Distribution of *Carex nakasimae* Ohwi, a Korean endemic sedge (Cyperaceae)

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ABSTRACT: *Carex nakasimae* Ohwi (Cyperaceae) is an endemic species on the Korean peninsula. This study reports a new locality of the species, updating the distribution map. A new population of the species was found during field surveys in 2014 in a small swamp in Haman-gun, Gyeongsangnam-do province, located in the southeastern part of the Korean peninsula. In the flowering and fruiting periods of the species, the population is associated with ca. 91 vascular plant taxa from 40 families. To conserve the endemic species, maintaining the habitat is critical. Furthermore, taxonomic and phylogenetic positions of the species should be clarified to establish biological conservation strategies for the rare, endemic *C. nakasimae*.

Keywords: *Carex*, *Carex nakasimae*, endemic, Cyperaceae

Carex L. (Cyperaceae) is the most species rich genus in the Korean peninsula although the number of species recognized differs (157–ca.180) depending on the literature cited (Oh, 2007; Park et al., 2016). The genus is the most diverse in the temperate zone with more than 2,000 species worldwide and is often a dominant or co-dominant in various habitats such as deciduous or mixed forests, grasslands and wetlands (Ball and Reznicek, 2002; Global *Carex* Group, 2015). Out of approximately 180 taxa in Korea, around 10 are endemic, including *C. nakasimae* Ohwi (Park et al., 2016; Chung et al., 2017).

Carex nakasimae (Hwa-san-sa-cho) is an endemic, rare species described in 1944 from Hwaseong-si city (Gyeonggi-do province), a small city in middle of the Korean peninsula (Figs. 1, 2A) (Ohwi, 1944; Son et al., 2017). Since its description, the species has been barely recognized, possibly due to its rarity and lack of available data. Lee (2003) included the species in the Korean floristic diversity and mentioned that

the type specimens was last. Son et al. (2017) designated a lectotype, choosing an isotype in National Museum of Nature and Science herbarium (Fig. 1). Park et al. (2016) placed the species in section *Physocarpae* Drejer ex L. H. Bailey as did Ohwi (1944) with four other Korean native taxa and considers *C. vesicaria* L. as the most similar species morphologically.

Carex nakasimae has long rhizomes, 2–3 terminal male spikes, and 2–3 lateral female spikes characterized by lanceolate perigynia with long, bifid, and curved beaks (1–2.5 mm) (Table 1, Figs. 1, 3D) (Lee, 2003; Park et al., 2016). Ohwi (1944) pointed out that the species was distinguished from *C. vesicaria* by narrow perigynia with bifid, curved beaks. Upo-neup wetland, a large wetland in Gyeongsangnam-do, is the only well-known habitat of the species (Park et al., 2016). This wetland is a nature conservation area composed of four swamps and is number 934 on the Ramsar List (Kim et al., 2011; <https://rsis Ramsar.org/ris/934>).

During field work in 2014, a new population of *Carex*

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Fig. 1. Isotype of *Carex nakasimae* Ohwi designated by Son et al. (2017).

Table 1. Diagnostic morphological characters of *Carex nakasimae* and *C. vesicaria*.

	<i>C. nakasimae</i>	<i>C. vesicaria</i>
Leaf width (mm)	3–8	2–3
Perigynium shape	Lanceolate	Ovoid
Perigynium length (mm)	8–9	6–8
Beak margin	Scabrous	Smooth
Beak shape	Bifid, curved	Bidentate

nakasimae was found in a small swamp in Haman-gun, Gyeongsangnam-do province (Figs. 2B, 3). The swamp is about 2,328 m² and branched from Haman-cheon creek, connected with Nakdong-gang river. Nakdong-gang river, the longest river in South Korea, runs 506 km from the Taebaek Mountains to the South Sea or Korean Strait and passes Uponeup wetland as well (Kim et al., 2011).

To understand the ecological features of the population's habitat, associated species were surveyed from 2014 until 2019 during flowering and fruiting times of *C. nakasimae*.

Fig. 2. Distribution of *Carex nakasimae*. **A.** Distribution in the Korean peninsula. Black star (★) type locality, black circles (●) specimens examined. **B.** Distribution in Haman-gun, Gyeongsangnam-do. Black circle (●) specimens examined, black triangle (▲) new locality.

This study updates the distribution of *C. nakasimae* and reports a new population with the floristic composition of its habitat.

