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Scarletina bolete (*Neoboletus erythropus* (Pers.) C. Hahn) – an overlooked edible mycorrhizal mushroom in Poland: distribution, dishes, names, safety and legal issues

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Abstract: Boletaceae is one of the most important edible fungi families eaten in the world. Apart from the main edible species., i.e. *Boletus edulis* Bull. s.l., a number of lesser-known species are consumed. Scarletina bolete, *Neoboletus erythropus* (Pers.) C. Hahn, is widely eaten in Poland, mainly in the southern part of the country, though this aspect of culinary culture has never been reported in detail. This paper aimed to characterise the use of scarletina bolete in Poland, in particular to map the locations where it is used and to document its culinary uses. An online questionnaire was used. As many as 388 people who gather this species in Poland responded, providing information on places where it is consumed and local names. The respondents also described the dishes made with scarletina bolete. The reasons for it being overlooked and confused with other Boletaceae species are also discussed. The species is usually well-cooked or fried before use, as it is believed to be heavy to digest. It is incorporated into soups and stews. It is also preserved, dried or pickled. Scarletina bolete is widely gathered in the southernmost parts of Poland. Some people are cautious about its preparation and boil it discarding the water afterwards, sometimes repeating the process 2 or 3 times. Some people boil it or fry without any other precautions. Scarletina bolete is occasionally sold in the markets although, officially, it is not on the list of species permitted for sale. The species is used in classic mushroom dishes known in Polish cuisine.

Keywords: edible fungi, ethnomycology, novel foods, mycophilia, non-timber forest products

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Introduction

Many edible fungi collected in the world from the wild are ectomycorrhizal mushrooms associated with trees. This explains why edible mushrooms are considered one of the most important non-timber forest products in the world, especially in Eurasia and Africa (Pérez-Moreno et al., 2021; Boa, 2004).

Among the most important ectomycorrhizal mushrooms globally, the following groups deserve special attention: the Boletaceae, Suillaceae, Cantharellaceae, Amanitaceae and Russulaceae families, including such genera as *Boletus sensu lato, Suillus, Cantharellus, Russula, Lactarius* and *Amanita* (Boa, 2004). Understanding the utilisation, habitats and occurrence of these taxa may increase human livelihoods in local communities.

Poland is one of the most mycophilic countries in the world. For example, the study performed by Kotowski et al. in central Poland yielded the longest list of locally collected fungi species ever recorded (Kotowski et al., 2019). Mushroom picking in Poland is a phenomenon both rooted in traditional rural culture and still widespread in modern times (Bartnicka-Dąbkowska, 1964; Pawłowska & Gajek, 1981; Lehr, 2000; Marczyk, 2003; Grzywnowicz, 2007; Kłodnicki & Drożdż, 2008; Marciniak, 2008; Łuczaj & Nieroda, 2011; Łuczaj & Köhler, 2014; Grzywacz, 2015; Referowska-Chodak E, 2015; Kotowski, 2019; Kotowski et al., 2019). It is no wonder then, that it attracted the attention of ethnographers. A question about mushroom picking was even included in Rostafiński's survey from 1883 although the results regarding mushrooms have only been published in this century (Łuczaj & Köhler, 2014). Bartnicka-Dąbkowska (1964) compiled a special monograph documenting mushroom names. In the Polish Ethnographic Atlas, questions about mushroom picking were included in Questionnaire No. 6 from 1964 to 1969. This information was later clarified by the publication of a further survey on *Russula* and *Lactarius* spp. (Pawłowska & Gajek, 1981).

The first author of this paper has lived most of his life in south-eastern Poland in the Krosno county and has been collecting edible fungi and interacting with other mushroom pickers there since 1984. While analyzing the above mentioned older ethnographic data, he noticed that the scarletina bolete (*Neoboletus erythropus* (Pers.) C. Hahn, syn. *N. luridiformis* (Rostk.) Gelardi, Simonini & Vizzini, *N. praestigator* (R.Schulz) Svetash., Gelardi, Simonini & Vizzini, *N,* and *Boletus erythropus* Pers.) is commonly collected throughout the region and named *podciecz*. This was confirmed by field studies carried out in the Czudec area and in a census of edible mushrooms sold in the markets of south-east Poland (Łuczaj & Nieroda, 2011). Scarletina bolete is regularly sold in the city market of Rzeszów (Kasper-Pakosz et al., 2016; Ł.Ł. personal observations). It is a popular mushroom in these areas (Fig. 1) and, although not as prized as *B. edulis*, it is nevertheless eaten and even dried for winter use. Its consumption was also reported from the Sanok area (Marciniak, 2008) and one locality in the Mazowsze region (as *pójdziec*) (Kotowski et al., 2019).

Fig. 1. Scarletina boletes freshly collected by a mushroom picker in a forest in southeastern Poland.

The species has been reported as traditionally used in some other parts of the world, e.g. Ukraine (Zerova & Rozhenko, 1988) as well as Papua New Guinea (as *Boletus erythropus* var. *novoguineensis* (Fr.) Alessio) (Sillitoe, 1995). A few countries in Europe allow the trade of the species, i.e. Belgium. Bosnia-Herzegovina, Switzerland, France, Slovakia and Serbia (Peintner et al., 2013). The Compendium for Mycologists 2024, issued as a syllabus textbook to prepare for the Norwegian mushroom inspectors exam, lists it as edible with a caveat against eating it raw (Norwegian Council for Mycology, 2024).

Older Polish ethnographic studies do not mention scarletina at all. The first report comes from 2008 (Marciniak, 2008). The species was only mentioned in passing in another older mushroom field guide by Zabłocka (1948), who wrote that it was reported to be edible, however, due to similarity to toxic species, it should be excluded from culinary use.

