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Categorized wetland preference and life forms of the vascular plants in the Korean Peninsula

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Abstract

Background: In 2020, a categorized list of wetland preferences, major habitats, and life forms of 4145 vascular plant taxa occurring in the Korean Peninsula was published by the National Institute of Biological Resources. We analyzed the list and explored the distribution patterns of the five categorized groups according to wetland preference, along with the information on the major habitats and the life forms of the plants belonging to those categories.

Results: Out of 4145 taxa, we found that 729 wetland plant taxa (18%) occur in Korea: 401 obligate wetland plants and 328 facultative wetland plants. Among the 729 wetland taxa, the majority (73%) was hygrophytes and the remaining 27% was aquatic macrophytes. Furthermore, almost all of the wetland taxa are herbs; so, woody plants are only 4.7%. The 16 carnivorous taxa distributed in Korea were characterized as obligate wetland plants.

Conclusions: We expect the categorized information would promote understanding of the characteristics of the plant species and would be an important source for understanding, conservation, and restoration of wetland ecosystems.

Keywords: Growth form, Habitat, Nutrition mode, Seasonality, Wetland indicator status

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Main text

In 2020, Choung et al. published a book on wetland preference and life forms of vascular plants occurring in the Korean Peninsula. The book contains information on 4145 native and naturalized vascular plant taxa based on the National Species List of Korea provided by the National Institute of Biological Resources (2019). The core content categorizes all vascular plants into five groups according to their wetland preferences. Additionally, it includes categorized details of the major habitats and life forms, such as growth form, seasonality, and nutritional mode. Categorizing plant species distributed over a broad spectrum into a small number of groups is truly useful because such information is necessary for understanding, conservation, and restoration of wetland ecosystems.

Information provided by most of the authors of this book was previously available (Choung et al. 2012). However, in the new book (Choung et al. 2020), the base list of the species was changed from Lee (1996) to the National Institute of Biological Resources (2019), and the definition of the wetlands was made more specific. Furthermore, the number of reference sources (books, websites, and publications) has increased in these few years. Based on those backgrounds, information on all the species was evaluated in the new book. Typically, the definition of wetland varies depending upon the countries, institutions, and researchers. Previously, the definition was based on the Ramsar Convention (1971), i.e., wetlands are areas of marsh, fen, peatland, or water, whether natural or artificial, permanent, or temporary, with water that is static or flowing, fresh, brackish, or salty, including areas of marine water, the depth of which at low tide does not exceed 6 m. In the new book, wetland was defined as an area where the soil or bottom substrate of the habitat is either underwater or wet regardless of the size whether large or small, respectively. By defining it specific, small spaces where only a few individuals can inhabit, such as small puddles or small damp places in the forest, were considered as wetlands. However, places with high air humidity, such as lower mountain slopes or valley forests, were not included as wetlands.

The purpose of this article is to report the distribution patterns of vascular plants in Korea categorized according to their wetland preference and to provide information on the major habitats and life forms such as growth form, seasonality, and nutritional mode of the plants belonging to five categories.

