Zeitschrift: Veröffentlichungen des Geobotanischen Institutes der Eidg. Tech. Hochschule, Stiftung Rübel, in Zürich

Herausgeber: Geobotanisches Institut, Stiftung Rübel (Zürich)

Band: 98 (1988)

Artikel: Shape and size of leaves and fruits of four European and Japanese "Fagus" species = Form und Grösse der Blätter und Früchte von vier europäischen und japanischen "Fagus"-Arten

Autor: Bialobrzeska, Maria / Truchanowicz, Janina / Zarzycki, Kazimierz

DOI: https://doi.org/10.5169/seals-308906

Veröff.Geobot.Inst.ETH, Stiftung Rübel, Zürich **98** (1988), 373-385

Shape and size of leaves and fruits of four European and Japanese *Fagus* species

Form und Grösse der Blätter und Früchte von vier europäischen und japanischen *Fagus*-Arten

by

Maria Bialobrzeska, Janina Truchanowicz, and Kazimierz Zarzycki

1. INTRODUCTION

The genus Fagus is of East Asiatic origin (TAKHTAJAN 1981). At present, the species of this genus are components of the forests in the northern hemisphere; some of them grow on extensive areas (SCHMUCKER 1942) under different conditions of habitat, and show considerable morphological differences. The variability of beech leaves and fruit, both contemporary and fossil, were the subject of interest of numerous research workers (WISNIEWSKI 1932, CZECZOTTOWA 1933, 1935, SZAFER 1935, MADALSKI 1938, 1947, 1951, MISIC 1960, TANAI 1960, 1972, 1974, SVOBODA 1972, SVOBODA

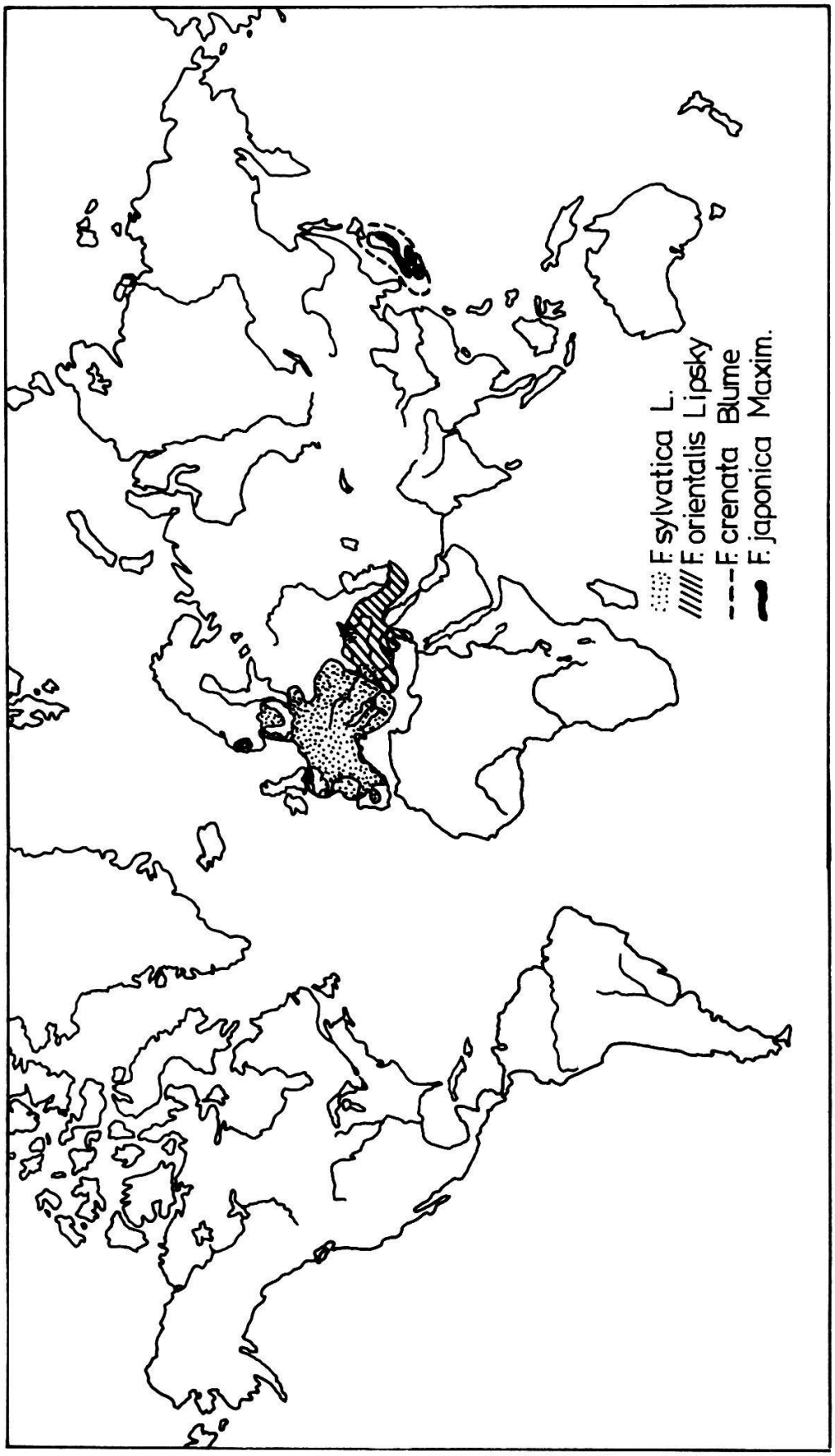


Fig. 1. Distribution of Fagus species (according to SCHMUCKER 1942)
Abb. 1. Verbreitung der Fagus-Arten (nach SCHMUCKER 1942)

