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FDC: 176.1 *Quercus robur* L., *Q. petraea* (Mattuschka) Liebl., *Q. pubescens* Willd., *Q. cerris* L.: 164,5 + 164,7 (497.12)

THE IMPORTANCE OF MORPHOLOGICAL CHARACTERISTICS FOR IDENTIFICATION OF OAK SPECIES

Ivan SMOLE*, Franc BATIČ**

Abstract

Taxonomical variability of herborized samples of four oak species from a preliminary examination is discussed in the paper. Stress is laid on statistical processing of morphological characteristics of oaks. 800 leaf samples of four oak species (pedunculate oak, sessile oak, pubescent oak, turkey oak) and 395 acorn samples (pedunculate oak, sessile oak, pubescent oak) from the whole territory of Slovenia were examined. It was found that the typical morphological characteristics (shape and dimensions of leaf lamina, length of petioles and fruit-stalks) are important especially for distinguishing oak species and that they also have an important role in intraspecific classification. No relationship or interdependence of these signs to other morphological characteristics - the trichomes, for example - or to the characteristics of acorns were noticed.

Key words: pedunculate oak (*Quercus robur* L.), sessile oak (*Q. petrea* (Mattuschka) Liebl.), pubescent oak (*Q. pubescens* Willd.), turkey oak (*Q. cerris* L.), herbarium samples, morphological characte., leaf, fruit, pure species, variety, hybrid

POMEN MORFOLOŠKIH ZNAKOV PRI DOLOČANJU HRASTOVIH VRST

Izvleček

Delo vsebuje taksonomsko obravnavo herbarijskih vzorcev štirih hrastovih vrst iz predhodne raziskave s poudarkom na statistični obdelavi morfoloških znakov. Obdelano je bilo 800 listnih vzorcev (doba, gradna, puhastega hrasta in cera) in 395 vzorcev želoda (doba, gradna in puhastega hrasta) iz vse Slovenije. Ugotovljeno je, da so tipični morfološki znaki (oblika in dimenzije listne ploskve, dolžina listnega in plodnega peclja) pomembni predvsem za razločevanje hrastovih vrst in da imajo pri notranjem členjenju specifično vlogo, ni pa ugotovljena večja zakonitost povezave ali soodvisnosti med temi znaki in morfološkimi znaki kot so listni laski ali trihomi in lastnosti želoda.

Ključne besede: dob (*Quercus robur* L), graden (*Q. petraea* (Mattuschka) Liebl.), puhasti hrast (*Q. pubescens* Willd.), cer (*Q. cerris* L.), herbarijski vzorci, morfološki znak, list, plod, čista vrsta, različica, križanec

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1 INTRODUCTION

The study of the morphological characteristics of oaks and evaluation of their importance for oak-species identification on our institute started in October 1990, when - within Slovene-Austrian research cooperation - oak sampling was carried out on 32 typical oak sites throughout Slovenia. The leaves were collected from 160 trees and the acorns from 93 trees of the same populations.

The results of the analysis of leaf samples (characteristics according to a key) have already been presented in the yearly report on the Austro-Slovene research cooperation (SMOLE 1991). It was cited in the report that among the 160 sample trees, there were 71 trees of pedunculate oak, 66 trees of sessile oak, 12 of turkey oak and 11 of pubescent oak. For the identification of species, the descriptions of morphological characteristics of leaves and acorns (RECHINGER 1957-1958, HESS et al. 1976) were applied. Measurable morphological characteristics visible with the naked eye (the shape, dimensions and other properties of different leaf parts) and characteristics visible only under a certain magnification (the shape and distribution of trichomes on various leaf parts, which differ significantly among oak species) were examined.

On some samples of pedunculate oak and sessile oak, significant deviations of micro-characteristics from characteristics declared significant for these two species in the above-mentioned literature were noticed. We therefore assumed that these samples belonged to mixed species or hybrids, while samples without any unusual characteristics belonged to pure species. According to this hypothesis, the 160 trees were classified into the following groups:

- pedunculate oak with no unusual characteristics	37 trees
- pedunculate oak hybrids (pedunculate oak : turkey oak)	31 trees
- pedunculate oak hybrids (pedunculate oak : sessile oak)	3 trees
- sessile oak with no unusual characteristics	11 trees
- sessile oak hybrids (sessile oak:turkey oak,sessile oak:pubescent oak)	55 trees

No variability in hairiness of different leaf parts was noticed in pubescent oak and turkey oak, so these two species were considered to be pure.

Intraspecific classification showed that with pedunculate oak, the proportion of nonhybridized individuals was almost equal to that of hybrids, while with sessile oak, there were five times more hybrids than trees of the pure species. It could therefore be deduced that in Slovenia, sessile oak is much more liable to crossbreeding with other species of oaks than pedunculate oak. It was further noticed that with hybrids of both oak species, the morphological characteristics of turkey oak prevailed (the shape of leaves, for example), and that with hybrids of sessile oak, the influence of pubescent oak was also possible - especially in the regions of the Karst, Slovene Primorje and Istra.

In this phase of the investigation, acorn samples were not analysed.

The first results of the investigation and the extensive herbarium collection required further work in order to find the relationship between typical characteristics of the leaf lamina (shape and dimensions) and trichomes as possible characteristics of species, and also to evaluate their importance for identification of oak species and their varieties. The findings of this investigation are presented in the article.

2 METHODS

In the first phase of the investigation, the following working procedure was used:

- All oak species were sampled at their native sites, defined by the principles of the Central European School for vegetation studies. Not only the sites in which oaks were the main element of forest plant associations were included in the investigation, but also sites in which oaks were only mixed among other species of trees.
- Four of the most abundant oak species in Slovenia were chosen for the investigation: pedunculate oak (*Quercus robur* L.), sessile oak (*Quercus petraea* (Mattuschka) Leibl..), pubescent oak (*Quercus pubescens* Willd.), turkey oak (*Quercus cerris* L.).
- Sampling sites were chosen on the basis of vegetation and forest stand charts (review charts of native sites and plant associations), adapted after various sources especially for this purpose.
- On the basis of this information, 32 sampling sites were chosen. On each site, from 5 trees chosen at random, the leafed twigs from the sunny side and the shady side of tree crowns were sampled for the herbarium. The observations were recorded in a special questionnaire (Appendix 1). From the same trees - if possible - acorns were also collected.
- For every chosen tree, one twig with leaves from the sunny side and one from the shady side was herborized, altogether 320 samples. Significantly less fruits were sampled, and only the acorns from 79 trees were later applicable for observation.
- Triplets of leaf samples were collected and herborized - one of them was then sent to Austria, to the herbarium collection in Vienna, and the other two are kept in the forestry herbarium at IGLG. One of them is destined for the herbarium collection of the Department of Biology of the University of Ljubljana.
- A review of sampling plots (in relation to species of oaks and their territorial distribution) is presented in Table 1 and Figure 1.

Appendix 1: Oak sampling in Slovenia

QUERCUS ROBUR L.

Sampling site no.: 26
Tree no. : 1
Date : October 15th, 1990

Place: Godešič by Škofja Loka

Gaus-Krueser coordinates x: 5450.6
y: 5114.1

Sampled by: E. Azarov
I. Smole

Quadrant: 9852/1

Height above sea level: 400m
Exposition: 0
Inclination: 0
Landscape type: FLAT LAND
Relief: HILLY/BROKEN

Bed-rock: diluvial clay
Soil: pseudogley

Plant association: *QUERCO-LUZULO-FAGETUM*

Description of the stand: uneven-aged in small areas, one-stratum stand, high forest

Phase of development: polewood forest

Complex: 0.8

Tree measurements:
- diameter: 29.0
- tree height: 12m
- height up to the crown: 5m

Description of the tree:
- at the edge of the forest
- predominated over
- very vital
- selfseeded
- well rooted

Trunk:
- inferior trunk, stout, one-axis, inclined, bent, twisted, thick-branched, few adventive shoots, few epiphytes

Crown:
- strongly asymetrical, open, narrowed at two sides, few adventive shoots, few epiphites

Fruit bear:
- high

Herbarium sample from: the crown periphery, tertiary branches at height of 5m

Table 1: Basic data on oak sampling in Slovenia in 1990 (Comment: The size of a sample series is 5 trees to a site)

Succes. no. of the serie	Date	Sampling plot	Oak species
1.	27.9.90 28.9.90	LJUBLJANSKO BARJE, Rakova jelša, Zgornji Log, along the main road and side roads	*Quercus robur* (5x)
2.	1.10.90	PRAGERSKO, Zgornja gorica, Grajevnik, along the forest road	*Q. robur* (5x)
3.	1.10.90	SREDIŠČE OB DRAVI, Obrež, V. Krče, along the local road, at the edge of the forest	*Q. robur* (5x)
4.	2.10.90	DOBROVA PRI LJUBLJANI, the mountain ridge above the local road	*Q. petraea* (5x)
5.	2.10.90	TOŠKO ČELO, Prevalnik, the mountain ridge, by the monument to the partisans	*Q. petraea* (4x) *Q. robur* (1x)
6.	3.10.90	LJUTOMER, Ključarovci, Ključarovski gozd, at the edge of the village	*Q. robur* (5x)
7.	3.10.90	MURSKA ŠUMA, the local road crossing, south of Ledava	*Q. robur* (5x)
8.	3.10.90	ČRNI LOG, Banuta, at the shore of the artificial pond	*Q. robur* (5x)
9.	4.10.90	KRAKOVSKI GOZD, Gmajna, along the local road Gmajna - Zameško	*Q. robur* (5x)
10.	4.10.90	KRAKOVSKI GOZD, Koprivnik, along the stream of Lokavec, the edge of the forest	*Q. robur* (5x)
11.	4.10.90	KOSTANJEVICA, M. Vodenice, M. Ban, along the local and the forest road	*Q. petraea* (5x)
12.	8.10.90	BELA KRAJINA, Vranoviči, along the local road Metlika - Črnomelj	*Q. robur* (5x)
13.	8.10.90	BELA KRAJINA, Stara Lipa pri Vinici, the edge of the pasture-overgrowing	*Q. robur* (5x)
14.	8.10.90	BELA KRAJINA, Razvaje by Damelj, along the local road Vinica-Stari trg	*Q. cerris* (5x)
15.	9.10.90	DIVAČA, at the foot of the hill of Kožlek, along the local road Divača - Lokev	*Q. pubescens* (5x)
16.	9.10.90	DIVAČA, at the foot of the hill of Kožlek, along the local road Divača - Lokev and along the railway	*Q. cerris* (5x)
17.	9.10.90	BRKINI, Ostrožno brdo, Boršt, the hill-slope above the forest road (Ljubljanska cesta)	*Q. petraea* (5x)
18.	10.10.90	NOVA GORICA, Panovec, the ridge south to the forest study way	*Q. petraea* (5x)
19.	10.10.90	NOVA GORICA, Stara gora, Strmec, along the local ridge road	*Q. petraea* (5x)
20.	10.10.90	COL, below the village, above the local road Ajdovščina - Col	*Q. pubescens* (5x)

