CZECH MYCOL. 60(1): 125–136, 2008

Ecology of the rare fungus *Hydropus atramentosus* (Basidiomycota, *Agaricales*) in the Czech Republic and its potential value as a bioindicator of old-growth forests

JAN HOLEC

National Museum, Mycological Department, Václavské nám. 68, 115 79 Praha 1, Czech Republic
jan_holec@nm.cz

Holec J. (2008): Ecology of the rare fungus *Hydropus atramentosus* (Basidiomycota, *Agaricales*) in the Czech Republic and its potential value as a bioindicator of old-growth forests. – Czech Mycol. 60(1): 125–136.

Hydropus atramentosus is a rare lignicolous fungus included in the Red Book and Red List of the Czech Republic and in red lists of 5 other European countries. To date, it has been recorded at 15 localities in the Czech Republic. Most of them are almost pure *Fagus* forests with rare presence of *Picea* and/or *Abies* at lower altitudes or mixed submontane or montane forests composed predominantly of *Fagus*, *Abies* and *Picea*. There is also one record from a man-made *Picea* forest. *H. atramentosus* was mostly found at slopes of mountains or hills but also in deep stream valleys in the hilly country. The fungus shows a clear preference for old-growth forests (mostly nature reserves). However, it is rarely found in man-influenced or even man-made stands. Consequently, *H. atramentosus* cannot be considered a relict species confined exclusively to true virgin forests almost untouched by man but can be used as a bioindicator of conservationally valuable stands (natural vegetation, presence of dead wood of *Abies* or *Picea*, stable meso– and microclimate). This conclusion was verified also in the Slovakia and Ukrainian Eastern Carpathians.

Key words: *Tricholomataceae*, Europe, distribution, virgin (primeval) forests, natural forests, near-natural forests.

Holec J. (2008): Ekologie vzácného druhu *Hydropus atramentosus* (Basidiomycota, *Agaricales*) v České republice a jeho potenciální hodnota coby bioindikátora přirozených lesů. – Czech Mycol. 60(1): 125–136.

Hydropus atramentosus je vzácná lignikolní houba zařazená do červené knihy a červeného seznamu hub České republiky a také do červených seznamů dalších 5 evropských států. Dosud byla v ČR nalezena na 15 lokalitách. Většina z nich představuje jednak téměř čisté bučiny se vzácným výskytem smrku a jedle (nižší polohy), jednak podhorské a horské smíšené lesy tvořené bukem, jedlí a smrkem. Existuje také jeden nález z kulturní smrčiny. *H. atramentosus* byl většinou nalezen na svazích hor nebo kopců, ale také v údolích potoků v kolinním stupni. Houba zřetelně preferuje přirozené lesní porosty, většinou zákonem chráněné. Vzácně se ale vyskytuje i v člověkem silně ovlivněných až uměle vytvořených porostech. Z toho důvodu nemůže být pokládána za reliktní druh vázaný pouze na minimálně dotčené pralesovité porosty, ale může být využita jako bioindikátor ochranářsky významných lesů (význačných přirozeným složením dřevin, přitomností mrtvého dřeva jedle nebo smrku a vyrovnaným mezo– a mikroklimatem). Tento závěr byl ověřen i pro území Slovenska a ukrajinských Karpat.

INTRODUCTION

Hydropus atramentosus (Kalchbr.) Kotl. et Pouzar is a rare lignicolous basidiomycete (*Agaricales*, *Tricholomataceae*) growing on dead wood of conifers (*Abies*, *Picea*). In Europe, it is known from its western, central, eastern and southern parts. Records of it from the Czech Republic (CR) were published by Kotlaba and Pouzar (1962), Kubička (1973), Kuthan (1981, 1990), Beran (1996), Holec (1999) and Papoušek (2004). Data on its ecology from the Czech (and Slovak) literature and herbaria were evaluated by Kotlaba et al. (1995). *H. atramentosus* was characterised here as a species of *Abies-Picea* forests, pure *Abies* forests and montane *Abies-Picea* forests (remark: data published here showed that such a generalisation is rather misleading), mostly having virgin character.

From the conservational viewpoint, *H. atramentosus* is considered a critically endangered species in the Red Book of the CR (Kotlaba et al. 1995) and an endangered species in the Red List of fungi of the CR (Holec and Beran 2006). In 2005 it was proposed by Czech mycologists to be included into the updated list of organisms protected by law (not accepted so far due to political obstructions). In Europe, *H. atramentosus* is included in the red lists of 6 countries (Tab. 1), which clearly shows that it deserves the attention of mycologists.