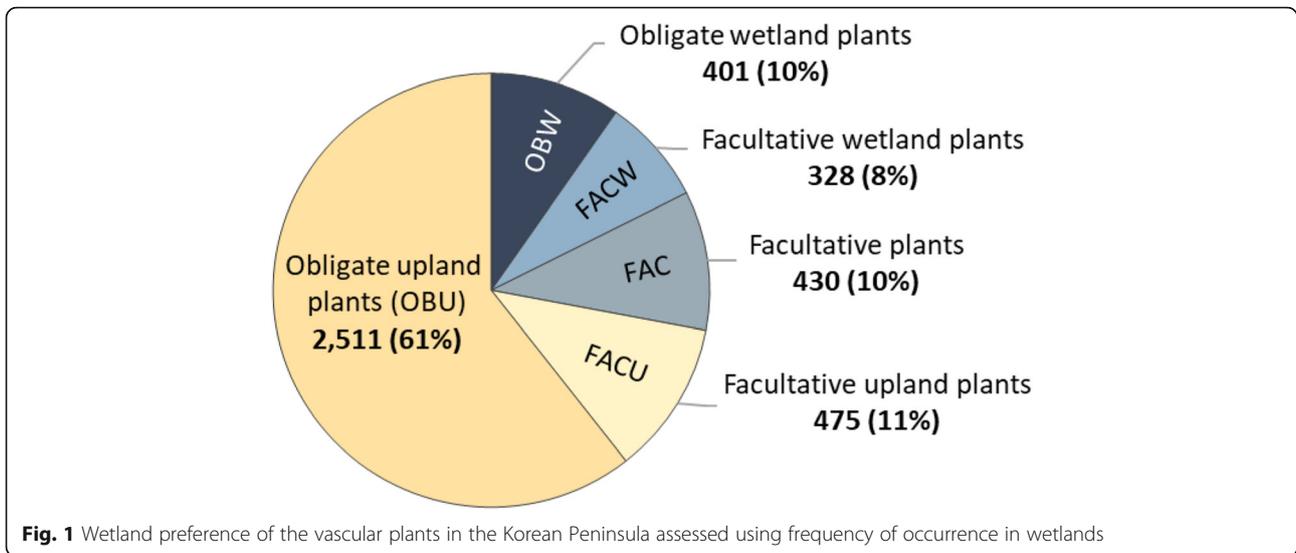
Categorizing wetland preference of vascular plants

Wetland preference of plants was categorized into five groups according to their frequency of occurrence in the wetlands. For classification, the U.S. Fish and Wildlife Service (1997) was modified and adopted. The categorization was not the result of quantitative research, but a product of collaborative discussion with the frequency values as a reference by a group of specialists with several decades of field experience.

- Obligate wetland plants (OBW) occur almost always in wetlands under natural conditions (estimated frequency of occurrence >98% in wetlands)
- Facultative wetland plants (FACW) usually occur in wetlands but occasionally found in non-wetlands too (estimated 71–98% in wetlands)
- Facultative plants (FAC) likely to occur equally in both wetlands and non-wetlands (estimated 31–70% in wetlands)
- Facultative upland plants (FACU) occasionally occur in wetlands, but usually occur in non-wetlands (estimated 3–30% in wetlands)
- Obligate upland plants (OBU) almost never occur in wetlands under natural conditions (estimated <3% in wetlands)

Based on this classification, 401 taxa (10%) and 328 taxa (8%) among 4,145 taxa were found to fall in the category of OBW and FACW, respectively (Fig. 1). A total of 729 wetland plant taxa (18%) are distributed in Korea, considering OBW and FACW as wetland plants. This is a significant difference, compared to the wetland plants previously at 12% (OBW and FACW 6% each) (Choung et al. 2015). It mainly resulted from the re-establishment of the spatial scopes of the wetlands. The FAC with the widest distribution range for moisture includes 430 taxa (10%). The OBU with 2,511 taxa becomes the largest group comprising 61% of the total taxa. When FACU with 475 taxa (11%) was included, the upland plants reached 72%.

The only information that can be compared with the above classification is the U.S. Army Corps of Engineers (2016). Of the 8080 taxa across the USA, OBW and FACW were 23 and 21%, respectively, resulting in total 44%. Since the USA has vast areas of lakes, swamps, and stream channels, there is a possibility that the proportion of wetland plants is higher in the USA than that in Korea (Hack 1968). However, this difference may mainly be due to the specific criteria of evaluation of the wetland plants. On comparing the common species of the two



countries, most of the plants distributed in habitats with high air humidity were evaluated as wetland plants in the U.S. Army Corps of Engineers (2016).