Succes. no. of the serie	Date	Sampling plot	Oak species
21.	11.10.90	ISTRA, Čela, the hill by the local road Gračišče - Pridvor	*Q. petraea* (5x)
22.	11.10.90	ISTRA, Labor, Peskovlje, along the local ridge road Labor - Boršt	*Q. pubescens* (5x)
23.	11.10.90	ISTRA, Cerje by Župančiči, the hill above the valley of Pinjevec	*Q. petraea* (2x) *Q. cerris* (2x) *Q. pubescens* (1x)
24.	15.10.90	GORENJSKA, Črnivec by Brezje, along the forest road Črnivec -Dvorska vas	*Q. petraea* (5x)
25.	15.10.90	GORENJSKA, Rodine by Begunje, the remainder of the frontal moraine below the village	*Q. robur* (5x)
26.	15.10.90	SORŠKO POLJE, Godešič by Reteče, along the railway and the lines man's cabin	*Q. robur* (5x)
27.	16.10.90	SELŠKA DOLINA, Podlonk by Železniki, forest edge at the foot of the hill of Lonk	*Q. petraea* (5x)
28.	16.10.90	POLJANSKA DOLINA, Hlavče njive, the ridge above the village	*Q. petraea* (5x)
29.	16.10.90	ŽIROVSKI VRH, Zadobje by Lučine, the hill above the village	*Q. petraea* (5x)
30.	17.10.90	POSAVSKO HRIBOVJE, Velika Preska by Polšnik, the hill above the village	*Q. petraea* (5x)
31.	17.10.90	CELJSKA KOTLINA, Lopata by Medlog, the forest behind the new village	*Q. robur* (5x)
32.	17.10.90	TOPOLŠICA BY ŠOŠTANJ, Sv. Jakob, the hill behind the church	*Q. robur* (5x)
Number of series: 32	Number of days: 13	Number of sampling sites: 32	Number of sample trees:	*Q. robur:* 71x *Q. petraea:* 61x *Q. cerris:* 12x *Q. pubescens:* 16x Total: 160x

Comment: The propertions of trees of different species in the table are corrected (with regard to the original classification - see Chapter 3.1)

In the second phase of the investigation, the primary identification of oaks was completed by analysis of a larger number of leaf samples. The measurable morphological characteristics of the same samples were afterwards examined in order to find the relationship between the typical leaf lamina characteristics and the trichomes of the species under analysis. It was also our intention to verify the hypothesis that the morphological characteristics of leaves growing on the sunny side of

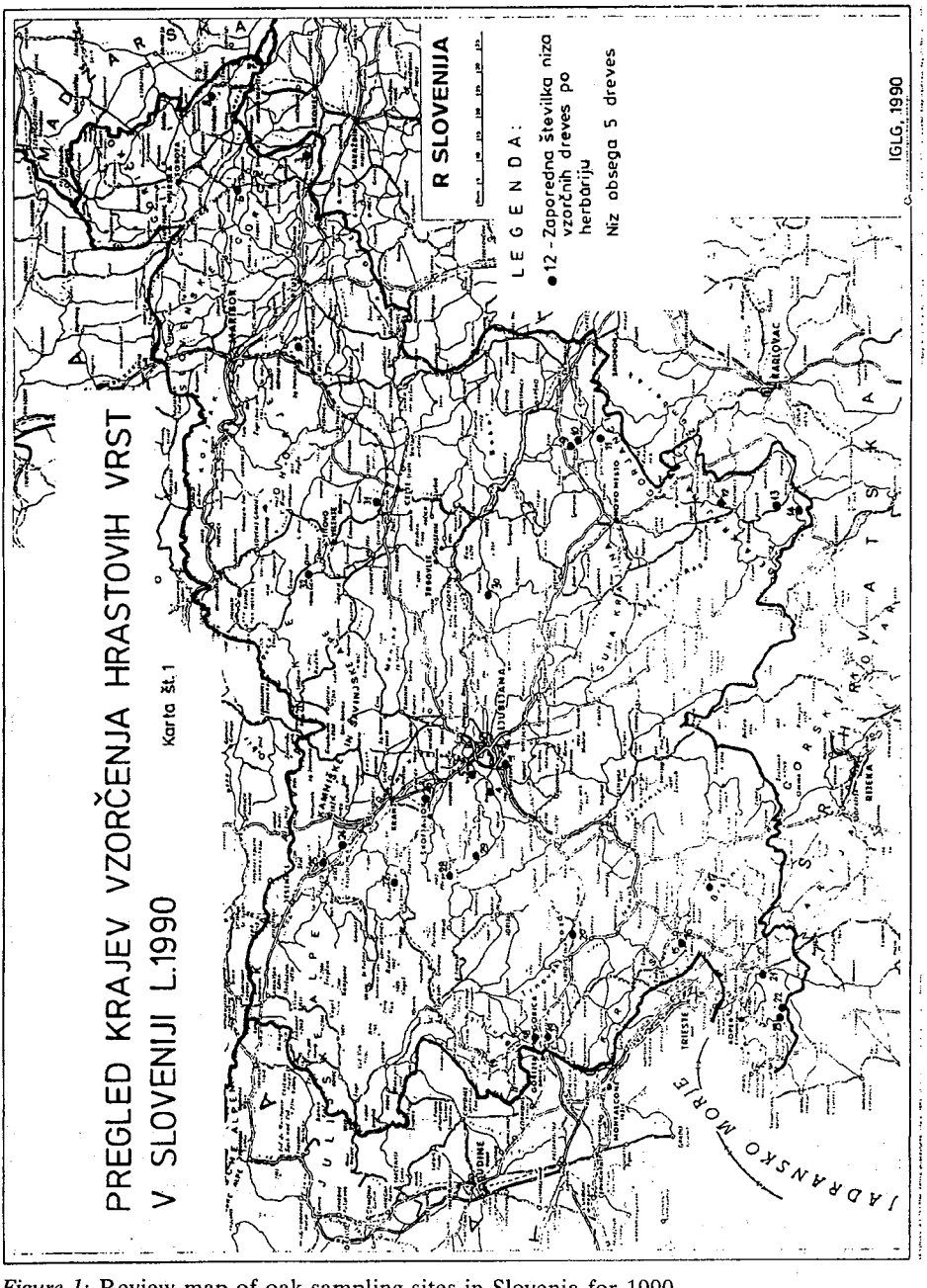

Figure 1: Review map of oak sampling sites in Slovenia for 1990

a tree crown (first of all the size of the leaf lamina) differ significantly from those of leaves from the shady side of a tree.

For this purpose, 5 randomly chosen leaf samples were collected from each tree: 3 samples from the sunny side and 2 from the shady side of the tree crown. The following parameters of each leaf were either measured or evaluated: length and width of leaf lamina, number of lobes at left and right side, length of petiole. Under stereomicroscope magnification of 100x, the hairiness of the following parts of the leaves was evaluated: leaf lamina, veins and leaf margin on the upper and lower surfaces. A model of a questionnaire, modified to allow the data to be entered on a computer is shown in Appendix 2. Eight hundred leaf samples of pedunculate oak, sessile oak, turkey oak and pubescent oak were examined by this method.

Measurements and evaluations of the morphological characteristics of oak fruits - acorns - were also obtained if at least 5 applicable samples to a tree were available. The following morphological characteristics were examined: number of fruits to a stalk, length of fruit stalk, length and width of fruit, typical shape of fruit, height and width of fruit cup (cupule), type of hairiness of the cupule and the shape of its scales. An example of the questionnaire is given in Appendix 3. Three hundred and ninety five acorn samples of pedunculate oak, sessile oak and pubescent oak were examined; the acorns of turkey oak were not collected because they ripen and fall in the second year after fruit-bear.

3 RESULTS

3.1 Corrections and additions to the primary identification of species

Because of shortage of time in the first phase of the investigation it had been necessary in the second phase to examine a larger number of leaf samples. The quantity of data now gathered allowed us to correct the primary identification of oaks. The same criteria as in the previous analysis were used. While in the preliminary investigation the deciding factors for oak classification were the morphological characteristics of leaf samples (shape and other characteristics of the leaf lamina, length of petiole, shape and persistence of stipules), the varieties within individual species in the second phase were distinguished by observation and evaluation of the hairiness of leaf parts under stereomicroscope magnification. For the identification of samples, the morphological characteristics described in Slovene and foreign literature were taken into consideration.

According to MARTINČIČ and SUŠNIK (1984), the distinguishing characteristics are:

Pedunculate oak: Leaves are obtusately pinnately lobed. Stipules are membranous and shed early. Cupule scales are closely overlapping. Young shoots and petioles hairless or slightly hairy initially. Leaves hairless, rarely initially

slightly hairy on the lower surface. Leaves sessile or shortly petioled. Fruit stalk is half as short as the associated leaf.

Sessile oak: In contrast to pedunculate oak, petioles are 2 - 4cm long. Fruits are sessile or with a very short common stalk.

Pubescent oak: In contrast to pedunculate oak and sessile oak, the young shoots and leaves are hairy. Petioles are 10 - 15mm long. Leaf blades with 4 -7 obtuse lobes on each side. Cupule scales are closely overlapping.

Turkey oak: Leaves deeply pinnately lobed, with pointedly sharpened lobes, hairy on the lower surface. Cupule scales protruding. Stipules thread-like, persistent.

According to TRINAJSTIC (1988), the following features are characteristic of *Quercus robur*:

Pedunculate oak: One-year old shoots are hairless. The torus (flower axis) is hairless, fruits are stalked. Leaves are entirely hairless, with a few simple hairs on the veins or leaf margins.

DOMAC (1984) mentions the following characteristics as typical of the studied four species:

Pedunculate oak: Lower surface of leaves is hairless, slightly hairy on the veins only. The fruit stalk is long, significantly longer than the petiole. The cupule is smooth, with short, roundish, closely overlapping, ringlike arrayed scales.

Sessile oak: In contrast to pedunculate oak, its fruit stalk is very short, never longer from the petiole, or the fruits are sessile. Leaves are hairy on the lower surface, especially on the veins.

Pubescent oak: Young branches are hairy. Leaves shallow lobed, densely hairy on the lower surface. The fruit stalk is short, 1cm long at the most. Cupule scales are small, roundishly ovate, closely overlapping.

Turkey oak: Leaves are pointedly lobed, hairy on the lower surface, the stipules persistent. Fruit scales are linear, protruding, curved.

ROTHMALER (1988) defines oak species as follows:

Pedunculate oak: Young branches and leaf buds hairless. The leaf lobes rounded, slightly heart-shaped at the base, bent downwards, the largest lobes towards the leaf apex. Petiole very short. Fruits stalky, ripen in the first year.

Sessile oak: Young branches and buds are hairless. Leaf lobes are rounded, the base of the leaf lamina is wedge-shaped, flat; the largest lobes are in the middle of the leaf blade. Petiole is 1 - 3cm long. The fruits are sessile, ripen in the first year.

Pubescent oak: Young branches and leaf buds stellately hairy. The leaf lobes are rounded; the lower leaf surface is covered with soft, long hair. The fruits ripen in the first year.

