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ASSESSMENT OF ENVIRONMENTAL AND CULTURAL VALUES OF JARMUTA HILL IN SZCZAWNICA (POLISH CARPATHIANS)

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Abstract

The aim of this article is to present the history and the current condition of Jarmuta Hill, situated in Szczawnica (Małe Pieniny Range, Western Carpathians in southern Poland) in relation to its environmental and cultural values. Authors have presented the hill on the background of Pieniny region as an intricate object where cultural heritage intertwines with natural values. It is also an important testimony to the biological and geological structure, where cultural values are of great significance, as traces of human activity date back to medieval times.

Keywords*: Fungi; Bryophytes; Plants; Andesite; Nature protection; Biodiversity*

Introduction

Pieniny Klippen Belt, where the eponymous Jarmuta Hill is situated, is a narrow 3-5km (exceptionally 20km) zone on the border of the Outer Western Carpathians and the Inner Western Carpathians, extending in the shape of an arc (roughly about 550 km long) from the vicinity of Vienna in Austria to the mountains of Maramures in Romania. Jarmuta Hill is a small part of Małe Pieniny Range (Little Pieniny) which is located in the Central Europe on the boundary between Poland and Slovakia (Fig. 1). The geographical coordinates of the top of the hill are 49°24'39.9"N 20°30'21.1"E. The Polish part of this picturesque mountain chain is divided into three regions: western (created by scattered limestone rocks), middle (the highest elevations with the rough relief between Dursztyn village and Riečka stream), and eastern (in Slovakia, as a continuity of the middle region from Rozdziele Pass). The complicated structure allowed a more detailed division of the middle region into further three ranges: Pieniny Spiskie, Pieniny Centralne and Małe Pieniny with Jarmuta Hill. The Pieniny Klippen Belt is a very low mountain chain where the highest peak, called Wysokie Skałki (Wysoka), reaches only 1050m a.s.l. The most famous places in Pieniny are: Dunajec River Gorge, peaks: Trzy Korony, Sokolica, Wysokie Skałki, and nature reserves: Biała Woda, Homole Gorge [1].

Apart from the most popular places in the Małe Pieniny, there occur glacial relic plants such as *Dryas octopetala*, *Crepis Jacquinii*, *Trisetum alpinum* [2]. The Małe Pieniny was established as a Natura 2000 site to protect habitats and animals which are important for the protection of the European nature.

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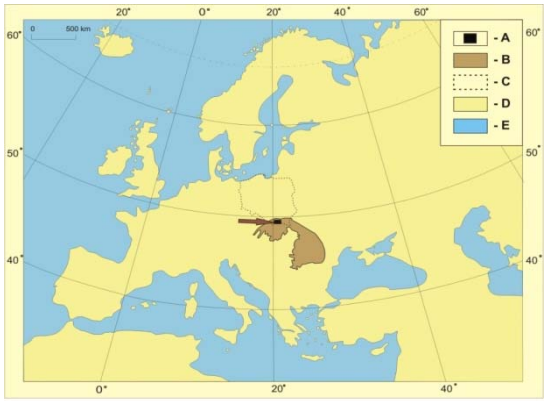

Fig. 1. The investigated area on the background of Europe. Explanations:
A – investigated area, B – the Carpathian mountains, C – Poland, D – lands, E – waters.

The Jarmuta Hill is a characteristic, isolated hill elevated 794m a.s.l. in the Małe Pieniny Range (ca 21km^2) in the southern part of Polish Carpathians (Western Carpathians), occupying an area of approximately 1.5km^2. The hill was already known to geographers in the 17th century and was described in 1616 as Hermut, and then in 1667 as Jarmonta [3]. Altogether with Wdżar and Bryjarka, it forms a series of andesite intrusion arranged along the northern border of Pieniny [4]. The nearest famous resort is Szczawnica on the Grajcarek river, which is the northern border of the Jarmuta Hill. From the south-east, the hill is delimited by Palkowski stream, and from the south-west - by Klimontowski stream. The southern part of Jarmuta borders with the Małe Pieniny Range, which is mainly built from limestone. The shape of Jarmuta allows to distinguish three peaks (Fig. 2): the highest one, Jarmuta (794m a.s.l), the eastern peak, Czuprana (777m a.s.l.), and the north-western peak, Jarmutka (690m a.s.l.). Currently, a conspicuous element in the area is the TV relay transmitter, which was installed in 1963 [3].