and PACLTOVA 1985), among others because of the role of the genus Fagus in the Tertiary history of Holarctic vegetation (SRODON 1985). Consequently, BIALOBRZESKA and TRUCHANOWICZOWNA (1983) performed a biometrical analysis of the Fagus fruits from the Neogen sediments of the West Carpathian Mts. utilizing, to a considerable degree, the results of research on its contemporary species. In connection with these studies, comparative investigations were carried out on the morphological differences of the leaves and fruits of two beech species from the western part of Eurasia (Fagus sylvatica and F. orientalis) compared with the two species F. crenata and F. japonica) growing in Japan, that is in the opposite eastern confines of Eurasia (Fig. 1). Deliberations were made whether the European beeches show any common features with the Japanese beeches as far as the morphology of their leaves and fruits are concerned, and whether there are any common features and general regularities in regard to the variability of all the Fagus species under investigation.

In connection with this, thorough studies were performed on the morphological differences of the leaves, cupules, and nutlets of all the species mentioned above. At the same time the leaves from short and long shoots, and those from the trees growing in lower and higher elevations in the mountains were studied. The full results of investigations enlarged by the anatomic studies of the Fagus leaves will be published elsewhere.

ACKNOWLEDGEMENTS

The financial support of the Polish Academy of Sciences, as well as of Geobotanisches Institut ETH, Stiftung Rübel (Zürich) and of the Yokohama National University enabled K. Zarzycki to take part in the International Excursion and Symposium on Vegetation Science (Japan 1984), and to collect the samples of Fagus crenata. Prof. Dr. Krystyna Grodzinska (Krakow), Prof. Dr. E. Landolt (Zürich), Prof. Dr. A. Miyawaki (Yokohama), Dr. M. Obsawa (Chiba), Prof. Dr. L. Stuchlik (Krakow), Dr. L. Wolejko (Szczecin), and Dr. Ewa Zastawniak (Krakow) made their material and information available. To all these persons, as well as to the keepers of the herbaria, the authors wish to express their cordial thanks.

2. MATERIAL AND METHODS

The leaves and fruits of the European beech species used for these studies were mainly derived from the herbaria of the Institutes of Botany of the Polish Academy of Sciences (KRAM) and of the Jagiellonian University (KRA) as well as from those owned by private persons (L. Stuchlik and E. Zastawniak). Samples of leaves and fruits of Japanese beeches were collected by K. Grodzinska in 1974, as well as by Masahiko Obsawa, L. Wolejko, and K. Zarzycki in 1984. Only fully grown leaves were taken into account.

Fagus sylvatica L. The material included herbarium specimens derived from 46 localities in the territory of Poland and West Europe: 96 leaves from short shoots, 51 from long shoots, 62 valves of cupules, and 36 nutlets.

Fagus orientalis Lipsky (F. macrophylla Koidz. = F. winkleriana Koidz.). The material derived from several localities in the Caucasus and the Balkan Mts., and from the Botanical Garden in Leningrad included 57 short shoot leaves, and 30 long shoot leaves, 65 valves of cupules, and 75 nutlets.

Fagus crenata Blume (= F. sieboldi Engler). The material collected in Japan (Hakhoda Mts., Daisengen Mts., Haguro Mts., Hatomachi, Park Nikko, and Bandai Plateau) amounted to 119 short shoot leaves, 70 long shoot leaves, 80 valves of cupules, and 30 nutlets.

Fagus japonica Maxim. The leaves and fruits were collected in the central part of Honshu. For measurements 25 short shoot leaves, 25 long shoot leaves, 50 valves of cupules, and 50 nutlets were taken.

The youngest leaves from the short shoots and the longest ones from the long shoots were measured. Their morphology was determined on the basis of 12 characteristics as follows: A length of petiole, B length of blade, C breadth of blade, D number of lateral nerves, E angle of the third nerve, F basal angle, G apical angle, H ratio of blade length to petiole length, I length to breadth ratio of blade, J average distance between lateral nerves, K position of the broadest part of the blade in % of the blade length, L number of leaves on shoot. Valves of the cupules and nutlets were drawn by means of an apparatus for photographic enlargements, and the outlines thus obtained were measured by means of a millimeter scale projected at the same enlargement. The size and shape

of the fruits were characterized on the basis of the following: Valves of the cupules: A length, B breadth, C apical angle, D basal angle, E length to breadth ratio of valves, F position of the broadest part of the valve in % of its length. When measuring the nutlets, similar characteristics were considered as with the cupules. The manner of measuring leaves and fruits is shown in Figure 2. The results of measurements are represented by means of Jentys-Szaferowa's graphical method (1959).

