Figure 73. From a collection of the Croatian Natural History Museum
(photo by M. Šašić)

1.3. Species and subspecies

DIVERSITY OF SPECIES AND SUBSPECIES

The previous chapter demonstrated a great diversity of ecological systems and habitats in Croatia, resulting in a great diversity of plant, fungi and animal species and subspecies. **The value of this diversity in European proportions** is clearly evident if we, among others, compare the relation between the number of species within the groups known and the surface area of Croatia with the same data for other countries. The wealth of Croatia in endemic taxa, as well as in numerous rare and threatened remnants from the tertiary or the Ice Age (tertiary and glacial relicts), is also very noticeable.

In the course of preparation of the NSAP the existing data on species and subspecies recorded in Croatia were integrated and analysed. **For the first time collective figures were related to corresponding data for Europe and the world** (Fig. 74, Tab. 1). This procedure pointed to unexplored or insufficiently explored groups and habitat types of priority importance that every further scientific work should focus on (for example, groups with a great number of endemic or threatened taxa, groups of economic significance and others).

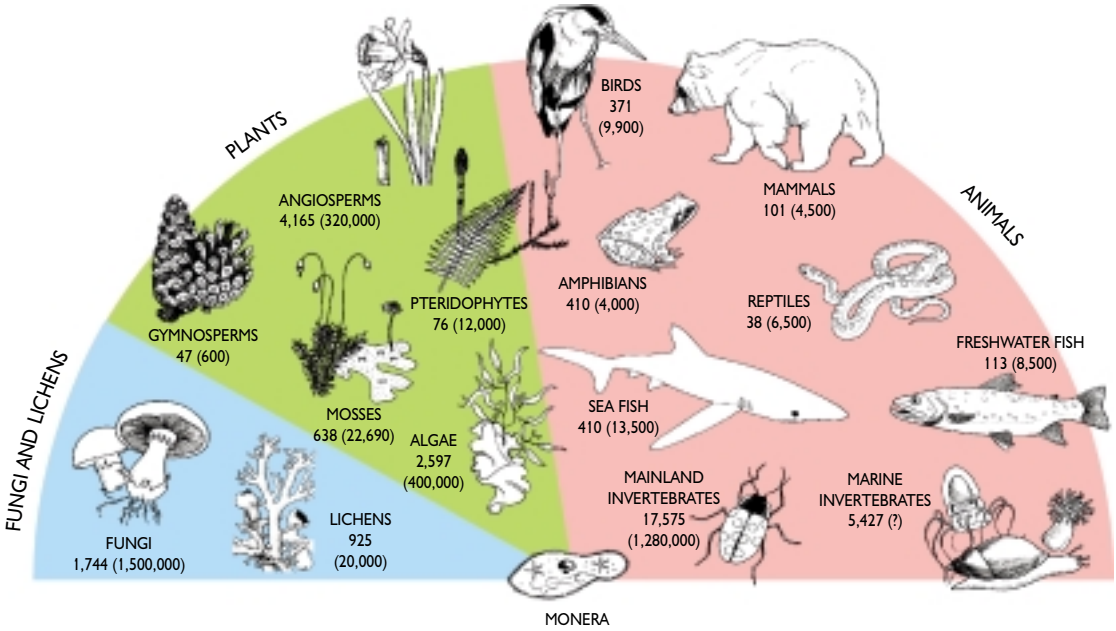


Figure 74. Number of species in Croatia in comparison with the total number of described species in the world (figures in brackets) by major groups
(drawings by T. Nikolić)

As a prerequisite for an efficient protection of biological diversity a great number of data have been collected, although not in full:

- inventory of species and subspecies in Croatia by individual explored groups
- inventory of nationally threatened species and subspecies by groups (red lists), specifying the area of spreading and threats to individual taxa
- inventory of species and subspecies threatened on European and on a global scale
- inventory of endemic species and subspecies including the identification of their level of endemism, and
- numerical relations and analysis of the above mentioned inventories.

It is true that more detailed data were available only for some plant groups (pteridophytes and spermatophytes) and, considering fauna, for some vertebrates. These groups make a comparatively low percentage of Croatia's flora, micoflora and fauna. However, despite insufficient data, considering the absolute number of species or rather the wealth of almost all organism groups Croatia belongs to the upper one third of countries of the wider European region (Tab. 2). According to a more objective indicator, taking into account the size of the territory too, i.e. the number of species by the unit of surface area, Croatia ranks third (vascular flora) or rather fourth (vertebrates) in Europe by its wealth.

	Croatia		World	
Group	Known	Assumed	Known	Assumed
Plants	7,522	8,708	270,000	500,000*
Fungi	1,744	25,000*	75,000–80,000	2,700,000*
Lichens	925	1,069	18,000	20,000
Animals	24,087	56,000	1,770,000	103,255.000*
Others *(viruses, bacteria)*	?	?	8,000	4,000,000
Total	**~34,000**	**~91,000**	**~2,150,000**	**~111,000,000**

*Table 1. Known and assumed number of species of major groups of living organisms in Croatia and world (*upper assumed no.)*

Country	Surface area (km²)	No.of vert. sp.*	No.of vert. species / km²	Ord. no.	No.of higher plant sp.	No.of higher plant sp./ km²	Ord. no.
Albania	28,748	372	0,013	1	3965	0,138	2
Austria	83,858	417	0,005	6	2873	0,034	6
Croatia	56,610	481	0,008	4	4275	0,075	3
Czech R.	78,864	384	0,005	6	2500	0,031	7
France	543,965	499	0,0009	10	4630	0,008	13
Germany	356,974	451	0,001	9	3203	0,009	12
Holland	40,844	299	0,007	5	1221	0,030	8
Hungary	93,032	388	0,004	7	2214	0,023	9
Italy	301,268	474	0,001	9	5820	0,020	10
Poland	323,250	402	0,001	9	2300	0,007	14
Romania	237,500	460	0,002	8	3350	0,014	11
Slovakia	49,036	536	0,010	2	2500	0,050	4
Slovenia	20,251	407	0,020	3	3216	0,160	1
U. K.	244,100	318	0,001	9	1623	0,006	15
Yugoslavia	102,173	511	0,005	6	4282	0,042	5

Table 3. Number of species of vertebrates and higher plants in individual countries in relation to their surface area (without sea fish)*

Group / Country	Mammals	Breeding birds	Reptiles	Amphibians	Freshwater fish	Invertebrates (estimate)	Vascular plants
Albania	68	215	31	13	45	–	3965
Austria	83	227	14	20	73	30000	2873
Belarus	70	208	7	13	58	10000	1720
Belgium	58	176	8	17	44	42000	1415
Croatia	86(7)	226(13)	36(5)	20(7)	113(2)	55000(3)	4275(7)
Cyprus	21	80	23	4	–	–	1682
Czech R.	87	199	13	20	65	27000	2500
Estonia	65	210	5	11	71	17600	1448
Finland	60	230	5	5	60	18499	1102
France	93	267	32	32	75	67500	4630
Germany	76	273	12	20	70	40000	3203
Greece	95	244	51	15	106	–	4992
Holland	55	187	7	16	34	27700	1221
Hungary	72	203	15	17	81	41460	2214
Island	11	80	0	0	5	1245	483
Ireland	25	141	1	3	26	–	950
Italy	97	245	44	32	56	57300	5820
Latvia	60	215	7	11	76	–	1658
Liechtenstein	51	123	7	10	–	–	1410
Lithuania	65	203	8	12	76	–	1609
Luxembourg	55	130	7	14	38	30000	1246
Malta	22	28	8	1	–	–	914
Norway	57	243	5	5	41	22000	1310
Poland	85	224	9	18	66	28384	2300
Portugal	63	214	29	17	28	–	3150
Romania	84	249	25	19	83	–	3350
Slovakia	85	209	20	21	58	2500	
Slovenia	74	196	22	21	94	3216	
Spain	82	275	53	25	68	25000	5048
Sweden	60	249	6	13	45	23400	1900
Switzerland	75	201	14	18	53	45400	2696
Turkey	116	284	102	18	175	–	8579
U. K.	50	219	8	7	34	30000	1623
Yugoslavia	96	260	33	21	101	31300	4282