The aim of this paper is to evaluate the relationship between occurrence of *H. atramentosus* and degree of naturalness of forests in the Czech Republic (with respect to adjacent countries) in order to make clear if the species can be considered a bioindicator of old-growth forests, at least in this part of Central Europe. Such an evaluation has not been carried out in Europe yet.

MATERIAL AND METHODS

The data on the occurrence of *Hydropus atramentosus* in the Czech Republic are based on herbarium specimens from PRM, BRNM, CB and BRA (for abbreviations, see Holmgren and Holmgren 1998), published records (see above) and finds (not documented by voucher specimens) by taxonomically erudite mycologists. In herbaria, recent collections are kept as *Hydropus atramentosus*, the older ones mostly as *Mycena fuliginaria*. In addition, Daniel Dvořák, Helena Deckerová, Josef Slavíček and Petr Vampola, important Czech field mycologists, were asked about possible finds of *H. atramentosus*, however all replies were negative.

For the purpose of this article, the following degrees of naturalness of forest stands are used [the terms are used in conformity with reviews published by Vrška and Hort (2003) and Vrška et al. (on-line), which reflect both the international context and concrete data from the Czech Republic]:

old-growth forests

virgin forest: possessing a natural tree species composition, multi-aged structure, long continuity (never completely cut), almost untouched by man (almost no selective cutting, no clearings, no removal of fallen trunks at present)

natural forest + near-natural forest: possessing a natural tree species composition, multi-aged structure, long continuity or having been naturally recovered after cutting, little influenced by man (selective cutting, forest paths, small clearings, pasturing in the past, removal of some fallen trunks, partly managed by foresters in near-natural forests). Natural and near-natural forests can be distinguished according to many characters (e. g. Vrška and Hort 2003, Vrška et al. on-line). However, for the purpose of this article they are combined in one category because of incomplete data on localities and habitats of *H. atramentosus* in literature and on labels of herbarium specimens.

cultural forests

man-influenced forest: possessing a natural tree species composition but homogeneous age structure, completely managed by foresters, some fallen trunks left.

man-made forest: possessing an unnatural tree species composition (mostly homogeneous *Picea* or *Pinus* plantations instead of a heterogeneous composition), completely managed by foresters.

Abbreviation: not. – from the Latin word notavit, i.e. recorded, a find which is only recorded but not documented by a voucher specimen.

RESULTS AND DISCUSSION

Hydropus atramentosus (Kalchbr.) Kotl. et Pouzar

≡ *Agaricus atramentosus* Kalchbr., ≡ *Collybia atramentosa* (Kalchbr.) Sacc., ≡ *Mycena atramentosa* (Kalchbr.) Höhn.

= *Collybia fuliginaria* (Batsch) Bres. sensu Bres., *Mycena fuliginaria* (Batsch) Kühner sensu Bres. etc., *Hydropus fuliginarius* (Batsch) Singer sensu Bres. etc.; non *Agaricus fuliginarius* Batsch

Distribution and threat in Europe

Based on published data from Europe, *H. atramentosus* is known from Switzerland (e. g. Breitenbach and Kränzlin 1991), Germany (e. g. Krieglsteiner 1991, 2001), Czech Republic (see Introduction and Tab. 2), Austria (Hausknecht et al. 1997, Hausknecht et al. 2006), Poland (e. g. Wojewoda 2003), Slovakia (e. g. Kubička and Svrček 1955, Kotlaba and Pouzar 1962, Kuthan et al. 1999, Škubla 2003), Lithuania (Urbonas 1970), Ukraine (Kubička and Svrček 1955: p. 23 – PRM 488548; Holec 2008) and Croatia (Tkalčec et al. 2007). Some records and photo-

graphs from France and Italy are published on-line. Occurrence in Romania is mentioned by Krieglsteiner (2001) but without any citation.

In all these countries *H. atramentosus* is characterised as a rare species (sporadic records only). Consequently, it is included in the red lists of 6 countries (Tab. 1).

The species is not known from the British Isles (Legon and Henrici 2005) or Nordic countries (Hansen and Knudsen 1992).

