Short Communication

Distribution and conservation status of the Critically Endangered *Scrophularia takesimensis*, a plant endemic to Ulleung Island, Republic of Korea

Hyeok Jae Choi, Hyun Do Jang, Yuji Isagi and Byoung Un Oh

Abstract *Scrophularia takesimensis* Nakai is a Critically Endangered plant species endemic to Ulleung Island, Republic of Korea. We provide updated information on the distribution and conservation status of this species. We located 39 subpopulations and counted a total of 443 individuals, including some reintroduced. Observations of dried and broken branches, with fruits, of *S. takesimensis* along the coast may indicate dispersal by sea. The construction of coastal roads is the main threat to the species. To conserve this species more effectively we recommend that: (1) the two habitats identified as a priority for conservation should be afforded special protection, (2) habitats to the seaward side of coastal roads are more suitable than habitat on the landward side for in situ conservation, and (3) the presently known subpopulations require continuous protection and monitoring.

Keywords Critical habitat, endemic species, Republic of Korea, *Scrophularia takesimensis*, Ulleung Island

The 73 km² Ulleung Island in the East Sea lies c. 150 km from the Republic of Korea mainland (Fig. 1a). The plant *Scrophularia takesimensis* Nakai, endemic to Ulleung Island and two adjacent islets, Juk and Gwaneum (Kim & Kang, 2010), is categorized as Critically Endangered in the Rare Plant Data Book of Korea (Lee, 2009). Such narrow endemics are susceptible to extinction for several reasons, in particular the destruction of their habitat (Lande, 1988; Schemske et al., 1994; Bizoux et al., 2004; Ali & Qaiser, 2011; Fenu et al., 2011; Martinell et al., 2011), and a single small-scale disturbance could trigger extinction (Bernardos et al., 2006). The goals of this study were to (1) provide an update on the occurrence of this species on Ulleung Island, (2) reassess its conservation status, and (3) use this information to propose priority areas for conservation of the species.

We reviewed information on the distribution of *S. takesimensis* available in Ahn (2005), Lim et al. (2008), Han et al. (2010) and Kim & Kang (2010). Kim & Kang (2010) also provided information about this species on the two adjacent islets (Fig. 1b) but, as the populations there comprise only c. 0.6% of the total known individuals (Kim & Kang, 2010), we did not examine them further. *S. takesimensis* usually exhibits a clumped structure, with the clumps formed by vegetative propagation of the root. We therefore counted individuals based on their clump; shoots composing a clump were considered an individual. During 2–9 August 2011 we examined all localities on Ulleung Island from which *S. takesimensis* had been reported, and other potentially suitable coastal localities. Habitats were divided into subpopulations based on the spatial separation of individuals (Lim et al., 2008), and locations were recorded with a global positioning system. All individuals within each subpopulation were counted.

We found 39 locations with *S. takesimensis* (Table 1; Fig. 1b) and consider each to be a subpopulation. These subpopulations have a highly fragmented distribution along the northern (67%), eastern (10%) and southern coasts (23%) of Ulleung Island at altitudes of 2–33 m. At two localities (20 and 39) *S. takesimensis* was restored by reintroduction of seedlings in 2005 (by Key-chungsan Botanical Garden) and 2006 (by Korea National Arboretum), respectively. Nearly all examined sites (95%) were within 5 m of the coastal road, on either the seaward or landward sides (Plate 1). Immature individuals were usually growing in a sandy substrate on the seaward side. All subpopulations were in previously known sites and we did not record any new locations. Of the previously known subpopulations (Ahn, 2005; Lim et al., 2008; Han et al., 2010) we were unable to locate 16 (29%; Fig. 1b) and conclude that the number of subpopulations is decreasing.

