Human impact on flora and habitats in Korean rural settlements

Vliv lidské činnosti na stanoviště korejských vesnic a jejich flóru

Yeon-Mee K i m [#], Stefan Z e r b e & Ingo K o w a r i k [*]

Dedicated to the memory of Slavomil Hejný

*Institute of Ecology, Technical University Berlin, Rothenburgstr. 12, D-12165 Berlin, Germany, email: Stefan.Zerbe@TU-Berlin.de, Kowarik@TU-Berlin.de; [#]Present address: 13-105 Seong Su I Ga 2 Dong, Seong Dong-Gu, Seoul, Republic of Korea, email: yeonmeekim@hotmail.com; *corresponding author*

Kim Y.-M., Zerbe S. & Kowarik I. (2002): Human impact on flora and habitats in Korean rural settlements. – Preslia, Praha, 74: 407–419.

Land use has direct and indirect effects on the environmental conditions, which play a major role in the dynamics and changes in landscape. In Central Europe, the hemeroby approach is broadly used to quantify human impact on habitats and their vegetation. In this paper, the hemeroby approach was adopted for studying the rural settlements in the East Asian Republic of Korea. Flora and habitats of eight villages were analysed. The habitats were classified according to the five degrees on the hemeroby scale (oligo-, β-meso-, α-meso-, eu-, and polyhemerobic). Hemeroby indicator values were derived for species that were typical of a specific level of hemeroby. Habitats with the same level of hemeroby were grouped. The highest species number was found in habitats that were only moderately influenced by man. This corresponds to the intermediate disturbance hypothesis. The flora of habitats that were subject to the highest level of human impact (polyhemerobic) was characterized by a high proportion of annual species, but unexpectedly not by the highest proportion of non-native species.

K e y w o r d s : Hemeroby, human impact, Korea, non-native species, rural settlements, village flora

Introduction

Land use directly and indirectly influences environmental conditions, which play a major role in the dynamics and changes in landscapes. In Europe, human impact on the flora and vegetation is well analysed both for large cities and rural areas. Intensive land use causes significant quantitative and qualitative changes in the flora, fauna, biocoenoses and habitats (Tüxen 1961, Sukopp & Trautmann 1976). In settlements, the often highly diverse flora and habitats reflect the numerous land use types (Hejný et al. 1978, Sudnik-Wójcikowska 1986, Sukopp et al. 1990, Klotz 1990, Pyšek 1998a, Zerbe et al. 2003). Additionally, the occurrence of non-native species is recorded more frequently in cities than rural areas and near natural vegetation (Falinski 1971, Lohmeyer & Sukopp 1992, Kowarik 1995).

The hemeroby approach is a helpful tool in ecological analysis. In this paper, the Republic of Korea is taken as an example. Among the Asian nations, Korea has experienced the fastest socio-economic development in the past few decades. This is indicated by the decline in the rural population from ca. 95% in 1929 to ca. 9% in 1999 (Academy of Korean Studies 1991, Ministry of Agriculture and Forestry 2000). Consequently, the rural environment with its traditional villages and land-use structures was strongly affected by this development (Zerbe & Lee 2000). The process of urbanization of the rural settlements not only optimized the exploitation of the natural resources, but also strongly increased the destruction of the natural environment in Korea (Lee 1982). However, there are no studies of these rapid environmental changes, because most ecological studies of Korean settlements focus on large cities (Schätzl 1992, Kim 1996, Song 1998, Oh & Lee 2000, Seoul City Administration 2000).

This study aims to qualitatively and quantitatively assess human impact on the flora and habitats in Korean rural settlements using the concept of hemeroby. First, the criteria for evaluating the habitats are defined. The habitats in eight villages are then classified according to the five degrees of the hemeroby scale, ranging from weakly to strongly affected habitats. Hemeroby indicator values are attributed to species that are typical of habitats with a distinct level of hemeroby. Finally, species richness, spectra of life forms, and the performance of non-native species are analysed in relation to the degree of hemeroby of the habitats.

The assessment of human impact on the flora and habitats in Korean rural settlements is essential for programs of village development and the conservation of nature and cultural identity in rural landscapes.