Tab. 1. *Hydropus atramentosus* in red lists of European countries. Abbreviations. CR: critically endangered, E: endangered, EN: endangered.

country	red list	category
Switzerland	Senn-Irlet et al. (2007)	EN (IUCN category)
Germany	Benkert et al. (1992)	stark gefährdet (German category)
Czech Republic	Holec and Beran (2006)	EN (IUCN category)
Poland	Wojewoda and Ławrynowicz (2006)	E (Polish category)
Slovakia	Lizoň (2001)	CR (IUCN category)
Croatia	Tkalčec et al. (2007)	EN (IUCN category)

Distribution in the Czech Republic

Most of the localities cited below are enumerated in the Red Book by Kotlaba et al. (1995) and the Red List by Holec and Beran (2006), but without exact data on individual collections.

Remarks. In most herbarium specimens of *H. atramentosus*, the exact altitude is not given. In the following survey, the value of the altitude is preceded by the abbreviation "alt." if the exact value is known. If it was deduced from maps according to data on the locality, by the abbreviation 'alt. ca.'.

Šumava Mts.

Mt. Boubín near Lenora: Boubínský prales virgin forest, alt. ca. 1000 m, *Abies alba*, decaying trunk, 1954, leg. K. Kříž (PRM 840463); ibid., 16–17 Aug 1953, leg. K. Kříž (BRNM 333436). Published data: Kotlaba and Pouzar (1962), Kubička (1973).

Mt. Boubín near Lenora: Lukenská silnice forest path, alt. ca. 1100 m, *Picea*? *Abies*?, strongly decayed trunk, 16 July 1953, leg. K. Kříž (PRM 840477).

Mt. Boubín near Lenora (exact site not indicated, but probably also the Boubínský prales virgin forest – pers. comm. Z. Pouzar), alt. ca. 1000 m, *Abies alba*, fallen trunk, 11 Sep 1955, leg. J. Kubička (PRM 839989); ibid., 30 July 1954, leg. K. Kříž (BRNM 333437). Published data: Kubička (1973).

Radvanovický hřbet ridge close to České Žleby near Lenora, alt. 900 m, decayed stump covered with mosses, 14 July 1998, leg. J. Holec (PRM 897040). Published data: Holec (1999).

Táborská pahorkatina upland

Libochovka nature reserve near Hluboká nad Vltavou, alt. 400 m, *Picea abies*, fallen trunk, 4 Aug 2005, leg. P. Špinar (PRM 857408); ibid., 4 Aug 2005, leg. P. Špinar (CB 14539); ibid., 21 Sep 2004 + 3 Sep 2005 + 6 Oct 2005 + 26 Aug 2007 + 29 Sep 2007, not. P. Špinar. All finds are from the same fallen trunk.

Novohradské hory Mts.

Žofínský prales national nature reserve close to Pohorská Ves near Nové Hrady, alt. ca. 750 m, *Abies alba*, 3 Sep 1970, leg. J. Kubička (PRM 777644); ibid., NE part, alt. 750 m, *Abies alba*, fallen decaying trunk, 26 Aug + 2 Oct 1995, not. M. Beran, 10 Sep 1995, leg. M. Beran (CB 9800); ibid., central part, alt. 770 m, fragment of decayed coniferous wood, 27 Aug 2004, leg. M. Beran (CB 14331), 12 Aug 2005, leg. M. Beran (CB 14538); ibid., N part, alt. 760 m, *Abies alba*, fallen decaying trunk, 19 July 2005, leg. M. Beran (CB 14537). The finds by M. Beran are from 4 microlocalities in the reserve. Published data: Beran (1996), Papoušek (2004).

Žďárské vrchy hills

Fryšavský kopec hill: E slope, 2 km W of Fryšava pod Žákovou horou near Nové Město na Moravě, alt. ca. 750 m, *Picea abies*, old stump, 15 July 1999, not. A. Vágner et V. Antonín.

Drahanská vrchovina highlands (including Moravian Karst)

Jelení skok nature reserve close to Vranov near Brno, alt. ca. 300 m, *Abies alba*, fallen decaying trunk, 7 Sep 1986, leg. A. Vágner (BRNM 462174).

Coufavá nature reserve close to Útěchov near Brno, alt. ca. 400 m, *Abies alba*, fallen trunk, 9 Aug 1986, leg. A. Vágner (BRNM 462171); ibid., *Picea abies*, fallen trunk, 22 July 1984, leg. A. Vágner (BRNM 457513).

Josefovské údolí valley close to Adamov near Brno, alt. ca. 350 m, *Picea abies*, fallen decaying trunk, 8 Sep 1968, leg. K. Kříž (BRNM 301976). At present, the valley represents a part of the Býčí skála national nature reserve.