Turkey oak: Leaves have 6 - 8 pointed leaf lobes. Both surfaces of young leaves are covered with grey hair and in old leaves, at least the lower surface - stellate hairs on the veins. The fruits ripen in the second year.

The oak species are the most thoroughly described by RECHINGER (1957-58) and HESS et al. (1976). Their descriptions were combined in the following resume:

Pedunculate oak: The leaves are wide wedge-like obovate, the widest above the middle or towards the apex in the upper third of leaf lamina. They are lobed, on every side with 5 - 6 obtuse to pointed lobes and unequal, wider or narrower obtuse and rather deep indentations. The bottom lobe is often small and rounded, the second one already much greater, the third and the fourth often lingulately lengthened and roughly irregularly toothed at the bottom. The upper lobes often egg-shaped and almost parallel, all - more often than not - rather widely rounded, on secondary shoots often distinctly pointed. Regarding the main rib, the leaves are often clearly asymmetrical. The leaf blades are 6 - 16cm long and 3 - 10cm wide.

The interspaces between lateral veins - up to 7 on each side - are rather wide. The veins are not distinctly parallel and are oriented towards the leaf lamina indentations. The leaf lamina is rough, irregular, densely reticulate, in youth slightly silky hairy, later completely hairless, roughly to leathery membranous, shiny green on the upper surface, undefined, light green to blue-gray-green on the lower surface. The upper surface of leaves is hairless, the lower with very few single simple hairs or hairless, never with stellate hairs (100x magnification). Petiole normally very short, 2-7mm long, rough, half-round, hairless. Stipules narrowly pointed and very unpersistent.

The fruits are sessile, single or 2 - 5 on a hairless or seldom slightly hairy stalk, which is about half as long as the subtending leaf, sometimes shorter or longer. The fruit is oblongly ovoid, pointed, 18 - 28mm long, 7 - 15mm broad, with the lower fourth or third, rarely up to a half, enclosed in the fruit cup (cupule).

The cupule is 8 - 12mm high, and of a diameter of 7 - 14mm; with tender, silky, egg-shaped, closely ovarlapping scales, the margins of which are distinctly grown together and thus form spirally twisted girdles, ending above with more or less hairless and not overgrown curled edges.

Sessile oak: The leaves are widely obovate to elliptically lanceolate, the widest in the middle or towards the apex, the base is shortly wedge-like narrowed or lengthened towards petiole, seldom rounded or cordate, earless, widely rounded or narrowed towards the apex. They are lobed, with 5 - 8 (or 10) rounded, smooth-edged lobes on each side (the bottom 1 - 2 lobes are sometimes toothed), and short, wide to narrow indentations, which are either shallow or stretch approximately to a fourth of the leaf lamina width. The leaves are 8 - 12 (16)cm long and 5 - 7 (10)cm wide.

Lateral veins, which split from the mid-vein at an acute or right angle, often lead only towards the lobes and not towards indentations. The intermediary venation is irregular, roughly meshy, sparse and inconspicuous. The upper surface of the leaf lamina is green, slightly shiny, the lower surface of a lighter

colour, overgrown with sessile, stellate hairs, the points of which are not longer than 0.2mm (100x magnification). In youth, sometimes a few simple silky hairs are also present on the veins, which later become hairless and remain hairy only in the vein axillas. The petiole is often conspicuously grooved, 12 - 24mm long, hairless. The stipules are drily membranous, hairless or hairy, shed early.

The fruits are sessile or on a common, up to 15 (20)mm long stalk in the leaf axillas, single or up to 5, seldom more. The fruit cup (cupule) is 6 - 12mm high, 8 - 14mm wide, with a thin shell and small, ovately lanceolate, pointed, at the back densely fuzzy hairy, slightly convex (never protruberantly knobby), closely overlapping scales. The fruits are ovoid, often distinctively pointed, 16 - 26mm long, 8 - 14mm wide.

Pubescent oak: The leaves are similar in shape to the leaves of pedunculate oak, they are obovate to oblongly obovate, only sometimes eared, often the widest in the middle. At the base they are narrowly wedge-like or cordate and obtuse at the apex. On both sides they have 4 - 7 (8) often shortly rounded lobes, which are curled under at the top. The lobes sometimes have a small point, with rather shallow and widely wavy rounded, seldom deeper and narrow indentations between them. The leaves are 5 - 8 (10)cm long and 4 - 6cm wide.

Lateral veins only go to the lobes and not to indentations. The leaf lamina is densely felty in spring, later pale green, fuzzy or whitely felty, at the end sometimes almost completely hairless. The lower surface of leaves is sometimes thickly covered with sessile, mostly 4 - 6 part stellate or bushy hairs, the points of which are mostly 0.3 - 0.6mm long.

The petiole is shorter than 2cm, often up to 1cm long, felty, covered with stellate hairs. It is shorter on the short shoots, the leaves are often sessile. The stipules are spade-like, linearly lanceolate, hairy at the apex, unpersistent, only on the secondary shoots more persistent.

The groups of 1 - 5 fruits, are almost sessile or shortly stalked. The fruits are smaller and slender than with pedunculate oak and sessile oak, oblong and smooth, pointed. The cupule is semicircularly cup-shaped and embraces the fruit to about one third or one half; it has various, brick-like arrayed, closely overlapping, thickly felty scales. The lower ones are a little wider and have clipped tip, the middle and the upper ones are triangularly pointed. The uppermost are narrowly lanceolate and shorter than the others.

Turkey oak: The leaves are oval in their outline, narrowly oblong to oblongly obovate, irregularly and usually deeply lobed (often almost to the main rib), seldom only lobedly toothed, normally with 4 - 9 triangular, smooth-edged or toothed (with 1 - 4 teeth) lobes on each side, which have short fringed points on top (1mm long at the most). The leaves are 3 - 15 (18)cm long and 2 - 9

(12)cm wide. The ratio between their length and width is approximately 2,5:1.

Lateral veins seldom go to indentations. In youth, the leaves are yellowishly stellately hairy on both surfaces, later almost hairless, somewhat paler green, membraneous leathery and very rough on both surfaces, brown to yellowish brown in autumn. On the upper surface they are dispersely and on the lower surface densely hairy, covered with sessile, mostly 6 - 10 part stellate hairs, because of which the lower surface is gray green. The hair points are normally not longer than 0.3mm.

The petiole is up to 2.5cm long. The stipules are linearly lanceolate or linear, protruding, felty hairy and do not shed even on the fallen leaves.

The fruits ripen in the second autumn. They are single or 2 - 4 to a short or longer, up to 27mm long stalk. The fruit is ovoidly oblong, slightly bigger than with pedunculate oak, up to 3cm long, brown, felty hairy in the upper part, elsewhere hairless. The fruit cup is bigger than with pedunculate oak, it embraces the acorn approximately to one third or one half. It is covered by linearly pointed, brown, felty scales, the lower of which have protruding processes, while the middle and the upper ones fold obliquely outwards immediately above their base and thus protrude almost to the whole length of the cupule.

Beaving in mind to the described morphological characteristics and hairiness of various leaf parts, the leaf samples were classified anew. It should be mentioned that the hairiness of leaf parts was only evaluated, and the length of trichomes and their points was not measured. The classification is presented in Table 2.

From the table below it can be seen that the primary identification of species was changed - in the case of pedunculate oak, the number of trees of the pure species is smaller, while the number of trees which are considered to be varieties or hybrids of the same species is much greater. The number of trees of sessile oak decreased, but the ratio between pure and hybrid trees remained almost unchanged. With pubescent oak, the number of trees increased proportionally to the decrease in the number of sessile oak. The reexamination of sampled material showed that some trees of pubescent oak species were falsely identified in the primary analysis as trees of sessile oak, with some characteristics unusual for this species.

The number of samples identified as turkey oak remained the same as before.

Table 2: Classification of sample trees according to the type of leaf hairiness

Oak species	Classification of leaf samples in relation to the hairiness of different leaf parts	Together	
		Number of trees	Propertion of trees in %
Quercus robur	Samples with characteristics typical of the species	31	19
*Q. robur**	Samples with unusual characteristics	40	25
Q. petraea	Samples with characteristics typical of the species	10	6
*Q. petraea**	Samples with unusual characteristics	51	32
Q. pubescens	Samples with characteristics typical of the species	16	10
Q. cerris	Samples with characteristics typical of the species	12	8
Total		160	100

* An accurate classification of the samples by this criterion is presented in Table 3 and Table 4.

Another aim of the thorough analysis of leaf samples was an accurate classification of individuals of pedunculate oak and sessile oak according to the specific hairiness of their leaf parts. The results are presented in the following table.

Table 3: Classification of pedunculate oaks according to the type of hairiness of their leaf parts

Oak species	Different types of hairiness of the leaf samples	Number of trees	Propertion of trees in %
Quercus robur	The upper surface of leaves hairless, the lower surface with simple hairs	31	44
Q. robur 1	Stellate hairs on the veins of the upper surface of leaves*	30	43
Q. robur 2	Stellate hairs on the veins of the lower surface of leaves	1	1
Q. robur 3	Stellate hairs on the upper surface of leaves	1	1
Q. robur 4	Stellate hairs on the veins and the lower surface of leaves	2	3
Q. robur 5	Stellate hairs on the veins of the upper and the lower surface of leaves	3	4
Q. robur 6	Stellate hairs on the veins of the upper surface and on the entire lower surface of leaves	3	4
Total		71	100

* Note: The lower surface of leaves of all the varieties of pedunculate oak is normally covered with dispersely arrayed, simple hairs, as with the pure species, in addition to other hairs mentioned.

The table above shows that the number of pedunculate oak hybrids exceeds the number of trees of pure species, but only the first of the varieties is abundant. It should also mentioned that all the composed hairs (with 2 - 6 or more points) were considered stellate hairs. Among the samples of pedunculate oak, there were many specimens with 2 - part, fork-like hairs absolutely predominating, among which no more-part hairs were found, even by examination of the complete sample from an individual tree. There is unfortunately no information or explanation in the available literature of such mutilated morphological characteristics.

In the case of sessile oak, the number of diverse varieties is much lower than with pedunculate oak. The results of the analysis are shown in Table 4.

Table 4: Classification of sessile oak trees according to the type of hairiness of the leaf parts

Oak species	Different types of hairiness of the leaf samples	Number of trees	Proportion of trees in %
Quercus petraea	The upper surface of leaves hairless, the lower surface with stellate hairs	10	16
Q. petraea 1	Stellate hairs on the veins of the upper surface of leaves*	40	66
Q. petraea 3**	Stellate hairs on the veins and the upper surface of leaves	10	16
Q. petraea 6	Stellate hairs on the veins of the upper surface, simple hairs on the lower surface of the leaves	1	2
Total		61	100

* Note: The lower surface of leaves of sessile oak varieties - as with the pure species - is covered with stellate hairs.

