium. CAB International, Wallingford (UK). Available: www.cabi.org/isc/datasheet/16711 [Accessed: 20.06.2019].

CABI (2018b). *Casuarina equisetifolia*. Invasive species compendium. CAB International, Wallingford (UK). Available: www.cabi.org/isc/datasheet/16718 [Accessed: 20.06.2019].

CABI (2018c). *Casuarina glauca*. Invasive species compendium. CAB International, Wallingford (UK). Available: www.cabi.org/isc/datasheet/16718 [Accessed: 20.06.2019].

Castle W.S., Andreu A. (2017). Field guide to identify the common *Casuarina* (Australian pine) species in Florida. Horticultural Sciences Department, IFAS Extension, University of Florida, Gainesville, FL, USA.

Gaskin JF., Wheeler GS., Purcell MF., Taylor GS. (2009). Molecular evidence of hybridization in Florida's sheoak (*Casuarina* spp.) invasion. Molecular Ecology 18, 3216-3226.

Groves RH. (1991). The biogeography of Mediterranean plant invasions. In: Di Castri F., Groves RH. (eds). Biogeography of Mediterranean Invasions, pp. 427-438. Cambridge University Press, Cambridge, England. ISBN 978-0-521-36040-1. pp. 427-438

Johnson LAS. (1982). Notes on Casuarinaceae II. Journal of the Adelaide Botanic Garden, 6:73-87.

McPherson EG., van Doorn N., de Goede J. (2016). Structure, function and value of street trees in California, USA. Urban Forestry & Urban Greening, 17:104-115.

National Herbarium of New South Wales (2019). *PlantNET - FloraOnline*. Available: plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=gn&name=Casuarina [Accessed: 19.03.2019].

Orwa C., Mutua A., Kindt R., Jamnadass R., Simons A. (2009). *Agroforestry Database 4.0*. World Agroforestry Centre. Available: www.worldagroforestry.org/treedb [Accessed: 13.03.2019].

Pernas T., Wheeler G., Langeland K., Golden E., Purcell M., Taylor J., Brown K., Taylor DS., Allen E. (2013). Australian pine *Casuarina equisetifolia* L. Management plan for Florida. Recommendations from the Australian pine task force. Florida Exotic Pest Plant Council, Gainesville, Florida,USA.

Potgieter LJ., Richardson DM., Wilson JRU. (2014). *Casuarina cunninghamiana* in the Western Cape, South Africa: determinants of naturalisation and invasion, and options for management. South African Journal of Botany, 92:134-146.

Riley IT. (2019). A case for assessing *Allocasuarina* and *Casuarina* spp. for use in agroecosystem improvement in semi-arid areas with a focus on Central Anatolia, Turkey. Frontiers of Agricultural Science and Engineering, 23 July 2019. [Epub ahead of print] doi: 10.15302/J-FASE-2019270.

Sever Mutlu S., Selim C., Ün G. (2017). Plant biodiversity of urban roadside trees in Antalya, Turkey. Kastamonu University, Journal of Forestry Faculty 17:80-87.

Uludag A., Aksoy N,. Yazlık A., Arslan ZF., Yazmış E., Uremis I., Cossu TA., Groom Q., Pergl J., Pyšek P., Brundu G. (2017). Alien flora of Turkey: checklist, taxonomic composition and ecological attributes. NeoBiota, 35:61-85.

Wagner WL., Herbst DR., Sohmer SH. (1999). Manual of the flowering plants of Hawaii (Revised edition. Bernice P. Bishop Museum special publication.). University of Hawaii Press and Bishop Museum Press, Honolulu, HI, USA. ISBN 0-8248-2166-1.

Whistler WA., Elevitch CR. (2006). *Casuarina equisetifolia* (beach she-oak) and *C. cunninghamiana* (river she-oak) (ver 2.1). In: Elevitch CR. (ed). Traditional trees of Pacific Islands: their culture, environment, and use. Permanent Agriculture Resources, Honolulu, HI, USA. ISBN: 978-0-9702544-5-0. pp. 227-242.

Wilson KL., Johnson LAS (1989). Casuarinaceae. In: George AS. (ed). Flora of Australia. Vol. 3: Hamamelidales to Casuarinales. Australian Government Publishing Service, Canberra, ACT, Australia. ISBN: 978-0-644-08499-4. pp. 100-174

Woodall SL., Geary TF. (1985). Identity of Florida casuarinas. U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, Asheville, NC, USA.
Xia N., Johnson LAS., Wilson KL. (1999). Casuarinaceae. Flora of China, 4:106-107.

Geliş Tarihi/ Received:Mayıs/May, 2019
Kabul Tarihi/ Accepted: Temmuz/Jully, 2019

To Cite : Riley I.T. and Korkmaz L.N. (2019). Identity of the *Casuarina* sp. In Turkey. Turk J Weed Sci, 22(2):159-168.

Alıntı için : Riley I.T. and Korkmaz L.N. (2019). Türkiye’de *Casuarina* sp.’nin Tanımlanması. Turk J Weed Sci, 22(2):159-168.