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Heracleum mantegazzianum in the Czech Republic: dynamics of spreading from the historical perspective

KEYWORDS

Heracleum mantegazzianum, Floristic data, Escape from cultivation, Spreading dynamics, 20th century, Czech Republic

ABSTRACT

PYŠEK P. (1991): *Heracleum mantegazzianum* in the Czech Republic: dynamics of spreading from the historical perspective. - Folia Geobot. Phytotax., Praha, 26:439-454. - The spread of *Heracleum mantegazzianum* in the Czech Republic has been reconstructed on the basis of floristic data. The species has spread from several spatially independent localities which have originated from the West Bohemian population introduced in the 19th century. Its expansion first followed the courses of great rivers. An exponential increase in the number of localities reported in particular years and in the cummulative number of localities was found. The species abundance decreases from the region of original introduction, which is located in the westernmost part of the country, to the east. The rate of spread in the last sixty years was the same in the Czech Republic and in Great Britain. The species is, however, more widespread in the North of Europe presumably because of the more favourable climate. It is found most frequently in habitats that encourage the greatest movement of diaspores. Floristic data can be used to infer retrospectively the dynamics of invasion of a species in a given area provided that there is a sufficient amount of floristic research over time.

INTRODUCTION

Heracleum mantegazzianum SOMM. et LEV. was introduced into Europe in the nineteenth century and, the giant hogweed is now widespread in many countries (LUNDSTRÖM 1984). The species forms extensive monospecific stands and hence may cause serious problems, especially in terms of (1) replacement of native vegetation and subsequent decrease in plant and animal diversity, (2) increased erosion in sites occupied by the species, especially on river banks, where, after plants die back in winter, they leave soil bare, (3) impeding routes within and to recreation areas, (4) reduced visibility along roads, (5) infestation of arable land (WILLIAMSON et FORBES 1982, LUNDSTRÖM 1984, BINGHAM 1990), (6) skin injury or recurrent dermatitis caused by strongly phototoxic furocoumarins (MIMRA 1963, DREVER et HUNTER 1970), (7) loss of cattle (KEES et KRUMREY 1983, ANDREWS et al. 1985) and poultry

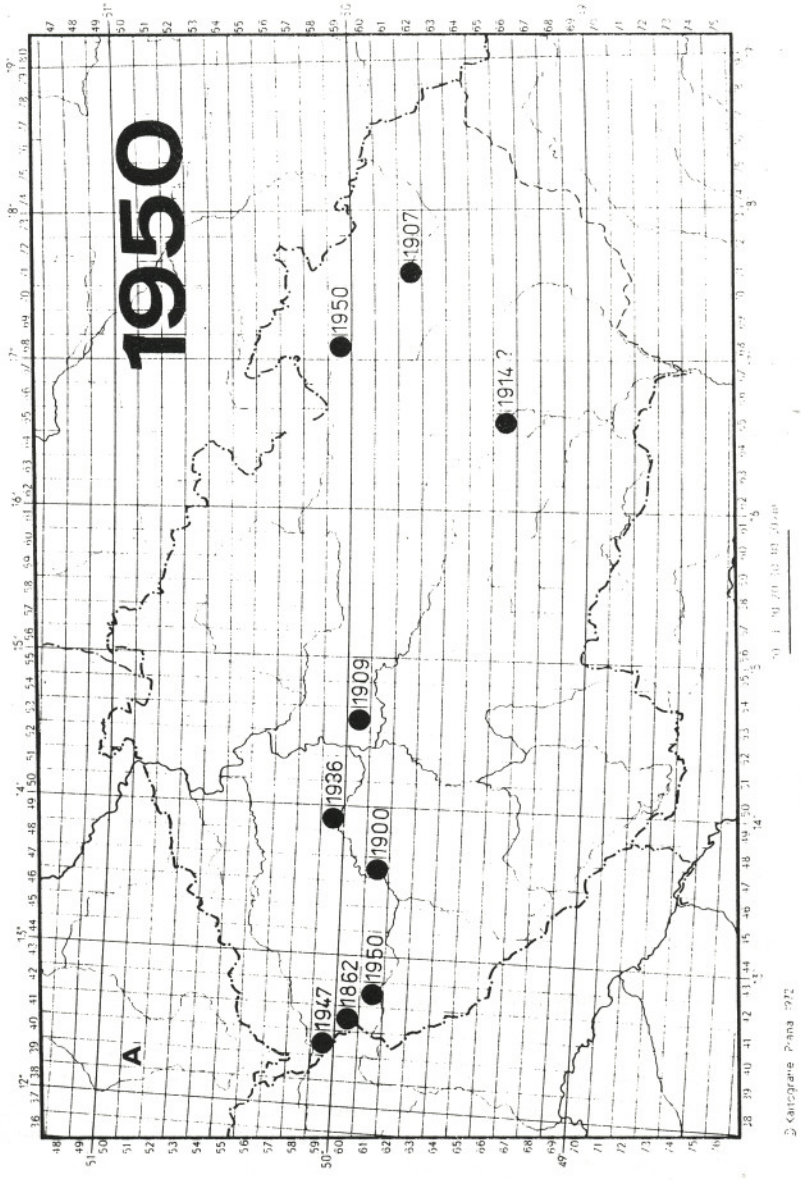
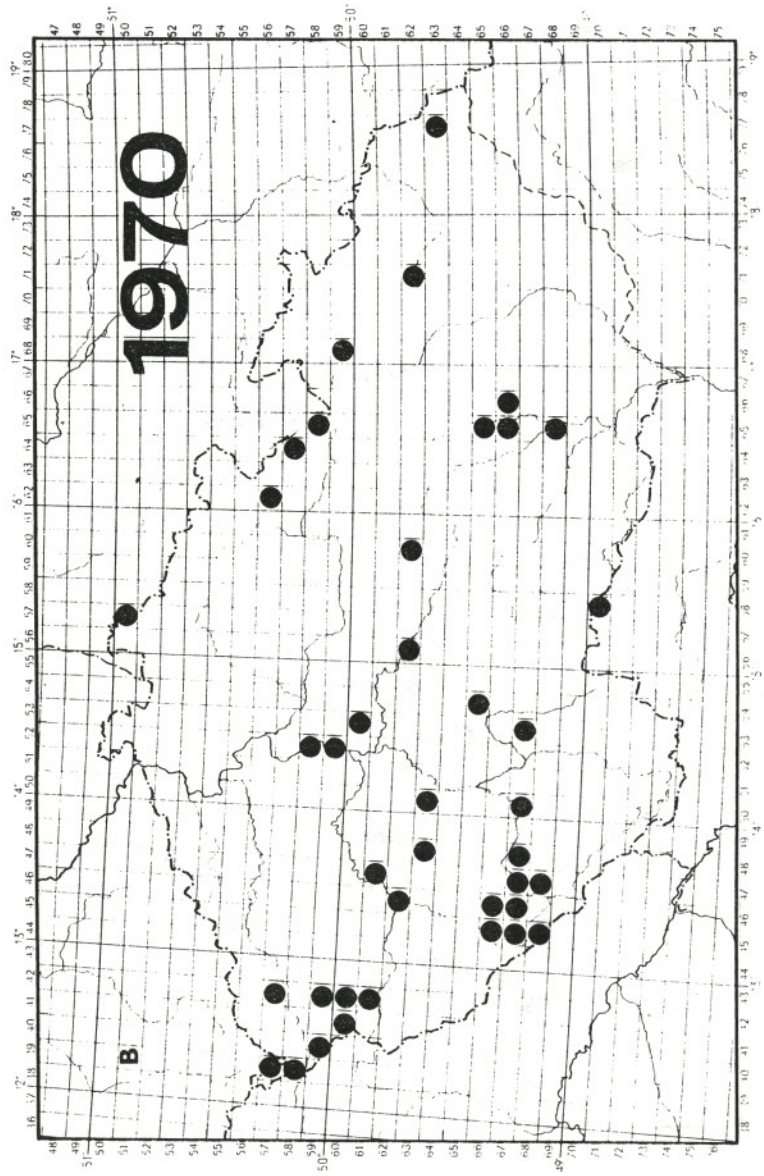