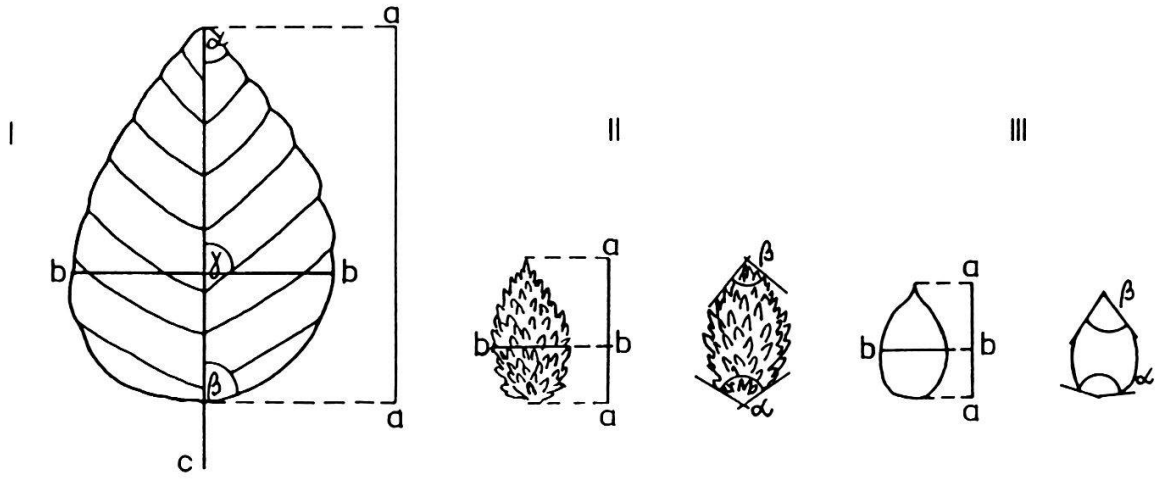


Fig. 2. Manner of measuring
Abb. 2. Messverfahren

I. Leaves - Blätter:
a-c = length of petiole - Länge des Blattstiels
a-a = length of blade - Länge der Blattspreite
b-b = breadth of blade - Breite der Blattspreite
a-b = distance of the broadest part of blade from base
Distanz des breitesten Teiles der Blattspreite von der Basis
α = apical angle - Scheitelwinkel
β = basal angle - Basiswinkel
γ = angle of the third nerve - Winkel des dritten Blattnervs

II. Valves of cupules - Fruchtbecherbrakteen:
a-a = length of valve - Länge der Braktee
b-b = breadth of valve - Breite der Braktee
a-b = distance of the broadest part of valve from base
Distanz des breitesten Teiles der Braktee von der Basis
α = basal angle - Basiswinkel
β = apical angle - Scheitelwinkel

III. Nutlets - Nüsschen:
a-a = length of nutlet - Länge des Nüsschens
b-b = breadth of nutlet - Breite des Nüsschens
a-b = distance of the broadest part of nutlet from its base
Distanz des breitesten Teiles des Nüsschens von der Basis
α = basal angle - Basiswinkel
β = apical angle - Scheitelwinkel

3. RESULTS

The results of these studies are represented in Figures 3 to 5. Standard silhouettes of leaves, cupules, and nutlets of the beeches under investigation drawn on the basis of the arithmetic means of the characteristics are listed in Figure 6.

Differences between the leaves on long shoots and those on short shoots were found in each of the four Fagus species. Above all, these differences concern the characteristics of size: the long shoot leaves are usually longer and broader, the distances between nerves are greater, and the leaf blades are set on longer petioles. Their shape is only slightly different from that of short shoot leaves (Fig. 3).

As the altitude above sea level grows, the leaves become pronouncedly smaller, both on the short shoots and on the long shoots (Fig. 4).

In the genus Fagus there are essential differences in the morphology of leaves and fruits between the Japanese and European species. The short shoot and long shoot leaves of F. crenata and F. japonica compared with those of F. sylvatica are longer and slimmer, which is emphasized by the more acute apical and basal angles and the greater number of lateral nerves. The leaves of F. orientalis approach the East Asiatic species in the majority of their characteristics.

Greater differences between the species were found in the size and shape of the cupules than in the quantitative and qualitative characteristics of the nutlets. F. sylvatica is distinguished by the largest cupules and nutlets. The other species, besides smaller cupules, have much more acute apical angles and broader basal angles, and the broadest part is found nearer the base. The cupules of F. japonica are very small, broad at the base, and their broadest part situated low down, by which they differ pronouncedly from all the remaining species. In the size and shape of the leaves and the characteristics of the cupules F. orientalis resembles the East Asiatic F. crenata. In the morphology of its nutlets, F. orientalis approaches F. sylvatica.