** Note: The varieties of sessile oak are numbered in the same way as varieties of pedunculate oak with regard to the trichome position on the leaves

The number of varieties (hypothetical hybrids) of sessile oak greatly exceeds the number of pure species trees, but only two of the varieties are more abundant. In this case, too questionable 2-part or fork-like hairs were included among the stellate hairs. An assumption was also made that the upper surface of leaves of this species is glabrous, although in the literature this is not additionally emphasized (as for example in the case of pedunculate oak).

A hypothesis exists that all deviations from the characteristical morphologic features of an oak species are signs of the influence of some other oak species. Assuming this hypothesis, the examined samples of pedunculate oak and sessile oak most frequently show the influence of turkey oak and pubescent oak, because only in these two species is the upper leaf surface stellately hairy.

A delimitation of their influence would probably only be possible by measuring the hair dimensions, although this was not done in our analysis. In the case of inter influence, sessile oak affects the features of pedunculate oak more frequently than vice versa, but such effects could only be found in a small number of samples.

3.2 Teritorrial dispersion of sample trees of pedunculate oak and sessile oak and their varieties

By mapping the territorial dispersion of sample trees we tried to discover whether any rules exist for the spread of individuals of pure species and their varieties. An understanding of this would make it possible to delimit the areas of major external influence from areas in which the influence is smaller or does not exist at all. Only sample plots in which all 5 trees were of the same oak species were taken into consideration.

In the case of pedunculate oak, the trees from 14 sampling plots were examined. It was discovered that on one sample plot all 5 trees belonged to the pure species, while on other sample plots, typical pedunculate oaks and varieties were mixed in different proportions. To make at least a rough territorial division, we decided on a compromise - so sample plots with at least three typical species trees were considered to be areas of low influence and sites with at least three hybrid trees were considered to be those greater influence. According to this criterion, 2 growing sites of pedunculate oak in Prekmurje, 1 growing site on Mursko polje, 1 in Krakovski gozd and 2 in Bela Krajina - all in the eastern part of Slovenia - were defined as areas of low influence. Large influence was found at 3 localities in the Ljubljana basin and 5 in eastern Slovenia - one of the sites surprisingly lying in Krakovski gozd, the largest continuous area of pedunculate oak in Slovenia. All the mentioned sites are presented in Figure 2.

The territorial dispersion of 11 growing sites of sessile oak showed that only one in the surroundings of Ljubljana could be considered a site of low influence, while all the other 10 sites, dispersed from the westernmost borders of Slovenia - from Istra and Nova Gorica over Brkini, Žirovski vrh, Selška and Poljanska dolina, Ljubljana basin and the Sava hills to the foothills of the Gorjanci and to Kostanjevica in the east - are places of large external influence, where varieties predominate over typical sessile oaks. The site dispersion is presented in Figure 3.

3.3 Results of statistical analysis of morphological characteristics of leaf samples

The visible morphological characteristics, which could be measured or at least evaluated (the frequency of their occurance, for example), were included in statistical analysis. First of all, the degree of uncertainty was calculated by the T-test. An eval-

uation of the significant differences of the given values was thus made possible. In cases in which such calculations would not be appropriate, reciprocal tabular intercomparisons of the desired parameters or phenomena were carried out. The following more important results were obtained:

- The degree of uncertainty estimates (made with the T-test) showed that no significant morphological differences existed between leaves from the sunny side and leaves from the shady side of a tree. The calculation is valid for all samples and all species of oaks, with the exception of one morphological characteristic in the fourth variety of pedunculate oak. In further analysis, the latter deviation was ignored, so all the leaf samples of a tree were treated as a homogeneous calculation sample. The results of the mentioned analysis are listed in the following summary table.

Table 5: Degree of uncertainty (T-test)[1] for significant differences between leaves from sunny side and the leaves from the shady side of the tree crown

Oak species	Number of lobes		Leaf dimensions		Petiole length
	right side	left side	length	width	
Quercus robur	0,572	0,745	0,610	0,932	0,370
Quercus robur 1	0,736	0,721	0,339	0,515	0,931
Quercus robur 2	0,596	0,789	0,666	0,524	0,870
Quercus robur 3	0,724	0,219	0,671	0,867	0,374
Quercus robur 4	0,007	0,067	0,890	0,578	0,326
Quercus robur 5	0,363	0,706	0,841	0,794	0,491
Quercus robur 6	0,245	0,332	0,931	0,851	0,852
Quercus petraea	0,765	0,728	0,830	0,910	0,580
Quercus petraea 1	0,890	0,719	0,660	0,777	0,570
Quercus petraea 3	0,858	0,665	0,477	0,640	0,895
Quercus petraea 6	1,000	0,789	0,709	0,886	0,663
Quercus pubescens	0,683	0,605	0,876	0,922	0,430
Quercus cerris	0,818	0,605	0,296	0,131	0,981

* Note: According to the theory of this calculation, the differences between the compared values are statistically significant when the degree of uncertainty is smaller than 0.05 (the uncertainty is below 5%).

1 To simplify comment, the abbrevations from the computer analysis are used for different varieties and species

Table 6: Mean values for morphological characteristics of the chosen leaf samples

Oak species	Leaf dimensions		Petiole length (cm)	Number of lobes to a leaf	
	length (cm)	width (cm)		left side	right side
Quercus robur	10,89548	6,61742	0,41290	5,5613	5,6645
Quercus robur 1	9,69200	5,99867	0,49333	5,2467	5,4067
Quercus robur 2	8,50000	4,90000	0,38000	5,2000	5,0000
Quercus robur 3	8,52000	5,38000	0,64000	5,8000	5,8000
Quercus robur 4	11,88000	7,51000	0,54000	5,5000	5,6000
Quercus robur 5	10,65333	6,59333	0,57333	5,4667	5,6667
Quercus robur 6	10,86000	6,63333	0,54667	5,3333	5,6000
Quercus petraea	10,38400	6,46400	1,77800	6,5800	6,7400
Quercus petraea 1	9,51700	5,91500	1,63000	6,3100	6,4450
Quercus petraea 3	9,83800	6,42600	1,67000	6,4600	6,3600
Quercus petraea 6	10,34000	5,50000	1,96000	5,6000	6,0000
Quercus pubescens	7,55500	5,24500	1,23875	6,0125	6,1250
Quercus cerris	10,84500	5,21333	1,29833	7,5000	7,2167
Average - all species together	9,86313	6,04725	1,06313	5,9925	6,0813

- The results of the calculation of the mean values of morphological characteristics of the studied oak species are shown in Table 6. The means for leaf dimensions and for leaf parts' number are presented because these two morphological characteristics are distinguishing signs for different species of oaks. In data processing, one has to bear in mind that the number of specimens to a species plays a decisive role in all further calculations. For that reason the results are - at a first sight - often in contradiction to the statements in Table 6.
- The estimates of uncertainty with the T-test, made on the basis of the means for the morphological characteristics from TABLE 6, are presented in TABLE 7. The morphological characteristics of leaves of all the four species of oaks vary among themselves most significantly.

The leaves of **turkey oak** differ significantly in all 5 parameters from the leaves of the first variety of pedunculate oak R1[2] and from the S1 variety of sessile oak. In

2 To simplify comment, the abbrevations from the computer analysis are used for different varieties and species

four parameters - with the exception of the leaf lamina length - they vary significantly from the leaves of typical pedunculate oak samples and of three varieties of this species - R4, R5 and R6 - and from the variety S3 of sessile oak. From the samples of other oak species (pure species and varieties), the leaves of turkey oak differ significantly in at least two morphological features.

The leaf samples of **pubescent oak** differ significantly in all 5 characteristics from the leaves of pure pedunculate oak and sessile oak and their varieties R1 and S1. From all other samples, they differ at least in the length of the petiole.

The leaves of pure **pedunculate oak** differ in all 5 morphological characteristics from the leaves of the variety S1 of sessile oak. From other samples, they vary in 1 - 4 features. The most frequent differences between the leaves of pedunculate oak and **sessile oak** are the differences in the length of the petiole. Differences in leaf lobeness are less frequent, and the fewest differences between the two species and their varieties occur in the length and width of leaf lamina. In this comparison, the most interesting variety is certainly the sessile oak variety S6, which only differs significantly from all the varieties of pedunculate oak in the petiole length, while differences in all the other morphological characteristics are not significant.

Much more important than the differences among leaf samples of the studied four species are the morphological differences within the same species. Attention should therefore be paid to the following statistical results:

With **pedunculate oak**, the only significant difference was noted between the leaves of typical pedunculate oak and the leaves of the most abundant variety R1. The leaf samples vary in 4 morphological characteristics: in length and width of the leaf lamina, in length of the petiole and in the number of lobes on the left side of a leaf. In addition the estimate of uncertainty made for the number of lobes on the right side of the leaves only slightly exceeds the permitted degree of uncertainty, with a value of 0,054 (see Table 7).

In all other cases, differences among pedunculate oak specimens are only significant in some characteristics. The leaves of pedunculate oak varieties R3, R5 and R6, for example, only vary from the typical individuals of this species in the length of petiole, and the significant difference between the leaf samples of varieties R1 and R4 is only the length and width of the leaf lamina.

Because of the established significant differences in the population of pedunculate oak samples, an additional tabular comparison of hairiness of the lower surface of leaves of this species was performed. It is presented in Table 8.

Table 7: T-test calculations

	C	P	R	R1	R2	R3	R4	R5	R6	S	S1	S3	S6
C	KD	,000	,000	,000	,001	,025	,001	,000	,000	,051	,000	,001	,055
	KL	,000	,000	,000	,002	,017	,000	,000	,000	,000	,000	,000	,007
	LD	,000	,916	,013	,084	,083	,304	,827	,986	,383	,003	,091	,712
	LS	,907	,000	,007	,707	,840	,001	,014	,009	,001	,012	,003	,725
	PD	,367	,000	,000	,000	,002	,000	,000	,000	,000	,000	,001	,002
P	KD		,003	,000	,033	,522	,167	,145	,093	,003	,042	,269	,806
	KL		,004	,000	,097	,662	,166	,068	,024	,004	,046	,026	,388
	LD		,000	,000	,535	,260	,003	,006	,004	,000	,000	,000	,177
	LS		,000	,001	,581	,827	,016	,051	,026	,000	,002	,001	,674
	PD		,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000
R	KD			,054	,201	,791	,862	,994	,832	,000	,000	,000	,513
	KL			,025	,498	,655	,875	,764	,470	,000	,000	,000	,942
	LD			,001	,107	,108	,356	,786	,968	,313	,000	,048	,709
	LS			,015	,089	,218	,220	,968	,979	,665	,003	,599	,264
	PD			,001	,701	,009	,280	,035	,010	,000	,000	,000	,003
R1	KD				,457	,467	,622	,420	,547	,000	,000	,000	,274
	KL				,935	,333	,542	,514	,797	,000	,000	,000	,533
	LD				,394	,400	,031	,257	,170	,154	,598	,776	,645
	LS				,273	,535	,038	,323	,286	,189	,725	,241	,616
	PD				,252	,139	,684	,185	,366	,000	,000	,000	,004
R2	KD					,308	,419	,291	,324	,002	,019	,028	,233
	KL					,412	,689	,635	,810	,013	,056	,026	,486
	LD					,991	,081	,256	,218	,136	,466	,394	,425
	LS					,719	,063	,179	,131	,111	,311	,161	,624
	PD					,059	,356	,147	,135	,000	,000	,000	,000
R3	KD						,756	,810	,706	,079	,290	,342	,740
	KL						,689	,553	,404	,151	,378	,237	,724
	LD						,070	,248	,209	,134	,474	,396	,399
	LS						,112	,321	,258	,263	,592	,331	,916
	PD						,564	,611	,399	,000	,000	,000	,001
R4	KD							,891	1,00	,006	,054	,090	,550
	KL							,947	,739	,011	,053	,027	,884
	LD							,405	,490	,120	,019	,083	,433
	LS							,361	,348	,159	,028	,183	,117
	PD							,787	,953	,000	,000	,000	,000