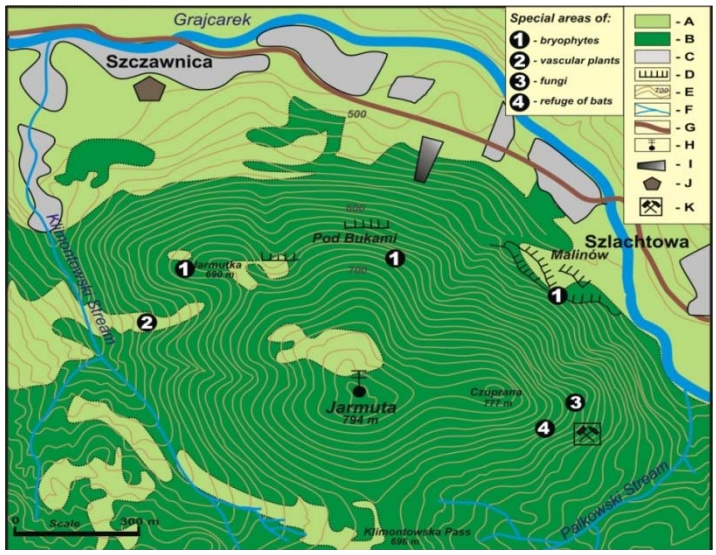

Fig. 2. Cultural and natural values of Jarmuta Hill (original drawing) . Explanations:
A – non-forest area, B – forest and thicket, C – buildings, D – quarries, E – countour lines,
F – streams, G – main road, H – TV relay transmitter, I – non-exist ski jumping hill,
J – place with remains from the Bronze Age, K – adit.

Methods

From the cultural values point of view the field archeological research was applied on the standard of surface investigation [5] enhanced it by GPS technology [6, 7]. The cultural heritage was described on the base on source query.

Methodology of mycology was done by observations of the biota of macromycetes on the Jarmuta Hill were conducted using the route method, trying to capture the greatest variety of terrain in June, September and October 2015. The subject of the research was non-lichenized fungi of different systematic, trophic and ecological groups. The collected material was determined by means of a light microscope with an immersion lens with a magnification of 100×. Microscopic preparations were made from fresh fruit - water, Melzer's reagent, Congo red 10% solution with ammonia and cotton blue solution [8]. Identification of species was made on the basis of keys: [9-11]. The Latin names of fungi were adopted as the Index Fungorum [12]. Threatened categories were adopted according to [13]. The location of valuable species was determined using the GPS receiver. Specimens of valuable species are kept in the author's private herbarium (PCh).

In another aspect, the methodology of the field works on the bryophytes and vascular plants was conducted mainly in the October 2015. During the field investigation various niches are checked. The liverworts and moos were identified based on the publication of *W. Frey et. al.* [14], using an optical microscope. The Latin names were accepted by *J. Szweykowski* [15] and *R. Ochyra et. al.* [16]. The vascular plants were recognized mainly by the *L. Rutkowski'*s key [17] and the names [18]. The stations of plots and the locations of protected and threatened species were determined using the GPS device. List of plant species contain the taxa found during the field researches supplemented by published data.

Climate

The Małe Pieniny Range is characterized by the specific meteorological conditions in comparison with other ranges of Polish Carpathians: relatively high air temperature, light precipitation and small cloudiness [19]. The average annual temperature ranges between from 3.9°C to 6.3°C. The warmest areas are the Dunajec valley, the tributaries, and the southern slopes. The lowest average monthly temperatures are recorded in January-February (the absolute minimum -36.3°C), whereas the highest montly temperatures are noted in July-August (the absolute maximum 34.7°C) [20]. Precipitation is relatively low, within the range of 700-900mm per year, with the highest rainfall in the period of June-July. This is a small amount comparing to the surrounding mountains (Gorce Mts 800-1200mm per year, the Tatras to 1876 mm per year). The minimum rainfall is recorded in January-February (30-40mm precipitation), while the maximum in July-August (to 115mm precipitation) [21]. The number of cloudy days (cloudiness greater than or equal to 80%) increases with the height above the sea level and depends on the exposure area – rises on the southern slopes. The greatest cloudiness is observed from November to March (11-16 days per month), and the lowest in September (8-10 days per month) [22].