Hostýnsko-vsetínská hornatina hills

Čerňava nature reserve close to Rajnochovice near Vsetín, alt. ca. 650 m, *Abies alba*, decaying trunk, 17 Aug 1966, leg. L. Stankovičová (PRM 725881).

Rajnochovice: part Košovy, direction Ožiňák, near Bystřice pod Hostýnem, alt. ca. 550 m, fallen trunk lying in water in an *Alnus* forest, 24 Aug 1979, leg. A. Vágner (BRNM 301977); ibid., *Picea*? *Abies*?, on stump, 17 Aug 1980, leg. A. Vágner (BRNM 289109).

Mt. Cáb near Vsetín, alt. ca. 700 m, *Abies alba*, fallen trunk, 22 Aug 1962, leg. F. Kotlaba (PRM 839872, 566858; BRNM 301978); ibid., *Abies alba*, fallen decaying trunk, 16 Aug 1966, leg. F. Kotlaba et Z. Pouzar (PRM 718129). According to

Z. Pouzar (pers. comm., 2008), the fungus was found at a site currently protected as Kutaný nature reserve.

Javorníky Mts.

Razula national nature reserve near Velké Karlovice, alt. ca. 700 m, *Abies alba*, decayed stump, 20 Aug 1962, leg. F. Kotlaba et Z. Pouzar (PRM 566903); ibid., *Abies alba*, fallen trunk, 21 Aug 1966, leg. Z. Pouzar (710605); ibid., *Abies alba*, decaying trunk, 28 Aug 1972, leg. J. Kuthan (BRA CR 2513).

Moravskoslezské Beskydy Mts.

Salajka national nature reserve near Bílá, alt. ca. 750 m, *Picea abies*, decaying stump, 13 Aug 2005, leg. V. Antonín et D. Janda (BRNM 695618); ibid., *Abies alba*, fallen trunk, 1 Aug 2003, leg. V. Antonín (BRNM 677317); ibid., *Abies alba*, fallen decaying trunk, 20 Aug 1967, leg. J. Kuthan (BRNM 301975); ibid., *Abies alba*, decayed trunk, 20 Aug 1967, leg. J. Kuthan (BRA CR2388). Published data: Kuthan (1981, 1990).

Mionší national nature reserve near Jablunkov, alt. ca. 850 m, *Abies alba*, fallen trunk, 23 Aug 1966, leg. Z. Pouzar (PRM 892593); ibid., *Abies alba*, 20 Aug 1962, leg. J. Lazebníček (BRNM 333438). Published data: Kotlaba and Pouzar (1962).

Tab. 2. Degree of naturalness and protected status of localities of *Hydropus atramentosus* in the Czech Republic. For details on individual finds see Collections studied. The column „information on naturalness" shows who provided data on the degree of naturalness of the habitats in question (mostly collectors of *H. atramentosus* or mycologists who know the localities personally).
Explanations: **** virgin forest, *** natural + near-natural forest, ** man-influenced forest, * man-made forest, NP zone 1 – zone 1 (strictly protected) of a national park, AV: Alois Vágner, JH: Jan Holec, MB: Miroslav Beran, NNR: national nature reserve (strictest category in the Czech Republic), NR: nature reserve, PŠ: Pavel Špinar, ZP: Zdeněk Pouzar.

locality	protection	habitat	geomorphology	degree of naturalness	information on naturalness (pers. comm.)
Mt. Boubín: Boubínský prales virgin forest	NNR	mixed montane forest (*Fagus*, *Picea*, *Abies*, *Acer pseudoplatanus*)	slope (mountain)	****	JH, ZP
Mt. Boubín: Lukenská silnice forest path	NNR? (exact site unknown)	mixed montane forest (*Fagus*, *Picea*, *Abies*, *Acer pseudoplatanus*)	slope (mountain)	***	JH, ZP
Radvanovický hřbet ridge	NP zone 1	mixed montane forest (prevailing *Picea*, admixed *Fagus*, *Abies*, locally *Ulmus glabra*, *Acer pseudoplatanus*)	slope (mountain)	***	JH
Libochovka	NR	herb-rich *Fagus* forest on slope above Libochovka stream, with rare occurrence of *Picea*	valley (stream)	***	PŠ