Fig. 1. Distribution of *Heracleum mantegazzianum* in the Czech Republic. a) 5940 - LHOTSKÝ 1950; 6041 - KRATZMANN 1862; 6142 - LHOTSKÝ 1950; 6147 - MALOCH 1900; 5949 - MLADÝ 1983, MLADÝ et KOLBEK 1990; 6053 - JEHLÍK et LHOTSKÁ 1970; 6665 - The species was planted before World War I (GRÜLL 1979); spontaneous occurrence was recorded at first in 1964 (HEJNÝ et al. 1971) but earlier escape from cultivation is highly probable; 5968 - KABELÍK 1950; 6271 - DUDA 1949. d) Squares from which at least 5 localities were reported are filled. Numbers of squares in which the species occurred: 1950-9, 1970-41, 1980-100, 1990-229.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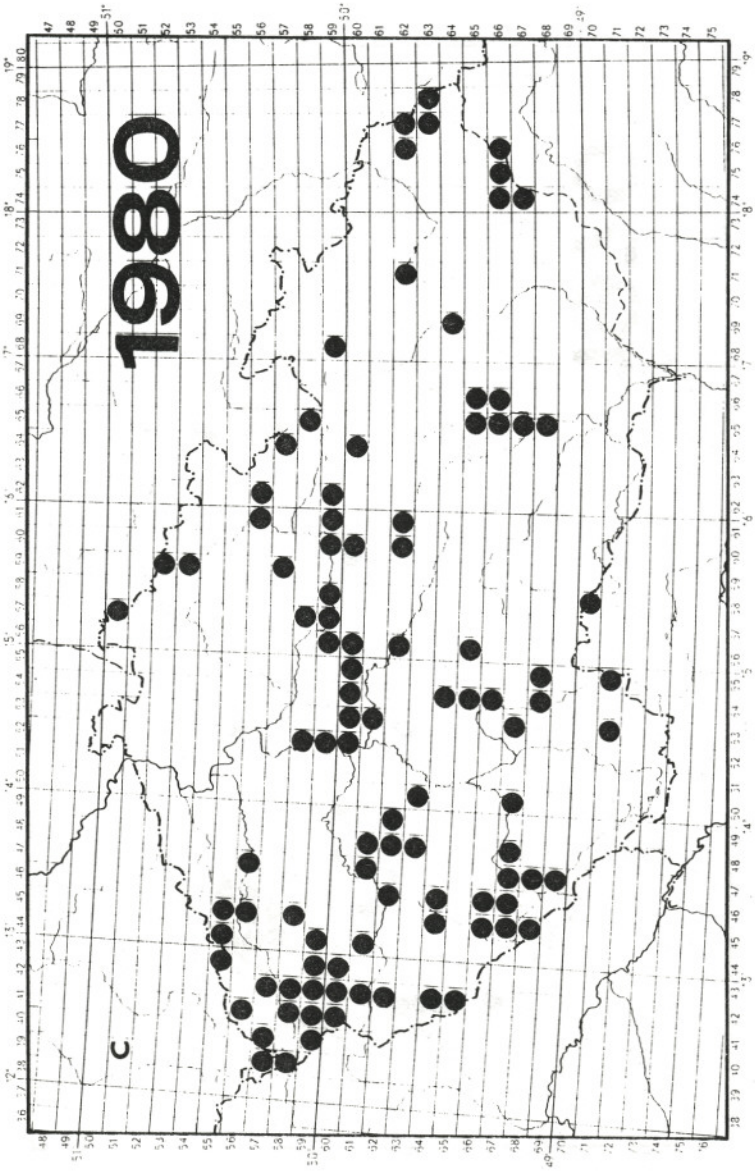
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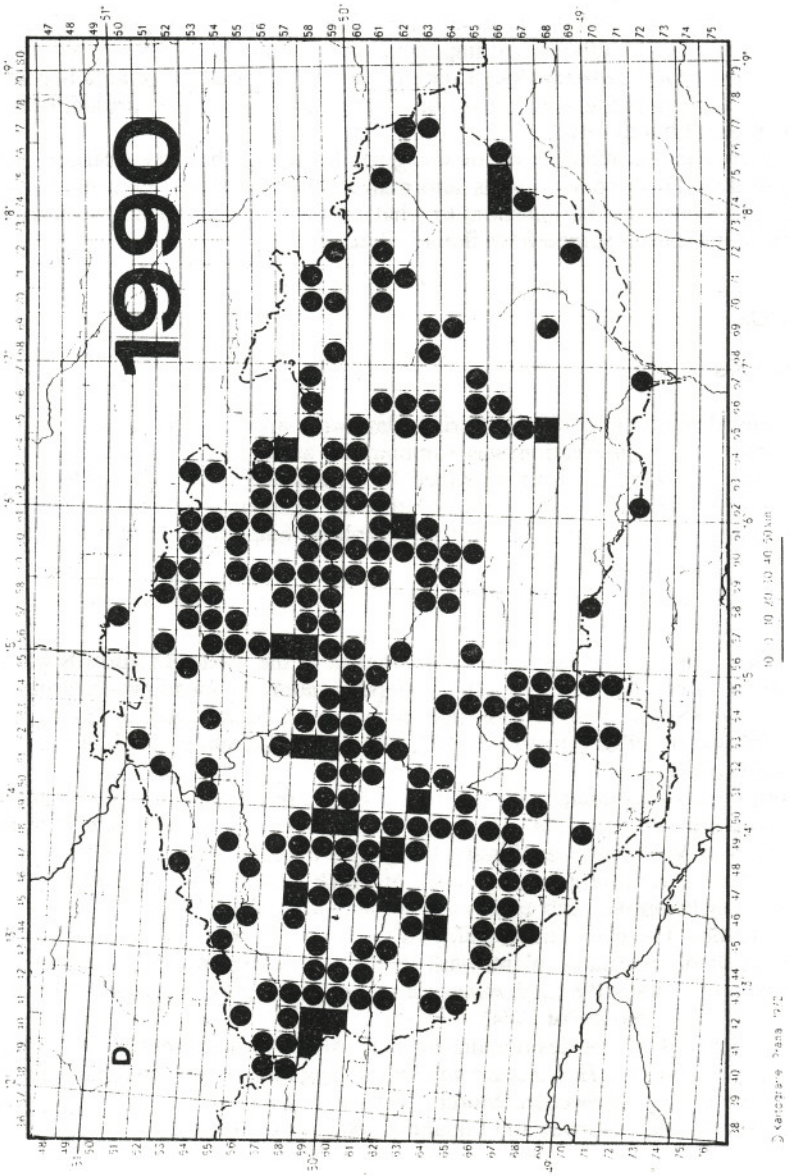
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(HARWOOD 1985), and (8) attacks on crops by fungi hosted by the species (GRAY et NOBLE 1965). Non-chemical methods (cutting, ploughing, grazing by cattle or pigs) and herbicides are used for control (BINGHAM 1990, LUNDSTRÖM 1990). Once a large area becomes infested, however, a comprehensive control programme may be prohibitively expensive (WILLIAMSON et FORBES 1982).