In both Bartnicka-Dąbkowska's work on Polish fungi names (Bartnicka-Dąbkowska, 1964) and the field work of the Polish Ethnographic Atlas (in the 1960s) (Pawłowska & Gajek, 1981), the researchers used a small, illustrated field guide for mushroom identification by Orłoś in interviews with respondents in which this species does not occur. In the former case it was the 2nd edition (Orłoś, 1953) and 4th edition (Orłoś, 1957), in the latter the 6th edition (Orłoś, 1963). Orłoś' field guide does not contain the scarletina bolete, so respondents either did not mention it or misidentified it as the *Gyroporus cyanescens* (Bull. Ex Fr.) Quél, *Xerocomus badius* (now *Imleria badia*) *or Boletus luridus* (now *Suillellus luridus* (Schaeff.) Murril). These are other mushrooms that turn blue after cutting or bruising which were featured in the field guide. Also, as scarletina boletes are not collected commonly throughout the whole of Poland, the researchers may have had difficulty

understanding which species was meant by participants – if mentioned.

N. erythropus is distributed throughout most the territory of Poland with the exception of the northeast where it is practically missing (iNaturalist Neoboletus erythropus; GBIF Neoboletus erythropus). It is a mycorrhizal mushroom associated with several tree species, both coniferous and deciduous, such as *Abies alba, Carpinus betulus, Fagus sylvatica, Picea abies, Quercus robur* and *Tilia*. (Wojewoda, 2003).

Due to the scarce and scattered information about the use of this mushroom in Poland, an online survey was published in 2021 that aimed to collect data on the gathering, use and names of *N. erythropus* throughout Poland. This study comes under the category of 'citizen science', a method that is more and more widely used in science, especially in recording the distribution of rare or invasive taxa. The wide availability of online identification keys and other visual stimuli, social media, and smartphones in general, makes such research highly effective at supplying researchers with a large body of additional data. In the era of the 'global village', citizen science projects provide an opportunity for valuable studies of the biogeography and ecology of various groups of organisms (César de Sá et al., 2019; Colombari & Battisti, 2010; Howard et al., 2022; Aavik et al., 2024) including mycology (Heilmann-Clausen et al., 2016). Citizen science data is increasingly used in ethnobiology (Prūse, 2020; Łuczaj et al., 2023; Mulhauser & Gaille, 2024). In fact, citizen science was the basis of early ethnography in Europe, when field correspondents gathered data in remote areas – sometimes as a part of a larger research programme (Koay et al., 2020; Kalle et al., 2022). Such was the case in Poland with the extensive Rostafiński's questionnaire of 1883 (Łuczaj & Köhler, 2014; Köhler et al., 2023), the Polish Ethnographic Atlas research starting with the publication of Moszyński's maps from the 1930s (Łuczaj, 2014), through further map editions of the atlas (Łuczaj, 2008; Pieńczak, 2018), and Fischer's plant dictionary (Kujawska et al., 2017). Recently, a citizen science ethnomycological study was carried out to record the spread, uses and names of an edible American bolete species which recently appeared in Europe (Pietras et al., 2025).

Methods

The online survey was advertised in September 2021 to mushroom user groups on social media (Facebook and YouTube). At the time the data was gathered, the survey was displayed to a large audience – over 70 thousand subscribers – due to the fact that the first author of the paper runs one of the largest foraging channels on Polish YouTube (Łukasz Łuczaj – *Rośliny Jadalne i Dziki Ogród*). The questionnaire included a photograph of the mushroom with the official Polish name and eight questions (see Appendix 1). A large proportion of answers, including negative ones (i.e. "the species is not collected in our region"), were from participants with a high level of expertise in edible fungi – apparent from their use of specialist mycological terms.

As many as 389 responses were received (see the raw data matrix in the Repository). However, one entry, from Brojce, was an obvious duplicate and was excluded from further analysis. Therefore, the total number of respondents was 388, with 59% of the respondents being male and 39% female. The age range was from 18 to 70 years old (mean 42, median 40 years).

After collecting the main data matrix in August 2025, a second questionnaire (see Questionnaire 2, Appendix 2) was issued that asked participants about the mycological identification of some common local names for scarletina bolete. The rationale was to double-check whether there were any other mushrooms called by the common names reported in Questionnaire 1 (see Appendix 2). This time 109 people answered (see raw data matrix in the Repository). As many 67% of the respondents were male, 31% female. The age ranged from 18 to 73, mean and median 45 years old.

The data was later transferred from Google Forms to an Excel spreadsheet. After data analysis all personal information from the comments section was erased. The spreadsheet was uploaded in the Repozytorium Danych Badawczych Uniwersytetu Rzeszowskiego (Data Repository of the University of Rzeszów).

Results

Out of 388 responses received on the edibility of the species, 320 contained detailed information on the preparation of the mushroom or on the dishes prepared with it. Most responses reported that it is eaten. As many as 48.2% respondents claimed that it is eaten by 'many' people in their region; 42.5% said it is eaten by only a 'few' people; whereas 7.5% claimed that the species is considered 'inedible' and 3.9% were 'not sure' about the answer.

The vast majority (71%) of positive responses came from southern Poland, from the Carpathian region where the species is common (southern parts of Podkarpackie, Małopolskie and Śląskie) (Fig. 2). A separate cluster of use was reported in southwestern Poland in the Sudety mountain range and their foreground, with some reports from the northern areas near the Baltic Sea, and from the Świętokrzyskie Mountains in central-southern Poland. The central