In the Pieniny Range, two climatic belts were distinguished – moderately warm and cool temperate [22]. The moderately warm belt with an annual air temperature in the range 6-8°C is noted only on the southern slopes, to a height 420-520m a.s.l. and is characteristic for the eastern part of Hombark-Branisko ridge, the Dunajec valley, or the wersten part of Małe Pieniny Range. The cool temperature belt with an annual air temperature 4-6°C occurs from 420m a.s.l. on the northern slopes and from 520m a.s.l. on the southern slopes to the highest tops [19].

Soils

The current lithological, biological, and relief diversity in the Pieniny Range reflects the soil cover. The most frequent type of soil is the initial soil, which is specific for mountain areas. Characteristic types of soil for the Pieniny are rendzinas. Their occurrence is related to the

presence of carbonate rocks in the bedrock. Besides the characteristic rendzinas, the largest area is covered by brown soils, while mineral or peaty; gley and the alluvial soils are limited to river valleys [19, 23].

Cultural heritage

From the point of view of research on prehistoric settlements and later settlements (medieval), the Jarmuta Hill is poorly examined. There exists information about conducting archeological excavations on the hill before the Second World War [24], but the result of the excavation is unknown. Moreover, there are theories from the 19th century about the discovery of bronze treasure and the location of an undefined early medieval temple [25]. Until today, this information has not been confirmed and cannot be confirmed without archeological excavations.

Stone tools made from andesite were found mainly in Slovakia [26]. The archeological research on the Neolithic sites on Spiš provided the relics made from a raw material that could be derived from deposits, among others, from the Jarmuta Hill [27]. The hypothesis about the utility of andesite from Jarmuta is probable since there are the largest deposites of raw material [28]. However, there is no evidence which could support the theory of andesite from Jarmuta used to produce stone tools. Probably, it could originate from rocky areas located in the south of the Małe Pieniny Range [29].

The surface research in the Centralne and Małe Pieniny has been conducted since 2012 and has covered the Jarmuta hill as well [6]. During the field works on the foothill on the NW slope, stone remains were found dating back to the Bronze Age. These could be evidence that the area was then inhabited by people. In addition, fragments of ceramics from the Middle Ages and the modern period were found as well (Fig. 2). In this case, we could probably consider the agricultural use of the land.

In the modern times, also in the 20th century, the Jarmuta Hill was used for agricultural purposes. A characteristic feature of the Małe Pieniny Range was using a large part of the range as arable fields (except for the strongly inclined slopes) which were caused by an excess of inhabitants in relation to the production capacity of soil ("land hunger") [1, 30]. Currently, the agriculture residues can be poorly observed in the landscape as the forest area increased or the agricultural use of land ceased [31, 32]. The effects of this phenomenon can also be observed on the Jarmuta Hill, especially on the northern, southern and western slopes.

At the same time, in the eastern part (higher belts of Czuprana peak), the ground was too rocky and inclined to allow the cultivation of the land. The ethnographic examinations confirmed the thesis that only the areas where it was "physically" impossible were not cultivated, while the remaining parts of the area were either forested, or suitable for grazing [32, 33]. The agricultural belt in the Małe Pieniny reached an altitude of 800-900m a.s.l., located on the Jarmuta Hill as well [34, 35].

The area was used for agricultural purposes, thus it may be assumed that farming there proceeded in a similar way like for the neighboring areas, including the fact that the fields were left fallow from time to time. This was due to high stoniness and considerable remoteness from the nearest permanent farms [36]. Early farming was very primitive. The trees, most commonly grey alder *Alnus incana*, were cut or burnt, and between the remains the oat was sown. In this farming method, improved properties of grey alder were used [37].