	C	P	R	R1	R2	R3	R4	R5	R6	S	S1	S3	S6
R5	KD								,868	,002	,031	,062	,561
	KL								,731	,001	,013	,005	,793
	LD								,879	,752	,175	,421	,872
	LS								,962	,838	,255	,808	,357
	PD								,763	,000	,000	,000	,004
R6	KD									,001	,019	,040	,467
	KL									,000	,004	,002	,597
	LD									,578	,110	,315	,790
	LS									,782	,224	,757	,288
	PD									,000	,000	,000	,004
S	KD										,156	,119	,168
	KL										,174	,607	,065
	LD										,068	,365	,973
	LS										,112	,931	,313
	PD										,105	,387	,516
S1	KD											,688	,466
	KL											,452	,217
	LD											,517	,557
	LS											,148	,677
	PD											,666	,202
S3	KD												,544
	KL												,116
	LD												,752
	LS												,385
	PD												,336

KD number of lobes on right side
KL number of lobes on left side
LD leaf length
LS petiol width
PD length of petiol

C *Quercus cerris*
P *Quercus pubescens*
R *Quercus robur*
S *Quercus petraea*

1 Stellulate trichomes on veins on upper leaf lamine side
2 Stellulate trichomes on veins on lower leaf lamine side
3 Stellulate trichomes on veins and on leaf lamine on upper side
4 Stellulate trichomes on veins and on leaf lamine on lower side
5 Stellulate trichomes on veins on upper and lower side of leaves
6 Stellulate trichomes on veins on upper lamine side and on the whole lower lamine side

Table 8: Comparison of hairiness of the lower surface of leaf lamina by samples of pedunculate oak

Oak species	Position of leaf samples		Type and density of hairs					
			0	E1	E2	Z1	Z2	Σ
Quercus robur	Sunny side	Number of samples		91	4			95
		% of samples		95,8	4,2			61,3
		% of total no. of samples		60,7	80,0			
	Shady side	Number of samples		59	1			60
		% of samples		98,3	1,7			38,7
		% of total no. of samples		39,3	20,0			
	Together	Number of samples		150	5			155
		% of samples (%)		96,8	3,2			100
Quercus robur 1	Sunny side	Number of samples	1	88	3			92
		% of samples	1,1	95,7	3,3			61,3
		% of total no. of samples	100	60,7	75,0			
	Shady side	Number of samples		57	1			58
		% of samples		98,3	1,7			38,7
		% of total no. of samples		39,3	25,0			
	Together	Number of samples	1	145	4			150
		% of samples (%)	0,7	96,7	2,7			100
Quercus robur 4	Sunny side	Number of samples		3		1	2	6
		% of samples		50,0		16,7	33,3	60,0
		% of total no. of samples		60,0		100	50,0	
	Shady side	Number of samples		2			2	4
		% of samples		50,0		1	50,0	40,0
		% of total no. of samples		40,0		10,0	50,0	
	Together	Number of samples		5		1	4	10
		% of samples (%)		50,0		10,0	40,0	100
Quercus robur 6	Sunny side	Number of samples		4		2	3	9
		% of samples		44,4		22,2	33,3	60,0
		% of total no. of samples		57,1		40,0	100	
	Shady side	Number of samples		3		3		6
		% of samples		50,0		50,0		40,0
		% of total no. of samples		42,9		60,0		
	Together	Number of samples		7		5	3	15
		% of samples (%)		46,7		33,3	20	100

Note: All leaf samples of the pedunculate oak varieties R2, R3 and R5 are uniformly hairy E1 = 100%

Key to other characters in the table:

- Type of hairs: E - simple hairs
  Z - stellate hairs

- Hair density: 0 - negligibly hairy or glabrous
  1 - single hairs
  2 - slightly hairy
  3 - averagely dense hairiness
  4 - densely hairy (pubescent)

It can be seen from the table that typical samples of pedunculate oak and its variety R1 do not differ significantly in hairiness. The deviation is more evident in a comparison of varieties R1 and R6, in which leaf samples with simple hairs and leaf samples with stellate hairs on the lower side of the leaf blade occur in a ratio of approximately 1:1. In the case of pedunculate oak varieties R2, R3 and R5, the hairiness of the lower surface of the leaves is entirely consistent with that of the pure pedunculate oak species.

With sessile oak, within the spectrum of the visible and measurable characteristics of the leaves, the statistical analysis showed no significant differences between trees of the pure species and hybrid trees. As with pedunculate oak, a tabular comparison of hairiness of the lower surfaces of leaves of this species was therefore performed. It is presented in Table 9.

Irrespective of the slightly variable hair density, for all three varieties of sessile oak, medium or average hairiness of the lower leaf surfaces is characteristic; this type of hairiness anyway is the most common with this oak species. No significant differences in this morphological feature existed among sessile oak specimens.

3.4 Results of statistical analysis of oak fruits

In the analysis of oak fruits, 395 samples were examined. Their classification to species is shown in Table 10.

With pedunculate oak and pubescent oak, acorn samples were observed in addition to leaf samples in 62% of trees. The fruits of sessile oak were only analysed in 41% of samples and in the case of turkey oak, no fruit samples were available.

On average, 49% of the sample trees were included in the analysis of oak fruits.

Table 9: Comparison of hairiness of the lower surfaces of the leaf samples of sessile oak

Oak species	Position of leaf samples		Type and density of hairs						
			0	E1	Z1	Z2	Z3	Z4	Σ
Quercus petraea	Sunny side	Number of samples			4	4	19	3	30
		% of samples			13,3	13,3	63,3	10,0	60,0
		% of total no. of samples			50,0	66,7	61,3	60,0	
	Shady side	Number of samples			4	2	12	2	20
		% of samples			20,0	10,0	60,0	10,0	40,0
		% of total no. of samples			50,0	33,3	38,7	40,0	
	Together	Number of samples			8	6	31	5	50
		% of samples (%)			16,0	12,0	62,0	10,0	100
Quercus petraea 1	Sunny side	Number of samples		1	16	27	78		122
		% of samples		0,8	13,1	22,1	63,9		61,0
		% of total no. of samples		100	57,1	65,9	61,9		
	Shady side	Number of samples	1		12	14	48	3	78
		% of samples	1,3		15,4	17,9	61,5	3,8	39,0
		% of total no. of samples	100		42,9	34,1	38,1	100	
	Together	Number of samples	1	1	28	41	126	3	200
		% of samples (%)	0,5	0,5	14,0	20,5	63,0	1,5	100
Quercus petraea 3	Sunny side	Number of samples			3	4	20	3	30
		% of samples			10,0	13,3	66,7	10,0	60,0
		% of total no. of samples			100,	33,3	62,5	100	
	Shady side	Number of samples			0	8	12		20
		% of samples				40,0	60,0		40,0
		% of total no. of samples				66,7	37,5		
	Together	Number of samples			3	12	32	3	50
		% of samples (%)			6,0	24,0	64	6,0	100

Note: For sessile oak variety S6, calculation was not possible, because of too few samples

The statistical analysis began with a calculation of mean values for the morphological characteristics, which is presented in Table 11.

On the basis of the mean values presented above, estimates for uncertainty with the T-test were made of the morphological characteristics for which such a statistical operation was reasonable. The following parameters were included in the calculation: number of fruits to a stalk, length of fruit stalk, length and width of a fruit and the height and width of the fruit cup (cupule). All other morphological characteristics of acorns were dealt with separately, in an individual way. The estimates of uncertainty with the T-test are shown in Table 12.

Table 10: Presentation of the relation between the number of leaf samples and the number of acorn samples of different species

Oak species	Leaf sample			Acorn samples			Ratio leaves: fruits	Portion fruits: leaves
	Number of trees	Number of samples	Portion of species (%)	Number of trees	Number of species (%)	Portion of species (%)		
Quercus robur	71	355	44	44	220	56	71:44	62
Quercus petraea	61	305	38	25	125	32	61:25	41
Quercus pubescens	16	80	10	10	50	12	16:10	62
Quercus cerris	12	60	8				12:0	
Total	160	800	100	79	395	100	160:79	49

Table 11: Mean values for the morphological characteristics of oak fruits

Oak species	No. of fruits to a stalk	Stalk length (mm)	Fruit			Fruit cup (cupule)			
			length (mm)	width (mm)	typical shape	height (mm)	width (mm)	hair type	scale shape
Quercus robur	2,0714	47,2286	23,2643	13,1571	2,4143	7,4286	14,3429	1,0000	1,3571
Quercus robur 1	1,8667	39,0667	21,2667	12,7833	1,7667	7,7667	14,0333	1,0000	1,5000
Quercus robur 3	2,0000	28,0000	20,2000	12,8000	1,8000	7,0000	14,4000	1,0000	1,0000
Quercus robur 5	2,4000	43,2000	24,0000	14,8000	1,0000	7,4000	16,6000	1,0000	1,0000
Quercus robur 6	1,9000	46,1000	25,7000	14,8000	2,2000	8,0000	15,4000	1,0000	1,0000
Quercus petraea	2,1333	6,7333	24,5333	13,0667	2,6000	8,7333	14,6000	1,0000	1,0000
Quercus petraea 1	2,5333	2,9067	16,5733	10,7867	1,6400	7,4533	13,0667	1,0000	1,6667
Quercus petraea 3	2,0667	2,6667	19,1333	10,8000	2,2000	7,1000	12,6000	1,0000	1,6667
Quercus petraea 6	1,6000	5,6000	16,6000	12,6000	1,0000	9,0000	15,2000	1,0000	1,0000
Quercus pubescens	1,5600	1,3600	20,0600	11,1400	2,4000	8,4600	13,0800	2,0000	3,9000
Average (all spec.)	2,0582	25,9949	20,9671	12,2633	2,1089	7,6684	13,8380	1,1266	1,7468

Note: No fruit samples were available for pedunculate oak varieties R2 and R4 and for turkey oak