No research in the distribution of the giant hogweed has been carried out so far in Czechoslovakia. This paper presents information on the species' occurrence in the Czech Republic and addresses the question, to what extent it is possible to reconstruct historical dynamics of any species spread from floristic data.

METHODS

DATA SOURCES

Both published and unpublished floristic data were analysed. Information, if available, on habitat and year of observation was summarized as well. A complete referenced list of localities (up to 1990) has been provided by PYŠEK et PYŠEK (1991). Distribution of the species has been expressed as presence or absence in squares of approximately 12 x 11 km. This method is commonly used in phytogeographical mapping (SCHÖNFELDER et BRESINSKY 1990).

STUDY SPECIES

Heracleum mantegazzianum (Apiaceae) is native to the western Caucasus where it occurs in the upper forest belt of the southern slopes, mainly in meadows, clearings and forest margins (MLADENOVA 1950). It was introduced as an ornamental to Europe in the 19th century (MORTON 1975, SHELDON 1982, KEES et KRUMREY 1983, LUNDSTRÖM 1984, BRONDEGAARD 1990).

A mature plant has pinnately divided leaves of 1 m or more in size and a hollow flowering stem up to 4-5 m tall. In winter, the foliage dies back, regrowing in spring from the large fleshy tap root (WILLIAMSON et FORBES 1982). The plant is perennial and takes 2-4 years to flower. It forms several large umbels each of which may shed about 5000 (27000 per plant are reported by BRONDEGAARD 1990) easily germinating (JEHLÍK et LHOTSKÁ 1970) seeds and then usually dies. The competitive ability of the species is ascribed to its enormous size and potential to shade associated plants with its massive leaves in the spring or early summer (WILLIAMSON et FORBES 1982). *H. mantegazzianum* forms pure stands which increase in area from year to year (LUNDSTRÖM 1984).