Table 2. Overview of biological diversity in individual European countries illustrated by the number of species. The figure in brackets shows the rank of Croatia in Europe by the number of species in a group

ENDEMICS

A very high number of endemics and tertiary relicts remained in the area of Croatia owing to the fact, among others, that during the tertiary they were not affected by icing. **The major endemic junctions for flora are the mountains Velebit and Biokovo.**

The endemics of Croatia's fauna are predominantly connected with the underground habitats and with Adriatic, particularly more distant islands of the open sea. The fauna of the karst underground is very poorly explored, so that in the forthcoming years numerous discoveries of new species and subspecies may be expected. **Some groups of invertebrates particularly rich in endemics** are snails, beetles, pseudoscorpions, crustaceans and land and water slaters. The underground leech discovered recently in the Luke's pit on Velebit, that will in all likelihood become a separate genus, is one of Croatia's peculiarities on a global scale, in which this karst region is abounding.

Among the **vertebrates** the Adriatic catchment area is **rich in endemic fish** and lizards, including the world-wide famous endemic amphibian olm (Box 53, p. 54). The ichthyofauna of Croatia's Adriatic rivers is generally considered one of the most important in Europe. By the number of freshwater fish taxa Croatia ranks second in Europe, after the much larger Turkey. Among 64 freshwater

Figure 75. Sibiraea altaiensis ssp. croatica, endemic taxon of northern and central Velebit
(photo by T. Nikolić)

Table 4. Total number of endemic taxa (species and subspecies) in Croatia by major groups

Group	Endemic (narrower and broader)
Plants (algae, mosses, spermatophytes)	439
Fungi	?
Lichens	82
Vertebrates	108
Invertebrates	730
Total	**1.359**

Figure 76. Adriatic salmon, Salmothymus obtusirostris ssp. krkensis, a rare and one of the most threatened salmonoid fish of Croatia
(photo by M. Mrakovčić)

fish species found in the Adriatic catchment area 33 are endemics of which 11 are widely distributed exclusively in Croatia. As many as six of these Croatian endemics belong to the genus *Paraphoxinus* – tertiary relicts of sink- rivers of the Adriatic catchment area. Out of 36 reptile species in Croatia five are endemic species of lizards. One of them – the Dalmatian wall lizard, including the more widely distributed Halian wall lizard are represented by a number of endemic subspecies on individual Adriatic islands (Tab. 4).

THREATENED TAXA

The threats to flora, micoflora and fauna, including ecological systems in Croatia, are only partly known. The red lists – inventories of species that are threatened or rare in Croatia – existed earlier only for higher plants and mammals, but the need for their revision is already felt. By making inventories of taxa within the NSAP, some still unpublished red lists for some new groups, primarily vertebrates, came into being.

As to threatened types of habitats, too little is still known about the majority of them to be able to estimate their status of threat. The major job on preparation of red lists of the flora, micoflora, fauna and habitats is just about to follow, but it is aggravated by the lack of finance allocated to the protection of nature, by an insufficient number of experts, scientists and trained amateurs who would be involved in data gathering.

THREATS

Devastation of habitats is certainly the main threat to the majority of plant, fungi and animal taxa. Various human activities bring about the transformation of one habitat into another or the changes of ecological conditions within a certain habitat. Today not a single part of Europe, including Croatia too, is completely free from human influence. Therefore expressions such as "natural ecological system", "untouched nature" or "virgin forest" bear little practical meaning.

Fragmentation of natural habitats is adversely affecting the taxa as well. It is a result of the construction of roads, settlements and utility infrastructure and of the extension of intensively managed agricultural land. Here natural and subnatural ecological system remain isolated like islands on which species cannot communicate any more with other related areas and consequently die out locally, thus contributing to a rapid reduction of biological diversity.

Intensive agriculture, forestry and mariculture result regularly in long lasting changes in the natural composition of species and impoverishment of biological diversity. The areas of monoculture are most affected. The wide use of pesticides causes the accumulation of these toxins whose effect is usually not evident immediately, but only after they have reached the critical concentration that affects in the first line vulnerable species. The massive and uncontrolled use of fertilizers is also affecting aquatic ecological system, causing eutrophication that changes completely the dynamic and natural composition of populations.

Excessive exploitation is threatening certain economically important species, for example hunting, fishing, gathering medicinal herbs, fungi, snails and frogs for commercial purposes, trading with animal pets, etc.

Introduction of allochthonous species that have formerly not lived in the area of Croatia is another human activity threatening the biological diversity. Introductions have almost regularly harmful effects on indigenous species and subspecies – in this country the phenomenon is particularly threatening the freshwater fish. A frequent consequence of introduction is also a total disturbance of ecological balance in certain ecosystems. There are many such negative examples from the past (for example, the introduction of Canadian-pondweed, locust, amorpha, etc.). The most recent case is the spreading of an extraordinary aggressive species of alga caulerpa in the Adriatic.

Pollution of water, air and soil is affecting the ecological systems by restricting or reducing the populations, particularly those of species vulnerable to a certain source of pollution.

Global climate changes will be increasingly noticeable in the period that follows, with the global warming of the

Figure 77. Thermal power plant Plomin in Istria
(photo by T. Nikolić)

atmosphere that will certainly play an important role in reduction of the diversity. The changes in microecological and macroecological systems are likely to eliminate competitively many more vulnerable taxa. The area of Croatia is an active participant in these processes, either as an area that contributes to the warming of the atmosphere, or as an area that is sharing the common destiny with other parts of the world.

Figure 78. White-tailed eagle, an threatened species whose survival in Croatia depends on the method of managing forests where it is nesting and carp ponds where it feeds
(photo by G. Robbrecht, the MEPPP archive)

PLANTS

Diversity of plant life

According to the present data, the greatest wealth of species may be found in higher flora that includes pteridophytes and spermatophytes with 4,288 species, followed by algae with 2,597 and mosses with 638 species known. The recorded subspecies of higher plants number 1,072, giving a total of 5,360 taxa (species and subspecies) of which 280 are endemic (Tables 5 and 6).

	Croatia			World
Group	known	assumed	level of knowledge (%)	assumed
Algae	2,597	3,717	69.87	400,000
Mosses	638	700	91.14	22,690
Pteridophytes	76	76	100.00	12,000
Gymnosperms	47	47	100.00	600
Angiosperms	4,165	4,170	99.80	320,000
Fungi	1,744	25,000[1]	~7	1,500,000
Lichens	925	1,069	86.52	20,000
Total	**10,192**	**34,777**	**29.3**	**2,280,000**

Table 5. Collective data on the diversity of flora and micoflora ([1] upper assumed limit for the entire fungi world)

The Croatian flora and micoflora are estimated to number in total some 34,800 species, of which so far 10,112 have been registered. For some groups (for example, certain systematic groups of fungi or certain ecological and morphological groups such as microphytobentos) it is impossible to identify even the approximate number. The number of known and assumed species is presumably by far greater (about 50,000?).