The concept of hemeroby for the assessment of human impact

Europe has a long tradition of assessing the naturalness of habitats and vegetation. According to the state of nature to which the man-induced changed state is related, two main approaches can be distinguished by their temporal perspectives: historical and status quo-oriented concepts (Kowarik 1988, 1999). In the first, vegetation or habitats are related to pristine nature, i.e. that which has not been affected by human impact ("ursprüngliche Vegetation" sensu Tüxen 1956). For example, the degree of naturalness of a site is how similar it is to its original state without the influence of man. In contrast, status quo-orientated concepts, such as the hemeroby approach, assess the naturalness of a site without reference to former conditions. In this case the highest level of naturalness is when the system has not been affected by man and is self-regulated. A low level of hemeroby (= high level of naturalness) may even occur on severely changed sites that will never be recolonized by their former natural vegetation. These two approaches give different results for irreversibly changed sites, e.g. urban-industrial areas, and similar results for natural woodlands. The hemeroby concept was introduced by Jalas (1955) and further developed by Sukopp (1969; see also Kunick 1974, Blume & Sukopp 1976) and Kowarik (1988). Kowarik (1990) defines hemeroby as "the sum of the effects of past and present human activities on the current site conditions or vegetation, which prevent the development to a final stage". This concept also integrates the site conditions that were irreversibly changed by human activities. Thus, the hemeroby approach allows us to assess human impact and the natural development, respectively, even of strongly changed urban-industrial sites.

Both, the historical and status quo-oriented approaches may provide valuable information on the role of humans in changing the environmental conditions of an area and the response of natural processes. In Korea, the status quo-oriented concept is particularly advantageous because of a near complete lack of historical data on the natural Korean flora, vegetation and habitats. This significantly reduces the effectiveness of a comparative analysis from an historical perspective.

Study area

In 1997 and 1998, the flora and habitats of eight Korean villages and their surroundings were investigated. The villages are located in central South Korea (Fig. 1) in different types of Korean rural settlements with varying land-use types. Rice cultivation dominates the lowland villages, dry field cultivation prevails in the mountainous region. The mean annual precipitation in the study area ranges between 1,130 and 1,320 mm, the mean annual temperature between 9.3 and 12.5 °C (Korean Meteorological Administration 2000). The big difference in the mean temperatures of the warmest and coldest months (ca. 30 °C) indicates a continental type climate.

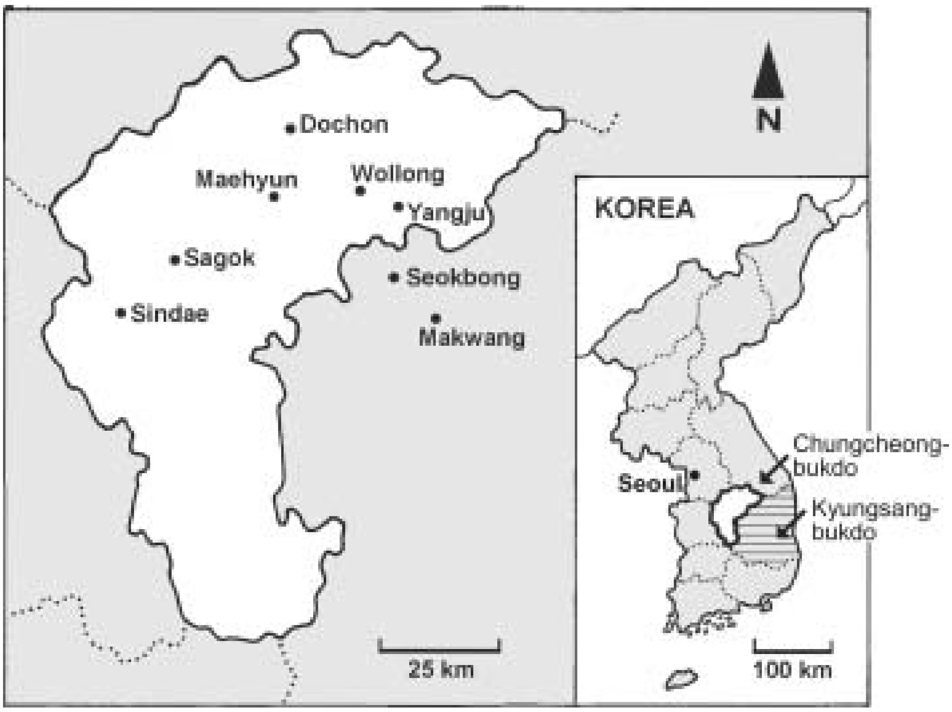

Fig. 1. – Location of the study area in Korea and the villages investigated.