locality	protection	habitat	geomorphology	degree of naturalness	information on naturalness (pers. comm.)
Žofínský prales	NNR	mixed montane forest (*Fagus*, *Picea*, *Abies*, *Acer pseudoplatanus*, *Ulmus glabra*)	slope (hill)	***	MB, JH
Fryšavský kopec hill	–	man-made *Picea* forest (50–60 years old)	slope (hill)	*	AV
Jelení skok	NR	mixed forest (prevailing *Fagus*, admixed *Abies*: living and fallen trunks)	slope (hilly country)	***	AV
Coufavá	NR	mixed forest (prevailing *Fagus*, admixed *Abies*, *Picea*, *Carpinus*)	valley without stream (side valley of a larger valley with a stream)	***	AV
Josefovské údolí valley	NNR	mixed forest (prevailing *Fagus*, admixed *Abies*, *Picea*, *Carpinus*)	valley (of stream)	***	AV
Čerňava	NR	mixed forest (prevailing *Fagus*, admixed *Abies alba*, *Acer platanoides*, *Fraxinus excelsior*)	slope (hill)	***	ZP
Rajnochovice: part Košovy	–	mixed forest near a stream (prevailing *Fagus*, admixed *Picea*, *Carpinus*; *Alnus* forest along the stream)	valley (of stream)	**	AV
Mt. Cáb	NR	mixed montane forest (prevailing *Fagus*, admixed *Abies*, *Picea*, locally *Fraxinus*)	slope (hill)	***	ZP
Razula	NNR	mixed montane forest (prevailing *Fagus*, admixed *Abies*, *Picea*, locally *Acer pseudoplatanus*, *Fraxinus*)	slope (hill)	***	ZP, JH
Salajka	NNR	mixed montane forest (prevailing *Fagus*, *Abies*, admixed *Picea*, *Acer pseudoplatanus*)	slope (hill)	***	JH
Mionší	NNR	mixed montane forest (prevailing *Fagus*, admixed *Abies*, locally *Acer pseudoplatanus*, *Ulmus glabra*, *Fraxinus*, *Acer platanoides*)	slope (mountain)	***	ZP, JH

Tab. 3. Altitudinal distribution of *Hydropus atramentosus* in the Czech Republic. The delimitation and terminology of the belts is taken from Kotlaba (1984).

belt (m a. s. l.)	planar belt = lowlands (0–200)	colline belt = hilly country (201–500)	submontane belt (501–800)	montane belt (801–1100)	supramontane belt (1101–1400)
number of localities	0	4	7	3	0

Evaluation of substrates, habitats and distribution in the Czech Republic

In the Czech Republic, *H. atramentosus* is a very rare fungus growing on dead wood of *Abies alba*, less frequently *Picea abies*. It occurs on decaying or decayed (fallen) trunks and stumps, sometimes covered with mosses. Its habitats include above all various types of *Fagus* forest with admixed *Abies alba* and/or *Picea abies* (and other broadleaved trees, see Tab. 2). Phytosociologically, they can be characterised as herb-rich *Fagus* forests or limestone *Fagus* forests (alliance *Fagion*) (Chytrý et al. 2001, Moravec et al. 2000). Visually, the habitats are either almost pure *Fagus* forests with rare presence of *Picea* and/or *Abies* (lower altitudes: hilly country, see Tab. 3) or mixed submontane or montane forests mainly composed of *Fagus*, *Abies* and *Picea* (+ *Acer*, *Ulmus*, etc.). However, there is one rather deviating record from Fryšavský kopec hill (Tab. 2), where *H. atramentosus* was found in a man-made *Picea* forest. However, in the past this area was also covered by forests dominated by *Fagus* with admixed conifers and other broadleaved trees.

As shown in Tab. 2, *H. atramentosus* was mostly found on slopes of mountains or hills. This is true for areas with higher altitudes (submontane and montane belts, see Tab. 3). However, 3 out of 4 localities situated in the colline belt (201–500 m a. s. l.), namely Libochovka, Coufavá and Josefovské údolí, are deep stream valleys. This shows that *H. atramentosus* requires habitats with a humid meso– and microclimate, which is either ensured by higher altitude or by microclimatic inversion in deep valleys. Further ecological requirements of this fungus are discussed in next chapter.

Thorough data on the ecology of *H. atramentosus* in Baden-Württemberg (Germany) were published by Krieglsteiner (2001). In many respects they are very similar to the data from the Czech Republic (substrates, occurrence among others in *Fagus* forests with admixed *Abies*, altitudinal distribution, preference for stream valleys, rareness). Polish data (Wojewoda 2003) show that its spectrum of habitats is broader (e. g. *Tilio-Carpinetum*, i. e. linden-hornbeam forest, obviously with presence of conifers as the substrate of *H. atramentosus*).