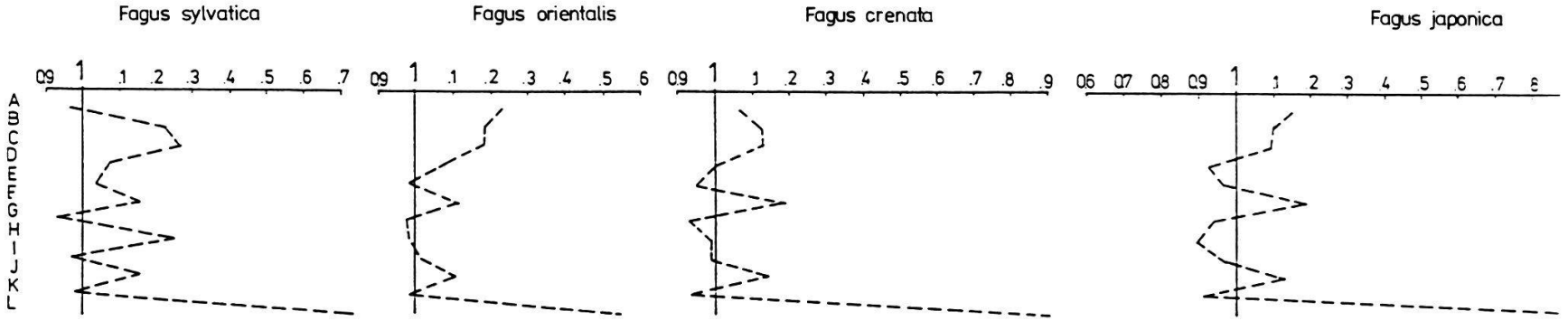


Fig. 3. Ratio of the arithmetic means of size and shape characteristics of leaves from long shoots (angular line) to those from short shoots (straight vertical line).
Abb. 3. Verhältnis der arithmetischen Mittelwerte von Blattmerkmalen von Langtrieben (gebrochene Linie) zu solchen von Kurztrieben (gerade vertikale Linie).

A length of petiole - Länge des Blattstiels
B length of blade - Länge der Blattspreite
C breadth of blade - Breite der Blattspreite
D number of lateral nerves - Anzahl der Nebennerven
E angle of the third nerve - Winkel des dritten Blattnerves
F basal angle - Basiswinkel
G apical angle - Scheitelwinkel
H ratio of blade length to petiole length - Verhältnis der Länge der Blattspreite zur Länge des Blattstiels
I length to breadth ratio of blade - Verhältnis der Länge zur Breite der Blattspreite
J average distance between lateral nerves - durchschnittliche Distanz zwischen den Nebennerven
K position of the broadest part of the blade in % of the blade length - Lage des breitesten Teils der Blattspreite in % der Lage der Blattspreite
L number of leaves on shoot - Anzahl der Blätter am Trieb