According to the data collected it may be concluded that in Croatia some 29% of plant and fungi species are known, while as much as 71% are still not discovered, or rather their presence has not been acknowledged yet (Graphs 4 and 5).

As regards algae living in mainland waters, the spring areas of many flowing waters and numerous rivers are poorly explored (e.g. rivers Mura, Rječina, Korana, Kupa, Neretva, Zrmanja). Data on algae found in artificial storage lakes and fishponds are also extremely deficient. For some ecological groups of algae there are no data available, e.g. for algae found in thermal waters, aerophyllous and land algae, including algae inhabiting caves.

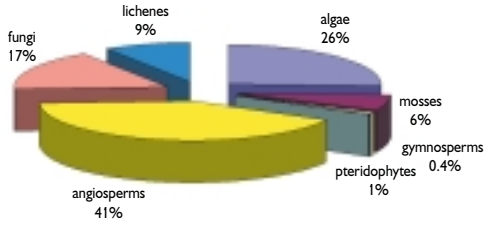
The marine phytoplankton has been explored unevenly, considering both the area and taxonomic groups. From the aspect of geography central and southern Adriatic are poorly explored, with the taxonomic system of nannoplankton being almost completely unknown in Croatia's territorial waters. Information related to benthos algae is particularly deficient when speaking of microphytobenthos that includes diatoms (class *Bacillarophyceae)* and blue-green benthos algae (*Cyanophyta*). Nobody has, namely, dealt with these groups so far.

The group of mosses is slightly more explored (despite a considerable age of data), with a substantial portion of research dedicated to representatives of higher flora where within pteridophytes and gymnosperms no changes are expected, neither will the discovery of new species of angiosperms modify significantly the overall picture.

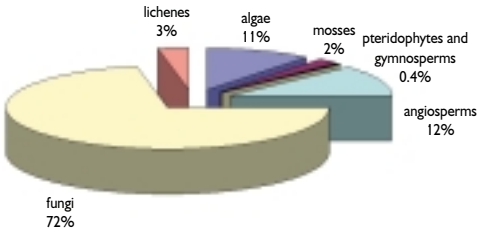
Although at the first glance it seems that mosses are well explored (some 90% of potential species are known), the actual state is most likely different. Namely, in the area of central Europe there are 800 known species, without the briologically particularly interesting Mediterranean part, which is a significant component of the national territory. At the same time, there has been no active briologist in Croatia for several decades.

Similar applies to lichens too. In terms of geography the Mediterranean area is, namely, poorly explored, and as to ecological groups the data on epiphytic lichens are defective. The last more comprehensive data are more than 40 years old.

Croatia's higher flora is undoubtedly the best examined component. In some groups (pteridophytes and gymnosperms) no substantial changes in their number are expected and, taken as a whole, neither will the changes in data affect vitally the overall picture of the diversity of Croatia's flora. On the other hand, the extreme importance of this group will very likely continue to keep it in the centre of interest.



Graph 4. *The total number of known species of individual plant and fungi groups in Croatia in relation to the entire number of species*



Graph 5. *The assumed number of species of individual plant and fungi groups in Croatia in relation to the entire assumed number of species*

With the exception of a small number of partial, but updated inventories (e.g. of individual alga and higher flora groups) the inventorying of Croatia's flora is yet to face temptations in terms of incorporation and systematization of the existing data, the collection of those new and their publication.

Endemics

Croatia is extremely rich in endemic flora. In comparison with some neighbouring countries (e.g. Slovenia with 0.7% of endemic taxa in narrower terms and considering all floristic groups) Croatia with its 5.8% of endemic species represents the **regional centre of endemism**. This situation is the result of specific historical, geomorphological and climatic conditions (Tab. 6).

The relatively great wealth of endemic taxa in Croatia is assumed to be even greater in reality.

Group	Endemics	Species total	%
Algae	152	2,597	5.85
Mosses	7	638	1.72
Pteridophytes	2	76	2.63
Gymnosperms	1	47	2.13
Angiosperms	277	4,165	6.65
Total	**439**	**7,523**	**5.830**

Table 6. *Number of endemic taxa in individual plant groups in Croatia*

Threats and threatened taxa

The direct use of flora for the purposes of human existence affects various groups to various extents. Certain groups of flora are in general not used (e.g. phytoplankton). Some groups are in general exploited, e.g. algae as cattle and human feed, lichens for flour, perfumes and paints manufacture, but in Croatia there is no such practice (low biomass, lack of tradition). A considerable portion of representatives of flora has, nevertheless, a significant use-related and economic value.

Higher plants are used for food, fuel, traditional medicine, grazing and others. The cutting down of woody species leads to the loss of diversity in the higher and middle belt of forest vegetation, although young forests springing up on newly cleared grounds may at the first stages of succession show even a greater diversity than climax forms. The effect is in fact secondary for a number of other organisms and caused by changes in competitive relations, by disturbing the food chain in the animal life, by changes in physical and microclimatic structure, etc. The removal of died trees for the purpose of firewood results mostly in disappearing of a smaller number of highly specialized species. The direct impact of intensive grazing on the composition of plant communities and the adverse effect on the diversity of grassland species have been documented in a number of times, with several dramatic instances present in the very Croatia.

Intensive farming activities have three types of impacts on the diversity of flora: (1) impact on natural ecological systems and related species in the sites where these activities are performed; (2) impact on genetic variability of cultivated taxa and global genetic erosion and (3) impact through chemical pollution caused by use of herbicides and insecticides. All of them are well documented, with their consequences varying from the reduction of numbers within populations and the reduction of the number of populations to the complete disappearance of taxa.

The development and the expanding mariculture, agriculture and forestry have, beside their direct and evident impact on the diversity, another, secondary component too, often not evident immediately, but only indirectly. So, for example, accumulation of pesticides causes changes after reaching critical concentrations, affecting first of all vulnerable species; intensive forestry in the littoral produces erosion and changes the composition of seawater in the maritime zone; increased deposition of suspended particles prevents the development of phytoplankton that has also some bottom-dwelling forms of spores in his development cycle, etc.

The anthropogenic impact on Croatia's aquatic ecological systems, including, among others, the flora of aquatic biotopes too, is to the most part connected with the encouragement of eutrophication. The massive and uncontrolled use of fertilizers has fully changed the dynamics of alga populations in inland waters and their natural composition. Nutritious salts in the sea accelerate the development of phytoplanktons, thus causing a higher accumulation of the phytoplankton mass ("sea blossoming"). The diversity of phytoplankton decreases and trophic relations in pelagial change considerably. Similar phenomena may be observed in case of phytobentos and members of the shallow-water flora (nutritious salts in tributaries, mariculture).