Currently, in the forests of Jarmuta Hill, it is possible to see the artificial relief of arable fields; they resemble terraces. Traces of ancient agricultural habits can be found in many mountain areas [38].

An important issue for the cultural heritage of Jarmuta Hill is mining and excavation of andesite in the quarries. The remains of these activities are visible in the landscape of the hill (Fig. 2).

Ore excavation was discussed in the literature of cultural heritage repeatedly, where the related mining infrastructure was described as well [39-42]. Near the adit on Jarmuta, there is a

second one in Palkowski Potok stream, which, due to its location outside the hill, will not be described here [39]. Some authors speculate that the attempts to search for ore in the vicinity of Szlachtowa village can be traced back to 14th century [39]. However, there is no direct evidence, apart from some enigmatic writings. It seems that the interest in bullion by Pieniny seekers can be considered since the 15th century, as indicated by the royal privileges on exploration [42]. Unfortunately, places where excavations could be held in this matter have not been discovered yet.

The existing adit on the Jarmuta Hill was explored in the 1730s. Specialist explorers worked there, supported by the local people. The adit has two levels: the upper one and the lower one. They are connected by a ramp. At present, the lower level is flooded by water [39 and cited references therein]. Probably, during mining operations, similar techniques were used like in other areas, for example timber framing of tunnels. For instance, in the Lower Silesia, dendrochronological examination of wood in old mines was conducted and the results showed that soft wood from coniferous trees like Scotch Pine was used to keep the celling [43].

The reason for mining was pyrite occurring on Jarmuta Hill, which is the result of propylitisation of andesite and which indicates the veins of ore (for southern areas) [44]. The occurrence of pyrite suggested the existence of precious metals. Besides, there is a presumption of the existence of primary gold deposits within the hill [45]. However, despite the fact that ore minerals such as native gold and negligible amounts of native silver were found in the adit found as well [44], this mountain has deposits so poor that mining works were abandoned relatively quickly. The calculations show that from 1 ton of harvested rock only 575 grams of iron and 1 gram of gold can be obtained [39, 46].

A chronologically earlier, yet a similar issue, is the remains of quarries. As in the case of Bryjarka Hill, andesite was mined here [26]. There were two places on the northern slope where the rocks were mined: the Malinów quarry (bigger) and the Pod Bukami quarry (Under Beeches quarry). They were established before the Second World War and remained intact until the 1970s [47]. Both quarries operated mainly after the 1940s, but the Pod Bukami quarry was just complementary to Malinów quarry, which was easier to access. The Pod Bukami quarry is located higher and is more difficult to use. The quarried stone was used in the road works [26 and cited references therein]. Probably, the andesite from Pod Bukami quarry was used as cladding of buildings where the Bank Gospodarstwa Krajowego in Warsaw was housed formely [48], but other authors believe that the andesite came from Wdżar Hill in Kluszkowce village [49].

The last element of secular heritage was the ski hill which was built in 1930s on the northern slope of Jarmuta. Its inrun was directed into Malinów quarry. Unfortunately, during the Second World War [50], the sport facility was destroyed (Fig. 2).

Beside the description of common heritage, a sacrum zone existed on the Jarmuta Hill. Within the sacred zone, there was the statue of Virgin Mary, built in the 19th century. This figure was located on the top of the hill and was placed on a base made from stone (andesite?) [51]. Contemporary, the statue does not exist, because it was destroyed by a lightning in the 20th century [52]. The current figure is relatively new and was founded, among others, by the Canadian Polonia. Besides, on the north side of the hill, there is a small wooden chapel and a cross founded by the inhabitants of Szczawnica.

Natural wealth

From the geological point of view, the Małe Pieniny Range belongs to the Pieniny Klippen Belt (PKB) structure, which is a long tectonic unit and forms the northern limit of the Inner Carpathians in Poland. Several kinds of sedimentary rocks (limestones, marls, siliceous, conglomerates, sandstones, shales etc), which occur in this region, were deposited during the Mesozoic and Paleogene times (200-20 million years ago, approximately) in northernmost part of the huge Tethys Ocean. During the Alpine orogenic movements, those rocks were extremely deformed (at least three times – during the so-called orogenic tectonic phases) which resulted in

very complicated tectonic structures in this area [53-55]. Continuous sequences of such rocks, their diversity and origin are a perfect fossil record of the long history of this part of paleo-ocean Tethys [56, 57].