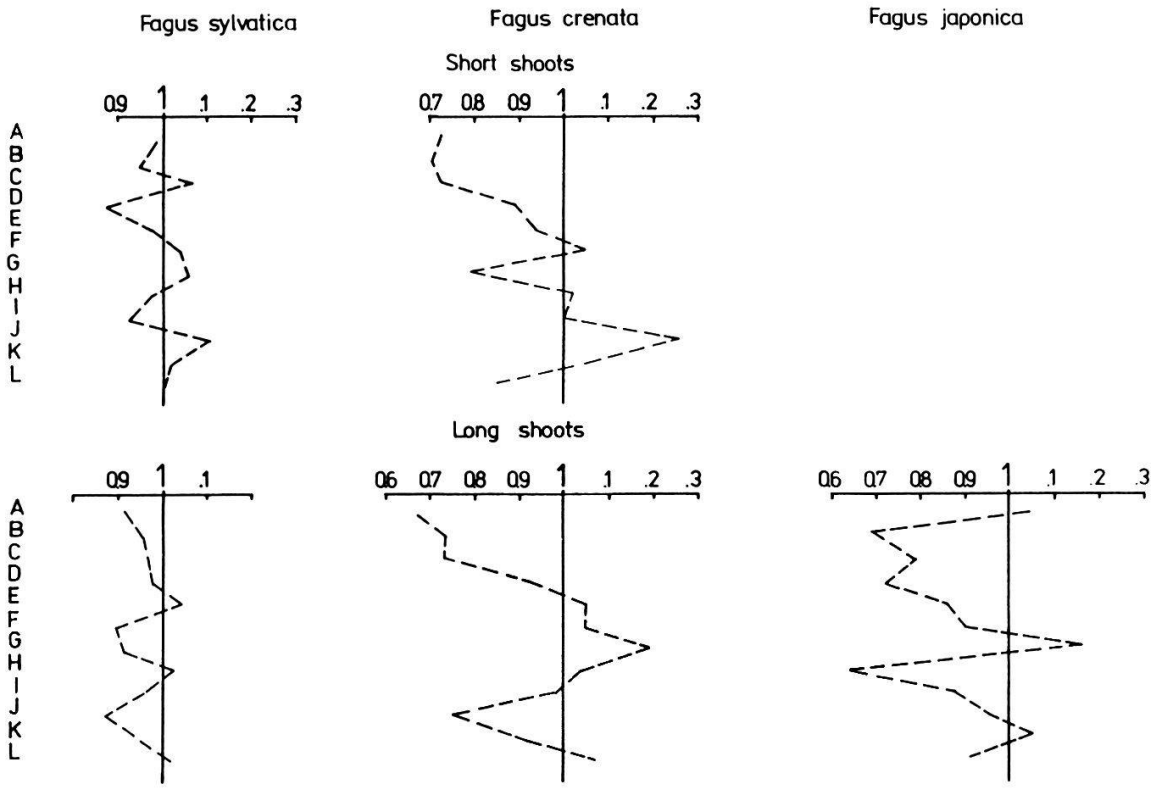
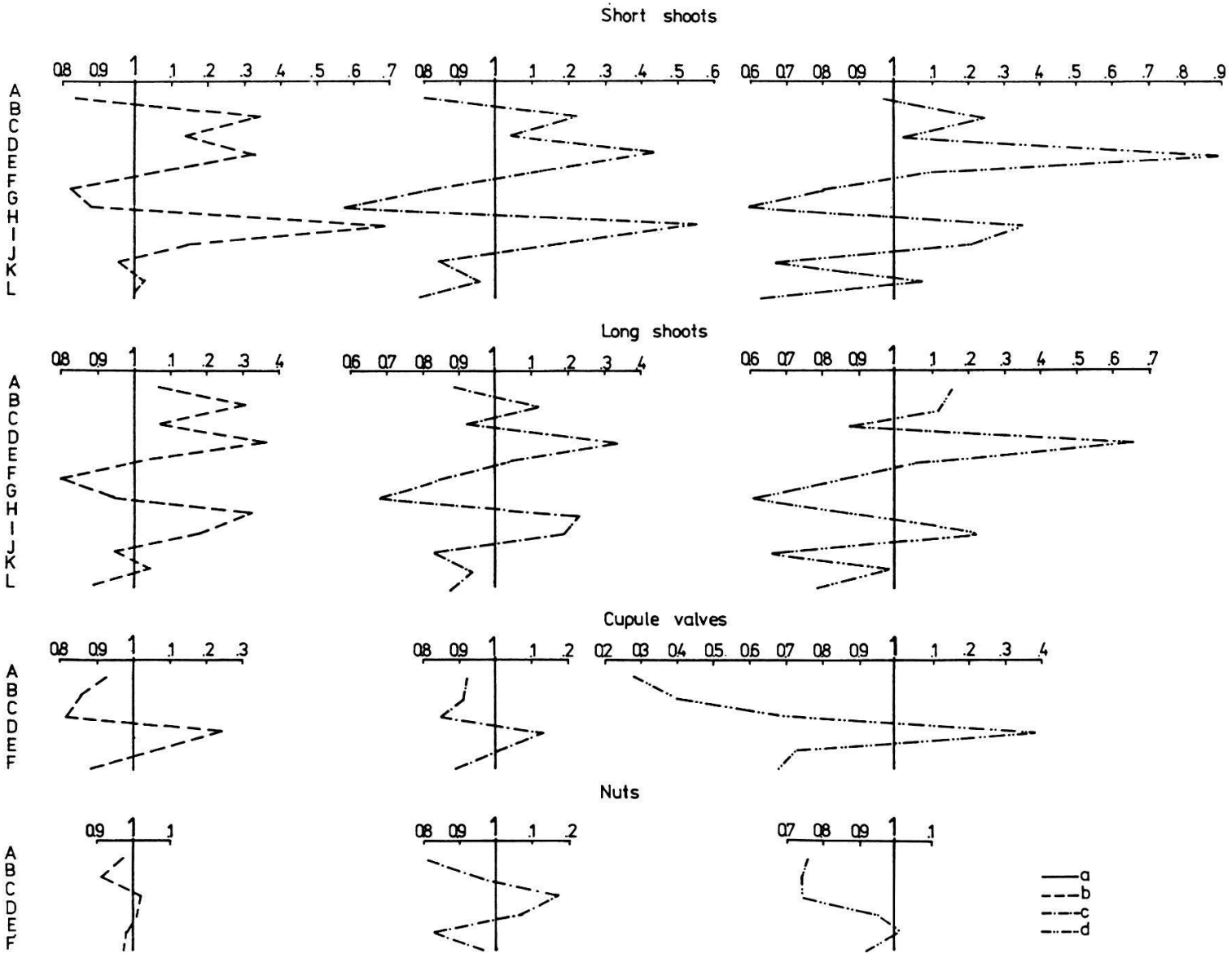


Fig. 4. Arithmetic means of the characteristics of leaves collected at 800-1550 m above sea level (angular lines) compared with those of the leaves collected at 350 m a.s.l. (straight vertical line). (For further information see Fig. 3)

Abb. 4. Vergleich der arithmetischen Mittelwerte der Merkmale der auf 800-1550 m ü.M. gesammelten Blätter (gebrochene Linie) mit den auf 350 m ü.M. gesammelten Blättern (gerade vertikale Linie) (Weitere Erklärungen s. Abb. 3)