The taxonomy of the species remains unclear. Although it is generally accepted that it has come from the Caucasus, *H. mantegazzianum* growing there is not identical to the type which occurs spontaneously in Sweden. Moreover, various types of wild *H. mantegazzianum* are reported from Sweden, Norway and Finland (LUNDSTRÖM 1984).

RESULTS AND DISCUSSION

RECONSTRUCTION OF SPREADING DYNAMICS

H. mantegazzianum was introduced to Czechoslovakia in the 19th century, having originally been planted in the garden of a castle in the Lázně Kynžvart (Fig. 1a, square 6041)

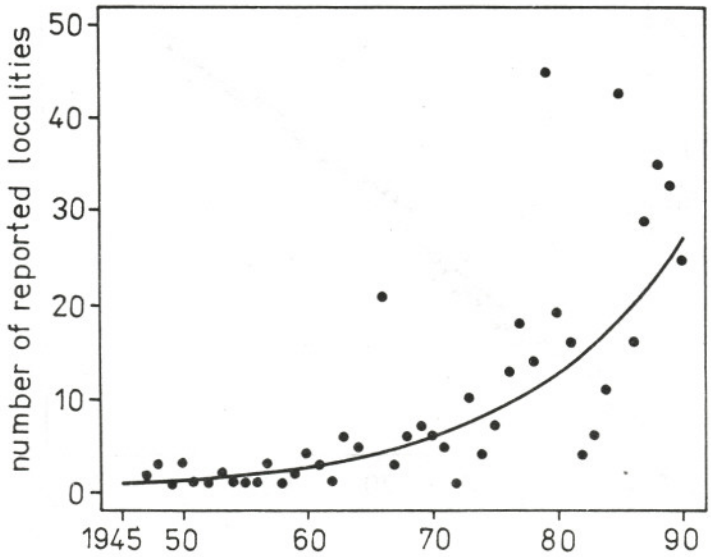

Fig. 2. Number of localities reported in respective years plotted against time. Y = exp(0.076X + 3.563), r = 0.82, P<0.0001.

(KRATZMANN 1862, SKALICKÝ et al. 1966). The species has been reported under various names: *H. speciosum* WEINM., *H. persicum* DESV., *H. elegans* (CR.) JACQ., *H. giganteum* HORNEM. (PYŠEK et PYŠEK 1991) which may have lead to misunderstandings: the oldest report is that of KRATZMANN (1862) concerning *H. elegans* (CR.) JACQ. However, Kratzmann's interpretation of this name probably corresponds to that of Tausch, in which sense the name was used later by ČELAKOVSKÝ (1867-81); the report thus appears to concern another species (SKALICKÝ, pers. com.).

H. mantegazzianum became a popular ornamental among gardeners (KOBYLKA 1977) and this has been a principal contributing factor to its spread due to escape from cultivation. Furthermore, attempts at introducing the species directly into natural communities have been recorded in recent times (KUBÁT, pers. comm.)

Different periods of species introduction are reported from other European countries: the middle of the 19th century (Sweden - LUNDSTRÖM 1984), late 19th century (Great Britain - WILLIAMSON et FORBES 1982), 1890 (Switzerland - MIMRA 1963). The species has been spreading over Europe probably through several independent introductions.

Localities known up to 1950 in the Czech Republic (Fig. 1a) may be considered as foci for spread. The origin of most of them, through escape from cultivation, has been documented (see caption to Fig. 1a). A pattern similar to that inferred within the range of Europe is thus observed. The species has spread from several spatially separate sources which, however, are all in the West Bohemian region. Comparison of Fig. 1a with the situation in 1970 (Fig. 1b)