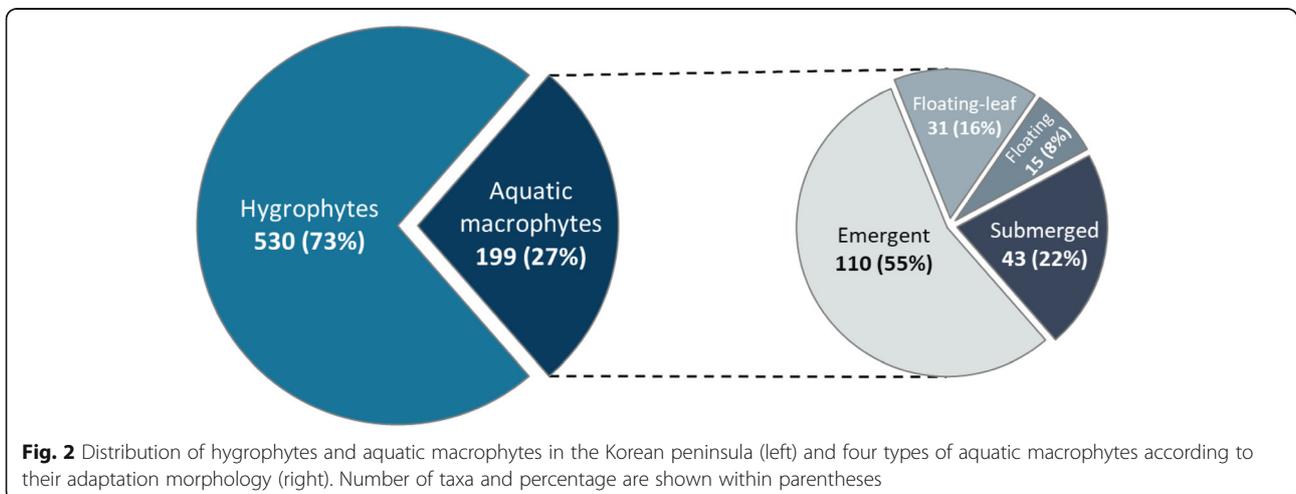
Among the wetland plants, the distributions of aquatic macrophytes and hygrophytes were analyzed. The aquatic macrophytes refer to plants that have adapted to environment such as fresh water and seawater, and grow inside water, or near water with a water level higher than the surface. The hygrophytes are plants that have adapted to a place which is usually saturated with water up to the surface, but having seasonal water level fluctuations. Among the 729 taxa of the wetland plants, most (73%) are hygrophytes and the remaining 27% are aquatic macrophytes (Fig. 2). Also, there are four types of aquatic macrophytes of which the emergent plants are the most common. To

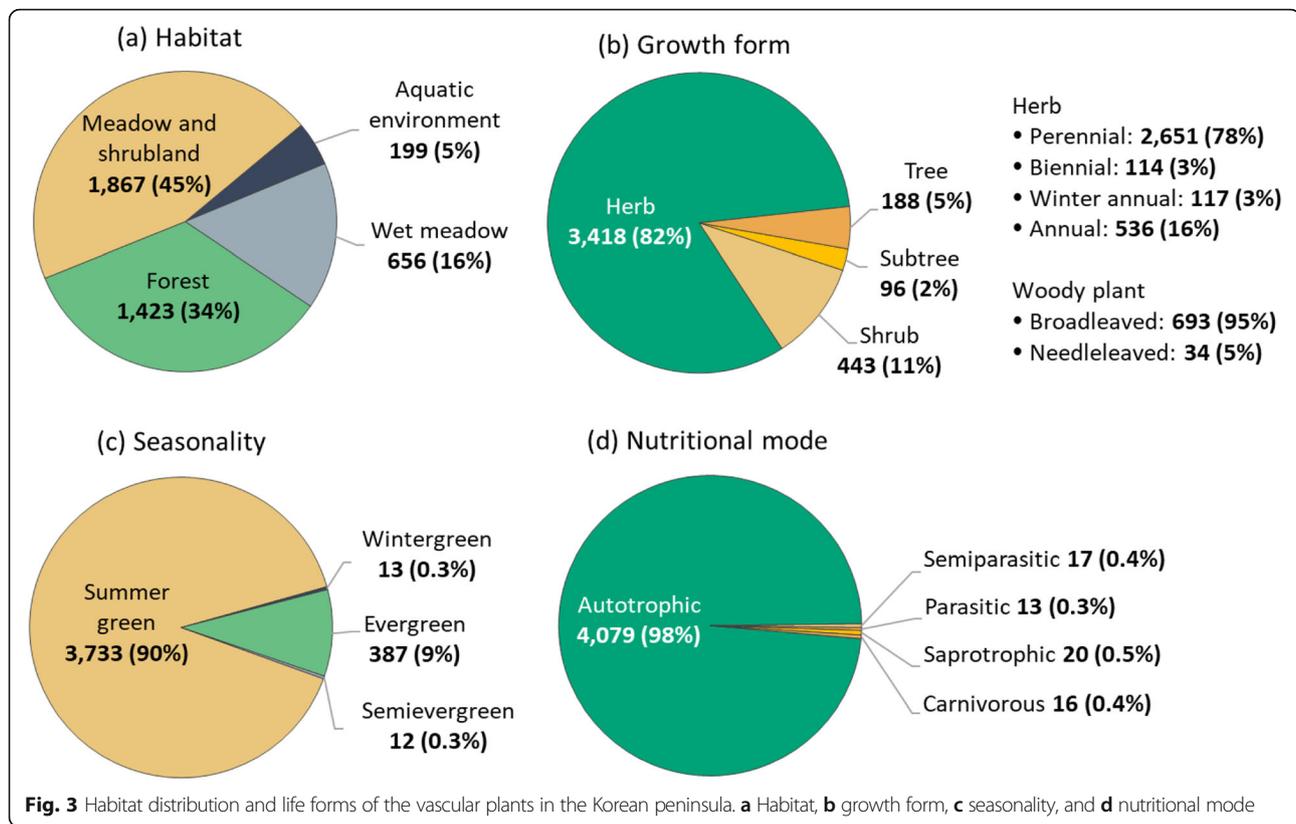
note, all the aquatic macrophytes (199 taxa) and a portion of the hygrophytes (202 taxa) belong to OBW, while FACWs comprises all the hygrophytes.