The Jarmuta Hill is one of the most distinctive parts of the Małe Pieniny Range and is built from the Mesozoic rocks (mainly Cretaceous) and Paleogene ones (Paleocene especially) of the so-called Grajcarek tectonic unit, which was originally distinguished by *K. Birkenmajer* [58] (see also – [53-55]) (Fig. 3).

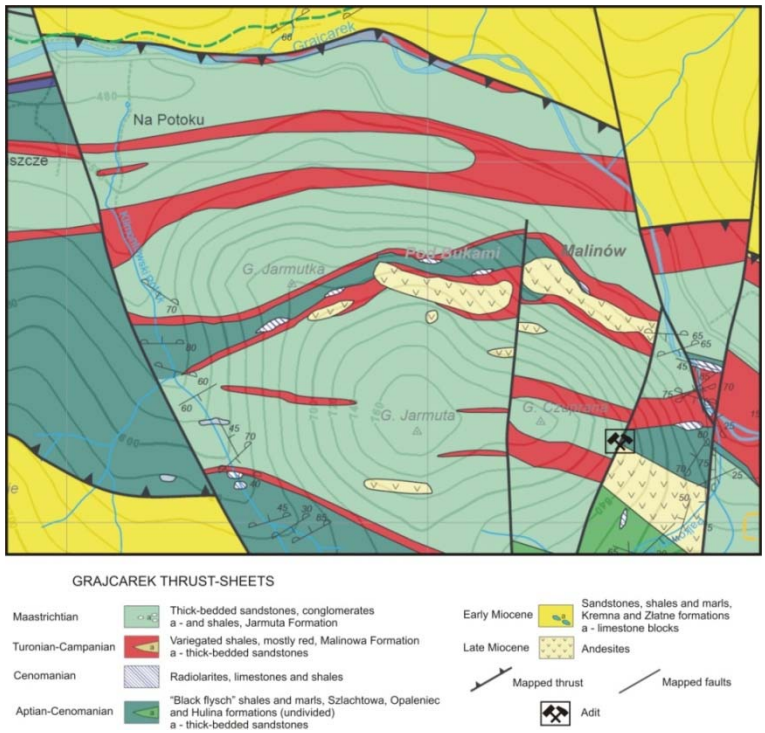

Fig. 3. Geology of Jarmuta Hill (after [73, 74])

In this area, there exist two stratotypes (*locus typicus*) of the Malinowa Shale Formation (Malinów – below Jarmuta Hill in the Grajcarek stream bed) and Jarmuta Formation (Jarmuta-Siodło and Grajcarek stream) [53, 59, 60]. The first one is represented by characteristic brightly red, sometimes variegated, multicolored (red, green, grey) non-calcareous shales mainly, and sometimes also marly shales (maximum 120 meters in thickness in this part of the PKB, but generally its thickness varies between 10 to 180 metres – comp [59]). Macrofossils are absent within it, but microfossils are very rich – mainly foraminifers, radiolarians and dinocysts [61, 62]. They have important stratigraphical value and indicate the Late Cretaceous age (Cenomanian-Turonian-Coniacian – about 94-90 million years ago; but possible they range up to Late Campanian; ±75 millions years – [59, 60]). Sometimes, thin sandstone intercalations manifest flyschoidal (turbiditic) character of deposits with flut casts and trace fossils (of the *Nereites* ichnofacies) on soles of these beds. Such fossil assemblages and sedimentological features document the deep-sea character of these pelagic rocks very well, most probably below CCD (*Calcite Compensation Depth*), where the sediments were poor in organic matter and were deposited in highly oxygenated conditions [61].