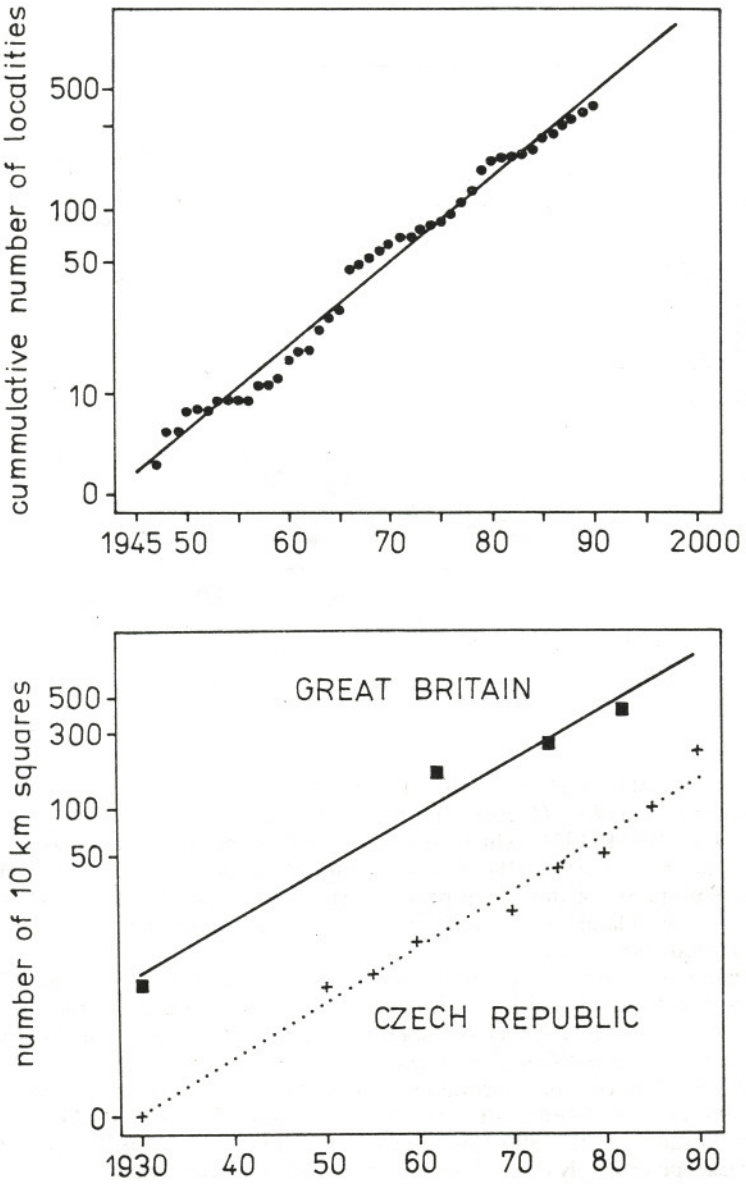

Fig. 3a. Cummulative number of localities plotted against time. Note the semilog scale. LN Y = 0.1085X - 3.614. 3b. Rate of the species spreading in the last 60 years. Note the semilog scale. Great Britain: LN Y = 0.0804X - 0.2989, Czech Republic: LN Y = 0.0835X - 2.4917. The data represent numbers of 10 km squares in which the species was recorded in Britain during counts in 1930, 1962 (PERRING et WALTERS 1962), 1974 (CLEGG et GRACE 1974), and 1982 (WILLIAMSON et FORBES 1982). In the Czech Republic, the number of occupied 12 x 11 km squares is presented.

and 1980 (Fig. 1c) shows that the expansion first followed the courses of great rivers. This pattern is no longer obvious from the current distribution (Fig. 1d) since the species is now widespread.

Both the number of localities reported in particular years (Fig. 2) and the total number of localities known in the respective years (Fig. 3a) have increased exponentially with time. A rapid increase in the total number of localities started in the middle of 1970s (89 in 1975, 267 in 1985 and 472 in 1990, see also Fig. 4).

The rate of expansion in the Czech Republic was compared with that in Great Britain using semilog plotting of the number of squares in which the species has been recorded against time (Fig. 3b). 1930 was taken as a starting point since the first count in Britain was carried out then (PERRING et WALTERS 1962). For both countries, regression lines of almost the same slope ($b=0.0835$ in the Czech Republic, $b=0.0804$ in Great Britain) were obtained, indicating very similar rates of expansion. The differences in magnitude of occurrence are expressed by the different intercepts of regression lines: in Great Britain, the species was recorded in almost 500 squares in 1982, compared to 146 in 1980 in the Czech Republic. However, when differences in areas (Britain - 245 000 sq.km, the Czech Republic - 79 000 sq.km) are taken into account the frequency of species occurrence is similar in both countries. The percentage of squares occupied by the giant hogweed at these times was 20.4 in Great Britain and 24.4 in the Czech Republic.

Unfortunately, although *H. mantegazzianum* was studied in many countries (Sweden, Norway - LUNDSTRÖM 1984, Denmark - LUNDSTRÖM 1990, Netherlands - GROOTEN 1988, Belgium - LHOEST et LEJEUNE 1987, Germany - KEES et KRUMREY 1983, Scotland - NEILAND et al. 1987, POWELL 1988, Ireland - WYSE JACKSON 1989, Canada - MORTON 1975, DAWE et WHITE 1979) more quantitative data on the rate of spread are needed. Nevertheless, it is clear that the species represents a serious threat to the landscape especially in northern Britain and Nordic countries. In Sweden, it occurs throughout the entire country (LUNDSTRÖM 1984), even as far as 68^{o} N near Tromsö (BRONDEGAARD 1990).

In Czechoslovakia, it is only a problem locally so far and this also holds for other central European countries (KEES et KRUMREY 1983). The differences between central and northwestern Europe cannot be explained by the time of introduction. It is, however, possible that the more massive occurrence in the North may reflect a more favourable climate for the species, which appears to prefer cooler, more humid areas. This may be supported by its current distribution in Czechoslovakia (Fig. 1d) which indicates that the species spread is conspicuously less successful in some warmer regions (part of north Bohemia and south Moravia).

Knowledge of its current distribution (Fig. 1d) is inevitably influenced by the intensity of floristic research in a given area. Similarly, the species abundance, expressed as number of localities in the square reflects not only the real occurrence (e.g. West Bohemia, squares 5940, 5941, 6041, the Křivoklát region 5949, 6049, large cities - Praha, 5852, 5952, Plzeň 6246, Brno 6865), but the attention paid to the area as well. Nevertheless, the abundance of *H. mantegazzianum* continues to increase within occupied squares (Fig.4) which is reflected by the growing difference between the number of localities [$Y = \exp(0.0663 X - 0.7969]$, $r = 0.94$, $P<0.001$) and number of squares [$Y = \exp(0.0576X - 0.593]$, $r = 0.95$, $P<0.001$, fitted by linear regression using log transformed data) in which the species was recorded.