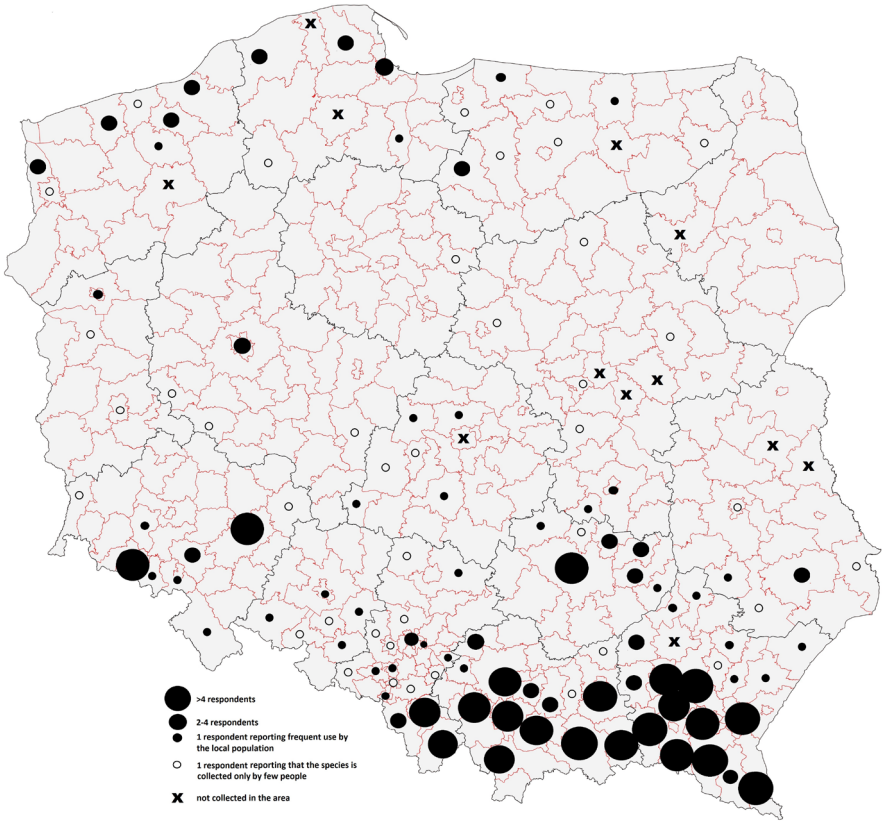

Fig. 2. The map of use of *Neoboletus erythropus* (and possibly to some extent also *S. luridus*) in Poland

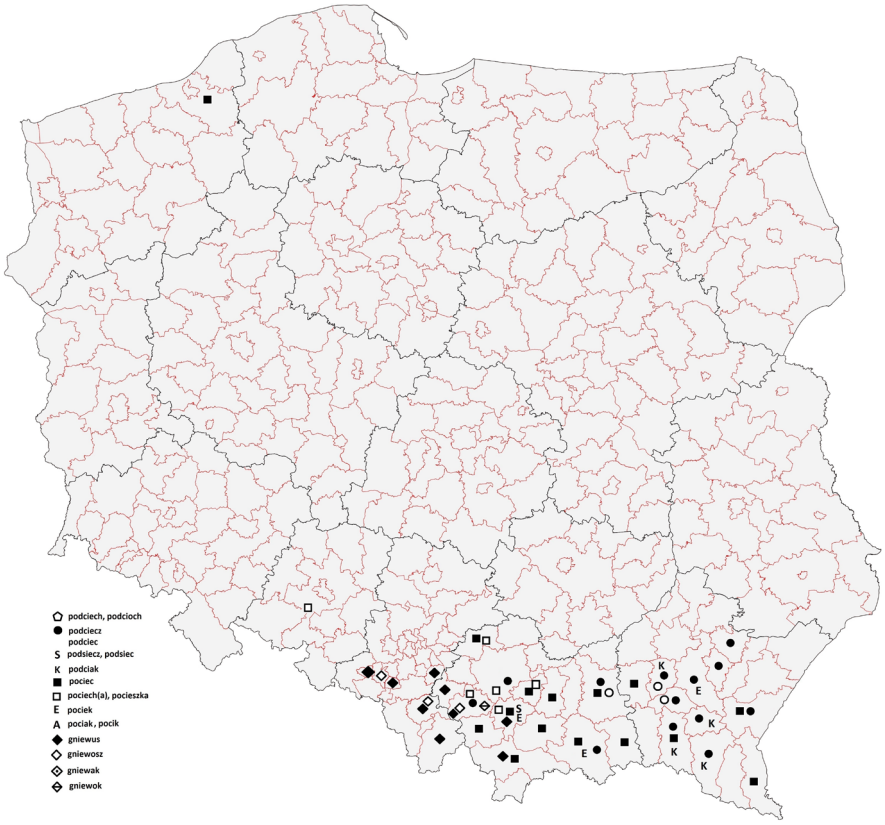

Fig. 3. Local names of *Neoboletus erythropus* (and possibly to some extent also *S. luridus*) that start with *po(d/t)c-* or *gni(e)w-*, with strong regional ranges, associated with the places where the mushroom has been traditionally used for generations

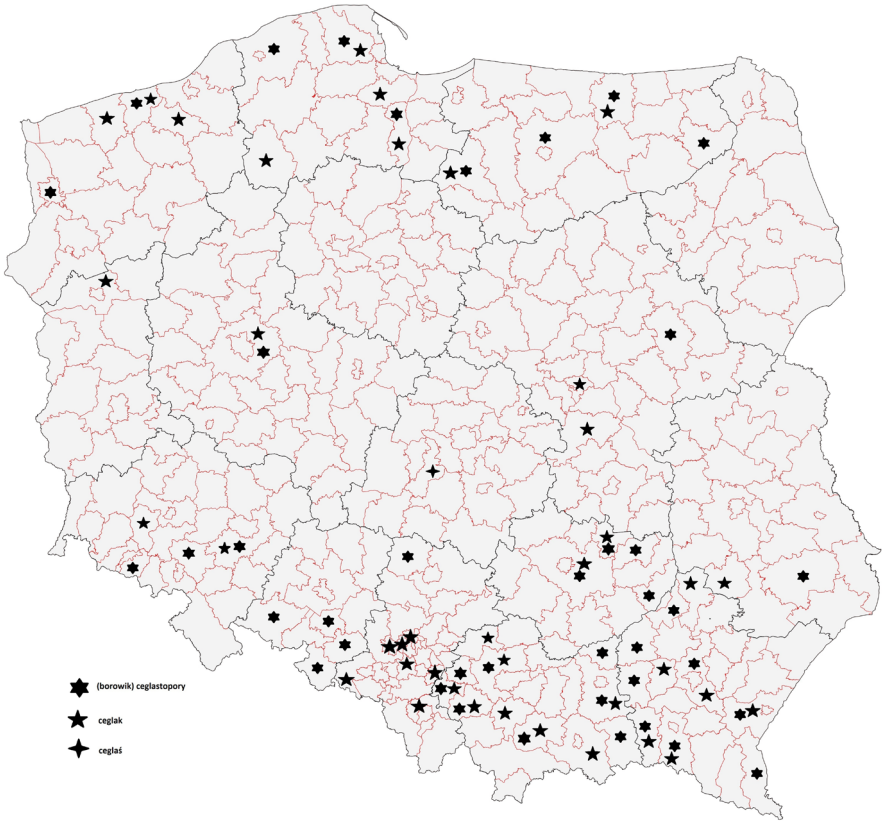

Fig. 4. Scarletina bolete names deriving from its official name created in the 20th century