Box 41. Velebit degenia (*Degenia velebitica*)

- Order: *Capparales*
- Family: *Brassicaceae*
- Croatian vernacular name: velebitska degenija
- IUCN: endangered (E)
- Protection in Croatia: protected at all natural sites pursuant to the 1964 Nature Protection Act

Croatia's flora is characterized by a special endemic flowering plants genus *Degenia*, the only species, well-known Velebit degenia. This species belongs to one of the most significant among both the Velebit and the European flora too. The plant was discovered in 1907 by the Hungarian botanist Arpad Degen while exploring the region round Šugarska duliba at the screes of Miljkovića Kruga. Recognizing this as an unusual plant he first of all believed to have found a new species of alyssum (genus *Alyssum*) or new memember

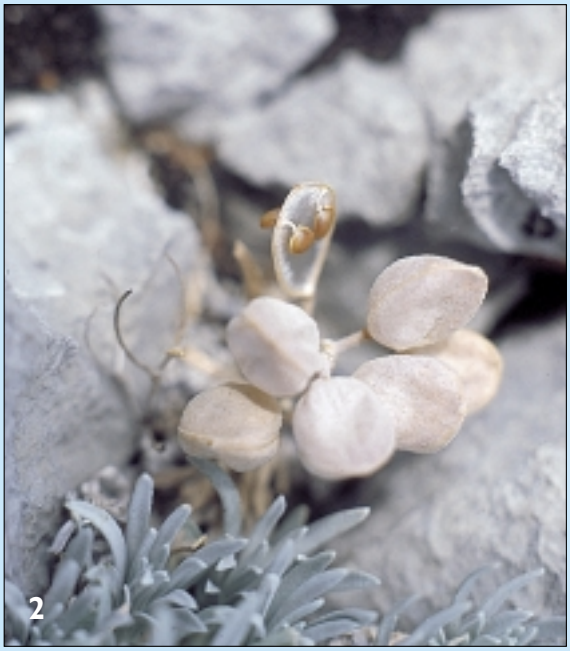
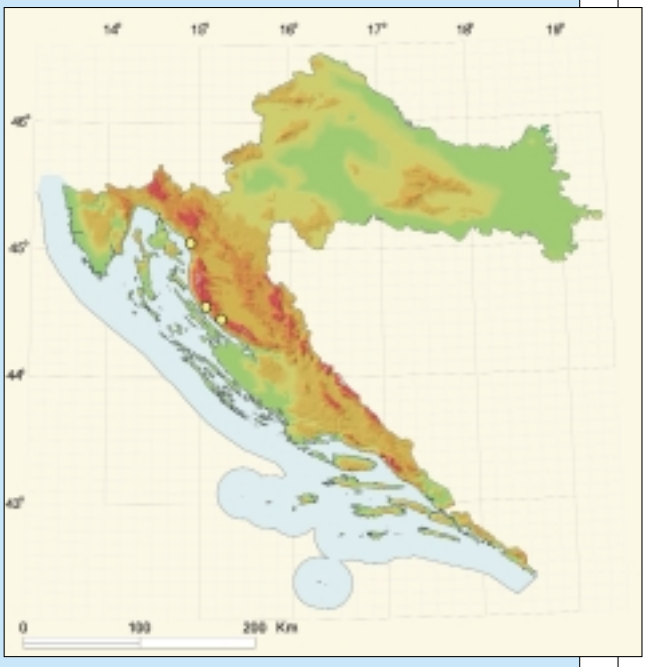


Figure 79. Velebit degenia (1) in blossom and (2) with fruits.
(1) (photo by N. Vadić)
(2) (photo by D. Mihelj)

of genus *Vesicaria*). Since the subsequent comparison showed no close relative of the plant discovered over the entire Euro-Asian continent he concluded that the newly discovered plant belonged to the endemic North-American genus *Lesquerella*. Degen officially made his finding known to the public in 1909 as the first finding of the species *Lesquerella velebitica.* However, the Austrian botanist Hayek, one of the experts in Balkan's flora as a whole, concluded that it was a genus until then unknown in the Euro-Asian flora and in honour if its discoverer named it *Degenia* in 1910. Thus this plant was finally named *Degenia velebitica*. Degenia is presently a threatened and legally protected plant, and to symbolize the peculiarity of Croatia's flora it became a motif for the coin of 50 lipas and a commemorative stamp.

In terms of morphology degenia is a typical representative of the family *Brassicaceae*. At the time of blossoming it is characterized by bright yellow blossoms of tetramerous structure, i.e. blossoms consisting of four petals and four calyces. At the time of fruit bearing it develops a pod inflated into a small ball characteristic for the family. It is reproduced by means of seeds. It appears in rocky habitats of Velebit, movable limestone screes exposed to fierce wind, within the community of *Bunio-Iberetum velebiticae* Horv. It has been recorded in only several sites (Šugarska duliba, Bačića kosa) on Velebit and recently also at lower heights above sea level (above Sibinje). Populations are not numerous and are suspected to have decreased since the species was described. Screes are becoming less movable, because colonization of other species increases the plant cover and calms down the ground. This is partly caused by the absence of grazing, particularly in recent times. One of the causes of the population decrease is the presence of people gathering rare and decorative plants, since plants in the culture have a short lifetime and in order to survive need to be renewed by new specimen.

T. Nikolić



Map 12. Distribution of Velebit degenia
(according to data from the CROFlora database)

Similar phenomena have been documented in numerous mainland habitats. In the vicinity of farms in and round which the concentration of organic wastes and fertilizers has increased the diversity of lichens has decreased. The trees in the vicinity carry only the green algae as epiphytes, while lichens stay away. Evaporations containing ammonia burden the habitats excessively with nitrogen, thus affecting directly the lichen vegetation and acidity of the base. Intensive forestry and removal of trees cut down naturally and artificially removes at the same time habitats for epiphytic lichen flora.

Figure 80. *Fibiqia triquetra, a rare species and an Illirian-Adriatic endemic*
(photo by T. Nikolić)

Adverse effects of introducing foreign taxa have been recorded in Croatia. The introduction of foreign plant species disrupts the intrapopulation and interpopulation relations of indigenous flora, ecological conditions in plant communities and a number of abiotic factors that are reflected in fauna too. There are numerous negative examples of this type from the past (e.g. Canadian water weed, locust, amorpha). An extreme case is just taking place in the national territorial waters due to the appearance of a foreign, highly aggressive phytobentos alga caulerpa as a result of anthropogenic activities.

The diversity of flora is, of course, affected by soil, water and air pollution too. Accumulation of pesticides, herbicides, rodenticides and heavy metals in the ground, salinization and changes in acidity modify the ecology of soils, inland waters and marine ecological systems, in most cases for a longer period of time. Microflora and macroflora are excluded from cycles of substances and energy circulation, which has a comprehensive impact on ecological systems. The impact of heavy metals and acidification has enormous and measurable consequences on, for example, forest vegetation, water plants, lichens, etc.

Air pollution is to the most part a consequence of fossil fuel combustion, emissions from industrial plants, transport, etc. The main pollutants are CO_2, SO_2, O_3, nitrogen oxides NO_X, ammonia, heavy metals and some organic compounds. The increase of the CO_2 concentration causes the so-called "greenhouse effect", i.e. the excessive atmosphere warming. Although some plants may benefit from this phenomenon, its negative impact on the insect-plant relation has highly negative consequences on a global scale. Lichen communities are particularly vulnerable (bioindicators) to atmospheric pollution that degrade the vulnerable symbiontic alga-fungi relation (e.g. the sensitive species *Lobaria lulmonaria* is disappearing almost all over Europe). Ectomycorrhizal fungi develop even before the higher plant into whose physiological processes they are included accelerating the process of dying. Dissolution of individual pollutants results in aggressive acids which again indirectly affect the systems of soils and waters or in activation of toxic elements (e.g. aluminium). By entering the food chain these phenomena affect all or almost all plants, as well as animals and humans.