In the 39 extant subpopulations we counted a total of 443 individuals, with subpopulations of 1–73 individuals (Table 1). The highest number of individuals was recorded in subpopulation 26, which does not lie close to a road. Most subpopulations (90%) contained < 30 individuals and eight subpopulations (21%) contained only one individual. The

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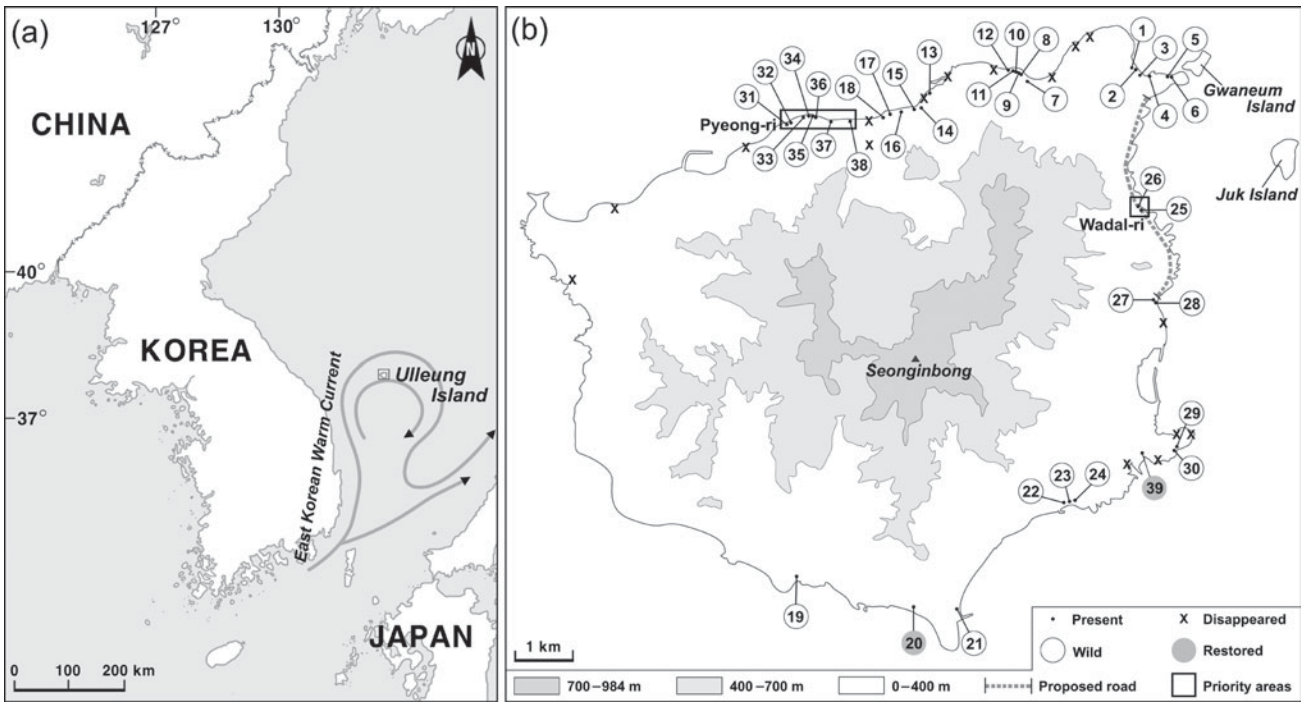

FIG. 1 (a) Location of Ulleung Island off the Korean mainland, with the direction of flow of the East Korean Warm Current, and (b) distribution of the subpopulations (1–39; Table 1) of *Scrophularia takesimensis* located on Ulleung Island in 2011.

PLATE 1 Habiats of *Scrophularia takesimensis* (circled) to the (a) landward and (b) seaward side of coastal roads.

number of shoots per individual was 1–22 (mean = 4.2; n = 100), and the total number of shoots was estimated to be c. 1,860. The number of fruits per reproductive shoot was 56–718 (mean = 200; n = 30); almost all individuals fruited normally, producing capsules. The mean number of seeds produced per individual was estimated to be c. 110,000 (n = 30) and we conclude that population viability is not limited by seed output. However, only a small proportion of the viable seeds germinate because of the harsh coastal habitat in which *S. takesimensis* grows (Kang et al., 2009).