Methods

The habitats in the villages are differentiated according to land use, which is a decisive site factor in settlement areas (e.g. Schulte et al. 1993). In each village, 10 to 20 habitats were investigated. A total of 53 habitat types (e.g. hedges, dry fields, fruit tree plantations) with 157 specific habitats were found. The spontaneously occurring plant species and site characteris-

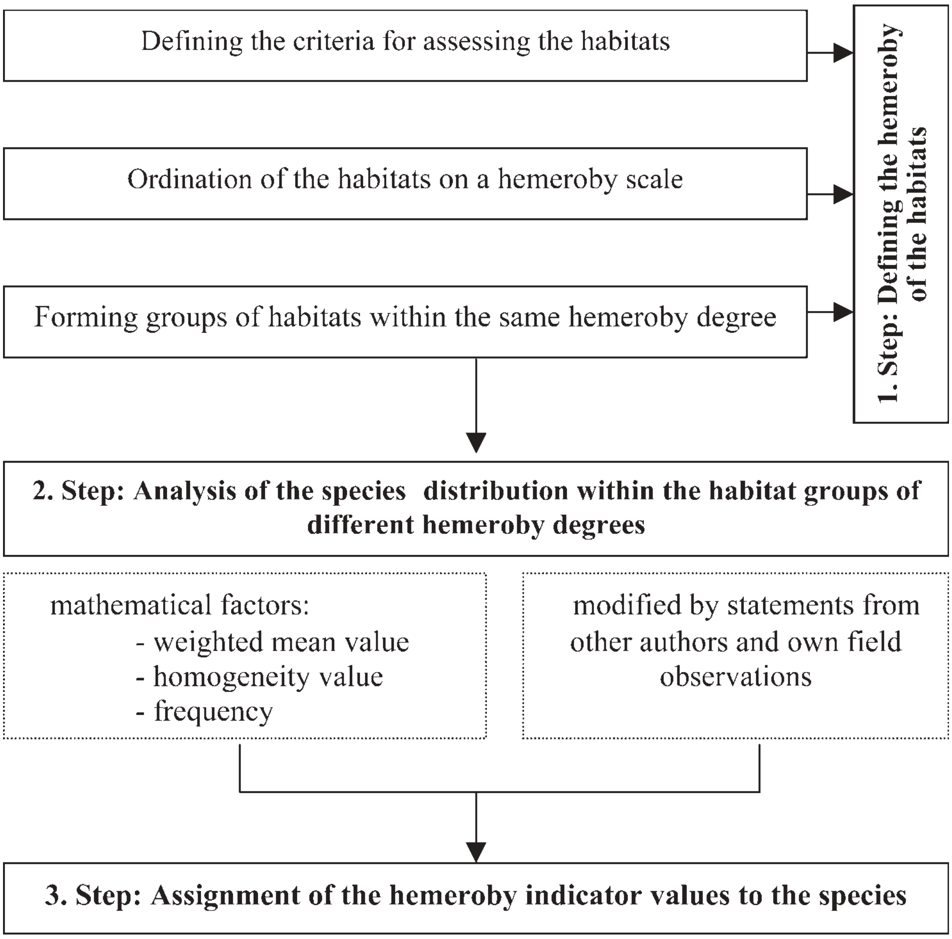

Fig. 2. – Steps in the determination of the hemeroby values for habitats and plant species.

tics of the habitats were recorded, focusing on the direct and indirect effect of man on the habitats. In order to analyse the varying human impact on the habitats, the rural settlement areas were differentiated according to the following disturbance factors: (i) mechanical disturbances of the soils (e.g., soil compression, ploughing, change in water balance by drainage or watering, soil sealing, embankment, waste deposition); (ii) direct mechanical disturbance of the vegetation (e.g., planting, harvesting plants or parts of them); and (iii) chemical disturbance (e.g., changes in soil chemistry due to fertilizers or pesticides).

The method of ascribing hemeroby values to habitats and species is shown in Fig. 2. In the first step, the habitats were ranked according to the hemeroby scale given in Table 1. The impact of each of the above mentioned disturbance factors was estimated, applying three categories (low, medium or high). The results were then compiled in a matrix (Table 1). Thus, for each habitat, the human impact is quantified, ranging from oligohemerobic (very weakly influenced) to polyhemerobic (very strongly influenced). The habitats with a similar degree of human impact were grouped according to their hemeroby value.

Table 1. – Matrix for the assessment of human impact on the habitats (hemeroby), taking the three factors (i) mechanical disturbance of the soil, (ii) direct mechanical disturbance of the vegetation, and (iii) chemical disturbance into account.