In Croatia 520 taxa have the status of being threatened, which makes some 10.5% of the total number, recorded. This percentage of taxa considered threatened is by 2 – 3 times below the amount in some neighbouring countries (Tab. 7.).

Group	Species known	Threatened species and subspecies	Threatened species in% of total number
Mosses	638	38	5.78
Pteridophytes	76	14	16.27
Gymnosperms	47	4	8.51
Angiosperms	4,165	459[1] (274[2])	8,8[1] (6.6[2])
Total	**4,926**	**520**	**10.55**

Table 7. *Share of threatened taxa (species and subspecies) of mosses and higher plants according to the IUCN categorization in the total number of species*
([1] according to the Checklist of Croatia's Flora, 1994–2000, [2]according to the 1994 Red List)

Economically significant taxa

Apart from the taxa used in agriculture and forestry, certain species or groups are gathered for food or because of their curative features. The gathering for personal needs is not limited, but gathering for commercial purposes is controlled by the system of special permits issued by the Ministry of

Figure 81. *Lavender, a species recently again updated in culture*
(photo by T. Nikolić)

Environmental Protection and Physical Planning and by determining the volumes that may be gathered from the nature. The gathering of medical herbs has particularly developed (sage, yarrow, common elder bourtree, rosemary, meadow saffron seeds, willow bark, alder buckthorn), including berries (common juniper, blue berry, hawthorn) and sweet chestnuts (Fig. 81). Threatened are also numerous species of attractive appearance used in floriculture or sold in the markets, particularly spring flowers such as snowdrops, primroses, spring-snowflakes, hellebores. Some protected decorative species such as butcher's broom, english holly, fritillary or medicinal yellow gentian are often illegally sold.

Legal protection

At the moment there are only 44 plant species protected, predominantly those that are either highly reduced in number or threatened by gathering for their decorative appearance or healing properties. In making the inventory of Croatia's flora and the level of threat to individual taxa at least 92 taxa of higher plants (with the Ex? or E status of threat) were found to deserve legal protection. Certain economically significant taxa gathered to a higher extent need to be protected by special protection measures.

FUNGI AND LICHENS

Diversity of fungi and lichens

While fungi represent a special kingdom, lichens are in fact an ecological rather than taxonomic group. A species of lichens consists of two or more types of fungi and algae, each of them already classified within the kingdom of fungi, or rather plants. In this overview lichens are mentioned together with fungi.

Fungi are by far the least explored group in Croatia. According to the existing data 1,744 fungi species have been recorded in Croatia. It is assumed that macromycetes (fungi with fruiting bodies visible by the naked eye) number about 4,500. Only the classes of *Discomycetes, Pyrenomycetes* (part) and *Gasteromycetes*, and orders of *Aphyllophorales* (a considerable portion) and *Agaricales* of the class *Hymenomycetes* are better explored. The groups mentioned make the majority of macromycetes. It is assumed that in Croatia a total of about 15,000–25,000 fungi species is living, which means that by the number of species they surpass the plant kingdom (Tab. 8).

There are 925 **lichen** species registered in Croatia, of which 82 are **endemic. So far not a single endemic fungi taxon has been described.**

Box 42. Fungus *Hygrocybe calyptriformis*, a rare European species

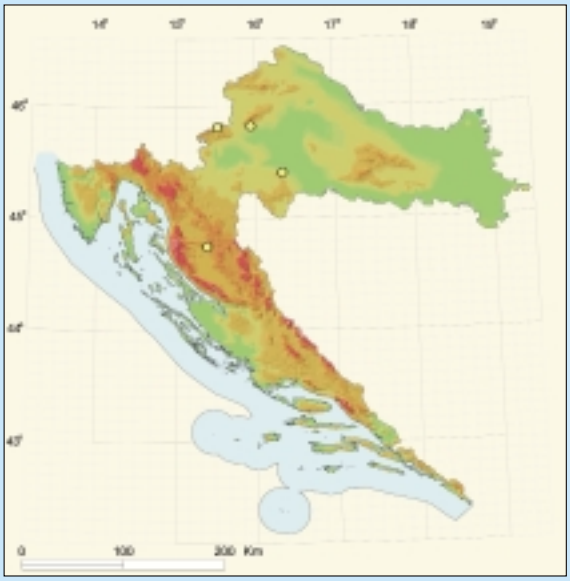
- Subdivision: *Basidiomycotina*
- Class: *Hymenomycetes*
- Order: *Agaricales*
- Family: *Hygrophoraceae*
- IUCN: endangered (E)
- Protection in Croatia: Protected pursuant to the Nature Protection Act

Fungus *Hygrocybe calyptriformis* can be found in Europe, North America and Japan. It is widespread, but rare in Europe. It occurs in old grasslands that are not managed intensively, on well-drained soil with the very low levels of dissolved nitrate and phosphate. Since this type of grasslands (periodically mowed or grazed for many years) is increasingly rare in Europe, and this species is pretty rare, it is considered threatened.

This species has a cap 20–70 mm wide, acutely conical at first, later expanded with acute umbo, radially splitting, most often with raised margin, minutely fibrillose, slightly viscid when moist, pink to lilac. Lamellae are free to narrowly adnate, pink to whitish. Stem is 40–120 mm long, 4–15 mm wide, more or less cylindrical, with dry, minutely fibrillose surface, white, rarely pale pink. Flesh is fragile, in cap pink, in stem white. Smell and taste are insignificant.

In Croatia this species has been so far recorded at only 4 sites and is protected by law.

Z. Tkalčec, A. Mešić



Map 13. Distribution of fungus Hygrocybe calyptriformis in Croatia
(according to data by Z. Tkalčec and A. Mešić)

Figure 82. Fungus Hygrocybe calyptriformis
(photo by A. Mešić)

Table 8. Number of known species within the fungi groups explored

(* nonlichens taxa only; ** partly treated, most of which belong to the families of *Corticiaceae* s. l. and *Polyporaceae* s. l.)

	Croatia		Europe
Group	known	assumed	known
Discomycetes	401*	1.400*	1.800*
Pyrenomycetes (Hypocreales)	10	?	?
Gasteromycetes	59	200	280
Aphyllophorales	443**	730**	1.000
Agaricales	831	2.700	3.400
Total	**1.744**	**~5.030**	**~6.480**

Threatened taxa

The preliminary list of rare and threatened fungi contains 130 species of above-mentioned groups analysed. The species listed have been recorded in Croatia and may be considered rare, whereas species with an uncertain identification have not been included in the list. The list contains also a part of species to be found in the Red List of threatened species of macromycetes in Europe. All species listed are either extremely rare or rare, as well as threatened due to their excessive gathering or growing in threatened or rare habitats.

In a whole 45 species of lichens are threatened and/or rare. On the basis of the meagre existing data it is not possible to propose the protection of particular species. Epiphytic lichens may be effectively protected indirectly, within the framework of measures for the protection of forest habitats, and lichens found on rocks within the framework of the protection of coastal areas and highland regions.