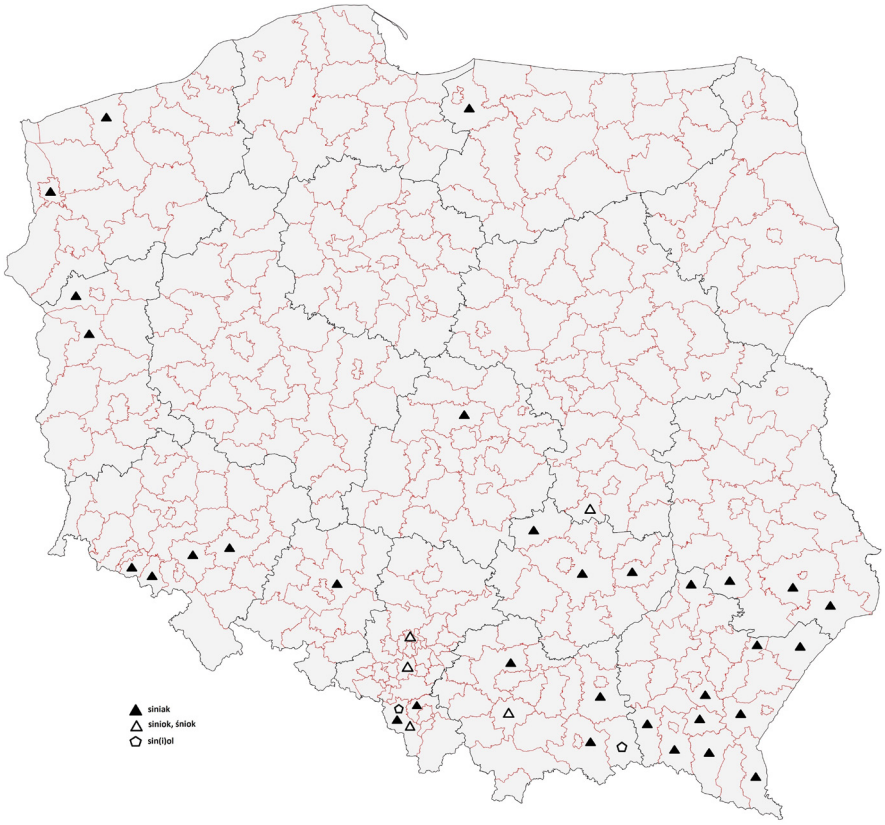

Fig. 5. Places where *Neoboletus erythropus* (and possibly to some extent also *S. luridus*) is named *siniak,* a name applied to a few other mushrooms species

Table. 1. Different sources of knowledge about the edibility of scarletina boletes. Selection of original statements of the respondents

Respondent's statement (translated from Polish)	Voivodship	County	Age	Gender
New uses				
I've been picking and eating them for 15 years or so. I learned to identify them myself, based on a mushroom atlas. For 5 years or so, I've been observing their popularity among mushroom-picking friends.	Dolnośląskie	Wrocław	61	Female
I've known and been picking them for over a dozen years, but no one in my family had ever picked them before.	Lubelskie	Lublin	46	Female
I've been picking it for four years; I wasn't familiar with it before because it didn't grow in the areas I went mushroom picking. I first encountered it in the forests near Mogielica, and since then, it's been a reliable place to pick this species every year.	Małopolskie	Limanowa	34	Male
We've been picking it for over a dozen years, in the Noteć Forest, in the Low Beskids near Wysowa, and in Lesser Poland near Myślenice. We're still discovering new mushrooms.	Małopolskie	Myślenice	66	Female
I learned about them myself, from an atlas. My mother thought they were „poisonous," „satanic."	Małopolskie	Nowy Sącz	34	Male
We've been eating it in our family for 15 years, when my dad joined a mushroom picking club.	Małopolskie	Wieliczka	27	Female
About 30 years ago, an alcoholic neighbor showed me these mushrooms. He still picks them and is still alive (and still drinks), so I figured that even for an alcoholic's metabolism (with a heavily burdened liver), the mushroom is safe. Maybe it even has medicinal properties, because most people I know would be living in a cemetery long ago if they consumed that much. And my neighbor is doing well considering his age despite such a debilitating hobby as he eats literally everything with alcohol. Later, when I met other mushroom pickers (mostly elderly people), I also confirmed the edibility of this species. But generally, the mushroom isn't widely picked (thankfully, because I mainly pick it in the summer, when other mushrooms are scarce or scarce).	Podkarpacie	Leżajsk	50	Male
I've known them for some time, but I recently started picking them with my family. We used to think this mushroom was inedible (indigestible). At my urging, we've already collected a lot of red boletes this year, and I hope that picking this species in our family will continue.	Podkarpacie	Stalowa Wola	18	Male
I included scarletina bolete in my diet contrary to family tradition.	Pomorskie	Słupsk	52	Female
I only encountered this mushroom in the 2000s; I hadn't encountered it before.	Pomorskie	Tczew	53	Male
I discovered this mushroom a few years ago at a mushroom gathering. Previously, I had only picked mushrooms in forests where it didn't occur and hadn't heard of it. This mushroom is what started my fascination with the world of fungi.	Śląskie	Gliwice	34	Female
I've been picking it for a short time; previously, it was very rare, but recently it's been more common.	Świętokrzyskie	Kielce	50	Female
I've been picking them for 5 years; my main source of information about this mushroom is the internet.	Świętokrzyskie	Sandomierz	47	Male
I taught my parents how to pick them from an atlas.	Świętokrzyskie	Ostrowiec Św.	34	Male
I started eating it when it started appearing more frequently in my area. My mother was afraid to pick it because she'd heard it was poisonous. Now everyone in the family eats it.	Warmińsko-mazurskie	Iława	25	Female
Traditional uses				
most people in my region are afraid to pick them, but there are some connoisseurs. My parents taught me about their edibility, so picking them isn't unusual for me.	Małopolskie	Gorlice	27	Female
From my parents.	Małopolskie	Nowy Sącz	46	Female
Well-known and loved. From my grandfather and great-grandfather.	Małopolskie	Sucha Beskidzka	39	Male
My dad has been picking these mushrooms in the wooded ditch behind the house for as long as I can remember.	Podkarpacie	Jarosław	26	Female
From my parents since I was a little kid.	Podkarpacie	Mielec	33	Male
A mushroom I've known since childhood.	Podkarpacie	Ropczyce-Sędziszów	35	Male
The mushroom was picked by my grandfather, who came from the Mszana Dolna area; the younger members of the family don't pick it anymore.	Śląskie	Bieruńsko-lędziński	26	Male
My grandfather taught me that they are edible and tasty, but many people consider them to be evil/poisonous.	Wielkopolskie	Poznań	37	Female