Dispersal by water is common for plant species typical of wetland and coastal areas (Cadée, 2005). We observed dried branches of *S. takesimensis*, without roots and leaves, in some coastal locations, with fruits and, in some cases, with seeds. Sections of the dried branches have a sponge-like cortex that enables the branches to break and float. Broken branches of *S. takesimensis* may thus be carried by the sea and their seeds subsequently dispersed by water, and by wind upon reaching land. *S. takesimensis* may have extended its range from the north coast to the eastern and southern coasts by means of the East Korean Warm Current (Fig. 1). This could explain the appearance of *S. takesimensis* on Juk and Gwaneum Islands.

The construction of coastal roads and small harbours, and subsequent habitat loss, is the greatest threat to *S. takesimensis* (Lim et al., 2008). Since construction of coastal roads began in 1963, 39.8 km of a planned 44.2 km have been completed. As a result the subpopulations are now on either the landward or seaward side of the coastal

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TABLE 1 Locality records and details of the 39 subpopulations of *Scrophularia takesimensis* recorded in 2011 on Ulleung Island. The locations of the numbered subpopulations are indicated in Fig. 1b.

Locality	Coordinates	Altitude (m)	Direction from road	Wild/ Restored	No. of individuals
1	37°32′35.1″N, 130°54′33.0″E	18	Landward	Wild	1
2	37°32′32.0″N, 130°54′34.8″E	8	Landward	Wild	2
3	37°32′32.0″N, 130°54′34.8″E	5	Landward	Wild	6
4	37°32′26.7″N, 130°54′39.9″E	5	Landward	Wild	1
5	37°32′27.1″N, 130°54′45.6″E	7	Landward	Wild	2
6	37°32′29.3″N, 130°54′48.0″E	4	Landward	Wild	1
7	37°32′27.7″N, 130°53′17.0″E	27	Landward	Wild	2
8	37°32′29.9″N, 130°53′15.5″E	33	Landward	Wild	1
9	37°32′30.2″N, 130°53′15.7″E	38	Landward	Wild	1
10	37°32′29.5″N, 130°53′15.6″E	22	Landward	Wild	1
11	37°32′32.3″N, 130°53′12.6″E	6	Landward	Wild	3
12	37°32′32.1″N, 130°53′07.5″E	6	Seaward	Wild	2
13	37°32′14.6″N, 130°52′05.1″E	8	Landward	Wild	2
14	37°32′11.2″N, 130°52′00.7″E	8	Landward	Wild	2
15	37°32′11.2″N, 130°51′55.3″E	5	Landward	Wild	5
16	37°32′09.0″N, 130°51′45.8″E	4	Landward	Wild	4
17	37°32′03.0″N, 130°51′15.5″E	10	Landward	Wild	1
18	37°32′03.1″N, 130°51′13.2″E	14	Landward	Wild	14
19	37°27′51.5″N, 130°50′39.5″E	10	Landward	Wild	14
20	37°27′34.7″N, 130°52′02.9″E	5	Landward	Restored	2
21	37°27′35.8″N, 130°52′31.8″E	5	Landward	Wild	12
22	37°28′32.9″N, 130°53′52.5″E	15	Landward	Wild	3
23	37°28′33.1″N, 130°53′52.9″E	14	Landward	Wild	8
24	37°28′32.6″N, 130°53′52.0″E	15	Landward	Wild	17
25	37°31′15.8″N, 130°54′37.8″E	3		Wild	61
26	37°31′16.1″N, 130°54′37.3″E	7		Wild	73
27	37°30′25.1″N, 130°54′48.6″E	22	Landward	Wild	22
28	37°30′25.0″N, 130°54′48.7″E	3	Seaward	Wild	12
29	37°29′04.8″N, 130°55′04.5″E	6	Seaward	Wild	10
30	37°29′02.1″N, 130°55′01.9″E	5	Seaward	Wild	2
31	37°32′03.4″N, 130°50′32.4″E	3	Seaward	Wild	1
32	37°32′04.4″N, 130°50′35.5″E	3	Seaward	Wild	51
33	37°32′07.1″N, 130°50′43.8″E	4	Seaward	Wild	19
34	37°32′07.0″N, 130°50′47.6″E	5	Seaward	Wild	5
35	37°32′06.9″N, 130°50′49.9″E	4	Seaward	Wild	23
36	37°32′07.2″N, 130°50′51.1″E	6	Seaward	Wild	7
37	37°32′06.0″N, 130°50′53.9″E	10	Seaward	Wild	6
38	37°32′03.4″N, 130°51′00.2″E	8	Seaward	Wild	14
39	37°29′00.6″N, 130°54′39.2″E	64	Landward	Restored	30