Degrees of hemeroby		Combination of the disturbance factors (irrespective of order)
H1	oligohemerobic	low + low +low
H2	β-mesohemerobic	low + low + medium
H3	α– mesohemerobic	low + medium + high
		low + low + high
		low + medium + medium
		medium + medium + medium
H4	euhemerobic	low + high + high
		medium + medium + high
		medium + high + high
H5	polyhemerobic	high + high + high

Then the hemeroby value of the plant species is determined by working out frequency spectra of the species (Fig. 2, Table 1). The weighted mean value of the species frequency in the habitat groups was determined as a preliminary hemeroby value. For species which occur with a frequency > 50% in those habitats with the same level of hemeroby, the hemeroby value of this habitat group is adopted as the hemeroby indicator value for the species. Species are regarded as indifferent to human impact, when they occur in more than four habitat groups and show a high level of homogeneity (Gini coefficient ≤ 0.2 – Weiner & Solbrig 1984). Finally, the hemeroby indicator value of a species so obtained was modified on the basis of field observations and expert statements (a complete list of species with their indicator values is published in Kim 2001). The hemeroby scale given in Table 1 can be applied to both habitats and species.

The total number of species and the occurrence of life forms and non-native species are analysed with respect to the habitat groups with a different degree of hemeroby. Due to the lack of information on the plant species occurring in Korea, the data on life forms and non-native species was obtained from different sources (Ohwi 1965, Yoshiwo 1972, Numata & Yoshizawa 1975, Lee 1993, Lindacher 1995).

Results

Differentiation and quantification of habitats on a hemeroby scale

The habitats of Korean rural settlements differ in degree of human impact: oligohemerobic (H1) are very weakly affected, β-mesohemerobic (H2) weakly affected, α-mesohemerobic (H3) moderately affected, euhemerobic (H4) strongly affected, and polyhemerobic (H5) very strongly affected. Ahemerobic habitats, which are unaffected by man, and metahemerobic habitats were not studied. Table 2 gives examples of the habitats studied in eight villages and their surroundings, ranging from very weakly affected habitats, like natural forests, to very strongly affected ones, like rubbish dumps.

Table 2. – Hemeroby scale and degrees of hemeroby corresponding to typical habitats and vegetation types in Korea.

Degrees of hemeroby		typical habitats and vegetation types
–	ahemerobic (non-disturbed)	almost non-existent in Korea (only in upper parts of mountains)
H1	oligohemerobic (very weakly influenced)	virtually non-affected habitats and vegetation in the upper mountains, e.g. natural coniferous forests, water vegetation, fens
H2	β-mesohemerobic (weakly influenced)	recently unmanaged deciduous and coniferous forests in the mountains
H3	α-mesohemerobic (moderately influenced)	managed forests, extensively used grassland
H4	euhemerobic (strongly influenced)	ruderal vegetation, grassland in urban areas (e.g. parks), weeds in extensively used fields
H5	polyhemerobic (very strongly influenced)	weeds in intensively used fields, rubbish dumps
–	metahemerobic (extremely disturbed)	built on areas (housing), poisoned areas, free of vegetation

The distribution of habitats according to the five degrees of hemeroby is shown in Fig. 3. Of the 157 habitats, 38% were strongly affected (H4) and 13% very strongly affected (H5). There were similar percentages (ca. 20%) of moderately (H3) and weakly affected (H2) habitats. Only 5% of the habitats were very weakly affected (H1). Thus, the majority of the habitats in Korean settlements were subject to strong or very strong human impact.

Assessing and quantifying the hemeroby values of the plant species

Of the 538 spontaneously occurring plant species recorded in the studied habitats, 134 (25%) were indifferent to human disturbance, i.e., they grew in a wide range of differently influenced sites. In contrast to the habitats, 50% of the species which could be assigned to one of the five hemeroby degrees (404 species in total, Fig. 4) indicate weakly affected sites (H2). There were similar percentages (ca. 20%) indicating moderately (H3) and strongly (H4) affected sites. Eight percent of the species were sensitive to disturbance (H1). Only 12 species (3%) were confined to very strongly affected sites (H5).

The effect of increasing disturbance on species richness is shown in Fig. 5, where the number of species that occurred in the habitats with the same degree of hemeroby is displayed. Highest numbers of species occurred in the weakly (H2 with 411 species) and the moderately affected (H3 with 350 species) habitats. Only 133 species were recorded in the very strongly affected habitats (H5).

Relationship between hemeroby and the occurrence of different life forms

In Fig. 6 the life forms of the plant species are correlated with the habitat groups of different degrees of hemeroby. The occurrence of therophytes (annual species) is correlated positively with the increasing effect of man. In oligohemerobic habitats (H1) only 15% of the plants were therophytes. However, the percentage increased gradually to 58% in polyhemerobic habitats (H5).