Is *H. atramentosus* confined to old-growth forests?

The data on the degree of naturalness of forest stands at Czech localities of *H. atramentosus* are presented in Tab. 2 and summarised in Fig. 1. The fungus shows clear preference for old-growth forests (for degrees of naturalness, see Material and Methods). The prevalence of natural and near-natural forests (which are slightly influenced by man) in comparison to real virgin forests is not caused by a low frequency of *H. atramentosus* in virgin forests but by the rareness of such habitats in the Czech Republic. In Boubínský prales virgin forest (the only virgin forest of the localities evaluated here) the species is well established, which is documented by its numerous records from there (Tab. 2).

However, the species is also able to live in man-influenced or even man-made forests. It is evident that a mere presence of a suitable substrate (fallen coniferous trunk or stump) combined with a humid microclimate of a closed forest stand (there are no records from clearings, forest margins, etc.) enables its occurrence. However, such records are really rare and accidental. On the other hand, when near-natural and especially natural and virgin forests with presence of old fallen trunks and stumps of *Abies* and/or *Picea* are investigated, the presence of *H. atramentosus* is highly predictable.

Clear linkage of *H. atramentosus* to old-growth forests is also documented by the fact that 13 of the 15 localities in the Czech Republic are various types of nature reserves (Tab. 2), where such forest types are protected.

From a purely scientific viewpoint, *H. atramentosus* cannot be considered a relict species confined exclusively to remnants of natural vegetation almost untouched by man. It clearly prefers old-growth forests but rarely occurs also in cultural ones. However, *H. atramentosus* can be used as a bioindicator of conservationally valuable forest stands (natural vegetation, presence of dead wood: fallen trunks and stumps in later stages of decay, stable meso– and microclimate), especially when combined with other species of similar character.

Such a conclusion relates primarily to the data from the Czech Republic. It is hard to judge its validity in a broader European context, as information on the degree of naturalness of the localities of *H. atramentosus* is lacking in literature. I can only discuss the records from Slovakia which were partly made by Czech mycologists or whose information is known due to the long common history (both political and mycological) of Slovakia and the Czech Republic. In Slovakia, *H. atramentosus* is also predominantly known from natural and virgin forests, mostly protected as nature reserves: Rozsutec, Dobročský prales, Švedlár: Na Hrabliach, Udava, Jarabá skala, Stužica (Kubička and Svrček 1955, Kotlaba and Pouzar 1962, Kuthan et al. 1999, Škubla 2003). I also know records from Ukraine, concretely from the Eastern Carpathians, where the fungus grows in natural montane forests, too (Kubička and Svrček 1955: p. 23 – PRM 488548, Holec 2008).

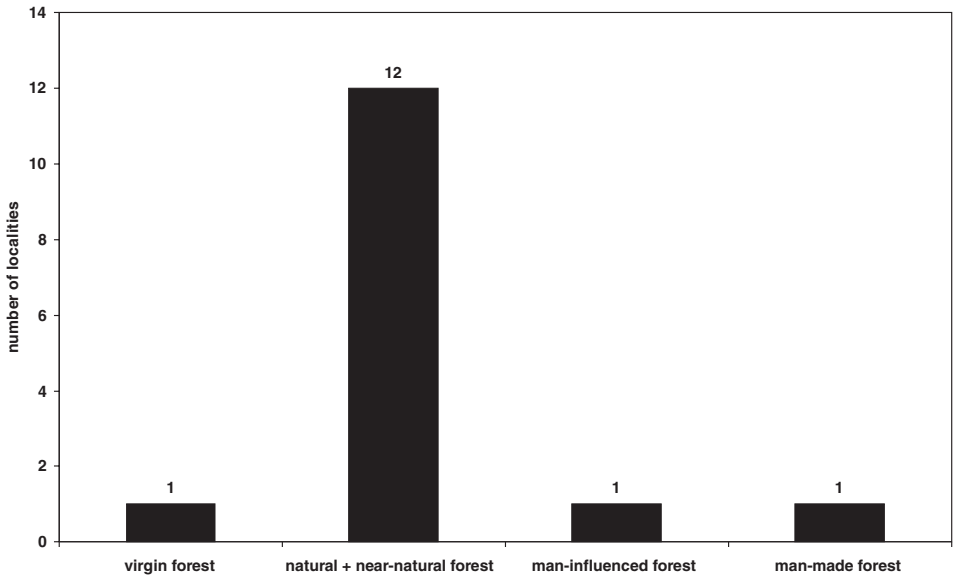

Fig. 1. Degree of naturalness of localities of *Hydropus atramentosus* in the Czech Republic. For description of the degrees of naturalness, see Material and Methods. The low number of localities characterised as virgin forest is caused by their rare occurrence in the Czech Republic, not by a low frequency of *H. atramentosus* in them.