Materials and Methods

Habitat survey

In the new population of *C. nakasimae*, associated vascular plant taxa were surveyed and collected in 2015, 2016, and 2019 during flowering and fruiting periods of the species (Fig. 2B). The resulting list of vascular plants follows the nomenclature of *The Genera of Vascular Plants of Korea* (Park, 2007). Identifications of the taxa were made based on Lee (2003), Park et al. (2016), and Hoshino et al. (2011). Scientific and Korean names of taxa follow the biodiversity portal (<https://species.nibr.go.kr/index.do>) provided by Korea National Institute of Biological Resources. Biological resources subject to overseas export approval, endemic, introduced, climate-sensitive biological indicator species, planted species, and floristic degrees of the species were also determined according to the portal. All voucher specimens and images are deposited at the Department of Division of Biological Science, Chonnam National University herbarium (CNU).

Fig. 3. New population in Haman-gun, Gyeongsangnam-do. **A.** Habitat in April 2016. **B.** Habitat in June 2016. **C.** Population in May 2019, red arrows indicate *C. nakasimae* individuals. **D.** *C. nakasimae* inflorescences with mature perigynia in May 2019.

Specimen examination

To make a distribution map, *C. nakasimae* specimens at the Korean National Arboretum herbarium (KH) and National Institute of Biological Resources herbarium (KB) were examined. The KH houses *Carex* specimens collected through ‘Research on unidentified native plant name in Korea’ and ‘a taxonomic review of Cyperaceae in Korea’ projects. In addition, the KB stores voucher specimens for various biodiversity research projects such as ‘National Ecosystem Survey’ and ‘the survey of new and unrecorded taxa in vascular plants’. The identifications of all the specimens were evaluated, and 18 verified specimens were utilized for determining the distribution of the species.

Results and Discussion

In the new population of *Carex nakasimae*, about 91 taxa in 70 genera and 40 families grow during the flowering and fruiting periods of the species (Appendix 1). Cyperaceae is the most dominant with about eight taxa, and Fabaceae and Polygonaceae follow with seven taxa each. For such a small swamp, the site includes important vascular plants from

floristic and environmental points of view; it is big enough to provide dynamic micro-habitats. There are nine biological resources subject to overseas export approval taxa and one climate-sensitive Biological Indicator Species designated by Korea Ministry of Environment. Furthermore, two Korean endemic species grow in the swamp: *C. nakasimae* and *Hemerocallis hakuunensis* Nakai. Both endemic species are not common and only occur in southern parts of the Korean Peninsula.

In the habitat, tall trees such as *Salix chaenomeloides* Kimura and *S. koreensis* Andersson shade on some areas in the swamp. However, some areas are more open and have shallow streams where *C. nakasimae* grows, as it prefers sunny, wet sites. The *C. nakasimae* population is in northwest side of swamp, which can only be accessed from the southeastern and northeastern sides, making hard to find it. Although many swamps in Haman-gun have been disturbed by wastewater from pig breeding and agricultural activities, this swamp might have avoided such disturbances.

Currently the distribution of *C. nakasimae* is restricted to a southeastern province, Gyeongsangnam-do, in Korea although the type locality of *C. nakasimae* is in a middle region of Korea

(Gyeonggi-do province) (Fig. 2A). Park et al. (2016) notes a *C. nakasimae* collection made in Seoul (Mok-dong) with voucher specimen information (Park s.n., without date, KH). However, we failed to locate the voucher specimen at KH, and none of the specimens found are from Gyeonggi-do province. It is suspected that the type locality and other possible habitats in Gyeonggi-do and Seoul have been destroyed by urbanization (Park et al., 2016). All the habitats of *C. nakasimae* are wet such as swamps, wetlands, or lakesides. Nakdong-gang river seems to play a very important role for the plant distribution, assisting dispersal and establishment.

The phylogenetic position of *C. nakasimae* has not been studied although Ohwi (1944) and Park et al. (2016) place the species in *Carex* section *Physocarpae* Drejer ex L. H. Bailey. Among five Korean species in the section (*C. rhynchophysa* C. A. Mey, *C. vesicaria* L., *C. nakasimae*, *C. rostrata* var. *borealis* (Hartms.) Kük, and *C. dickinsii* Franch. & Sav.), *C. vesicaria* assembles with *C. nakasimae* (Park et al., 2016). *C. vesicaria* is broadly distributed in Asia, Europe, and North America in wet places (Ball and Reznicek. 2002; Dai et al., 2010). The treatment of the species in *Carex* section *Vesicariae* (Heuffel) J. Carey (Reznicek and Ford, 2002; Hoshino et al., 2011) suggests taxonomic research on the entirety of the two sections *Physocarpae* and *Vesicariae* is required. Phylogenetic work on *Carex* section *Vesicariae* proposes sub-sectional systems (Shekhovtsov et al., 2012), but the study does not include *C. nakasimae*. The taxonomic and phylogenetic positions of *C. nakasimae* need to be clarified.