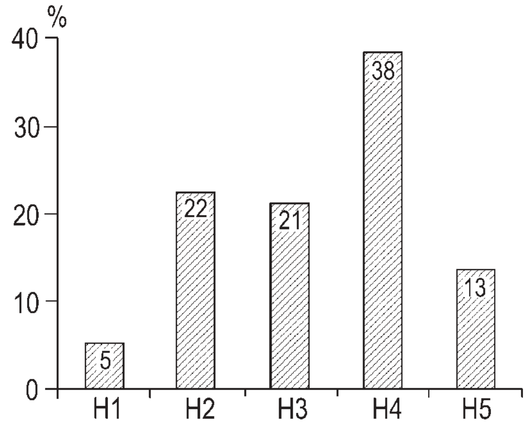

Fig. 3. – Percentage of habitats (n = 157) on the hemeroby scale from H1 to H5; for the degrees of hemeroby see Table 1.

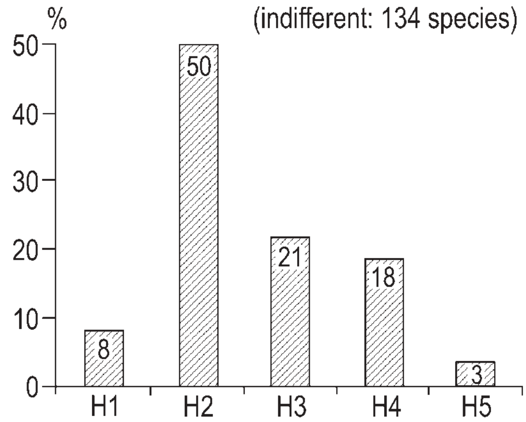

Fig. 4. – Percentage of species with different hemeroby indicator values (n = 404 species); the species unaffected by man are not included (n = 134); for the degrees of hemeroby see Table 1.

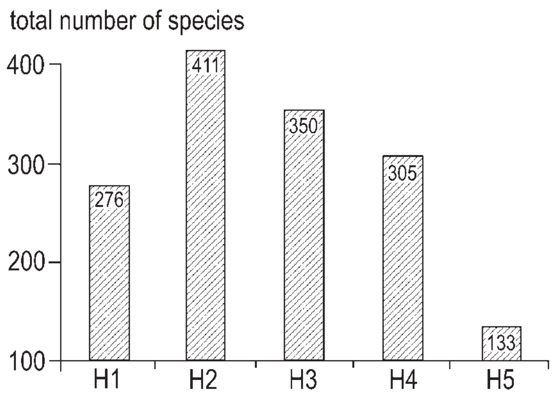

Fig. 5. – Total number of species occurring in the habitats with varying intensity of human impact factors; for the degrees of hemeroby see Table 1.

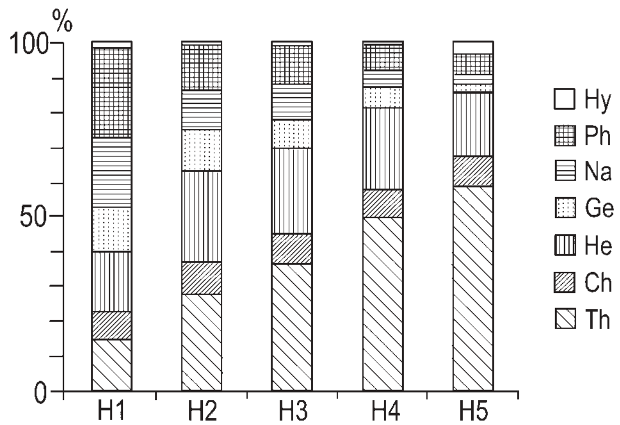

Fig. 6. – Percentage of life forms (Hy: hydrophytes, Ph: phanerophytes, Na: nanophanerophytes, Ge: geophytes, He: hemicryptophytes, Ch: chamaephytes, Th: therophytes) occurring in the habitats with varying intensity of human impact factors; for the degrees of hemeroby see Table 1.

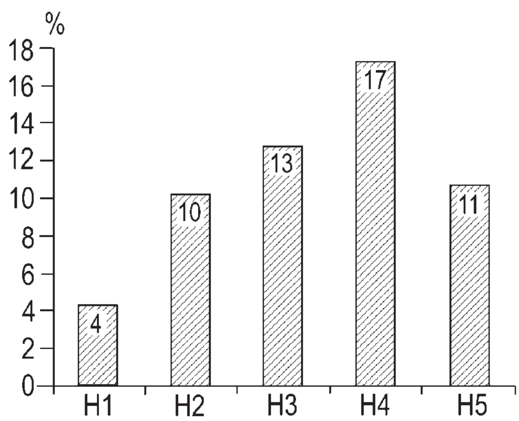

Fig. 7. – Mean percentage of non-native species occurring in the habitats with varying intensity of human impact factors; for the degrees of hemeroby see Table 1.