Box 43. Fungi that may be gathered for commercial purposes

- chanterelle (*Cantharellus cibarius*) – excluding *C. cibarius* var. *amethysteus*
- horn of plenty (*Craterellus cornucopioides*)
- edible boletus (species: *Boletus aereus*, *B. edulis*, *B. pinophilus*, *B. reticulatus*)
- spreading hydnum (species: *Hydnum repandum*, *H. rufescens*)
- honey mushroom (species: *Armillaria borealis*, *A. cepistipes*, *A. gallica*, *A. mellea and A. ostoyae)*
- orange-milk lactarius, red-milk lactarius (species: *Lactarius deliciosus*, *L. deterrimus*, *L. hemicyaneus*, *L. quieticolor*, *L. salmonicolor*, *L. sanguifluus*, *L. semisanguifluus*)
- big white truffles (species: *Tuber asa* and *T. magnatum*),
- black truffles (species: *Tuber aestivum*, *T. brumale*, *T. hiemalbum*, *T. macrosporum*, *T. malenconii*, *T. melanosporum*, *T. uncinatum*).

Figure 83. Big white truffle, one of the most appreciated species of commercially important fungi in Croatia growing wild, traditionally gathered in Istria

(photo by N. Matočec)

Economically significant taxa

In Croatia fungi are intensively gathered for commercial purposes and for personal needs. Up to 1,000 tons of these species are gathered yearly, of which nearly the entire volume is exported, chiefly to Slovenia, Italy and France.

Threats

The threat to fungi in Croatia has not been investigated and therefore may be discussed only on the basis of corresponding knowledge acquired from the research work carried out in other European countries.

Box 44. Threats to fungi

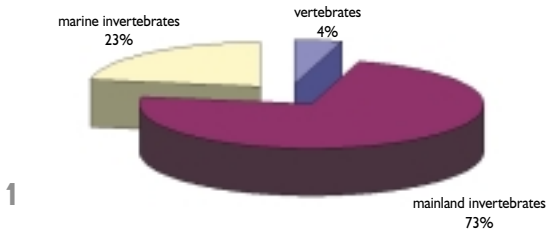
- disappearing, threatening and fragmentation of habitats
- environmental pollution
- excessive exploitation and degradation of fungi and
- introducing of or encouraging expansion of invasive foreign plant species.

Legal protection

The 1998 *RuleBook on Protection of Fungi* identifies the species that may be gathered for commercial purposes and governs in full all the problems related to protection of fungi. All of 130 threatened species of macromycetes are fully protected. Other species may be gathered for personal needs only, in fact up to 2 kg of fungi daily. When gathering, the prescribed protection measures are to be observed. The protection of commercial species is performed by means of issuing permits for gathering and export to legal and physical persons that are registered for this business and obliged to train adequately their gatherers. Such permits are issued by the Ministry of Environmental Protection and Physical Planning.

ANIMALS

According to present data Croatia's fauna numbers at least 23,893 species. Together with species inhabiting Croatia periodically the fauna consists of some 24,000 species. In relation to the assumed number of species (about 56,000)



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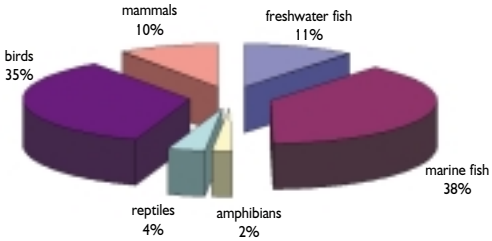

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Box 45. Fungus *Poronia punctata*, a rare and threatened European species

- Subdivision: *Ascomycotina*
- Class: *Pyrenomycetes*
- Family: *Xylariaceae*
- Order: *Xylariales*
- IUCN: endangered (E)
- Protection in Croatia: not protected

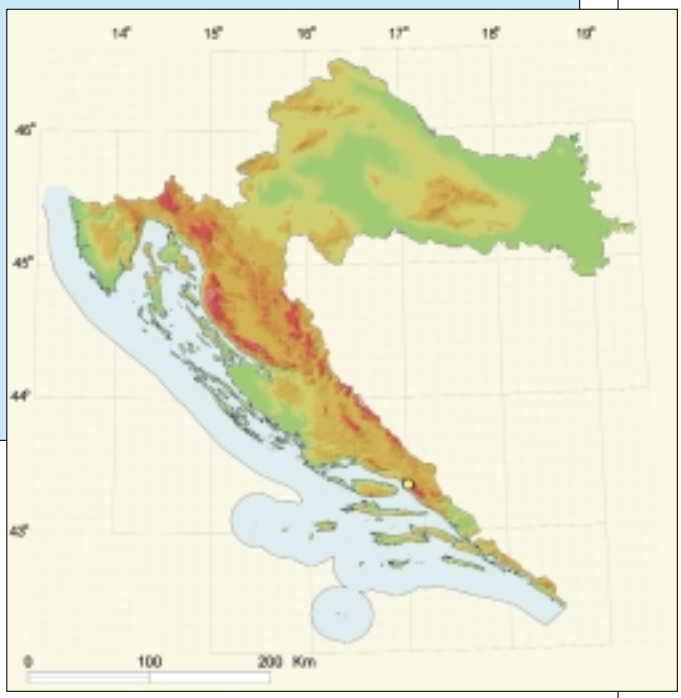
The species *Poronia punctata* (L.:Fr.) Fr. belongs to the group of sac fungi (subdivision *Ascomycotina*). The group was named after the ascus – a sac-formed sporangium in which ascospores are produced and which is typical of this subdivision. Ascospores are cells for reproduction of these fungi.

The species is coprophilous, which means that only dung may form its substratum (of horses, donkeys and cows). Its distribution is restricted almost exclusively to grasslands near the sea, while in other habitats its is extremely rare or not present at all. Mycelium, the body of this fungus, develops in the dung and under favourable conditions produces a compact mass – stroma with fertile structures, i.e. hymenia. The stroma consists of a very thin stem that on the substratum surface changes into the disc-shaped expanded part with a diameter of 2.8–15 mm. While the lower surface of this expanded part is of dark brown colour, the upper surface is almost entirely white to greyish-white and black dotted when ripe (see the photo). Hymenia are situated inside minute black pear-shaped cases – perithecia closed inside the stroma and lined up at single level immediately below its upper surface. With their upper, thinned, short tubular part – ostiole with a tiny hole on the top the perithecia come out to the upper surface of stroma giving it that dotted appearance.

The cause of decline of the this species has never been ascertained. Some authors even speculate that causes might be the change in horse, donkey and cow nutrition, the use of fertilizers and disappearance of individual horse and donkey populations. However, decline is more likely caused by major changes of stockbreeding. The animals in question are kept indoors, so grazing in open pasture stoped and therefore the fungus was left without suitable supstrate. The species is considered extinct in numerous European countries and is included into the group of the most threatened species of macromycetes in Europe. The need for its protection is pressing, therefore habitats in European countries in which it can still be found may be considered important in terms of the protection of biological diversity. Despite the long-time research only one locality (Bast, Biokovo) has been found in Croatia so far. Since this species was discovered in Croatia only after the first legal protection of fungi on the basis of the Preliminary List of Rare and Endangered Species had been established, it is at present not covered by legal protection. This should by all means be modified in the first forthcoming revision of the protection.