Carex nakasimae is endemic to the Korea peninsula (Park et al., 2016), but it has been under-reported. The species is not included in recent Korea endemic vascular plant diversity studies such as Chung et al. (2017). To establish biological conservation strategies for the species, further research on ecological, taxonomic, and phylogenetic features of *C. nakasimae* should be conducted. In addition, the new habitat in Haman-gun, Gyeongsangnam-do should be well conserved and maintained for the conservation of the Korean rare, endemic taxa (*C. nakasimae* and *Hemerocallis hakuunensis*) in nature.

Specimens examined. KOREA. Gyeongsangnam-do: Changnyeong-gun, Ibang-myeon, Okcheon-ri, Uponeup (swamp), 6 Jun 2013, J.-H. Kim 13-38 (KB); 27 May 2012, J.-H. Kim *Carex*-Kim199 (KB); 1 Jun 2011, Y. Cho WR-20110601-002 (KH); 1 Jun 2013, Y. H. Cho 1207 (KH); 6 Jun 2013, Y. Cho et al. Uk_v2013038 (KH); Daehap-myeon, Jumae-ri, Uponeup (swamp), 17 May 2009, J.-H. Kim 139 (KB); Yueo-myeon, Sejin-ri, Uponeup (swamp), 28 Jun 2012,

H. J. Choi Changnyeong-gun (Uponeup)-120628-001 (KH); Haman-gun, Daesan-myeon, Seochon-ri, 14 Jun 2014, J.-H. Kim 141057 (KB); Gaya-eup, Sanseo-ri, 31 May 2015, K.-S. Chung 1207 (CNU, KH); 22 May 2016, T. Hoshino et al. OKAY-24745 (OKAY); Miryang-si, Samnangjin-eup, Samnang-ri, Milyanggang (river), 11 May 2018, J.-S. Kim MR0082 (KB); Yangsan-si, Wondong-myeon, Yongdang-ri, Wondong (wetland), J.-H. Kim 13-36 (KB).

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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Appendix 1. Vascular plants in the new population with images and voucher specimens.

Scientific name (Korean name)	Voucher specimen	Note*
Equisetaceae (속새과)		
<i>Equisetum arvense</i> L. (쇠뜨기)	Lee001	
Athyriaceae (개고사리과)		
<i>Athyrium niponicum</i> (Mett.) Hance (개고사리)	Lee002	
Lauraceae (녹나무과)		
<i>Lindera glauca</i> (Siebold & Zucc.) Blume (감태나무)		
Ranunculaceae (미나리아재비과)		
<i>Ranunculus chinensis</i> Bunge (젓가락나물)	Chung et al. H005, H004, H003, H002, H001	
Papaveraceae (양귀비과)		
<i>Chelidonium majus</i> var. <i>asiaticum</i> (Hara) Ohwi (애기똥풀)	Chung et al. H045	
Ulmaceae (팽나무과)		
<i>Celtis sinensis</i> Pers. (팽나무)	Chung et al. H043	
<i>Ulmus parvifolia</i> Jacq. (참느릅나무)	Chung et al. H049	Degree I
Cannabinaceae (삼과)		
<i>Humulus japonicus</i> Siebold & Zucc. (환삼덩굴)	Chung et al. H040	
Moraceae (뽕나무과)		
<i>Morus bombycis</i> Koidz. (산뽕나무)	Chung et al. H010, H009	
Urticaceae (췌기풀과)		
<i>Boehmeria spicata</i> (Thunb.) Thunb. (췌개잎나무)		
Fagaceae (참나무과)		
<i>Quercus aliena</i> Blume (갈참나무)		

Appendix 1. Continued.