Distribution maps (Fig. 1) do not allow a determination of either the direction of spread or the trends in species abundance within the area. The data recorded during excursions of floristic summer schools, organized annually by the Czechoslovak Botanical Society, were

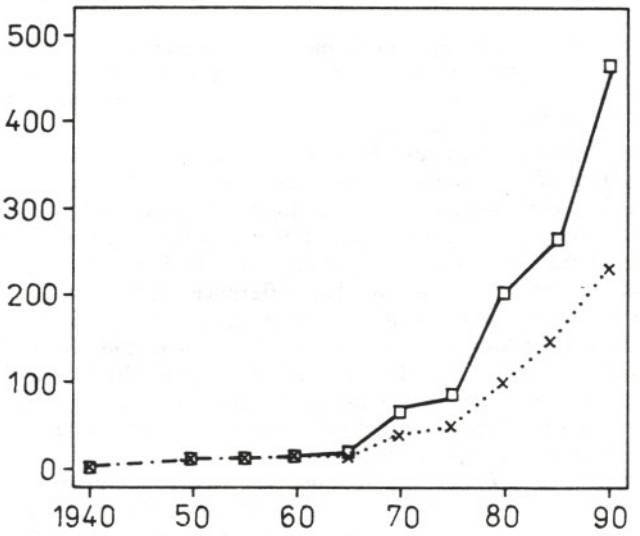

Fig. 4. Increasing difference between the cummulative number of localities (□—□) and the number of squares in which the species was recorded (×···×).

therefore treated separately. Floristic records collected in a consistent manner giving detailed information on the flora in given areas of comparable size are the main reasons for considering summer schools as a kind of standardized sampling method.

The number of localities in which *H. mantegazzianum* was recorded during a particular summer school increased significantly both with year ($P<0.01$) and the proximity of the sampled area to Mariánské Lázně ($P<0.05$), i.e. the region of the earliest species introduction to Czechoslovakia (Fig. 5). The more significant effect of time was confirmed by the higher value of the partial correlation coefficient ($r=0.77$ compared to $r = -0.63$ for distance). These results reflect the fact that until the species became common in the Czech Republic, it had only rarely been recorded even though summer schools had taken place quite close to its centre of spread (1966, 1971). Thus, until the middle of the 1970s, the number of records was usually low, regardless of the region investigated (Fig. 5). Nevertheless, it may be concluded that the current abundance of the species decreases from the westernmost part of the country to the east in the Czech Republic.

H. mantegazzianum occurs in the Czech Republic over a wide range of altitudes (from 150 m a.s.l.). Several localities over 1000 m have been reported (1279 m, the Krkonoše Mts. - ŠPATENKOVÁ-SKALSKÁ 1980; 1214 m, the Krušné hory Mts. - KUBÁT 1978; 1093 m, the Šumava Mts. - VANĚČEK, pers. com.; 1071 m, the Javorníky Mts. - TOMÁŠEK 1979).

H. mantegazzianum frequently occurs (more than half the localities, see Fig. 6) in habitats which particularly favour the transport of seeds by wind, water or human-related factors (JEHLÍK et LHOTSKÁ 1970). It spreads readily along watercourses, roads and railways. Seeds are carried downstream by water and deposited on the banks as they retain the ability to

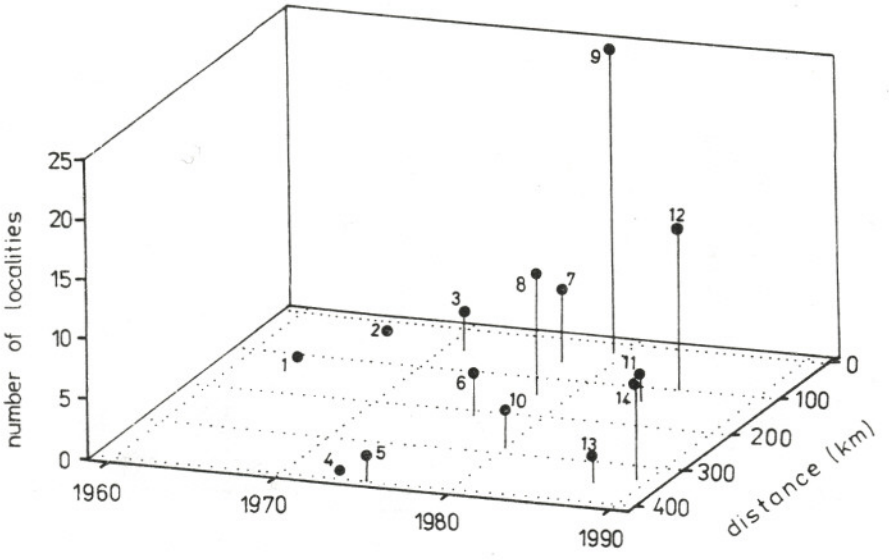

Fig. 5. Number of localities recorded during the floristic summer school related to the year in which it took place and to the distance from Mariánské Lázně, representing the supposed centre of spread. The fitted multiple regression is LN (NUMBER+1) = -6.66661 + 0.00988 YEAR + 36.1171 (1/DISTANCE), R^2 = 0.605, with significance levels $P<0.01$ for year, and $P<0.05$ for distance. Note that the inverse value of distance was used for calculation as it is correlated with the number of localities in the same way as time (i.e. positively). 1 - Milevsko 1963 (0 localities); 2 - Tachov 1966 (ŠEDO 1980, 0); 3 - Horšovský Týn 1971 (ŠEDO 1980, 3); 4 - Valašské Klobouky 1973 (0); 5 - Frýdek Místek 1975 (2); 6 - Pardubice 1976 (PROCHÁZKA 1977, 3); 7 - Kadaň 1977 (KUBÁT 1978, 6); 8 - Kostelec nad Černými lesy 1978 (FÉR et al. 1981, 10); 9 - Toužim 1979 (ŠEDO 1983, 25); 10 - Blansko 1980 (3); 11 - Děčín 1984 (KUBÁT 1986, 2); 12 - Příbram 1985 (HROUDA et SKALICKÝ 1989, 13); 13 - Uherské Hradiště 1987 (GRULICH 1987, 2); 14 - Bruntál 1989 (8).

float for up to 3 days (BRONDEGAARD 1990, but see JEHLÍK et LHOTSKÁ 1970). Seed dispersal is supported by the popularity of the plant for dried flower arrangements and its seeds finding their way into, and plants establishing in, abandoned rubbish dumps (LUNDSTRÖM 1984).