Table 12: Calculation of uncertainty by the T- test

		P	R	R1	R3	R5	R6	S	S1	S3	S6
P	STPL		,000	,058	,262	,024	,225	,029	,000	,007	,912
	PED		,000	,000	,005	,000	,000	,001	,001	,082	,000
	PMD		,000	,220	,929	,018	,017	,010	,000	,305	,034
	PMS		,000	,000	,008	,000	,000	,000	,215	,433	,026
	CMV		,000	,079	,085	,207	,473	,592	,001	,000	,519
	CMS		,000	,022	,051	,000	,000	,021	,965	,139	,003
R	STPL			,111	,849	,371	,521	,788	,001	,977	,200
	PED			,001	,049	,100	,873	,000	,000	,000	,000
	PMD			,039	,262	,788	,221	,439	,000	,001	,016
	PMS			,282	,731	,000	,030	,883	,000	,000	,594
	CMV			,293	,580	,971	,314	,005	,917	,179	,044
	CMS			,448	,955	,000	,146	,673	,000	,000	,400
R1	STPL				,751	,185	,911	,322	,000	,293	,506
	PED				,067	,081	,356	,000	,000	,000	,000
	PMD				,424	,365	,050	,082	,000	,077	,123
	PMS				,986	,000	,006	,628	,000	,000	,851
	CMV				,446	,715	,754	,037	,354	,056	,222
	CMS				,773	,000	,137	,467	,026	,002	,363
R3	STPL					,524	,857	,825	,287	,872	,524
	PED					,030	,114	,009	,006	,005	,009
	PMD					,085	,074	,116	,083	,616	,075
	PMS					,002	,059	,732	,019	,048	,829
	CMV					,524	,305	,016	,523	,846	,013
	CMS					,016	,263	,853	,153	,012	,467
R5	STPL						,268	,621	,784	,371	,050
	PED						,697	,000	,000	,000	,000
	PMD						,578	,847	,001	,031	,010
	PMS						,00	,002	,000	,000	,052
	CMV						,529	,054	,940	,556	,029
	CMS						,128	,005	,000	,000	,158
R6	STPL							,586	,077	,575	,500
	PED							,000	,000	,000	,000
	PMD							,627	,000	,001	,008
	PMS							,027	,000	,000	,063
	CMV							,273	,313	,190	,305
	CMS							,332	,001	,000	,828

		P	R	R1	R3	R5	R6	S	S1	S3	S6
S	STPL								,193	,818	,327
	PED								,012	,004	,437
	PMD								,000	,001	,009
	PMS								,000	,001	,595
	CMV								,004	,000	,689
	CMS								,010	,004	,589
S1	STPL									,033	,058
	PED									,750	,081
	PMD									,011	,990
	PMS									,975	,038
	CMV									,185	,032
	CMS									,178	,024
S3	STPL										,213
	PED										,094
	PMD										,246
	PMS										,084
	CMV										,001
	CMS										,001

STPL number of fruits per stalk
PED length of fruit stalk
PMD length of fruit
PMS width of fruit
PZD characteristic fruit form
CMV hieght of cupule
CMS width of cupule
CTD characteristics of scoles: trichom types
COL characteristics of scoles: form of scoles

P *Quercus pubescens*
R *Quercus robur*
S *Qercus petraea*

1 stellulate trichomes on veins on upper leaf lamine side
2 stellulate trichomes on veins and lamine surface on upper leaf side
3 stellulate trichomes on veins and lamine surface on lower leaf side
4 stellulate trichomes on veins on upper leaf sides and on whole surface of lower leaf side

As expectated, the biggest differences were shown in the inter-species comparison of fruits of the studied three species of oaks. Only the fruits of pubescent oak and pedunculate oak showed significant differences in all 6 morphological characteristics, the fruits of pubescent oak, pedunculate oak variety R5 and sessile oak typical samples varied in 5 characteristics (with the exception of the fruit cup height), as

well as the fruits of pure pedunculate oak and sessile oak variety S1 and the fruits of pedunculate oak and sessile oak varieties R1 and S1. The fruits of pubescent oak differed from the fruits of all the other oak species in at least two morphological characteristics.

In addition to those already mentioned, some significant differences also existed between the fruits of pedunculate oak and sessile oak; however, these differences were more frequent in the case of their varieties than in typical species samples. The most frequently occuring were differences in the fruit stalk length, fruit length and width and fruit cup width.

Among all these comparisons, the most interesting finding was that the statistical analysis had not shown any significant differences among individuals of **pedunculate oak** and the varieties of this species. Differences were found in 3 morphological characteristics at most, but it was not possible to find any rules to their occurance.

In the case of **sessile oak** on the contrary, significant differences existed. With this species, the fruits of typical individuals varied significantly from the fruits of its most frequent varieties S1 and S3 in 5 morphological characteristics. On the other hand, among the fruits of sessile oak varieties, no such differences existed that a special rule could have been defined for their occurance.

The other morphological characteristics of acorns were treated by special calculation procedures because the mean values calculation for these parameters gave no useful results.

The first characteristic - **typical form of a fruit** - was in the phase of sample examination classified by the following standards:

1 - smooth fruit
2 - ring-striped fruit
3 - longitudinally-striped fruit

The mean value calculation for this parameter (see Table 11) only showed that two species of oaks had uniform fruit shape and that in the other specimens, the shape varied. The variation of this morphological characteristic can be seen in the following table.

Table 13: Typical fruit shape distribution among the studied species of oaks

Oak species		Typical fruit shape			
		Smooth	Ring striped	Longitudin. striped	Total
Quercus robur	Number of samples	41		99	140
	% of samples	29,3		70,7	35,4
	% of total number of samples	26,2		50,3	
Quercus robur 1	Number of samples	37		23	60
	% of samples	61,7		38,3	15,2
	% of total number of samples	24,0		11,7	
Quercus robur 3	Number of samples	3		2	5
	% of samples	60,0		40,0	1,3
	% of total number of samples	1,9		1,0	
Quercus robur 5	Number of samples	5			5
	% of samples	100,0			1,3
	% of total number of samples	3,2			
Quercus robur 6	Number of samples	4		6	10
	% of samples	40,0		60,0	2,5
	% of total number of samples	2,6		3,0	
Quercus petraea	Number of samples	3		12	15
	% of samples	20,0		80,0	3,8
	% of total number of samples	1,9		6,1	
Quercus petraea 1	Number of samples	44	14	17	75
	% of samples	58,7	18,7	22,7	19,0
	% of total number of samples	28,6	31,8	8,6	
Quercus petraea 3	Number of samples	6	12	12	30
	% of samples	20,0	40,0	40,0	7,6
	% of total number of samples	3,9	27,3	6,1	
Quercus petraea 6	Number of samples	5			5
	% of samples	100,0			1,3
	% of total number of samples	3,2			
Quercus pubescens	Number of samples	6	18	26	50
	% of samples	12,0	36,0	52,0	12,7
	% of total number of samples	3,9	40,9	13,2	
Together	Number of samples	154	44	197	395
	% of samples	39,0	11,1	49,9	100,0

It can be seen from the table that approximately one half of the fruits are longitudinally-striped, there are 10% fewer smooth fruits is and the remaining fruits are ring-striped.

In the case of pedunculate oak - with the exception of variety R5 - the combination of smooth and longitudinally-striped fruits is predominant, but the ratio of the two types shows no rules.

With sessile oak, all three types of fruits were found. With typical sessile oak trees, the combination is the same as in case of pedunculate oak, in varieties S1 and S3 all three fruit types were found, and the last variety S6 only had smooth fruits.

All three types of fruits are also characteristic of pubescent oak, whereby ring-striped fruits are the most numerous.

Special treatment was also required for two morphological features, termed together the **characteristics of the scales of the fruit cup**: the type of hairs on the cupule scales and the shape of the scales.

The **type of trichoms** on the cupule scales was classified in the analysis into the following two categories:

1 - scale knobs covered with short, dense hairs, the scale tips hairless,
2 - cupule throughout covered with short, dense hairs.

From Table 11 it can be seen that this morphological characteristic is decisive for distinguishing the fruits of pubescent oak from the fruits of the other two species (pedunculate oak and sessile oak), between which no significant differences of this kind exist.

The second feature - **the shape of the cupule scales** - was classified into 4 categories with the following characteristics:[3]

- Triangular or ovate, rarely rounded, knobby at the bottom, with one or two processes, above with a triangular, clipped or rounded, overlapping, seldom protruding, flattened tip. Individual scales are evidently separate and are more or less evenly arrayed throughout the cupule (pedunculate oak, sessile oak).
- Tending to triangular, flattened, only at the bottom of the cupule considerably knobby, almost grown together, arrayed as wavy stripes or rings around the cupule. Above with triangular, more or less rounded, flattened tips, usually protruding from the cupule. The scales distinguishable and very evenly arrayed

3 Descriptions of the cupule scales correspond to the actual findings of our examination of this morphological feature and are not entirely identical to statements in the literature (see Chapter 3.1!). With pedunculate oak and sessile oak, two types of scales often appear, one of which (type 1) is not even mentioned in the literature. However, this type of scale was the most frequent in our investigation.

throughout the cupule (pedunculate oak).

- Lanceolate, wider and moderately convex at the bottom, above flattened, duck-beaked, at the top rounded or clipped, normally pressed to the cupule. They are very evenly arrayed (sessile oak).
- Lanceolate or almost lens-shaped, only slightly convex to almost flat at the bottom, pressed to the cupule and very evenly arrayed (pubescent oak).

Table 14: A review of the shape of cupule scales by the studied species of oaks

Oak species		Shape 1	Scales 2	Fruit 3	Cupule 4	Together
Quercus robur	Number of samples	90	50			140
	% of samples	64,3	35,7			35,4
	% of total number of samples	39,1	62,5			
Quercus robur 1	Number of samples	30	30			60
	% of samples	50,0	50,0			15,2
	% of total number of samples	13,0	37,5			
Quercus robur 3	Number of samples	5				5
	% of samples	100,0				1,3
	% of total number of samples	2,2				
Quercus robur 5	Number of samples	5				5
	% of samples	100,0				1,3
	% of total number of samples	2,2				
Quercus robur 6	Number of samples	10				10
	% of samples	100,0				2,5
	% of total number of samples	4,3				
Quercus petraea	Number of samples	15				15
	% of samples	100,0				3,8
	% of total number of samples	6,5				
Quercus petraea 1	Number of samples	50		25		75
	% of samples	66,7		33,3		19,0
	% of total number of samples	21,7		62,5		
Quercus petraea 3	Number of samples	20		10		30
	% of samples	66,7		33,3		7,6
	% of total number of samples	8,7		25,0		
Quercus petraea 6	Number of samples	5				5
	% of samples	100,0				1,3
	% of total number of samples	2,2				
Quercus pubescens	Number of samples			5	45	50
	% of samples			10,0	90,0	12,7
	% of total number of samples			12,5	100,0	
Together	Number of samples	230	80	40	45	395
	% of samples	58,2	20,3	10,1	11,4	100

Since the calculation of mean value for this characteristic only gives useful results for some groups of samples, additional cross tabular estimates were also made, similarly as for the shape of acorns. The results of these are presented in Table 14.

From the table it can be seen that the first type of fruit scale is the most frequent; it is only absent in the fruits of pubescent oak. For the majority of pedunculate oak samples, the combination of the first two types of scale is characteristic and for the majority of sessile oak samples, a combination of the first and the third scale type. The latter combination also appears together with the fourth scale type, which is otherwise predominant in the fruits of pubescent oak.