Scientific name (Korean name)	Voucher specimen	Note*
<i>Quercus acutissima</i> Carruth. (상수리나무)	Chung et al. H064, H063	
Phytolaccaceae (자리공과)		
<i>Phytolacca americana</i> L. (미국자리공)	Chung et al. H047	In
Amaranthaceae (비름과)		
<i>Achyranthes japonica</i> (Miq.) Nakai (쇠무릎)		
Caryophyllaceae (석죽과)		
<i>Sellaria quatica</i> (L.) Scop. (쇠별꽃)	Chung et al. H021, H006	
Polygonaceae (마디풀과)		
<i>Fallopia dumetorum</i> (L.) Holub (닭의당굴)	Chung et al. H034, H022	
<i>Persicaria japonica</i> (Meisn.) H. Gross ex Nakai (흰꽃여뀌)	Chung et al. H018	
<i>Persicaria maackiana</i> (Regel) Nakai ex T. Mori (나도미꾸리늪시)	Chung et al. H013, H007	
<i>Persicaria perfoliata</i> (L.) H. Gross (머느리배꼽)	Chung et al. H060	
<i>Persicaria senticosa</i> (Meisn.) H. Gross ex Nakai (머느리밀씻개)		
<i>Persicaria thunbergii</i> (Siebold & Zucc.) H. Gross (고마리)	Chung et al. H020	
<i>Rumex crispus</i> L. (소리쟁이)	Chung et al. H059	In
Violaceae (제비꽃과)		
<i>Viola verecunda</i> A. Gray (콩제비꽃)	Chung et al. H029	
Cucurbitaceae (박과)		
<i>Actinostemma lobatum</i> (Maxim.) Franch. & Sav. (뚜껍덩굴)		Degree I
Salicaceae (버드나무과)		
<i>Populus deltoides</i> Marsh (미류나무)	Chung et al. H076, H075, H074, H073, H072, H071	Pl
<i>Salix caprea</i> L. (호랑버들)	Chung et al. H069	
<i>Salix chaenomeloides</i> Kimura (왕버들)	Chung et al. H070	Degree I
<i>Salix graciligrans</i> Nakai (눈개버들)	Chung et al. H068	
<i>Salix koreensis</i> Andersson (버드나무)	Chung et al. H053, H052, H051, H050	
Brassicaceae (십자화과)		
<i>Capsella bursa-pastoris</i> (L.) Medik. (냉이)		
<i>Cardamine flexuosa</i> With. (황새냉이)		
<i>Thlaspi arvense</i> L. (말냉이)		In
Styracaceae (때죽나무과)		
<i>Styrax japonicus</i> Siebold & Zucc. (때죽나무)		BSOA
Rosaceae (장미과)		
<i>Duchesnea chrysantha</i> (Zoll. et Morr.) Miq. (뱀딸기)	Lee003	
<i>Prunus jamasakura</i> Siebold ex Koidz. (벚나무)	Lee004	
<i>Rosa multiflora</i> Thunb. (절레나무)	Chung et al. H019	
<i>Rubus crataegifolius</i> Bunge (산딸기)	Chung et al. H068, H067	
<i>Rubus parvifolius</i> L. (명석딸기)		
<i>Spiraea prunifolia</i> var. <i>simpliciflora</i> (Nakai) Nakai (조팝나무)	Lee005	BSOA
Fabaceae (콩과)		

Appendix 1. Continued.

Scientific name (Korean name)	Voucher specimen	Note*
<i>Amphicarpaea bracteata</i> subsp. <i>edgeworthii</i> (Benth.) H. Ohashi (새콩)		
<i>Astragalus sinicus</i> L. (자운영)		In
<i>Glycine soja</i> Siebold & Zucc. (돌콩)		BSOA
<i>Lespedeza cuneata</i> (Dum. Cours.) G. Don. (비수리)	<i>Chung et al. H012, H011</i>	BSOA
<i>Vicia amoena</i> Fisch. ex Ser. (갈퀴나물)		
<i>Vicia sativa</i> L. (살갈퀴)		
<i>Vicia tetrasperma</i> (L.) Schreb. (얼치기완두)		
Vitaceae (포도과)		
<i>Vitis flexuosa</i> Thunb. (새머루)		
Aceraceae (단풍나무과)		
<i>Acer buergerianum</i> Miq. (중국단풍)	<i>Chung et al. H044</i>	PI
<i>Acer palmatum</i> Thunb. (단풍나무)	<i>Chung et al. H048, H036</i>	BSOA, Degree III
Rutaceae (윤향과)		
<i>Zanthoxylum schinifolium</i> Siebold & Zucc. (산초나무)		BSOA
<i>Zanthoxylum piperitum</i> DC. (초피나무)		BSOA
Apiaceae (미나리과)		
<i>Oenanthe javanica</i> (Blume) DC. (미나리)	<i>Lee006</i>	BSOA
<i>Torilis japonica</i> (Houtt.) DC. (사상자)	<i>Chung et al. H061, H058, H057</i>	
Boraginaceae (지치과)		
<i>Trigonotis peduncularis</i> (Trevir.) Steven ex Palib. (꽃마리)		
Lamiaceae (꿀풀과)		
<i>Agastache rugosa</i> (Fisch. & C. A. Mey.) Kuntze (배초향)		
<i>Leonurus japonicus</i> Houtt. (익모초)	<i>Chung et al. H015, H014</i>	
<i>Mosla dianthera</i> (Buch.-Ham. ex Roxb.) Maxim. (취개풀)	<i>Lee007</i>	
Oleaceae (물푸레나무과)		
<i>Ligustrum obtusifolium</i> Siebold & Zucc. (쥐똥나무)	<i>Chung et al. H035</i>	
Scrophulariaceae (현삼과)		
<i>Veronica persica</i> Poir. (큰개불알풀)	<i>Lee008</i>	CBIS
Rubiaceae (꼭두선이과)		
<i>Galium pogonanthum</i> Franch. & Sav. (산갈퀴)		
<i>Galium spurium</i> L. (갈퀴덩굴)	<i>Lee009</i>	
<i>Paederia foetida</i> L. (계요등)		
<i>Rubia argyi</i> (H. Lév. & Vaniot) H. Hara ex Lauener & D. K. Ferguson (꼭두선이)		
Asteraceae (국화과)		
<i>Artemisia princeps</i> Pamp. (쑥)	<i>Chung et al. H031</i>	
<i>Crepidastrum sonchifolium</i> (Bunge) Pak & Kawano (고들빼기)	<i>Chung et al. H032</i>	
<i>Erigeron annuus</i> (L.) Pers. (개망초)	<i>Chung et al. H028</i>	In
<i>Hemistepta lyrata</i> Bunge (지칭개)	<i>Lee010</i>	
<i>Lactuca indica</i> L. (왕고들빼기)	<i>Chung et al. H037</i>	