Various classifications, taking the time, species abundance and the type of habitat invaded into account, were proposed to describe the process of biological invasion (e.g. NEWSOME et NOBLE 1986, DI CASTRI 1990, KORNAŚ 1990) Although it is sometimes difficult to distinguish between particular categories, especially in Central Europe (e.g. "undisturbed natural" and "less disturbed natural" vegetation, see KORNAŚ 1990), *H. mantegazzianum* may be classified as a species which is already naturalized in man-made habitats and is penetrating massively into communities under a lesser influence of man (Fig. 6). This trend may be expected to continue in the near future. Generally, only few aliens naturalized in undisturbed vegetation have been reported from central Europe (see KORNAŚ 1990 for a review).

The simple introduction of a species does not necessarily lead to its naturalization and subsequent dispersal (DI CASTRI 1990). In *H. mantegazzianum*, there was a remarkably long

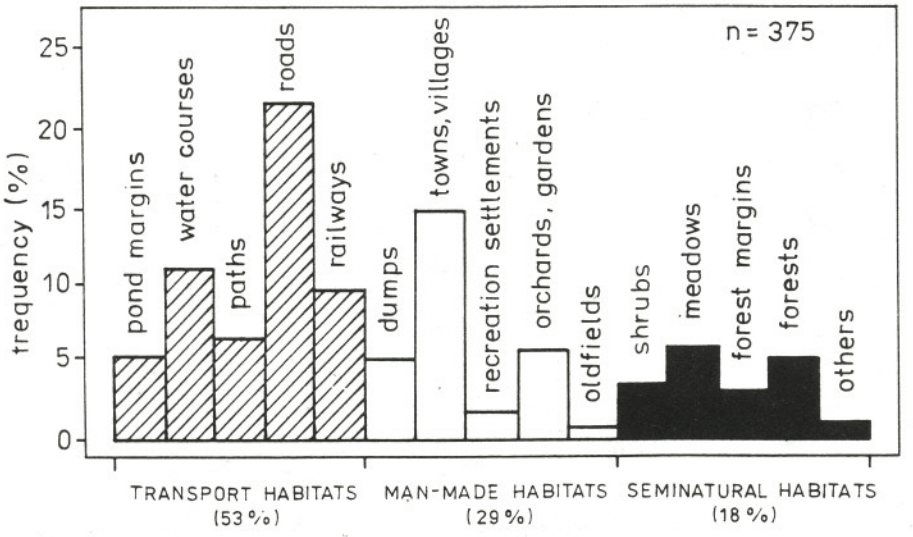

Fig. 6. Frequency distribution of habitats.

lag-stage which lasted several decades before the exponential spreading. The present mode of spread across various habitats indicates the species' competitive superiority over most of the native flora and the less important role of the recipient habitats (NOBLE et NEWSOME 1986, ROY 1990). However, little is known about those demographical and ecophysiological attributes of *H. mantegazzianum*, that are generally considered important with respect to the invasive success of a species (BAKER 1965, NOBLE 1989). Nevertheless, some of its competitive superiority may be ascribed to the sheer size of the plant (GRIME 1979, KEDDY 1990, ROY 1990). A large seed set is also important since the dispersal distance is a negative function of seed density (HARPER 1977, NOBLE 1989).

USE OF FLORISTIC DATA FOR THE RETROSPECTIVE ASSESSMENT OF SPREADING DYNAMICS

There have been remarkable amount of botanical information accumulated over the last 100-200 years in central Europe. Unfortunately, this information has not been sufficiently used (KORNAŚ 1990). Maps showing spread (generally using the earliest record in a given locality) were provided for some alien species (ŚWIEBODA 1963, KORNAŚ 1990, GUILLERM et al. 1990). Surprisingly, the quantitative data gained from such floristic observations have not been presented: the study reconstructing the invasion of *Impatiens parviflora* (TREPL 1984) is an exception.

The present paper demonstrates that floristic data, systematically gathered over an area for a long time may be used to (1) reconstruct the pattern of a species invasion on a large