and northeastern part of Poland seems unfamiliar with the species and its use (Fig. 2).

Some of the more commonly used names have distinctive distribution ranges. For example, the name *podciecz* is mainly used in the easternmost part of the Carpathian range, *pociec* further east, and *gniewus* in the westernmost part of the Polish Carpathians. These name ranges only slightly overlap (Fig. 3).

Three types of name are distributed more evenly throughout Poland: *ceglastopory/ceglak/ceglaś* (Fig. 4), *siniak* (Fig. 5), as well as the lesser used name *szatan* (literally 'Satan'). The latter is mainly used in those areas where the species is not treated as edible and the name *szatan* is commonly applied to many inedible or toxic boletoid fungi, throughout Poland.

Only 85 respondents mentioned the source of their knowledge on the edibility of scarletina boletes. Just 29% of them stated that it was their family tradition. As many as 63% had learned about using this mushroom from books or internet sources, and 7% learned from friends or colleagues. Examples of some of the stories that describe the ways that respondents learned to use the species are found in Table 1.

Numerous respondents stated that scarletina boletes were rarer in the past and that they became more abundant during the beginning of the 2000s. However, this may be a bias as many people only notice individual species when they know to look for them.

As many as 320 respondents gave details on the culinary use (Table 2). Stewing to make sauce was reported by 39%. The same proportion of respondents dried the mushrooms for further use, whereas 24% pickled them in vinegar. Making soup was also relatively common (24%). Less common uses included: frying the mushroom with eggs (5%); using it as a dumpling filling (4%); and as an ingredient for cabbage dishes – mainly *bigos* (3%), a traditional Polish dish.

There was a clear consensus that scarletina boletes are always processed by either boiling and/or frying them. Some respondents recommended first boiling, then straining the water before then frying or, alternatively, boiling them 2 or 3 times. Many people reported that dried specimens can be directly added to a soup. However, there was no consensus on the preparation techniques, e.g. various boiling times were suggested, even up to one hour. These long preparation times may indicate an uncertainty as to the scarletina's edibility, as most other edible boletes are only cooked once.

Many respondents did emphasize that the species can be used as "any other mushroom". In the context of Polish cuisine, this means using it for soups and stews – often with meat or/and cabbage; frying in butter with onions – often with cream added; or frying with eggs. Such dishes were also mentioned directly in the responses (Table 2). On the other hand, some people were reluctant to cook the species as it stains the sauce or water dark, nearly black. This could be the main reason why most report that the fungus is boiled and then the cooking liquid strained off.

Table 2. Processing techniques and dishes made with *N. erythropus*

Technique / dish	N	% (N = 320)
stewed to make sauce	125	39.1
dried for further use	124	38.7
pickled in vinegar	78	2.4
used in soups	73	22.8
fried	47	14.7
just prepared like other mushrooms	46	14.4
boiled	33	10.3
fried with eggs	15	4.7
used as filling for dumplings	12	3.7
frozen for further use	9	2.8
ingredient of bigos (a cabbage dish with meat)	9	2.8

Discussion

Distribution

Apart from the main area of scarletina bolete's traditional use in the Carpathians (Fig. 2), some isolated islands of use occur in southwestern and northern Poland. These are areas that were resettled after World War II, mainly by Poles from the present territory of Ukraine, and by Ukrainians from southeast Poland (Domke, 2009). These settlers may have brought the gathering traditions from the Ukraine with them.

The genus *Neoboletus*, with its main representative *N. erythropus*, is distributed all over Poland but it has hardly any localities in the northeastern part of the country (GBIF Neoboletus; GBIF Neoboletus erythropus). The maps of the distribution of scarletina bolete in Poland, in the iNaturalist website (see link in the references) and in the GBIF database, are very similar to the map recording the use of the species in Poland (Fig. 2) – with many localities in the Carpathians and the Sudety mountains, the coastal areas, plus scattered localities in the western and central part whilst completely missing from the North-East. Also, Wojewoda (2003) in the checklist of the Basidiomycetes in Poland, mentions that the species is common only in the Carpathians.

Another species from the same genus in Poland is *Neoboletus xanthopus* (Klofac & A. Urb.) Klofac & A. Urb., which was described in 2014 as *Boletus xanthopus* (Klofac & A. Urb.). This species is very little known in Poland and may well be collected with

N. erythropus as its fruiting bodies are very similar and edible in the same way. It prefers thermophilous broadleaved forest and is known to occur in Poland, but the data on its distribution in all parts of Europe are insufficient (see GBIF Neoboletus xanthopus; Urban & Klofac, 2015).