Appendix 1. Continued.

Scientific name (Korean name)	Voucher specimen	Note*
<i>Youngia japonica</i> subsp. <i>elstonii</i> (Hochr.) Bab. & Stebbins (뽕리뱅이)	Chung et al. H042, H041	
Potamogetonaceae (가래과)		
<i>Potamogeton crispus</i> L. (말즘)	Lee011, Lee012	
Hydrocharitaceae (자라풀과)		
<i>Hydrilla verticillata</i> (L.f.) Royle (검정말)	Chung et al. H039	
Lemnaceae (개구리밥과)		
<i>Spirodela polyrhiza</i> (L.) Schleid. (개구리밥)		
Commelidaceae (닭의장풀과)		
<i>Commelina communis</i> L. (닭의장풀)	Chung et al. H033	
Cyperaceae (사초과)		
<i>Carex breviculmis</i> R. Br. (청사초)	Chung6196	
<i>Carex cinerascens</i> Kük. (회색사초)	Chung6196	
<i>Carex dimorpholepis</i> Steud. (이삭사초)	Chung6196	
<i>Carex dispalata</i> Boott (삿갓사초)	Chung6196	
<i>Carex maackii</i> Maxim. (타래사초)	Chung6196	
<i>Carex nakasimae</i> Ohwi (화산사초)	Chung6196	En
<i>Carex transversa</i> Boott (화살사초)	Chung6196	
<i>Eleocharis</i> sp. (바늘굴속)	Chung et al. H030	
Poaceae (벼과)		
<i>Arthraxon hispidus</i> (Thunb.) Makino (조개풀)	Chung et al. H008	
<i>Beckmannia syzigachne</i> (Steud.) Fernald (개피)	Chung et al. H062	
<i>Miscanthus sinensis</i> Andersson (억새)	Chung et al. H046	
<i>Oplismenus undulatifolius</i> (Ard.) Roem. & Schult. (주름조개풀)	Chung et al. H023	
<i>Phalaris arundinacea</i> L. (갈풀)	Chung et al. H065	
<i>Phragmites australis</i> (Cav.) Trin. ex Steud. (갈대)	Chung et al. H056, H055, H054	
Liliaceae (백합과)		
<i>Hemerocallis hakuunensis</i> Nakai (백운산원추리)	Chung et al. H038, H024	En, BSOA
Iridaceae (붓꽃과)		
<i>Iris ensata</i> var. <i>spontanea</i> (Mak.) Nakai (꽃창포)	Lee013	
Dioscoreaceae (마과)		
<i>Dioscorea batatas</i> Decne. (마)	Chung et al. H025	
<i>Dioscorea tokoro</i> Makino (도꼬로마)	Chung et al. H027	

BSOA: Biological resources subject to overseas export approval; En: Endemic; In: Introduced; CBIS: Climate-sensitive Biological Indicator Species; Pl: Planted.