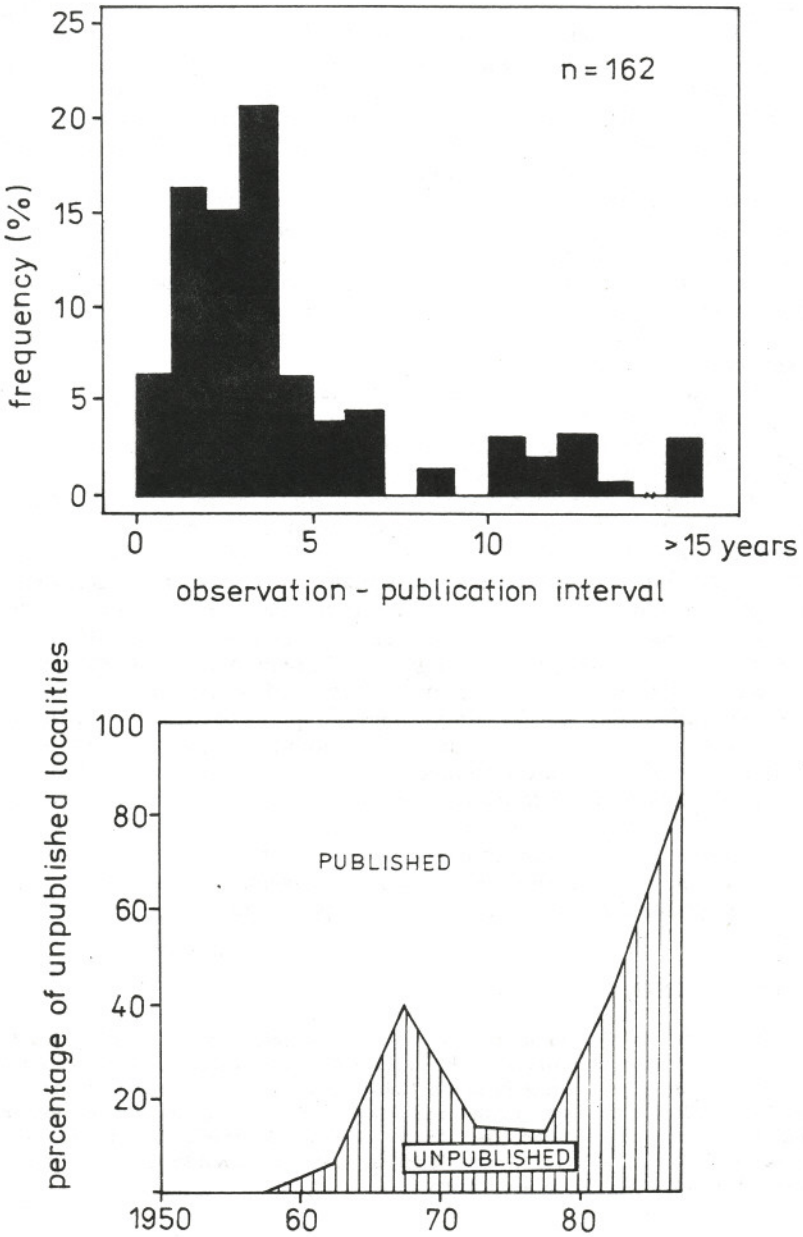

Fig. 7a. Frequency distribution of intervals between the year of observation and the year of publication of the respective findings. 7b. Changes in the relative proportion of published vs. unpublished localities of the species.

geographical scale (Figs. 1-3a); the comparison of Great Britain with the Czech Republic (Fig. 3b) shows that similar patterns of spread are revealed using different approaches (subsequent records in time vs. reconstruction). Furthermore, (2) it was possible to discover the pattern of species abundance in the landscape and its development over time (Fig. 5). The floristic data also (3) provided information on the species ecology; the spectrum of habitats occupied supports the dynamic nature of its contemporary occurrence (Fig. 6).

There are, however, some limitations to floristic data generally which should be emphasized. A sufficient intensity of floristic research within an area is necessary for successful retrospective analysis of species spread. This is clearly kept because of the strong, long-term floristic tradition in the Czech Republic. The species itself should be currently (1) worthy of note, i.e. rare enough or otherwise interesting from the point of view of ecology, spreading dynamics etc., (2) conspicuous in order not to be overlooked, and (3) taxonomically unproblematic, i.e. easily recognizable by amateur botanists who are the main producers of floristic data.

Those two latter points are fulfilled by *H. mantegazzianum* (the taxonomical confusion referred to earlier is not of much relevance within the Czech Republic since at least the vast majority of observations concern the same species). The first assumption, however, depends on the species' rarity and the kind of the floristic research involved. If systematic recording of the flora is carried out, one can assume that the more common a species is, the more often it is recorded. However, this sort of report does not always represent the main bulk of data since localities of rare and remarkable species are often published individually. This is why earlier records (Fig. 1a-c) reflect the real situation better: *H. mantegazzianum* was not a common species and its observation was more "worthy of publication". At this stage, the published occurrences may be considered reliable sources of information on the species. Even if exact dating of the record is not given, its spread in historical terms may be inferred simply from the year of publication as more than 65 % of localities are published within 5 years of observation (Fig. 7a). The proportion of unpublished records (i.e. those obtainable merely by personal communication) varies considerably over five years intervals but there is a clear overall trend of increase with time (Fig. 7b). The steep increase in the proportion of unpublished data corresponds to the exponential spread of the species through the country in the mid 1970s (Fig. 4). From then on, obtaining a real picture of the species dynamics is strongly dependent on personal communications and the "sampling error" increases. The accessibility of the data therefore becomes another factor affecting their usefulness for the evaluation of species dynamics from the historical perspective.

ACKNOWLEDGMENTS

My thanks are due to A. Pyšek for help with floristic research, V. Skalický and M. Marek for providing unpublished data and other information. I thank R.L. Hall, T. Herben, J. Lepš, K. Kubát and J. Puntieri for their comments on the manuscript. I am grateful to R.L. Hall and P.S. Savill for improving my English, and E. Švejdová and J. Pyšková for drawing the figures. Furthermore, I am grateful to I. Bingham, H. Lundström and H. Kees for providing the less accessible literature. The following colleagues are thanked for providing their unpublished floristic records: P. Bureš, L. Faltys, V. Grulich, R. Hlaváček, V. Chán, J. Kaisler, J. Kurka, V. Pluhař, J. Rydlo, B. Trávníček, J. Vaněček, L. Vaněčková, and J. Sádlo.

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Received 18 March, 1991, accepted 15th October, 1991