As the Carpathians is a place where the scarletina bolete is most abundant, it could become an easily recognised, steady component of the regional diet. Mushroom picking can benefit socially disadvantaged communities, in both urban and rural areas, contributing positively to both diet and income (Olah et al., 2020). While the scarletina bolete occurs in other parts of Poland, it is considered a rare mushroom and is not commonly collected there.

Trustworthiness of the reports

The fact that such an important food species was overlooked by ethnographers for over a century, although not misidentified, demonstrates that using visual stimuli in ethnographic and ethnobiological research may lead to misinterpretations, and that rural populations often have problems with identifying organisms in illustrations (de Medeiros et al., 2008). The species did not occur in the Orłoś's field guide of edible fungi (Orłoś, 1953; Orłoś, 1957; Orłoś, 1963) (used in studying fungi names and fungi use in the 1960s), which led to the fact that names for this mushroom were often assigned to other taxa that turn blue after bruising (*S. luridus*, *G. cyanescens* and *I. badia*).

Nowadays identifying fungi is much easier, even for amateurs, by using richly illustrated field guides, online AI-supported identification software, and discussion groups on the internet. That is why mapping the use of the species has become easier and more accurate.

On the other hand we note that, in some cases, respondents may have occasionally confused *N. erythropus* with *S. luridus*. Although the two taxa are distinguished by very experienced mushrooms pickers we may suspect that in some areas the two species may bear the same folk name and be the same folk species (for literature on folk taxonomy see Berlin et al., 1973).

Folk names

The distribution of names of mushrooms starting from *po(d/t)-* and *gni(e)-* in the Dąbkowska's atlas (assigned to various fungi species) (Fig. 6) can be compared with the distribution of names for scarletina boletes in this study (Fig. 3). According to the results from Questionnaire 2, it seems that the names *podciecz, pociec, gniewus* and the like are nearly

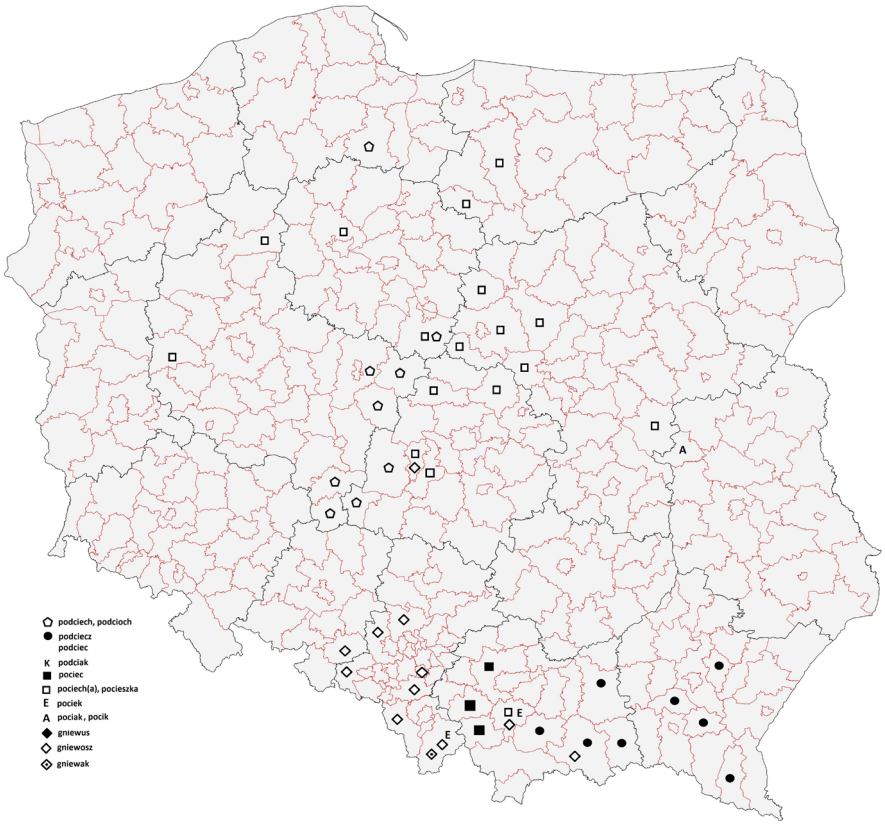

Fig. 6. Mushroom names starting with *po(d/t)c-* and *gni(e)w-* using data extracted from the atlas of Polish fungi names by Bartnicka-Dąbkowska (1964).

exclusively used to name scarletina boletes, whereas the name *pociech(a)* is used for scarletina boletes mainly in southern Poland, while in central-western Poland (Łódzkie region) *pociech(a)* is used to name *Suillus variegatus* (Sw.) Richon & Roze, and in central Poland (Mazowieckie region) to name the orange capped *Leccinum* species.

It is worth noticing that the names starting from *po(d)-* and *gni(e)-* seem to be old folk names in contrast to the names now spreading, such as *ceglastopory, ceglak* and *ceglaś*. The latter group are transformations from the official name *borowik ceglastopory* given to the species by the Polish mycologist Alina Skirgiełło in the 20th century (Skirgiełło, 1939; Skirgiełło, 1960; Wojewoda, 1977). In 2021, the official name was changed to *krasonoborowik ceglastopory* by the Polish Mycological Society.

Those names starting with *po(d/t)-* could be derived from the word *pot* meaning 'sweat'. One explanation of the etymology is that scarletina's red colouring reminds one of a sweaty person. Another interpretation is that the consumption of it can cause sweating (an explanation mentioned by Orłoś (1957) in the chapter about *S. luridus* but probably confused by him with *N. erythropus*). However, considering phonological reasoning and the presence of some variants of the names, it is more likely that it evolved from a name which had a stem *–ciec*, meaning *to drip*, or *-ciesz-* or *–ciech-* meaning *joy*. Moreover, *pociecha* means something like 'comfort, loser's prize' and some participants reported that the mushroom is sometimes more abundant than the more highly-prized *Boletus edulis*. So, for some people, finding this species is better than nothing – although it is considered second-best.