In contrast to therophytes the occurrence of phanerophytes, nanophanerophytes, and geophytes correlated negatively with increasing human impact (Fig. 6). For instance, the percentage of phanerophytes decreased from about 26% in oligohemerobic habitats (H1) to 6% in polyhemerobic habitats (H5). No correlation was found in the patterns of occurrence of chamaephytes and hemicryptophytes.

Relationship between hemeroby and the occurrence of non-native species

In Fig. 7, the occurrence of non-native species is correlated with the habitat groups of different degrees of hemeroby. In general, the percentage of non-native species increased with increase in anthropogenic effects at a site. Approximately 4%, the lowest, was recorded in oligohemerobic habitats (H1) and 17%, the highest, in euhemerobic habitats

(H4). However, in polyhemerobic habitats (H5), the percentage of non-native species was about 10%, which is similar to β- and α-mesohemerobic habitats (H 2 and H 3).

Discussion and conclusions

The human impact on the flora and habitats in Korean rural settlements was investigated by analysing the field data within the framework of the concept of hemeroby. The study revealed that anthropogenic disturbance of natural sites has a considerable effect on species richness, life form patterns, and the occurrence of non-native plant species. The variation in species richness at differently impacted sites corresponded to the intermediate disturbance hypothesis, formulated by Connell (1978; see also Hobbs & Huennecke 1992). According to this hypothesis, moderate disturbance leads to an increase in species richness compared to sites that are very weakly or very highly disturbed. The highest number of species was found in ß-mesohemerobic habitats (Fig. 5). Thus, both high or low levels of human disturbance have a negative effect on species richness. This accords with the investigations on the flora of Berlin (Kunick 1974, Kowarik 1988, 1990, Schmitz 2000) and Thienemann's principle that "the more variable the habitat conditions, the higher the diversity in a biocoenosis" (Klötzli 1992).

The results on the occurrence of therophytes in habitats with varying degrees of anthropogenic disturbance are similar to those obtained for the urban flora of Berlin (Kowarik 1988, Schmitz 2000) and Vienna (Jackowiak 1998), which show a positive correlation between the degree of hemeroby and the percentage of therophytes. In the Korean rural settlements 41% of the species were annuals (Fig. 6). This is not surprising considering the great variety and often high intensity of disturbance due to agricultural activities like ploughing, mowing, cutting, weeding, hoeing or the application of pesticides. Compared to the other life forms, the occurrence of therophytes was most conspicuously related to human impact. However, use of the occurrence of therophytes as indicator of the human impact is limited to sites and ecosystems where a considerable pool of this life form exists (e.g. Zerbe 1993 for forest ecosystems). In Berlin, a significant correlation between the percentage of annuals and the level of hemeroby was found in 70% of the vegetation types (35 of 50 phytosociological alliances; Kowarik 1988).

The percentage of non-native species in the habitats of the eight rural settlements in Korea is rather low, ranging from 4 to 17% (Fig. 7). In Central European urban floras there are up to about 60% (Pyšek 1998a). In villages in the Czech Republic, approximately 30% are recorded (Pyšek 1998b). The relatively low percentages of non-native species in Korean settlements can be explained by (1) the short period for which the alien flora of Korea has been investigated, (2) the lack of comprehensive surveys on non-native species in Korea, (3) the lack of knowledge for differentiating between archaeophytes and natives, and (4) the difference in the political and economic development of Central European and East Asian countries. There is a short history of introducing non-native species into the rural landscape of Korea because development processes in rural areas started comparatively late. Thus, the percentages of non-native species in habitats affected by varying degrees of human impact should be regarded as preliminary.

The assessment of human impact on flora and habitats is of great importance for landscape planning and nature conservation, becaue of the increasing human impact on the traditional Korean cultural landscape (Zerbe & Lee 2000), the rapidly expanding urban-industrial areas and intensified agriculture. A major task for the future will be the development of comprehensive data on flora, vegetation and habitats found in Korean rural settlements as an aid to ecological decision making. As in Central Europe (Kowarik 1999) the concept of hemeroby was useful for assessing the effect of human impact, both on rural and urban-industrial landscapes. That is, nature conservation strategies have to be developed not only for natural environments but also for urban and rural settlements.