Fig. 5 (p. 381). Ratio of the arithmetic means of the characteristics of leaves, cupules, and nutlets of three Fagus species (angular lines) to those of F. sylvatica (straight vertical line). (For further information see Fig. 3)

Abb. 5 (S. 381). Verhältnis der arithmetischen Mittelwerte der Merkmale der Blätter, Fruchtbecher und Nüssen von drei Fagus-Arten (gebrochene Linie) zu jenen von F. sylvatica (gerade vertikale Linie). (For further information see Fig. 3)


Short shoots
Long shoots
Cupule valves
Nuts
A
B
C
D
E
F
G
H
I
J
K
L
a
b
c
d

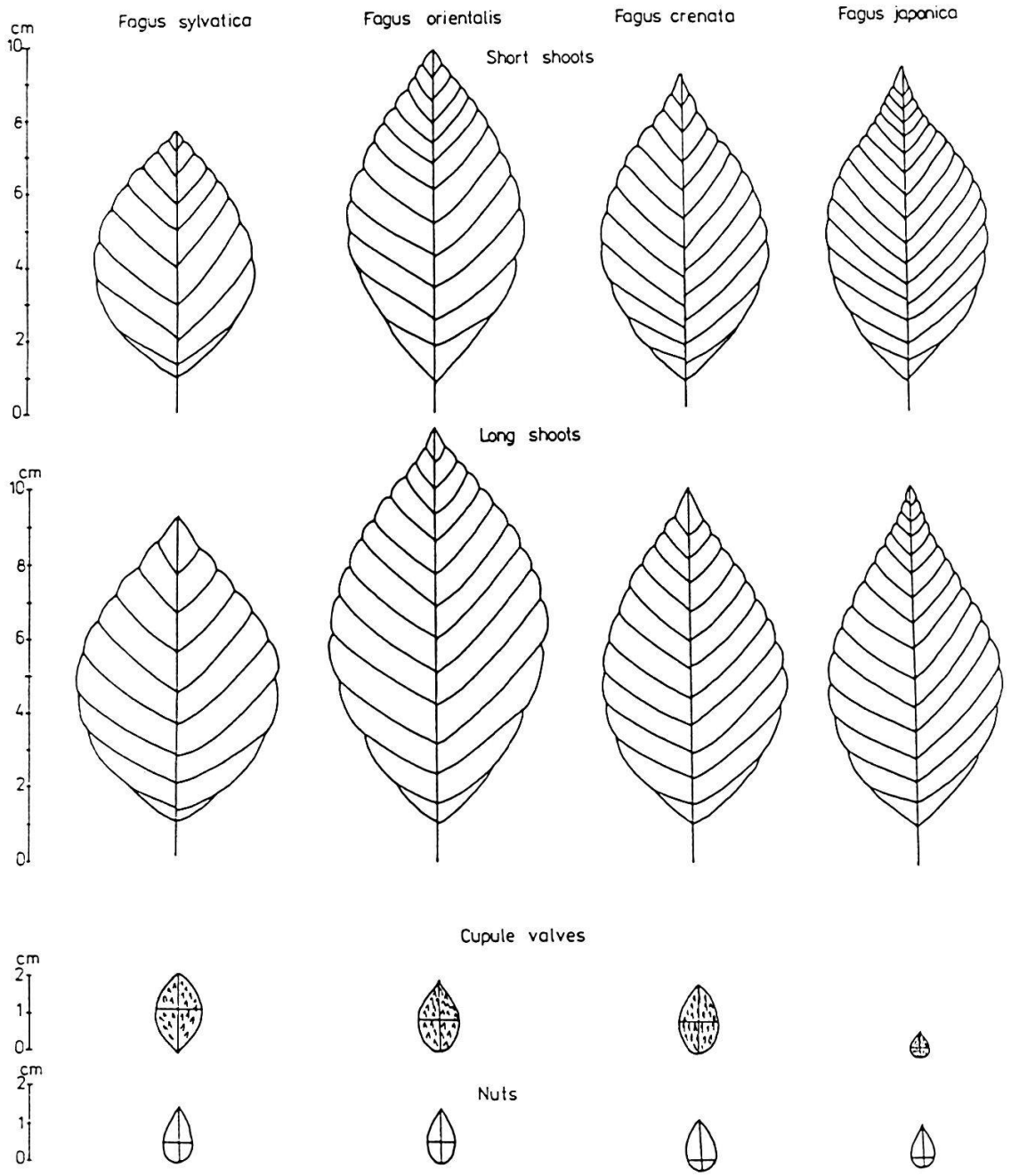


Fig. 6. Leaves, cupules, and nutlets of four Fagus species drawn on the basis of the arithmetic means of their characteristics.

Abb. 6. Blätter, Fruchtbecher und Nüsschen von vier Fagus-Arten, nach den arithmetischen Mittelwerten ihrer Merkmale aufgezeichnet.