N. Matočec

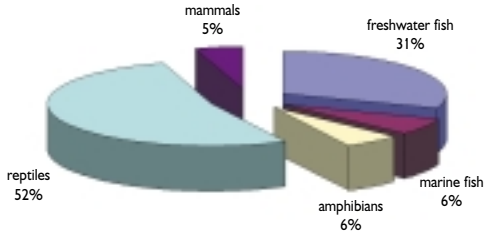
Figure 84. *Fungus Poronia punctata*
(photo N. Matočec)



Map 14. *Distribution of fungus Poronia punctata*
(according to data by N. Matočec)

32,000 species are waiting to be described which means that about 40 per cent of the fauna are known.

The most numerous (about 21,000 species have been discovered) and at the same time the least known species (the presence of about 54,000 species is assumed) are invertebrates, especially those of the mainland and inland waters. Among vertebrates marine fish (410 species discovered) and birds (a total of 371 species recorded) are the richest in species. They are followed by freshwater fish (113 species), mammals (101 species) and particularly reptiles and amphibians (38, or rather 20 species respectively). The best explored among them are sea fish (Graph 6, Tab. 9 and 10).



Graph 7. *Share of endemic species in the total number of species in major groups of vertebrates*

Graph 6. *(1) Relation between the number of species of vertebrates, marine and mainland invertebrates; (2) number of species in individual vertebrate groups in relation to the total number of species*

Box 46. Diversity of animal world

Table 9. Collective data on diversity of fauna: [1] – breeding birds, [2] – recorded in total, [3] – species only, [4] – species and subspecies found, [5] – total, [6] – breeding in Croatia

	Croatia			World
Group	**Known**	**Assumed**	**Knowl. (%)**	**Known**
Mainland invertebrates	17,575	49,000	31.8	1,280,000
Marine invertebrates	5,427	6,000	90.30	?
Freshwater fish	113[3] 145[4]	157	92.4	8,500
Marine fish	410	415	98.8	13,500
Amphibians	20	22	90.1	4,000
Reptiles	36[6] 38[2]	41	92.7	6,500
Birds	371[2] 226[1]	380	97.7	9,881
Mammals	86[6] 101[5]	106	95.3	4,327
Total	**23,893 (24,087)**	**56,121**	**39**	**1,326,708**

Table 10. Number of endemic species and subspecies in Croatia in individual fauna groups

Group	**Endemic**
Freshwater fish	33
Marine fish	7
Amphibians	6
Reptiles	57
Birds	0
Mammals	5
Invertebrates	730
Total	**838**

Vertebrates

Freshwater fish and lampreys

Croatia's freshwaters are inhabited by 145 fish taxa of which about 21 taxa may be found in both freshwater and salt-water.

In the **Black Sea catchment area of Croatia** (58% of the surface area) there are 78 fish taxa, 15 of which were introduced from other countries chiefly in this century. According to the total number of freshwater fish species Croatia ranks second in Europe, after Turkey with a much larger territory. Three **endemic species** for the Black Sea catchment area may be found in Croatia too.

Box 47. Dalmatian barbelgudgeon (*Aulopyge hugeli*)

- Order *Cypriniformes*
- Family *Cyprinidae*
- IUCN status: threatened (E)
- Protection: listed among protected species according to the Bern Convention

Dalmatian barbelgudgeon – *Aulopyge hugeli* inhabits in a small number rivers Zrmanja and Krka and is slightly more numerous in river Cetina and in sink-rivers and lakes of the fields Livanjsko and Sinjsko. It is common in lakes Blidinsko and Visovačko and in the storage lake of Buško blato. Little is known about the biology and ecology of this species. It is known to live in shoals. It spawns on rocks and submarine plants. Its skin is scaleless which is most likely the adaptation to the underground way of life. The head is markedly pointed and has 4 barbels around the mouth. The body is gold-brown coloured with black spots and a wavy lateral line. There is a sexual difference between the male and female that has a ovipositor on the pelvic fin. It is assumed that Dalmatian barbelgudgeon, like the majority of Croatia's endemics, survived all geomorphological changes taking place in this region from the Tertiary to this day in an almost unmodified form. Much as the Adriatic salmon too, this species is markedly connected with karst and Dalmatian rivers and cannot be found in other areas.

The literature contains data about this species wintering underground and in sink-rivers. Dalmatian barbelgudgeon is very strong and resilient and can take the shortage of food and oxygen in water well.

Extensive changes happening in Dalmatian rivers have completely modified ecological conditions under which this species is living. The commonest changes are land reclamation, regulations, water obstruction and pollution. It is known that all species that old, with very poor genetic adaptation possibilities and restricted distribution ranges are classified as threatened species. All rivers accommodating this species have in the last 20 years experienced extensive land reclamation and construction of at least 20 dams, with further storage lakes being in the process of planning. For river Krka five storage lakes are planned, there are already five on river Cetina and three on river Zrmanja. According to our knowledge Dalmatian barbelgudgeon is a threatened species and listed among European species protected by the Bern Convention. According to the IUCN categorization it is on the borderline between threatened and critically threatened.

M. Mrakovčić

Figure 85. Dalmatian barbelgudgeon
(photo by M. Mrakovčić)

The **Adriatic catchment area** (42% of the surface area) is inhabited by 64 fish taxa, of which 41 are endemic for the wider Mediterranean region, 37 species are endemic for the Mediterranean region and **12 appear only in Croatia** or, possibly, in Bosnia and Herzegovina too. All in all, the Mediterranean part of Croatia is for Europe one of the most important centres of ichthyofauna diversity with a great number of endemics. The endemics are to a high extent connected with specific karst habitats of underground waters. The most important endemic fish in Croatia include 6 species of the genus minnow and the species minnow nase, Cetina bleak, Croatian dace, Balkan dace, Dalmatian barbelgudgeon, Vrgorac goby, Adriatic salmon and endemic subspecies of brown trout. As many of the species are still not described in detail, they are the subject of scientific research both in Croatia and worldwide.

A zoogeographical analysis of the country's ichthyofauna was carried out only partly. Large areas were not included in regular investigations, so that, consequently, the areas of distribution could not have been identified for many species. Numerous less known species and subspecies are not described in full. It may be expected that in the Adriatic catchment area even more new, presumably endemic taxa will be found.

About 40 species of freshwater fish are economically significant within various types of fishing industry.

So far no **species** of freshwater fish has been **legally protected.** A practical protection of the majority of threatened species may be carried out only by protecting their habitats, which calls for special action plans for each species. For the purpose of protecting the endemic fish two ichthyological reserves have been established so far: areas of the springs of rivers Vrljika (Adriatic salmon) and Jadro (*Salmothymus obtusirostris salonitana*).

Box 48. Special threats to freshwater fish in Croatia

- pollution of rivers by diverse toxins and organic substances
- amelioration and regulation of watercourses
- introduction of allochthonous species
- need of contemporary man for industrial and drinking water
- overfishing
- tourism and
- river dams preventing migrations in hatcheries.

In Croatia's watercourses 5 fish species are extinct and 32 are critically **threatened.** Their habitats have been recently undergoing substantial changes due to various human influences. This primarily refers to pollution, regulation of rivers and construction of hydropower plants and water tanks. The result of these activities is the change of physical and chemical properties of water, with far-reaching consequences for the living world of rivers.

One of the most serious consequences of the anthropogenic influence on fish is certainly the **introduction of allochthonous species** to a region (Box 49). This usually occurs accidentally, but some species were often introduced on purpose, with the objective that in most cases was not achieved. If it survives in the new surroundings, the species introduced may considerably change the fish community, which frequently leads to disappearance of vulnerable indigenous species.