The naming of the mushroom as *siniak* is another issue. This name derives from the adjective *siny* meaning blue or bluish-grey. It has been applied to many species of fungi which turn blue or grey (Referowska-Chodak, 2015), especially *Gyroporus cyanescens* and *Imleria badia*.

Citizen science

Citizen science is increasingly used in ecology and other biological sciences, as mentioned in the introduction (Beck et al., 2024). It is only gradually gaining traction in regular ethnobiology (Vandebroek & Albuquerque, 2024) including ethnomycology (Pietras et al., 2025). This may well be due to the fact that ethnobiological research explores interactions with low-educated or even illiterate rural populations, who are often without internet access – although internet use is rapidly increasing. Moreover, voucher specimens are usually needed for ethnobiological publications. The shift from only allowing voucher specimens to accepting photographs, together with widespread internet access on smart phones, may encourage the greater use of citizen science data (Greene et al., 2023; Holt et al., 2023). We hope that this study will also encourage the application of citizen science to ethnomycology. As well as its relevance for studies of the use of fungi, it could also be applied to recording changes in the population dynamics observed by mushroom pickers. This could be an especially important tool on monitoring the ectomycorrhizal relationships between mushrooms and trees. Some promising results of combining ethnomycology and population monitoring have already been provided by Kotowski et al. (2021). In the latter study, the views of interviewed rural inhabitants on the changes in mushroom populations were recorded. This could be extended to large communities of mushroom pickers in online questionnaires.

Dynamics

It is not apparent that the scarletina bolete was ever a preferred mushroom. Łuczaj and Nieroda (2011) reported it being 11th in the frequency of mushrooms gathered in the Dynów Foothills of southeastern Poland. This is probably the centre of the area where it is most frequently gathered. However, the use of scarletina boletes does seem to be increasing in Poland. This is illustrated by the fact that nearly two thirds of the respondents learned of its use from the media, thus the use of the species is expanding outside the regions of its local traditional consumption.

There may be two reasons for this. Firstly, the abundance of fruting bodies and the number of localites is possibly increasing – reported by mushroom pickers. This may be caused by climate change, although solid data is missing. Although the species occurs in most of western and central Europe and is recorded from coastal Norway to Greece, it achieves the limit of its distribution in eastern Europe. So there may be benefits from the increasing winter temperatures? Another reason could be the change in arboreal composition of the forests (e.g. the shift from pine plantation to deciduous forests). Unfortunately, the dynamics of edible mushroom populations is still little understood. Interviews with mushroom pickers throughout Poland (Kotowski et al., 2021), and the first author's life-long observations of the Polish mycobiota, show dramatic, unexplained changes in the abundance of some edible species in the last decades.

Secondly, with the advent of modern identification tools people feel more confident in gathering this species – as it can be confused with some less valuable Boletaceae species (*Suillellus luridus* (Schaeff.) Murrill), toxic (*Rubroboletus satanas* (Lenz) Kuan Zhao & Zhu L. Yang, syn. *Boletus satanas* Lenz) or the very bitter *Caloboletus calopus* (Pers.) Vizzini).

It must be stressed that overall interest in fungi gathering is still immense. Although less variety of fungi species are sold in open-air markets (see discussion in Kasper-Pakosz et al., 2016), compared to the results of fungi gathering in the 1920s reported by Szulczewski (1933), there is even a website nowadays that reports the daily occurrence of edible fungi fruiting in Poland – like a weather report (Snowarski, 2025) – with detailed descriptions of all the fungi species and numerous photos. In the first half of 2025, a group of experts from the Polish Mycological Society recommended the inclusion of the scarletina bolete in the new not yet published version of the official list of fungi allowed for food trade in Poland – the current one was updated in 2023 (see Ministerstwo Zdrowia, 2023) with one recent small change (Ministerstwo Zdrowia, 2025).

Safety

Although scarletina bolete is eaten by thousands of people in Poland and is regionally regarded as edible, many people report it as "heavy to digest" and recommend either thorough frying, or boiling and discarding the water. Problems with digestibility may, perhaps, arise because of the very firm texture of the fruiting body, which is attractive from the sensory perspective but may make it less palatable. This could be due to high levels of chitin – a hard-to-digest, insoluble fibre – recorded in some Boletaceae (Manzi et al., 2001). People may also fear the effect of the water turning black when boiled, associating it with poison or death.

At the present date, scarletina bolete does not feature in clinical reports from hospital toxicology units (Gawlikowski et al., 2015). There is one recorded case of vomiting after eating a lightly-cooked (sautéed) specimen (Arora, 1986). The species is not bitter, even in the raw state, and an indigestible compound or group of compounds has not been identified. However, many Boletaceae contain some, often only trace, levels of amatoxins, muscarine and gastrointestinal irritants (Faulstich & Cochet-Meilhac, 1976; Spoerke & Rumack, 1994). Even *Boletus edulis* contains amatoxins but in such low concentrations that it does not affect edibility. Spoerke and Rumack's *Handbook of Mushroom Poisoning* (1994) reports that some of the red-pored boletes, e.g. *Boletus luridus* (now *Suilellus luridus*), *B. pulcherrimus* (*Rubroboletus pulcherrimus* (Thiers & Halling) D. Arora, N. Siegel & J. L. Frank and *B. satanas* (now *R. satanas*) were found to contain muscarine, while many more species, including *N. erythropus, S. luridus* and *R. satanas* all contain gastrointestinal irritants. A group of variable compounds is suspected in gastrointestinal irritation as, in some cases, cooking neutralises the effect. These irritants are suspected to relate to the red colouration rather than the bluing, as many non-red boletes that turn blue are eaten without discomfort. The bluing is caused by enzymatic oxidation of the yellow pigments xerocomic and variegatic acids.