4. DISCUSSION

The leaves and fruits of the Fagus species under investigation seem to be only slightly different. However, the application of the precise biometrical method showed the differences, and enabled us to distinguish the essential diagnostic characteristics from the whole complex. The length and breadth of the leaf blade were taken into account earlier; the ratio of these two values was determined by TANAI (1972) as the leaf index (F. japonica). The studies performed by the present authors show

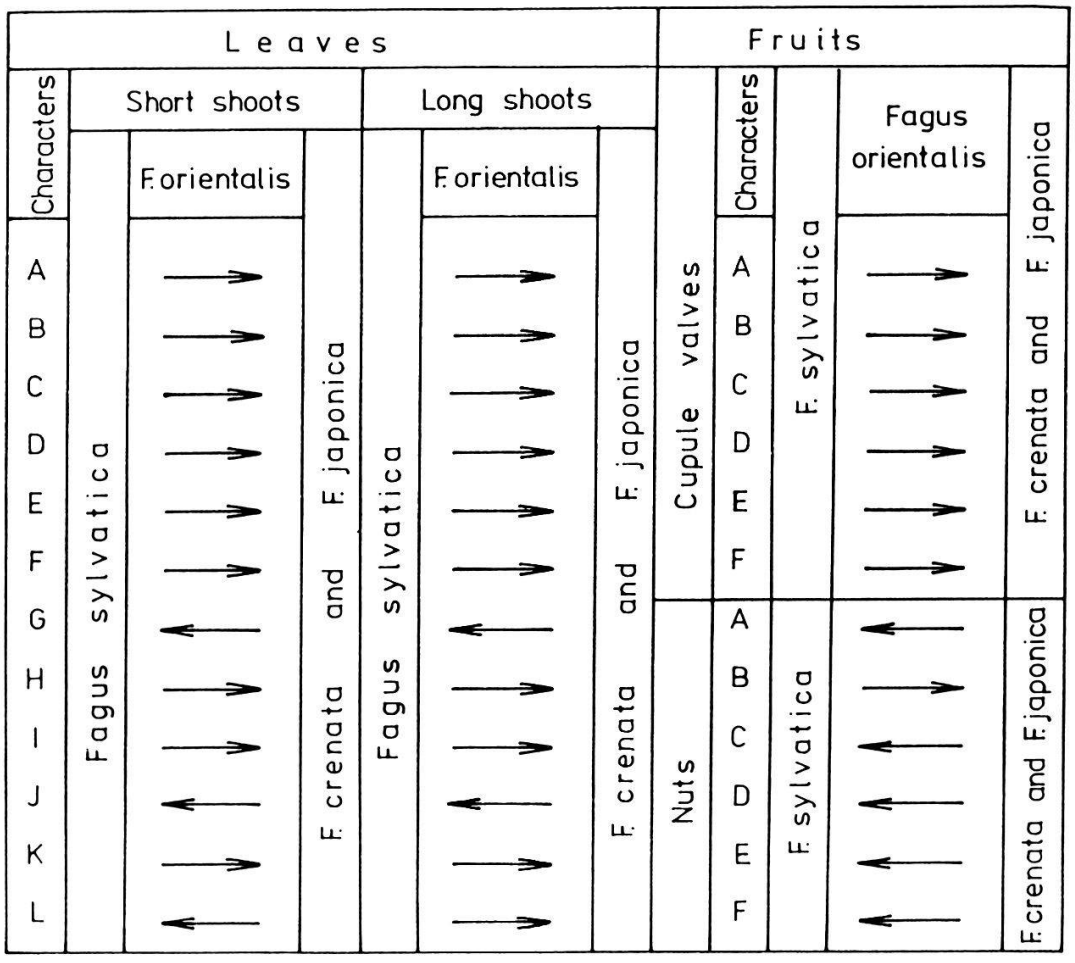


Fig. 7. Differences and similarities of Fagus orientalis compared with F. sylvatica, F. crenata and F. japonica on the basis of the morphology of their leaves and fruits.

Abb. 7. Unterschiede und Aehnlichkeiten zwischen Fagus orientalis, F. sylvatica, F. crenata und F. japonica aufgrund der Morphologie ihrer Blätter und Früchte.

that the number of nerves and the basal and apical angles are also important characteristics, which may prove helpful in the study of fossil material. Concentrating their attention on interspecific differences in the present paper the authors do not consider the intraspecific variability. The case of F. moesiaca and F. taurica, which occupy an intermediate position between F. sylvatica and F. orientalis (CZECZOTTOWA 1933, 1935; MADALSKI 1947, MISIC 1960, DUTY 1985) has been altogether omitted.

Special attention should be paid to the surprising similarity of F. orientalis, F. crenata, and F. japonica as regards numerous characteristics of their leaves and cupules (Fig. 7), which was also indicated by the results of other studies (SVOBODA and PACLTOVA 1985). This is connected with the Tertiary history of the genus Fagus and will be discussed in more detail in another paper.