ACKNOWLEDGEMENTS

I would like to thank Vladimír Antonín, Miroslav Beran, Zdeněk Pouzar, Pavel Špinar and Alois Vágner (all from the Czech Republic) for providing field data on their finds of *Hydropus atramentosus*, Armin Mešić (Croatia) and Beatrice Senn-Irlet (Switzerland) for reprints of literature, Tomáš Vrška (Czech Republic) on valuable discussion on the degree of naturalness of forests in the Czech Republic and Ivona Kautmanová (Slovakia) for data on specimens of *H. atramentosus* in herbarium BRA. The work was financially supported by the Ministry of Culture of the Czech Republic (MK00002327201).

REFERENCES

BENKERT D. et al. (1992): Rote Liste der gefährdeten Großpilze in Deutschland. – 132 p. Eching.

BERAN M. (1996): Houby Českokrumlovska [Die Pilze des Bezirks Český Krumlov]. – 32 p. Český Krumlov.

BREITENBACH J. and KRÄNZLIN F. (1991): Pilze der Schweiz. Vol. 3. – 394 p. Luzern.

CHYTRÝ M., KUČERA T. and KOČÍ M., eds. (2001): Katalog biotopů České republiky [Habitat catalogue of the Czech Republic]. – 304 p. Praha. (in Czech with English summary)

HANSEN L. and KNUDSEN H. (1992): Nordic Macromycetes. Vol. 2. – 474 p. Copenhagen.

HAUSKNECHT A., KLOFAC W. and KRISAI-GREILHUBER I. (1997): Die Gattung *Hydropus* in Österreich. – Österr. Z. Pilzk. 6: 181–210.

HAUSKNECHT A., KRISAI-GREILHUBER I., OSWALD I. and OSWALD W. (2006): Ergebnisse des Mykologischen Arbeitstreffens in Nenzing (Vorarlberg) im August/September 2004. – Österr. Z. Pilzk. 15: 67–93.

HOLEC J. (1999): Houby Šumavy chráněné zákonem nebo zahrnuté v Červené knize: nálezy v roce 1998 [Bohemian Forest fungi protected by law or included in Red Book: finds in the year 1998]. – Silva Gabreta 3: 17–24.

HOLEC J. (2008): Interesting macrofungi from the Eastern Carpathians, Ukraine and their value as bioindicators of primeval and near-natural forests. – Mycologia Balcanica 5(1–2) (in press).

HOLEC J. and BERAN M., eds. (2006): Červený seznam hub (makromycetů) České republiky [Red list of fungi (macromycetes) of the Czech Republic]. – Příroda 24: 1–282. (in Czech with English summary)

HOLMGREN P. K. and HOLMGREN N. H. (1998; continuously updated): Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. – http://sweetgum.nybg.org/ih/. [accessed 19 May 2008]

KOTLABA F. (1984): Zeměpisné rozšíření a ekologie chorošů (*Polyporales* s. l.) v Československu [Geographical distribution and ecology of polypores (*Polyporales* s. l.) in Czechoslovakia]. – 194 p. Praha. (in Czech with English summary)

KOTLABA F. and POUZAR Z. (1962): Lupenaté a hřibovité houby (*Agaricales*) Dobročského pralesa na Slovensku [Agarics and boleti (*Agaricales*) from the Dobročský virgin forest in Slovakia]. – Česká Mykol. 16: 173–191. (in Czech with English summary)

KOTLABA F. et al. (1995): Červená kniha ohrozených a vzácnych druhov rastlín a živočíchov SR a ČR. Vol. 4. Sinice a riasy. Huby. Lišajníky. Machorasty [Red book of threatened and rare species of the Slovak and Czech Republics]. – 221 p. Bratislava. (in Czech with English and German summaries)

KRIEGLSTEINER G. J. (1991): Verbreitungsatlas der Großpilze Deutschlands (West). Band 1: Ständerpilze. Teil B: Blätterpilze. – 1016 p. Stuttgart.