Red shales of the Malinowa Shale Formation are overlain by younger clastic rocks (Jarmuta Formation), mainly represented by coarse- and fine-grained yellowish and/or brownish

sandstones and mudstones, but sometimes by fine-grained conglomerates and breccia as well [59]. The age of these rocks is determined as the uppermost Cretaceous (Maastrichtian) – Lower Paleogene (Middle Paleocene) (about 70-60 million years ago) based on microfossils (foraminifers and nannoplankton). Between these two formations, some stratigraphical gap (hiatus) exists and manifests one of the most intensive tectonic, orogenic movements, which produced tectonic nappes and trusts of the so-called Laramian phase of the Alpine orogeny [53-55, 58, 63] and gave rise to pra-Pieniny Mountains for the first time.

The deposits of the Jarmuta Formation constitute the main mass in the mountains and are represented mainly by flysch rocks (intercalations of conglomerates, sandstones, mudstones and shales in variable proportions). In some places along the Grajcarek stream, on the eastern slope of Jarmuta Hill, this formation is manifested as an almost thirty meters thick sequence of breccias horizons intercalated by coarse-grained calcareous sandstones and mudstones. *K. Birkenmajer* [53, 59, 64] interpreted such rocks as "cliff breccia basal member" of the Jarmuta Formation (e.g., [59]: p. 133), as sedimentary breccia full of local, Pieniny rocks, which eroded during the latest Cretaceous-Paleocene times from the pra-Pieniny folded orogenic belt, with a small amount of exotic clasts as well. The Jarmuta Formation consists of a wide spectrum of flyschoidal clastic rocks, dominated by thick- and medium-bedded calcareous sandstones intercalated by mudstones and rare shales. Sedimentologically, they are represented by very proximal aprons of submarine mass movements (sedimentary breccia), channel-type deposits (thick-bedded sandstones) and fan-shaped turbiditic system with lobes (thin-bedded sandstones and mudstones).

The stratigraphical gap between these two units (Malinowa Shale Formation and Jarmuta Formation) and such sedimentary features of basal part of the latter unit perfectly document the effect of origin of folding nappes, then the new Paleocene transgression, the submarine erosion of rocks, building nappes, and finally their redeposition as post-orogenic mollase-type deposits. For this reason, the Maastrichtian-Paleocene rocks of the Jarmuta Formation are named as clastic cover (Klippen mantle, Jarmuta Cover), and represent intra-arc and fore-arc settings of the Laramian Pieniny fold belt, which unconformably covers pre-Laramian tectonic units of the so-called Klippen successions [55].

The last important sedimentary rocks of the Jarmuta Hill vicinity are black beds of the Szlachtowa Formation [53, 58, 59], which are unique turbiditic sandy-crinoidal thin-bedded flysch represented by fractionation beds of encrinitic sandy limestones, mudstones and shales. There are a lot of muscovite flakes on the bedding surfaces with strongly diversified lamination structures (e.g., cross-bedding, ripplemarks etc) [53, 59, 64, 65] with deposits of trace fossils typical for flysch assemblage [66]. It has been one of the most controversial geological objects in the PKB for about 50 years (e.g., [67-69] and during the current decade, this unit has been a point of hot debate again, especially by the virtue of high controversy concerning its age, when [70-73] suggested mid-Cretaceous (Albian-Cenomanian) age and questioned the Middle Jurassic age (Aalenian), which had been documented previously [53, 58, 59, 74-81].

Apart from sedimentary rocks, magmatic rocks constitute a very important element of the Jarmuta Hill geology. They are represented by andesite exposed in the abandoned Malinów quarry (the northern slope of Jarmuta), and form a south-dipping sill, which intrudes two tectonic thrust sheets through sedimentary rocks of both the Jarmuta and Malinowa Shale formations, and is very well visible both on the detail cartographic sketches on the Jarmuta Hill surroundings (including Pod Bukami and Malinów localities) [53, 63, 81-86] (Figs. 3B, 4, 5 and 6) and on the geological map with wider context of geological structures of the Małe Pieniny Range [73, 74] (Fig. 2).