Souhrn

Koncept hemerobie se používá ve středoevropské literatuře ke kvantitativnímu vyjádření vlivu člověka na stanoviště a jejich vegetaci. V této práci byl přístup využit při studiu vesnických sídlišť v Korejské republice. Byla analyzována stanoviště a flóra 8 vesnic. Stanoviště byla zařazena do jednoho z pěti stupňů hemerobie (oligo-, β-meso-, α-meso-, eu-, and polyhemerobní); kritériem pro klasifikaci byla intenzita (i) mechanického narušování půdy, (ii) přímé mechanické disturbance vegetace a (iii) chemické disturbance. Podle distribuce výskytu druhů na stanovištích s různým stupněm hemerobie byly stanoveny jejich indikační hodnoty hemerobie. Nejvyšší počet druhů byl zjištěn na stanovištích středně ovlivněných člověkem, což odpovídá hypotéze intermediární disturbance (Connell 1978). Člověkem nejsilněji ovlivněná stanoviště byla typická zvýšeným výskytem jednoletých druhů, nikoli však druhů zavlečených.

References

Academy of Korean Studies (1991): Korean national culture encyclopedia. – Seoul.

Blume H.-P. & Sukopp H. (1976): Ökologische Bedeutung anthropogener Bodenveränderungen. – Schr.-R. Vegetationskde. 10: 75–89.

Connell J. H. (1978) : Diversity in tropical rain forests and coral reefs. – Science 199: 1302–1310.

Falinski J. B. (ed.) (1971): Synanthropisation of plant cover II. Synanthropic flora and vegetation of towns connected with their natural conditions, history and function. – Mater. Zakl. Fitosoc. Stos. Univ. Warsz. 27: 1–317.

Hejný S., Husák Š. & Pyšek A. (1978): Vergleich der Ruderalgesellschaften in erwählten Gesamtheiten südböhmischer und südmährischer Dörfer. – Acta Bot. Slov. Acad. Sci. Slov., ser. A, 3: 271–281.

Hobbs R. J. & Huenneke L. F. (1992): Disturbance, diversity, and invasion: Implications for conservation. – Conserv. Biol. 6: 324–337.

Jackowiak B. (1998): The hemeroby concept in the evaluation of human influence on the urban flora of Vienna. – Phytocoenosis 10: 79–96.

Jalas J. (1955): Hemerobe und hemerochore Pflanzenarten. Ein terminologischer Reformversuch. – Acta Soc. Fauna Flora Fenn. 72: 1–15.

Kim K.G. (ed.) (1996): Eco-city planning guidance. – Seoul National University. [105 pp.]

Kim Y.–M. (2001): Untersuchung von Flora, Vegetation und Biotoptypen in der dörflichen Kulturlandschaft Koreas. – Diss. Techn. Univ. Berlin. [221 pp.]

Klotz S. (1990): Species/area and species/inhabitants relations in European cities. – In: Sukopp H., Hejný S. & Kowarik I. (eds.), Urban ecology, p. 99–104, SPB Acad. Publ., The Hague.

Klötzli F. A. (1992): Ökosysteme. Ed. 3. – Fischer, Stuttgart & Jena. [447 pp.]

Korean Meteorological Administration (2000): Climate data. – URL [http://www.kma.go.kr/ema/ema04/climate.htm].

Kowarik I. (1988): Zum menschlichen Einfluß auf Flora und Vegetation. Theoretische Konzepte und ein Quantifizierungsansatz am Beispiel von Berlin (West). – Landschaftsentw. u. Umweltforsch. 56: 1–280.

Kowarik I. (1990): Some responses on flora and vegetation to urbanisation in Central Europe. – In: Sukopp H., Hejný S. & Kowarik I. (eds.), Urban ecology, p. 45–74, SPB Acad. Publ., The Hague.

Kowarik I. (1995) On the role of alien species in urban flora and vegetation. – In: Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.), Plant invasions: General aspects and special problems, p. 85–103, SPB Acad. Publ., Amsterdam.

Kowarik I. (1999): Natürlichkeit, Naturnähe und Hemerobie als Bewertungskriterien. – In: Konold W., Böcker R. & Hampicke U. (eds.), Handbuch Naturschutz und Landschaftspflege. – Ecomed, Landsberg, p. 1–18.

Kunick W. (1974): Veränderungen von Flora und Vegetation einer Großstadt, dargestellt am Beispiel von Berlin (West). – Diss. Techn. Univ. Berlin. [472 pp.]

Lee C.-B. (1993): Illustrated flora of Korea. – Hyang Mun Sa, Seoul. [990 pp.]

Lee M.-G. (1982): Sociology and social change in Korea. – Seoul National Univ. Pr., Seoul. [336 pp.]