roads, resulting in a reduction in genetic diversity (Park et al., 2010) and thus decreasing the probability of survival (Schaal et al., 1991; Neel & Ellstrand, 2001). Considering that putative seed dispersal is by the sea, the effect of the roads is probably more severe on the landward subpopulations (Cassel & Tammaru, 2003), and most of the subpopulations with only one individual occur on this side of the road (Table 1).

For the long-term conservation of *S. takesimensis* its population size needs to be larger (Park et al., 2010) and in situ measures such as protection and restoration of natural habitats will be the most effective methods (Lande, 1988). Key-chungsan Botanical Garden planted c. 2,000 seedlings of *S. takesimensis* on the landward side of the road of subpopulation 20 in 2005. However, we found only two adult individuals there. In terms of the importance of connectivity among the remaining subpopulations (Park et al., 2010), the seaward localities will be more favourable candidates for in situ conservation.

The conservation strategy for a threatened species usually starts with the identification of the main threats and, subsequently, with the selection of critical habitat (Cultus Sockeye Recovery Team, 2005). Critical habitat is that necessary for the survival or recovery of a threatened species (SARA, 2003). Based on our surveys we propose two priority areas for the conservation of *S. takesimensis:* the northern

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(Pyeong-ri) and eastern (Wadal-ri) coast, comprising eight (31–38) and two (25 and 26) wild subpopulations, respectively (Fig. 1b). The subpopulations of these two areas are located on the seaward side of roads (Pyeong-ri) or in coastal areas without roads (Wadal-ri), and harbour 63% of the wild individuals recorded (126 individuals in Pyeong-ri and 134 in Wadal-ri). Because of its inaccessibility Wadal-ri is the only undisturbed site and has a relative abundance of immature individuals. There is a need to halt the planned construction of a coastal road in this area, which could cause irreparable damage to this critical habitat. Forthcoming studies of the genetic structure and variation of all remnant individuals of this species will be essential for further identification of critical individuals and habitats and for planning the conservation of the species' genetic diversity.

In summary, *S. takesimensis* is highly threatened, with only 443 individuals in 39 known subpopulations, and is restricted to coastal areas. The typical habitat of the species has been greatly reduced by human influence, and in particular by the construction of coastal roads. To conserve this species more effectively we recommend that: (1) the two habitats identified as a priority for conservation should be afforded special protection, (2) habitats to the seaward side of coastal roads are more suitable than habitat on the landward side for in situ conservation, and (3) the presently known subpopulations require continuous protection and monitoring.

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Biographical sketches

Hyeok Jae Choi previously studied the systematics of the genus *Allium*. His research interests are currently focused on the conservation genetics of threatened plant species of Korea and Japan. Hyun Do Jang carries out taxonomic research on the genus *Scrophularia* in Korea. Yuji Isagi is a molecular ecologist and has been leading projects on the conservation of species based on genetic information. Byoung Un Oh is a botanist with an interest in the taxonomy, distribution and conservation of the vascular plants of north-eastern Asia.