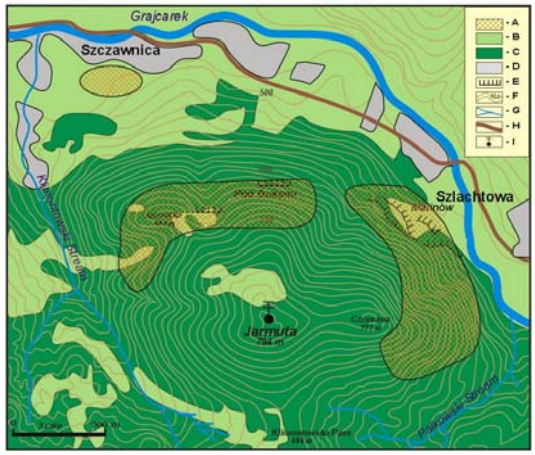

Fig. 4. Special areas of Jarmuta Hill (original drawing). Explanations: A – special areas, B – non-forest area, C – forest and thicket; D – buildings, E – quarries, F – contour lines, G – streams, H – main road, I – TV relay transmitter

Fig. 5. Jarmuta Hill in 1967 (Photo by K. Jabłoński with the consent of Fotopolska)

Fig. 6. Jarmuta Hill in 2017 (Photo by P. Chachuła, 2 January 2017)

The thickness of the sill is about 100m. It is built of fine-porphyritic amphibole andesite, which contains plates (up to a few mm long) of euhedral plagioclase and elongated phenocrysts

of amphibole occurring in grey matrix formed by recrystalization of volcanic glass with grains of quartz, chlorite, magnetite, calcite etc. In some places, the andesites are rich in xenoliths (sedimentary rocks – derived from Mesozoic formations of the Grajcarek Unit, metamorphic and plutonic ones – from continental-crust type rocks, and volcanic rocks – older hypabyssal/abyssal intrusions associated with the Pieniny Volcanic Arc; [74]) derived from deeper, underground sources. In the Jarmuta Hill [87, 88] mentioned 23 intrusions. The magmatic processes in the Pieniny region are connected with Middle Miocene (Sarmatian) time [63, 89] and formed the post-collisional, so-called Pieniny Volcanic Arc [86, 93], and were radiometricaly dated here as ca. 11Ma years old ([85, 86, 89-94].

The Pieniny andesite line (about 20 km long) cuts of the border between the Pieniny Klippen Belt and Outer Flysch Carpathians obliquely (Magura Nappe) [54], and forms two phases of intrusive activity. In the Jarmuta Hill case, andesite sills belong to the older, first phase, set of subparallel to the PKB. The magmatic chamber of these andesites was probably formed at a depth of 10-20km [84, 89, 93]. Some paleomagnetic studies indicate the Late Miocene counterclockwise rotation of the Pieniny andesites at the contact of the Inner and Outer Carpathians [94].

During the intrusion processes in the contact zone between the intruded magmas and the hosting sedimentary rocks, the metamorphosed aureole originated (so-called contact, thermal metamorphism), and produced ore-bearing veins by the activity of some hydrothermal fluids (e.g. limonite, magnetite, galena, sphalerite, pyrite, arsenopyrite, apatite, bornite, malachite, azurite) [95-97]. These rocks were researched and mined for lead, silver, and gold at the beginning of the 17th century (e.g., Bania w Jarmucie) [39, 53, 98] and the age of this mineralization was determined by isotopic K-Ar dating, and resulted to be contemporaneous with andesite intrusion (11.34±0.50 Ma) [84]. The Jarmuta Hill, being rich in ore, was the main object of mining interest area in the Pieniny region [39, 98].

Finally, the weathering process of the andesitic rocks produced a typical "gołoborze" (= stone sea), which is located on northern slope of the hill (Pod Bukami) [53, 99] (Fig. 3).

Fungi (Macromycetes)

In June, September and October 2015, the first observations of mycobiota on the Jarmuta Hill were conducted. During the research, 46 species of Macromycetes, including 8 species of Ascomycota and 38 Basidiomycota, were found, respectively.

Among them, there are 12 rare species in Poland and the Polish Carpathians, 7 species from the Red list of Macromycetes in Poland ([13]: categories E – 1 species, V – 2, R – 4, respectively). There are endangered species (category E) – *Mycena tenerrima*, which grows on the hazelnuts lying on the ground, vulnerable species (category V) – *Dichomitus campestris* growing on dead of branches of hazel and *Ischnoderma benzoinum*, which was observed on the lying spruce log, and rare species (category R) – *Calyptella capula* growing on the dead stem of *Chaerophyllum hirsutum*, *Climacocystis borealis* on the trunk of spruce, *Mycena crocata* with the orange milk and *Pycnoporus cinnabarinus* growing on the beech timber.