4 DISCUSSION

The following findings of the investigation should be emphasized:

- Two levels or spectra of morphological characteristics have significance for the identification of oak species: visible and measurable characteristics and characteristics which can only be observed and evaluated (or measured) under a certain magnification.
- Visible morphological characteristics are mainly decisive in the identification of oak species, while hybrids or morphological varieties within species were identified on the basis of hairiness of parts of the leaves.
- On the basis of the described criteria, the results of the primary phase of the investigation were verified and irregularities revealed were corrected. Afterwards, in a thorough analysis, new insights were achieved.
- The establishment that pedunculate oak and sessile oak had several morphological varieties was confirmed, while pubescent oak and turkey oak were shown to be morphologically uniform species, not affected by any external factors. No rule seemed to exist for the territorial distribution of typical species and morphological varieties of pedunculate oak and sessile oak. For this reason it was not possible to define the areas of different intensity of mutual influence of the studied oak species.
- The hypothesis that the morphological characteristics of leaves from the sunny side of a tree crown vary significantly from the characteristics of leaves from the shady side (above all the dimensions), was disproved by this investigation. Despite the unequivocal statistical results, this finding has to be judged with certain reservations, because of the way of collecting of leaf samples. As a rule, the leaves were collected at a height of approximately 5m. On the sunny side, the tree crowns are deeper and the sampling was not difficult; on the shady side, the lowest branches are sometimes more difficult to reach. In such a case, the leaf samples were taken from the shady parts of branches, but not strictly from the northern side of the crowns. Such a style of sampling could have had negative effects on the results of the investigation.
- The statistical analysis showed that as far as the morphological characteristics of leaves were concerned, pedunculate oak only had two varieties. The first was identical to the pure species and the second to the hybrid R1. The latter has shorter and narrower leaf lamina, not so many lobes and a longer petiole

than trees of the pure species. Their fruits did not differ significantly. The deviations found suggest the possibility of the influence of pubescent oak, although in a territorial sense, such a connection does not seem logical.

- In the case of leaf samples of sessile oak, no significant morphological differences were found. The examination of fruits showed that the fruits of pure species differed significantly from the fruits of the most numerous hybrids S1 and S3. The latter were shorter and narrower, they had a shorter stalk and lower and narrower cupule than the fruits of the pure species. No significant differences existed in other characteristics of the fruits of the pure species and the two hybrids of sessile oak. On the basis of these differences, it was not possible to define exactly which oak species could have induced such changes. Besides - due to the smaller number of samples - the results of fruit analysis are probably not so reliable as the results of the examination of the leaves.

5 CONCLUSION

By statistical analysis of a large number of leaf and fruit samples of four species of oaks, we wanted to find a possible relationship between the characteristic morphological features of leaves and their typical hairiness (trichomes). On the basis of the examination of samples, an internal classification of the species of pedunculate oak and sessile oak was performed. It turned out that in some cases, the relationship is very close, while in the others it is rather loose or does not exist at all. With pedunculate oak, a close relationship was found between the morphological characteristics of the leaves and the trichomes. No significant morphological differences existed among the fruits of this species. It was not possible to define any such pattern for the leaves of sessile oak, but significant morphological variety existed among the fruits of this species. In both cases, the role of morphological features is characteristically narrowed to their dimensions, in which a certain rule could be observed. With very few exceptions, the range of dimension of morphological signs is greater among individuals of the pure species than among their hybrids. Nevertheless, it should be mentioned that we did not succed in finding any general rules about the relationship or interdependence of the morphological characteristics of oak leaves and specifical hairiness of their leaf parts. The finding is only valid for the pedunculate oak and sessile oak species, to which our full attention was given during the investigation.

An unwelcome methodological slip must be mentioned, which could have affected the results of the investigation decisively. According to the instructions of the Botanical Institute from Vienna, only oak leaves sampled in the summer months of July and August, and only from the tree crowns, should be used for examination of morphological characteristics of oaks. In the instructions it was additionaly emphasized that the leaves from adventive shoots and other secondary formations were not suitable for this purpose. The samples for our investigation were collected (in agreement with Austrian colleagues) in the first half of October, some of them also from adventive branches.

It can be concluded from everything mentioned above that it is not yet possible to speak about intraspecific morphological classification of pedunculate oak and sessile oak in Slovenia, since the present investigation has not given hard-and-fast enough evidence.

In future investigations of oak taxonomy, the following topics will still have to be worked on:

- Characteristics of the stipules
- Hairyness and other characteristics of the inflorescence
- The periods of leaf formation and flowering (phenological analyses)

In executing all three goals, the season of sampling or observation plays a decisive role. Some further tasks:

- Evaluation of hairyness of one year twigs and buds, distribution and shape of lenticeles
- Analysis of bark (the form of bark)
- Evaluation of distinguishing characteristics

This investigation was only a first small step towards the study of oak in Slovenia. However, we hope that at least to a certain degree, our work with help elucidate some aspects of identification and intraspecific classification of Slovene oak species - which are, as elsewhere in Europe, already affected by the process of forest decline.

6 RESUME

The results of oak sampling in Slovenia - which was carried out as a part of the Slovene-Austrian scientific cooperation programme - are presented in *Chapter 1*.

In *Chapter 2*, the methods of work are described. Leafed twigs and acorns from 160 trees of pedunculate oak, sessile oak, pubescent oak and turkey oak were sampled at autochtonous oak sites throughout Slovenia. 800 leaf samples and 395 fruit samples were chosen for morphological observation. With leaf samples, the dimensions of leaf lamina and petiole were measured, the number of lobes to a leaf blade was counted and the type and density of hairs (trichomes) on various leaf parts was evaluated under the stereo microscope. With fruit samples, the dimensions of fruits, cupules and fruit stalks were measured, the number of fruits to a stalk was counted, the fruit shape was recorded and the type of hairs and shape of scales on the cupule was evaluated. All the data were adapted for computer analysis.

In *Chapter 3* and *Chapter 4*, the results of the investigation and an explanation of the results (discussion) are presented. As a first step, the primary results of sampling were supplemented and partly corrected. On the basis of the hairiness of different leaf parts, an intraspecific classification into trees of the pure species and hybrids was performed for pedunculate oak and sessile oak; pubescent oak and turkey oak once again proved to be pure species. The territorial distribution of "pure species" and hybrids has not shown any laws of the mutual influence of the studied species.

The statistical analysis of leaf samples showed that no morphological differences between leaves from the sunny side and leaves from the shady side of the tree crown existed among the studied four species. Pedunculate oak - according to the morphology of leaf samples - was classified into two varieties. The first corresponded to the pure species and the second to the most abundant pedunculate oak hybrid. The leaf samples of sessile oak were morphologically uniform. With fruits, the situation was the inverse; the acorns of pedunculate oak were uniform, while the fruits of sessile oak were classified into three varieties, which corresponded to the pure species and its two most frequent hybrids.

In the fifth, concluding chapter, it is mentioned that despite some positive results, it was not possible to define any general rule of relationship or interdependence between the morphological characteristics of leaf samples and their specifical hairiness pedunculate oak and sessile oak. The use of unsuitable samples could also have influenced the reliability of the results of our investigation. The samples were collected in autumn instead in summer and some samples were taken from adventive shoots, which should not have been done. The investigation has not, therefore, given reliable enough evidence for claiming an intraspecific classification of pedunculate oak and sessile oak undoubtedly exists in Slovenia. In future, many further questions will have to be answered and new explanations will have to be found to elucidate the problem of oak taxonomy in Slovenia.

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Appendix 2: Morphological characteristics of oak fruits

Series 26

Quercus robur

OAK SPECIES	SUCCES. NO. tree	sample	NO. OF FRUITS TO A STALK	FRUIT STALK length cm	FRUIT DIMENSIONS length cm	width cm	Typical shape	CUPULE DIMENSIONS heigth cm	width cm	Char. of scales hair type	shape of scales	COMMENTS, EXPLANATIONS
Quercus robur (6)	26/1	1	3	3,0	2,7	1,6	1	1,0	1,7	1	1	The prevailing type is I/II, with clearly distinguishable scales, always convex at the bottom, flattened at the cupule edge. The tips overlapping
	26/1	2	3	4,1	2,4	1,7	1	1,1	1,7	1	1	
	26/1	3	1	2,6	1,2	1,2	1	0,7	1,5	1	1	
	26/1	4	3	4,9	2,9	1,6	3	0,9	1,6	1	1	
	26/1	5	2	2,6	2,6	1,4	3	1,0	1,5	1	1	
Quercus robur (1)	26/2	1	4	4,1	2,8	1,2	1	0,7	1,3	1	2	The prevailing type is II; the scales are grown together, flattened, hardly distinguishable, arrayed ring-like around the cupule. Only at the bottom, the scales are knobby
	26/2	2	3	3,7	1,4	1,1	1	0,7	1,3	1	2	
	26/2	3	3	4,0	1,3	1,0	1	0,7	1,3	1	2	
	26/2	4	4	4,3	1,6	1,0	1	0,6	1,2	1	2	
	26/2	5	4	4,7	1,7	1,1	1	0,7	1,3	1	2	
Quercus robur	26/3	1	1	3,0	2,9	1,5	3	1,0	1,7	1	2	Type II completely prevailing; the scales are grown together, flat, arrayed ring-like and very homogeneous by apperance. The tips slightly protruding
	26/3	2	2	3,1	3,5	1,4	3	0,7	1,5	1	2	
	26/3	3	2	3,5	3,6	1,4	3	0,6	1,4	1	2	
	26/3	4	1	2,7	3,5	1,4	3	0,9	1,6	1	2	
	26/3	5	2	3,1	3,5	1,4	3	0,6	1,3	1	2	
Quercus robur (1)	26/4	1	1	5,8	1,7	1,1	3	0,4	1,1	1	1	Specific type of flat, slightly knobby scales with distinct hairless tips, triangular and separate
	26/4	2	1	2,7	1,8	0,9	1	0,4	0,9	1	1	
	26/4	3	2	1,8	1,8	1,1	1	0,4	1,2	1	1	
	26/4	4	3	2,9	2,0	1,2	1	0,4	1,1	1	1	
	26/4	5	3	4,3	1,8	1,1	1	0,4	1,1	1	1	
Quercus robur (3)	26/5	1	4	3,4	1,8	1,2	1	0,8	1,4	1	1	The type I/2 is prevailing, however also the type II is admixed, especially at the top of fruit cup. Mostly the scales are clearly distinguishable.
	26/5	2	2	3,2	2,1	1,4	1	0,6	1,6	1	1	
	26/5	3	2	3,8	2,3	1,3	3	0,8	1,5	1	1	
	26/5	4	1	1,1	2,1	1,2	1	0,7	1,2	1	1	
	26/5	5	1	2,5	1,8	1,3	3	0,6	1,5	1	1	

FRUIT TYPE: 1 - smooth
2 - ring striped
3 - longitudinally-striped

HAIRINESS 1 - on the scale knobs only
2 - throughout the fruit cup

SHAPE OF SCALES: 1 - single, knobby, ovelapping
2 - grown together, flat, protruding
3 - lanceolate, knobby, overlapping
4 - lanceolate, flat, overlapping