KRIEGLSTEINER G. J., ed. (2001): Die Großpilze Baden-Württembergs. Band 3. Ständerpilze: Blätterpilze I. – 634 p. Stuttgart.

KUBIČKA J. (1973): Přehled dosud publikovaných druhů hub z Boubínského pralesa na Šumavě [Übersicht den bisher veröffentlichten Pilzarten aus dem Kubani Urwald (Boubín) im Böhmerwald]. – Česká Mykol. 27: 212–228.

KUBIČKA J. and SVRČEK M. (1955): Helmovka sazová – *Mycena fuliginaria* (Batsch ex Fr.) Bres. v Československu [*Mycena fuliginaria* (Batsch ex Fr.) Bres. in Czechoslovakia]. – Česká Mykol. 9: 19–23. (in Czech)

KUTHAN J. (1981): Československo-polský mykotoxikologický seminář [Czechoslovak-Polish mycotoxicological seminary]. – Mykol. Listy 5: 22–24. (in Czech)

KUTHAN J. (1990): Mykoflóra SPR „Salajka" v Moravskoslezských Beskydech [Die Pilzflora des NSG "Salajka" in den Mährisch/schlesischen Beskyden]. – In: Kuthan J. and Kotlaba F. (eds.), Výzkum a ochrana hub v přírodních rezervacích – I., p. 21–31, Praha. (in Czech with German summary)

KUTHAN J., ADAMČÍK S., TERRAY J. and ANTONÍN V. (1999): Huby národného parku Poloniny [Fungi of the national park Poloniny]. – 197 p. Liptovský Mikuláš, Snina. (in Slovak with English summary)

LEGON N. W. and HENRICI A. (2005): Checklist of the British & Irish Basidiomycota. – 517 p. Kew.

LIZOŇ P. (2001): Červený zoznam húb Slovenska. 3. verzia (december 2001) [Red list of Slovak fungi. 3rd version (December 2001)]. – In: Baláž D., Marhold K. and Urban P., eds., Červený zoznam rastlín a živočíchov Slovenska, Ochr. Prír. 20., Suppl., p. 6–13.

MORAVEC J., HUSOVÁ M., CHYTRÝ M. and NEUHÄUSLOVÁ Z. (2000): Hygrophilous, mesophilous and xerophilous deciduous forests. – In: Moravec J. (ed.), Vegetation survey of the Czech Republic, Vol. 2, 319 p., Praha.

PAPOUŠEK T., ed. (2004): Velký fotoatlas hub z jižních Čech [Large atlas of mushroom photographs from southern Bohemia]. – 820 p. České Budějovice. (in Czech with German, French and English summary)

ŠKUBLA P. (2003): Mycoflora slovaca. – 1103 p. Šaľa.

SENN-IRLET B., BIERI G. and EGLI S. (2007): Rote Liste. Grosspilze. Rote Liste der gefährdeten Arten der Schweiz. Ausgabe 2007. – 92 p. Bern.

TKALČEC Z., MEŠIĆ A. and MATOČEC N. (2007): Crveni popis gljiv a Hr. – http://www.dzzp.hr/publikacije/Crveni%20popis%20gljive.pdf, http://www.dzzp.hr/eng_redlist.htm. [accessed 28 April 2008]

URBONAS V. (1970): 41 novyi dlya flory agarikovych gribov Litovskoi SSR vid. – Trudy Inst. Biol. Akad. Nauk Litovskoj SSR, ser. B, 2(52): 41–55.

VRŠKA T. and HORT L. (2003): Terminologie pro lesy v chráněných územích [Terminology for forests in protected areas]. – Lesnická Práce 82: 585–587.

VRŠKA T. et al. (on-line): Pralesy.cz. Přirozené lesy České republiky [Pralesy.cz. Old-growth forests of the Czech Republic]. – http://www.pralesy.cz/. [accessed 21 May 2008] (in Czech)

WOJEWODA W. (2003): Checklist of Polish larger basidiomycetes. – 812 p. Kraków.

WOJEWODA W. and ŁAWRYNOWICZ M. (2006): Red list of the macrofungi in Poland [Czerwona lista grzybów wielkoowocnikowych w Polsce]. – In: Mirek Z., Zarzycki K., Wojewoda W. and Szeląg Z. (eds), Red list of plants and fungi in Poland [Czerwona lista roślin i grzybów Polski], p. 53–70, Kraków.