Categorizing major habitats of vascular plants

Out of the total vascular taxa, 79% inhabits in terrestrial environments, such as meadow, and shrublands, and forests as their major habitats, while the rest 21% inhabits in wetlands (Fig. 3). Meadows and shrublands represent mountain slope, open slope and area, thicket, scrub, and coast where most of the light-demanding plants thrive. On the other hand, forest is a particular area which houses plants with some degree of shade-tolerance.

OBWs are distributed in both aquatic environments and wet meadows in similar proportions (Table 1).





The aquatic environment is an area located in a body of water, and while the wet meadow is an area such as a moor, the riparian, and littoral zone, which are saturated with water throughout much of the year. Among the OBWs, 1 taxon (*Glyceria lithuanica*) is distributed in the forests. FACW does not appear in aquatic environment, and 92% occurs in wet meadows, such as watersides, ditches, and rice fields. The remaining 8% taxa are distributed in forests which developed from wet meadows. The FACs thrive under the widest distribution of moisture conditions—from wet meadows and damp forests to shrublands and roadsides. The FACUs are mostly found in forests, shrublands, and open areas, but infrequently they appear in wetlands too. By contrast, the OBUs are mainly distributed in forests, shrubs, and grasslands and almost never inhabit in wetlands under natural conditions.

Categorizing growth forms of vascular plants

Among growth forms of the total taxa, herbs accounted for 82% (3418 taxa). Of the herbs, 78% are perennial and 16% are annual (Fig. 3). Shrubs and trees account for 443 taxa (11%) and 188 taxa (5%), respectively. Among the woody plants (shrubs, subtrees, and trees), 95% are broadleaved and the rest

are needleleaved. Almost all of OBWs (99%) are herbs (Table 1). There are no OBWs among the trees or subtrees, only 4 shrub taxa, namely *Andromeda polifolia*, *Chamaedaphne calyculata*, *Vaccinium microcarpum*, and *V. oxycoccus* are OBWs. The trees and subtrees of 16 taxa such as *Salix* and *Populus* belong to FACW.

Categorizing seasonality of vascular plants

Among the total taxa, summer green plants are the most distributed (90%), while evergreen trees are only 387 taxa (9%) (Fig. 3). The wintergreen plant is a plant with green leaves in the winter and lose leaves in the summer. The wintergreen contains 13 taxa, e.g., *Botrychium atrovirens* and *Diplazium mettenianum*. They are all ferns and have been found in Jeju Island. Only 9 taxa (1.2%) of the OBWs and FACWs are evergreen plants (Table 1). Generally, most of the evergreen and semievergreen plants are OBUs. The semievergreen plant is a plant that is incompletely evergreen. Some leaves fall in autumn, whereas the rest near the surface stay evergreen in winter.