Sampled on: 26.02. 1991, by Smole Ivan

Successive number of a series: 26

Sampling site: SORŠKO POLJE, Godešič by Škofja Loka, along railway and the lineman's cabin

OAK SPECIES	LEAF DIMENSION		NUMBER OF LOBES		PETIOLE	LEAF HAIRINESS - ABOVE			LEAF HAIRINESS - BELLOW			COMMENTS, EXPLANATIONS
	Length cm	Width cm	Left side	Right side	length	leaf blade	veins	margin	leaf blade	veins	margin	
Quercus 26/1O	11,3	8,0	5	6	0,5				e/1			- Stellate hairs on the veins and the entire upper surface and on the veins below - the rest without comment
robur 26/1 O	9,8	7,7	6	6	0,3				e/1			
(6) 26/1 O	6,1	4,2	4	4	0,5				e/1			
26/1 O	15,1	10,1	7	7	0,8		z/1		e,z/1	e,z/1		
26/1 O	6,2	4,0	5	5	0,5		z/1		e/1			
Quercus 26/2O	10,1	6,5	5	5	0,4				e/1	e/1		- Stellate hairs on the veins of the upper surface - Simple transparent hairs on the veins bellow
robur 26/2 O	9,8	6,6	6	6	0,4		e,z/1		e/1	e/1		
(1) 26/2 O	6,0	3,8	3	4	0,4		e/1		e/1	e/1		
26/2 O	10,5	6,2	5	5	0,4		e,z/1		e/1	e/1		
26/2 O	6,0	3,1	4	4	0,4		e/1		e/1	e/1		
Quercus 26/3O	9,9	5,1	6	6	0,3		e/1		e/1			- Except for the simple hairs on the venis above without comment
robur 26/3 O	7,9	3,5	6	6	0,4				e/1			
26/3 O	5,7	3,2	6	6	0,4				e/1			
26/3 O	10,5	5,0	7	7	0,6				e/1			
26/3 O	6,2	3,4	6	6	0,3				e/1			
Quercus 26/4O	10,8	6,7	7	7	0,8		z/1		e/1			- Stellate hairs on the veins of the upper surface - Bellow without comment
robur 26/4 O	9,1	5,4	6	7	0,7				e/1			
(1) 26/4 O	6,6	3,2	4	3	0,4		z/1		e/1			
26/4 O	10,1	5,7	6	6	0,8		e/1		e/1			
26/4 O	5,7	3,0	4	4	0,5		z/1		e/1			
Quercus 26/5O	10,2	6,9	6	6	0,7		z/1		e/1	e/1		- Stellate hairs on the leaf surface and veins upper surface - Below without comment
robur 26/5 O	8,2	5,0	6	5	0,7		z/1		e/1			
(3) 26/5 O	5,7	3,8	7	6	0,3	z/1	z/1		e/1	e/1		
26/5 O	11,9	7,8	6	7	0,8		z/1		e/1	e/1		
26/5 O	6,6	3,4	4	5	0,7		z/1		e/1	e/1		

HAIRINESS: e - simple
z - stellate (composed)
g - bushy hairs

DENSITY: 1 - single hairs
2 - slight density
3 - medium density
4 - great density

O - samples from sunny side of tree crown
O - samples from shady side of tree crown

Sampled on 11. 1. 1991, by Smole Ivan

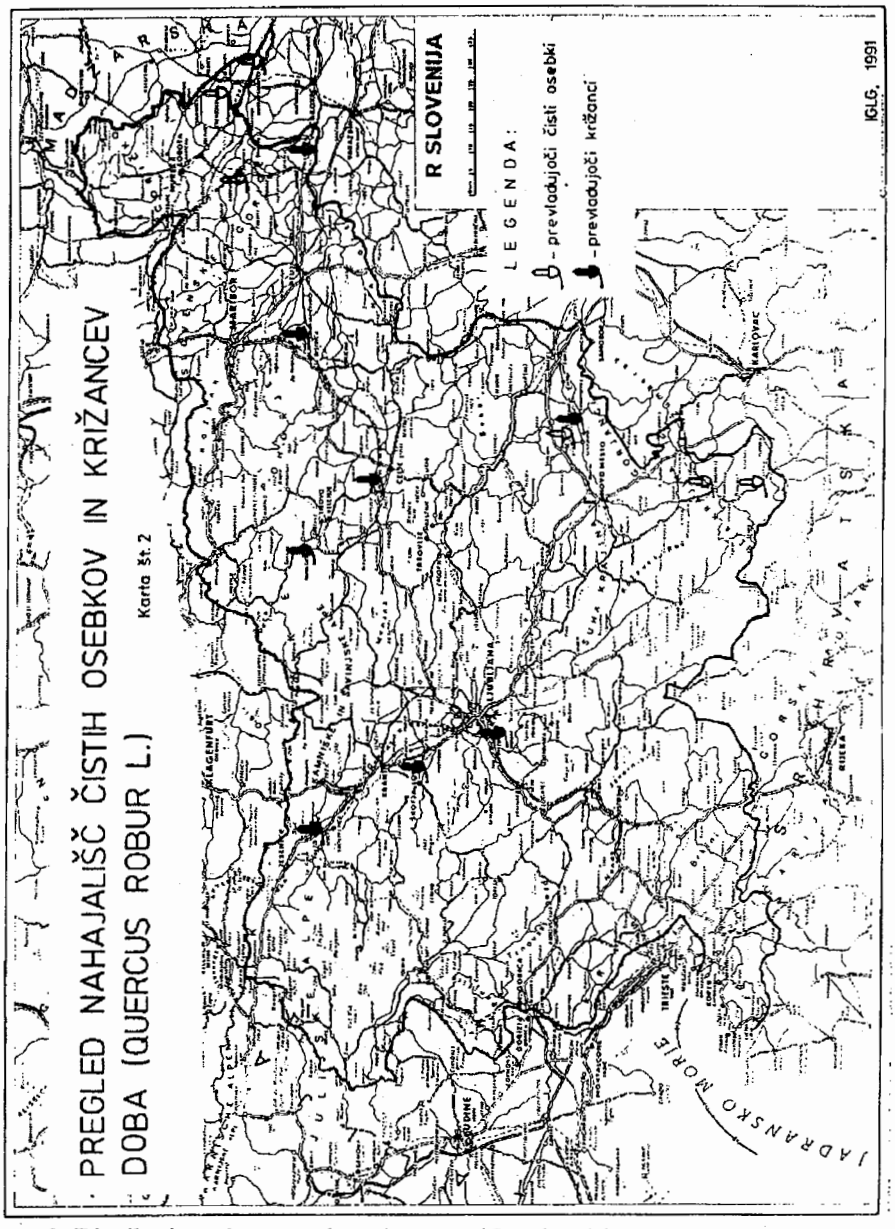

Figure 2: Distribution of pure pedunculate oak (*Q. robur L.*) samples (open acorns), and it's hibrids (closed acorns)

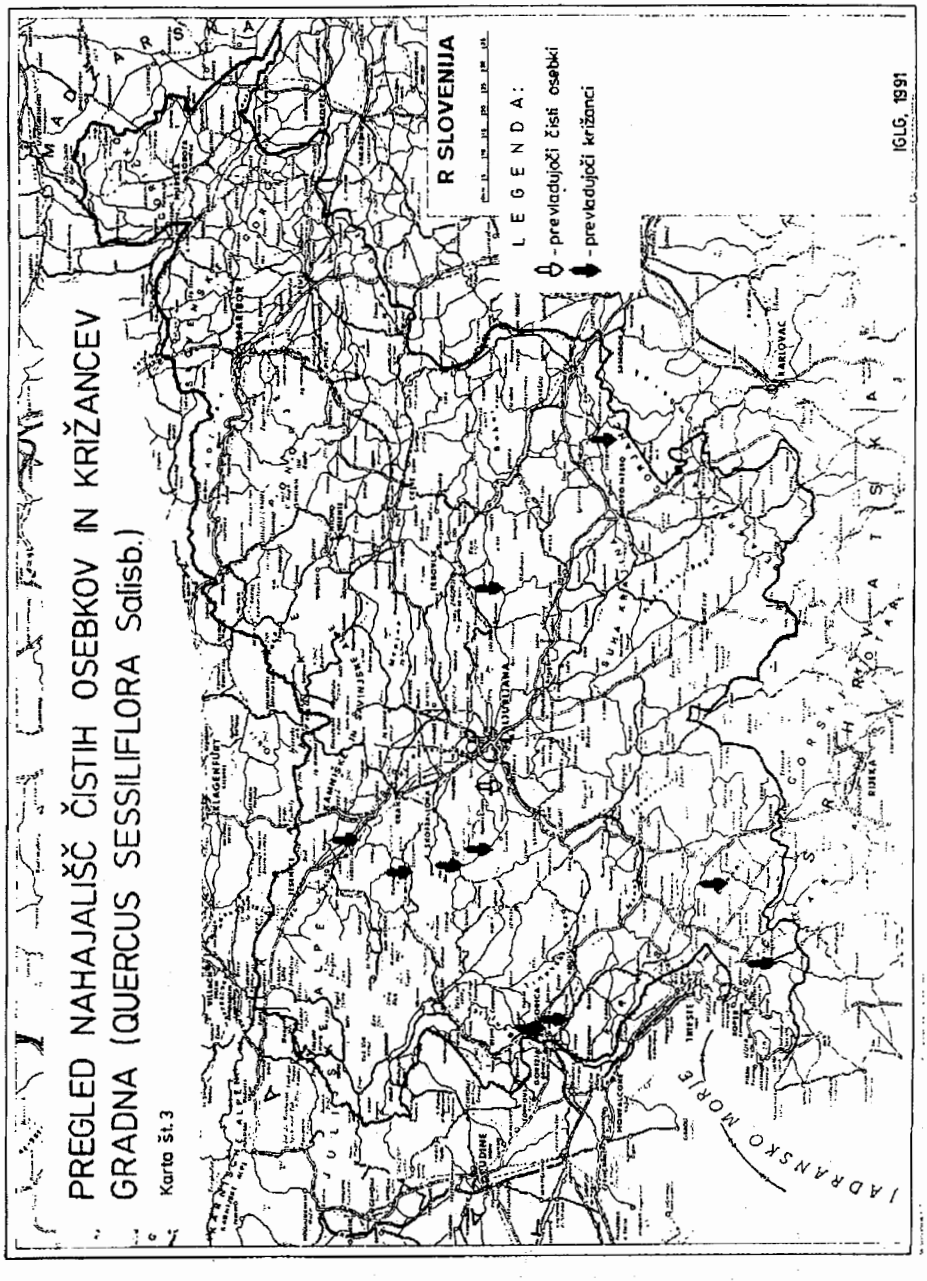

Figure 3: Distribution of pure sesile oak (*Q. petraea* (Mattuschka) Leibl) samples (open acorns), and it's hibrids (closed acorns)