Order	Family	Species total	Species assum.	Threatened nation.	Threatened Europe	Endemic total	Endemic %	Endemic Threat.	Nat. list	Nat. red list
Acipenseriformes	*Acipenseridae*	7	7	7	4+3	–		–	+	7
Anguilliformes	*Anguillidae*	1	1	–	–				+	–
Atheriniformes	*Cyprinodontidae*	1	1	1	+3	–	–	–	+	1
	Atherinidae	2	2	2		–	–	–	+	–
Clupeiformes	*Clupeidae*	3	4	?	3	?			+	1
	Esocidae	1	1	–	–	–	–	–	+	–
Cyprinodontiformes	*Poecolidae*	1	1	–	–	–	–	–	+	–
Cypriniformes	*Cobititidae*	6	7	3		3	50	3	+	6
	Cyprinidae	60	65	14	56+2	21		14	+	21
Gadiformes	*Gadidae*	1	1	–					+	–
Gasterosteiformes	*Gasterosteidae*	1	2–3	1	2	1			+	–
Mugiliformes	*Mugilidae*	6	6	–	–				+	–
Perciformes	*Blennidae*	1	1	1	1				+	1
	Gobiidae	8	11	5	12	5	63		+	5
	Centrarchidae	2	2	–					+	–
	Percidae	8	9	2	5+1	2			+	2
	Serranidae	1	1	–	–				+	–
	Sparidae	1	1	–	–				+	–
Petromyzontiformes	*Petromyzontidae*	6	7	3	7+1	1			+	3
Pleuronectiformes	*Pleuronectidae*	1	2	–	–	–	–	–	+	–
Salmoniformes	*Salmonidae*	16	16	12	2				+	–
	Coregonidae	2	3	–	8 all				+	–
	Thymallidae	1	1	–	1				+	–
	Umbridae	1	1	1	+1				+	1
Scorpaeniformes	*Cottidae*	1	3	?	2				+	?
Siluriformes	*Siluridae*	1	1	–	2				+	–
	Ameiuridae	2	2	–	–				+	–
Synentognathi	*Syngnathidae*	2	2	–	2+2				+	1
Total	**28**	**145**	**157**	**52**	**110+13**	**33**			**145**	**55**

Table 11. Review of data on freshwater fish and lampreys

Table 12. Freshwater fish and lampreys calling for action plans for protection;
***E** – Croatia's endemic taxa;*
1 – taxa calling for immediate protection measures;
2 – protection measures to be planned and defined;
3 – generally threatened taxa or unidentified subtaxa calling for scientific analysis and protection;
4 – taxa calling protection of habitats

Vernacular name	Latin name	E	1	2	3	4
	PETROMYZONTIDAE					
Po brook lamprey	*Lethenteron zanandreai* (Vladykov, 1955)			☑		☑
	SALMONIDAE					
huchen	*Hucho hucho* (Linnaeus, 1758)			☑		☑
Zubatak	*Salmo trutta dentex* (Heckel, 1851)	☑	☑			
marble trout	*Salmo trutta marmoratus* (Cuvier, 1817)		☑			
Visovac trout	*Salmo trutta visovacensis* (Taler, 1951)	☑	☑			
Zrmanja trout	*Salmo trutta zrmanjensis* (Karaman 1937)	☑	☑			
Krka Adriatic salmon	*Salmothymus obtusiristris krkensis* (Karaman 1926)	☑	☑			☑
	Salmothymus obtusiristris obtusirostris (Heckel, 1851)	☑	☑			☑
Neretva Adriatic salmon	*Salmothymus obtusiristris oxyrhynchus* (Steindachner 1882)		☑			☑
Solin Adriatic salmon	*Salmothymus obtusirostris salonitana* (Karaman1926)	☑	☑			☑
Mediterranean toothcarp	*Aphanius fasciatus* (Cuvier and Valenciennes 1821)			☑		
	COBITITIDAE					
Cetina spined loach	*Cobitis taenia dalmatina* (Karaman, 1928)	☑		☑		
Neretva spined loach	*Cobitis taenia narentana* (Karaman, 1928)	☑		☑		
three-spined stickleback	*Gasterosteus aculeatus* (Linnaeus, 1758)			☑		☑
	CYPRINIDAE					
alborella	*Alburnus albidus* (Filippi, 1848)			☑		
Dalmatian barbelgudgeon	*Aulopyge hugeli* (Heckel, 1841)	☑		☑		☑
Po barbel	*Barbus plebeius* (Valenciennes 1842)				☑	
Dalmatian soiffe	*Chondrostoma kneri* (Heckel 1843)	☑		☑		
minnow nase	*Chondrostoma phoxinus* (Heckel 1893)	☑	☑			☑
Cetinska uklija	*Leuciscus ukliva* (Heckel, 1843)	☑	☑			☑
	Leuciscus illiricus (Heckel et Kner, 1858)	☑			☑	☑
	Leuciscus microlepis		☑			☑
Croatian dace	*Leuciscus polylepis* (Steindachner, 1866)	☑	☑			☑
souffie	*Leuciscus souffia muticellus* (Bonaparte, 1837)	☑	☑			☑
Balkan dace	*Leuciscus svallize* (Heckel et Kner, 1858)	☑			☑	
	Leuciscus turskyi tenellus	☑	☑			☑
	Leuciscus turskyi (Heckel, 1843)		☑			☑
Adriatic minnow	*Phoxinellus alepidotus* (Heckel, 1843)		☑			☑
Croatian minnow	*Phoxinellus croaticus* (Steindachner, 1865)	☑	☑			☑
Dalmatian minnow	*Phoxinellus ghetaldi* (Steindachner, 1885)	☑	☑			☑
South Dalmatian minnow	*Phoxinellus pstrossi* (Steindachner, 1882)		☑			☑
spotted minnow	*Phoxinellus adspersus* (Heckel, 1843)	☑		☑		☑
basak	*Rutilus basak* (Bianco 1986)	☑			☑	
rudd	*Scardinius erythrophthalmus hesperidicus*	☑			☑	
rudd	*Scardinius erythrophth. scardafa* (Bonaparte 1832)	☑			☑	
Visovac goby	*Knipowitschia mrakovcici* (Miller, 1990)	☑		☑		
Vrgorac goby	*Knipowitschia punctatissima croatica* (Mrakovcic et al. 1994)	☑	☑			☑
mottled black sea goby	*Proterorhinus marmoratus* (Pallas 1811)				☑	
monkey goby	*Neogobius fluviatilis* (Pallas, 1811)				☑	

Figure 86. Goldfish
(photo by M. Povž)

Box 49. Threat of introducing foreign fish taxa

Experts for fish agree that introduction of false rasbora brings about changes in fish communities wherever it appeared. This small fish was introduced into Romania from China in 1960. It is assumed that already in the course of the 70s it reached our waters. During the 80s it was found in all fishponds and some open waters. Today this species inhabits almost all waters of the Croatia's Adriatic and Black Sea catchment area. The Adriatic catchment area and our endemic taxa are extremely threatened, because in this catchment area there are no natural predators that could destroy this species.

Another serious threat to the indigenous ichthyofauna of Croatia is posed by the **gold fish** as well. It made its way from an almost unknown species in the 50s to a highly invasive species with extremely high populations. It is present in a great number in all waters of both the Black Sea and the Adriatic catchment area. Gold fish is a direct competition to carps whose populations have proportionally decreased. Its impacts and consequences on the rest of ichthyofauna are unknown.