Lindacher R. (1995): Phanart. Datenbank der Gefäßpflanzen Mitteleuropas. Erklärung der Kennzahlen, Aufbau und Inhalt. – Veröff. Geobot. Inst. ETH, Stiftung Rübel, 125: 1–436.

Lohmeyer W. & Sukopp H. (1992): Agriophyten in der Vegetation Mitteleuropas. – Schr.-R. Vegetationskde. 25: 1–185.

Ministry of Agriculture and Forestry (2000): Agricultural basic statistics. – URL [http://www.maf.go.kr/agriinfo/statistics_02_02.asp].

Numata M. & Yoshizawa N. (eds.) (1975): Weed flora of Japan – illustrated by colour. – Zenkoku Noson Kyoiku Kyokai. [414 pp.]

Oh C.-H. & Lee K.-J. (2000): Assessing the biotope for urban nature conservation – in case of New Seoul Town. – J. Landsc. Architect. 27: 130–137.

Ohwi J. (1965): Flora of Japan. – Smithsonian Institution, Washington, D. C. [1067 pp.]

Pyšek P. (1998a): Alien and native species in Central European urban floras: a quantitative comparison. – J. Biogeography 25: 155–163.

Pyšek P. (1998b): Alien plants in Czech village flora: an analysis of species number. – Fedd. Repert. 109: 139–146.

Schätzl L. (1992): Raumwirtschaftspolitische Ansätze in den Wachstumsländern Ost-/Südostasiens. Fallbeispiele: Südkorea, Malaysia, Thailand. – Geogr. Rundsch. 1: 18–24.

Schmitz S. (2000): Die spontane Gefäßpflanzenflora zwischen Berlin-Mitte und Berlin Köpenick. Transektuntersuchung zu Auswirkungen von Stadt-Umland-Gradienten und Nutzungen. – Landschaftsentw. u. Umweltforsch. 116: 1–181.

Schulte W., Sukopp H. & Werner P. (eds.) (1993): Flächendeckende Biotopkartierung im besiedelten Bereich als Grundlage einer am Naturschutz orientierten Planung. – Natur u. Landschaft 68: 491–526.

Seoul City Administration (2000): Survey on biotopes in Seoul and principles of planning for eco-city. – Ms., 245 pp. [1st year Report; depon. in: Seoul City Administration.]

Song I.-J. (1998) : Analyse des Stadtökosystems als ökologische Grundlage für die Stadtplanung. Am Beispiel von Seoul. – Dr. Kovač, Hamburg. [472 pp.]

Sudnik-Wójcikowska B. (1986): Distribution of some vascular plants and anthropopressure zones in Warszaw. – Acta Soc. Bot. Pol. 55: 481–496.

Sukopp H. (1969): Der Einfluß des Menschen auf die Vegetation. – Vegetatio 17: 360–371.

Sukopp H. & Trautmann W. (eds.) (1976): Veränderungen der Flora und Fauna in der Bundesrepublik Deutschland. – Schr.-R. Vegetationkde. 10: 1–409.

Sukopp H., Hejný S. & Kowarik I. (eds.) (1990): Urban ecology. Plants and plant communities in urban environments. – SPB Acad. Publ., The Hague. [282 pp.]

Tüxen R. (1956): Die heutige potentielle natürliche Vegetation als Gegenstand der Vegetationskartierung. – Angew. Pflanzensoz., Stolzenau/Weser 13: 5–42.

Tüxen R. (ed.) (1961): Anthropogene Vegetation. – Ber. Int. Sympos. IVV, Dr. W. Junk Publ., The Hague. [398 pp.]

Weiner J. & Solbrig O. T. (1984): The meaning and measurement of size hierarchies in plant population. – Oecologia 61: 334–336.

Yoshiwo H. (1972): Atlas of the Japanese flora I. – Gakken Co., Tokyo.

Zerbe S. (1993): Fichtenforste als Ersatzgesellschaften von Hainsimsen-Buchenwäldern. Vegetation, Struktur und Vegetationsveränderungen eines Forstökosystems. – Ber. Forschungszentr. Waldökosyst., ser. A 100: 1–173.

Zerbe S. & Lee Y.-M. (2000): Cultivated plants in farm gardens reflecting cultural history and current development of the rural landscape – Korean highland villages as an example. – Arch. Natursch. u. Landschaftsforsch. 39: 191–214.

Zerbe S., Maurer U., Schmitz S. & Sukopp H. (2003): Biodiversity in Berlin and its potential for nature conservation. – Landsc. Urban Plann. (in press).

Received 18 March 2002
Revision received 20 June 2002
Accepted 23 September 2002