SUMMARY

The shape and size of the leaves and fruits (cupules and nutlets) of Fagus sylvatica L., F. orientalis Lipsky, F. crenata Blume and F. japonica Maxim. were studied using biometrical methods. Each of the species under investigation is distinguished by the peculiar shape and size of its leaves and fruits. The ratio of the leaves from short shoots and of those from long shoots is similar in all the species studied, while the leaves become smaller the higher above sea-level they grow. The leaves and cupules of F. orientalis show more common features with those of the beeches from Japan, although geographically distant, than with those of the beeches from the neighbouring F. sylvatica. The results of these studies find application in palaeobotanical investigations.

ZUSAMMENFASSUNG

Form und Grösse der Blätter und Früchte (Fruchtbecher und Nüsse) von Fagus sylvatica L., F. orientalis Lipsky, F. crenata Blume und F. japonica Maxim. wurden biometrisch untersucht. Jede der untersuchten Arten zeichnet sich durch ihre besondere Form und Grösse der Blätter und Früchte aus. Das Verhältnis der Blätter der kurzen Sprosse zu jenen der langen Sprosse bleibt sich gleich in allen untersuchten Arten aber die Blätter werden kleiner je höher ihr Standort ü.M. ist. Die Blätter und der Fruchtbecher von F. orientalis haben mehr Gemeinsamkeiten mit den Buchen Japans als mit der benachbarten F. sylvatica, trotz der geographischen Distanz. Die Ergebnisse dieser Untersuchungen können in der Palaeobotanik verwendet werden.

REFERENCES

BIALOBRZESKA M., TRUCHANOWICZOWNA J., 1983: Fruits of the genus Fagus from the Neogene of the Western Carpatians - biometrical study. Acta palaeobot. **23/3**, 103-120.

CZECZOTTOWA H., 1933: A study on the variability of the leaves of beeches: F. orientalis Lipsky, F. silvatica L. and intermediate forms. (In Polish). Rocz.Polsk.Tow.Dendrol **5**, 45-121.

CZECZOTTOWA H., 1935: A study on the variability of the leaves of beeches: F. orientalis Lipsky, F. silvatica L. and intermediate forms. (In Polish). Rocz.Polsk.Tow.Dendrol **6**, 1-68.

DUTY J., 1985: Die Fagus-Sippen Europas und ihre geographisch-soziologische Korrelation zur Verbreitung der Assoziationen des Fagion. Vegetatio **59**, 177-184.

JENTYS-SZAFEROWA J., 1959: A graphical method of comparing the shapes of plants. Rew.Pol.Acad.Sc. **4/1**, 9-38.

MADALSKI J., 1938: On a new beech in Poland belonging to the forms of Fagus orientalis Lipsky. (In Polish). Sylwan, A **56/1**, 1-7.

MADALSKI J., 1947: Studies on Fagus silvatica L. and Fagus moesiaca (Maly, Domin) Czeczott. (In Polish). Acta Soc.Bot.Pol. **18/2**, 129-154.

MADALSKI J., 1951: Supplementary note on the discovery of Fagus orientalis Lipsky on the northern border of Podolia. (In Polish). Rocz. Sekcji Dendrol. P.T.B. **7**, 115-122.

MISIC V., 1960: Individual variability of the relic Balcan beeches from Garvan Klisuru (NR Makedonija) and the Caucasian ones fron Batumi (SSSR). (In Polish). Zborn.Rad.Biol.Inst. NR Serbij **3**, 1-31.

SCHMUCKER T., 1942: The tree species of the northern temperate zone and their distribution. Berlin.

SVOBODA A.M., 1972: Variability of beech leaves (Fagus silvatica L.). (In Polish). Ph.D.Thesis. Studie CSAV **2**, 1-143.

SVOBODA A.M. and PACLTOVA B., 1985: Beitrag zur Kenntnis der fossilen und rezenten europäischen Buchen. Fedd.Rep. **96**, 1,2, 47-61.

SZAFER W., 1935: The forest and the steppe in west Podolia. (In Polish). Rospr.Wydz.Mat.Przyr.PAU **71/31**, 1-123.

SRODON A., 1985: Fagus in the forest history of Poland. Acta palaeobot. **25**, 1,2, 119-137.

TAKHTAJAN A., 1981: Flowering plants: origin and dispersal. Oliver and Boyd, Edinburg. 153 pp.

TANAI T., 1960: On the fossil beech from the Ningyo - toge area, in Chugoku district, Japan. Trans.Proc.Palaeontol.Soc.Japan **37**, 193-200.

TANAI T., 1972: Tertiary history of vegetation in Japan. In: GRAHAM A. (ed.), Floristics and palaeofloristics of Asia and Eastern North America. Elsevier, Amsterdam. 248-252.

TANAI T., 1974: Evolutionary trend of the genus Fagus around the northern Pacific Basin. Dept. of Geology and Mineralogy, Hokkaido Univ. Sapporo.

WISNIEWSKI T., 1932: Biometrische Untersuchungen über die Variabilität der Rotbuche (Fagus silvatica) in Polen. (In Polish). Sylwan **50/6**, 1-27.

Address of the authors: Dr. Maria BIALOBRZESKA
Dr. Janina TRUCHANOWICZ
Prof. Dr. Kazimierz ZARZYCKI
Institute of Botany
Polish Academy of Sciences
ul. Lubicz 46
31-512 Krakow, Poland