If gastrointestinal irritation does occur in red-pored boletes, the onset is within 15 minutes to 2 hours and may include nausea, vomiting, diarrhoea and stomach cramps or pain (Spoerke & Rumack, 1994). These symptoms generally resolve without treatment within 24 to 48 hours. Further chemical studies are needed to fully assess the edibility of scarletina bolete, as even widely-consumed mushrooms may be on the spectrum of toxicity and edibility (Nieminen & Mustonen, 2020).

More recently, a cytotoxicity assay carried out with both aqueous and methanolic extracts of *N. erythropus* on human foreskin fibroblasts-1 (HFF-1) in vitro, showed the extracts had no cytotoxic effect on HFF-1 cell lines (Garcia et al., 2022). However, there is some evidence that scarletina bolete is a mercury accumulator (Árvay et al., 2022) so it should not be harvested in contaminated or industrial areas, although Krejsa et al. (2024) concluded – after analysis of levels of 19 elements in the fruiting sporocarps – that occasional consumption was not likely to result in any negative effect on human health.

Legality

One of the reasons inhibiting wider use of *N. erythropus* in Poland is its legal status. In Poland, only fungi from an approved list can be legally traded in open-air markets, sold in shops and served in restaurants. Currently the list contains 71 species (Ministerstwo Zdrowia, 2023; with small update by Ministerstwo Zdrowia, 2025). *N. erythropus* is not on the list, partly because it was so overlooked and partly because it has a similar appearance to toxic species (e.g. *Rubroboletus satanas*). The fact that it is legal to trade it in a few countries of the European Union (Peintner et al., 2013) and in Norway (Norwegian Council for Mycology, 2024) supports the argument for the full legalisation of its trade in Poland, as well as all the countries of the E.U.

Cultural heritage

Scarletina bolete should be promoted as local culinary heritage in south-eastern Poland and the most important local names, such as *podciecz* and *pociec,* should be used in information brochures about edible fungi. That the use of scarletina bolete in south-eastern Poland is part of a long, uninterrupted tradition, is evidenced by the reporting of the mushroom in Rostafiński's questionnaire of the 19th century (Łuczaj & Köhler, 2014). In this paper's dataset, a mushroom called *pociec* is reported from Bystra

near Jordanów (Małopolskie region), and *gniewosz* from the villages of Brzeźnica, Czernichów, Kalwaria, Liszki, Skawina, Tyniec, also in the Małopolskie region, both corresponding to the present distribution of these names used for scarletina bolete in southern Poland. Moreover, the Ukrainian name *potiuk* was recorded in Winniki near Sambor (Ukraine, very close the present Polish border). Thus, in the case of scarletina bolete, it is not a case of creating a new fashion but of expanding a tradition of local use that was once restricted to parts of southern and southeastern Poland but is now spreading to new areas, due to increased identification possibilities and knowledge exchange. Also of significance, is that some respondents use this mushroom to prepare their *Wigilia,* i.e. Christmas Eve meal, which is the most important meal of the year, full of archaic dishes. The presence of the species on the table on that special day confirms that it is well-engrained in the culinary culture (Slevinski, 2007; Makała, 2015).

Conclusions

1. Scarletina bolete is widely gathered in the southernmost parts of Poland, in the Carpathians. It is quite appreciated but regarded as a second-class mushroom, inferior to *Boletus edulis*.
2. Some people are cautious about its preparation and boil it discarding the water afterwards, sometimes repeating the process 2 or 3 times. Some people boil it or fry without any other precautions.
3. Scarletina bolete is occasionally sold in the markets though officially is not on the list of species permitted for sale.
4. A matter requiring further study is the issue that *N. erythropus* is sometimes confused with the very similar *S. luridus*.
5. The species is used in classic mushroom dishes known in Polish cuisine. However, no specific dishes unique to this species are known.

Declarations

Consent for publication

Not applicable

Availability of data and materials

The dataset supporting the conclusions of this article is available in the data repository of the University of Rzeszów (Repozytorium Danych Badawczych Uniwersytetu Rzeszowskiego): https://rdb.ur.edu.pl/items/301a1e87-96c4-4c2e-83eb-f76985eb00f6.

Ethics approval and consent to participate

The research adhered to the Code of Ethics of the International Society of Ethnobiology (International Society of Ethnobiology, 2016). The participants agreed to take part in the research by filling in the questionnaires.

Competing interests

The authors declare that they have no competing interests.

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Authors' contribution

Research design, methodology, data analysis – Ł.Ł., original draft – Ł.Ł., M.W.

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List of figures

Appendix 1. Questionnaire no. 1

1. The mushroom has a cap that is brown on top, reddish underneath, and turns blue when cut. Its current scientific name is the scarletina bolete (*Neoboletus luridiformis, Boletus luridiformis, Boletus erythropus*). The research results will be used to develop a map of its use in Poland. The research is being led by Dr. Łukasz Łuczaj, professor. UR, University of Rzeszów
2. Provide the traditional name of the scarletina bolete in the town where you are completing the survey.
3. Is this mushroom considered edible there?
4. How is it prepared and what dishes are made? If they tell you something interesting about it, please write about it too. If you've only recently learned to eat this mushroom and don't know it from regional or family traditions, please describe it.
5. Voivodeship covered by the survey
6. County covered by the survey
7. Town or towns covered by the survey
8. Your age
9. Gender
10. Are you from this town and have you spent a significant part of your life there?

Appendix 2. Questionnaire no. 2

1. If you have ever encountered mushroom names such as: podczecz, pociecha, pociecha, gniewus, gniewosz, siniak, and similar, please specify below which of these names you have encountered. What species of mushroom does this name refer to according to the modern nomenclature of mushrooms (or describe the mushroom)?
2. Is this mushroom considered edible there?
3. Voivodeship covered by the survey
4. County covered by the survey
5. Town covered by the survey
6. Your age
7. Gender
8. Are you from this town and have you spent a significant part of your life here?
9. Please provide your comments or your email address for correspondence.