Categorizing nutritional mode of vascular plants

Autotrophic plants account for 98% of the total taxa. On the other hand, semiparasitic (e.g., *Viscum*

Table 1 Habitat distribution and life forms of the vascular plants in the Korean Peninsula according to wetland preference categories

Properties	Wetland preference				
	Obligate wetland plants (OBW)	Facultative wetland plants (FACW)	Facultative plants (FAC)	Facultative upland plants (FACU)	Obligate upland plants (OBU)
Habitat					
Aquatic environment	199 (49.6)				
Wet meadow	201 (50.1)	300 (91.5)	155 (36.0)		
Forest	1 (0.2)	28 (8.5)	129 (30.0)	139 (29.3)	1125 (44.8)
Meadow and shrubland			146 (34.0)	336 (70.7)	1386 (55.2)
Total	401 (100)	328 (100)	430 (100)	475 (100)	2511 (100)
Growth form					
Herb	397 (99.0)	298 (90.9)	398 (92.6)	422 (88.8)	1903 (75.8)
Shrub	4 (1.0)	14 (4.3)	22 (5.1)	37 (7.8)	366 (14.6)
Subtree		4 (1.2)	4 (0.9)	6 (1.3)	82 (3.3)
Tree		12 (3.7)	6 (1.4)	10 (2.1)	160 (6.4)
Total	401 (100)	328 (100)	430 (100)	475 (100)	2511 (100)
Seasonality					
Summer green	397 (99.0)	323 (98.5)	404 (94.0)	439 (92.4)	2170 (86.4)
Wintergreen			2 (0.5)		11 (0.4)
Evergreen	4 (1.0)	5 (1.5)	24 (5.6)	36 (7.6)	318 (12.7)
Semievergreen					12 (0.5)
Total	401 (100)	328 (100)	430 (100)	475 (100)	2511 (100)
Nutritional mode					
Autotrophic	385 (96.0)	328 (100)	428 (99.5)	473 (99.6)	2465 (98.2)
Semiparasitic			1 (0.2)	1 (0.2)	15 (0.6)
Parasitic			1 (0.2)	1 (0.2)	11 (0.4)
Saprotrophic					20 (0.8)
Carnivorous	16 (4.0)				
Total	401 (100)	328 (100)	430 (100)	475 (100)	2511 (100)

Values are number of taxa and percentage (in parentheses) within each wetland preference

coloratum and *Melampyrum setaceum*), parasitic (e.g., *Cuscuta japonica* and *Orobanche coerulea*), and saprotrophic plants (e.g., *Cymbidium macrorhizon* and *Monotropa uniflora*) are only 50 taxa (Fig. 3). These plants obtain energy from other plant sources, most of which are OBUs (Table 1). Apart from these, 16 taxa are carnivorous plants (e.g., *Drosera rotundifolia* and *Utricularia tenuicaulis*) which take inorganic nutrients from other organisms. All of them belong to OBWs (Table 1).

Conclusions

To conclude, we analyzed the list of categorized vascular plant species according to wetland preferences. Such analysis gives deeper insight into the characteristics of plant species distributed in the Korean Peninsula. In particular, we expect the categorized information to

serve as the indicator for health assessment of aquatic ecosystems, including rivers and lakes, thereby providing better understanding, conservation, and restoration of wetland ecosystems.

Abbreviations

OBW: Obligate wetland plant; FACW: Facultative wetland plant; FAC: Facultative plant; FACU: Facultative upland plant; OBU: Obligate upland plant

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Authors' contributions

CY wrote the manuscript; MBM, LKS, CKH, JKY, HJO, NHR, OHK, NGH, and KJS revised the manuscript; and CS, LJ, JS, and LJ analyzed the database. The author(s) read and approved the final manuscript.

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Availability of data and materials

The categorized list of all vascular plants is open-accessed at the National Institute of Biological Resources.

Declarations**Ethics approval and consent to participate**

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Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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