In the studied area, 6 species are included in the Red List of Macrofungi in the Polish Carpathians as rare species (category R) [100], among others: *Pseudochaete tabacina* growing on the branches of hazel, *Fuscoporia ferruginosa* and fruiting bodies of *Junghuhnia nitida* on the lying branches of *Cornus sanguinea*. Moreover, 2 mycorhizal species were observed – *Tomentella ellisii* on the decaying wood of fence post and *Xerocomellus porosporus*, which is known from only a few localities in Poland [101, 102]. Other species of the noted fungi are the saphrotrophs. Seven new species for Pieniny Range are also worth noticing, being *Annulohypoxylon multiforme* var. *multiforme*, *Hypoxylon howeanum*, *Dichomitus campestris*, *Junguhnia nitida*, *Skeletocutis nivea*, *Tomentella ellisii* and *Xerocomellus porosporus*.

Certainly, the observed fruiting bodies of 46 species of macrofungi do not present the full mycological richness of the area. In contrast with the Pieniny National Park, where 1041 taxa were found [103], macromycetes of the Jarmuta Hill present themselves as a small group. The factors limiting the presence of a number of taxa can be at least several, including lack of calcium carbonate in soil or a small amount a large sized logs. Also, most of only a few species build the forest in the juvenile phase, like *Alnus incana*, *Cornus sanguinea*, *Corylus avellana*, less *Salix caprea*, *Fraxinus excelsior* and *Sambucus nigra* (Fig. 2).

Plants

The floristic richness of vascular plants in the Pieniny Range was noticed already in the 19th century by Franciszek Herbich and Aleksander Zawadzki. The continuers of their surveys with the greatest achievements were Feliks Berdau, Bronisław Gustawicz, Józef Zubrzycki, Eustachy Wołoszczak and Ferdynand Fliarszky. Thanks to their efforts, the foundations of botanical knowledge about the Pieniny Range were created [104].

The publications of the subsequent research complement the earlier data until the *K. Zarzycki*'s monograph in 1981, which collected information published in several countries and in a dispersed collection of herbaria. In the both Polish and Slovakian Pieniny Range, 1015 species of vascular plants were described [100], but the amount of the observed taxa is still increasing. The list was enriched with the observations of another 42 taxa, which were published in the papers [105-111].

Currently, in the Pieniny Zachodnie (Western Pieniny), Pieniny Centralne (Central Pieniny) and Małe Pieniny about 30% species of the Polish flora were found. The Pieniny Range, being a small mountain chain, hosts two endemic species *Taraxacum pieninicum* Pawł. and *Erysimum pieninicum* (Zapał.) Pawł., three endemic varieties *Artemisia absinthium* L. var. *calcigena* Rehm., *Centaurea triumfettii* All. var. *pieninica* Pawł. and *Sedum acre* L. var. *calcigena* Woł. On the Jarmuta Hill, which is the subject of this paper, 347 vascular plants were described, representing about 12% of whole Polish flora (Appendix 1).

In addition to the endemic taxa in the Pieniny Range, it is the only place of the occurrence of *Dendranthema zawadzkii* (Herbich) Tzvelev, which is a glacial relict. Another interesting species for the Pieniny's flora is *Juniperus sabina* L., which has northernmost localities and is probably the remnant of the Tertiary range of this species [112]. The natural values of the Jarmuta Hill are species of protected by the law or threatened. There are three strictly protected species occurs on the hill *Gladiolus imbricatus*, *Orchis mascula* subsp. *signifera*, *Polystichum aculeatum*, and 14 species covered by partial protection were recorded, which represents about 6% of all vascular plant species protected by Polish law [113].

The vulnerable species (category V) are *Alchemilla glabra*, *Carex ornithopoda*, *Orchis mascula* subsp. *signifera*, *Polystichum aculeatum* [114]. It is only ca 1% of the treathened species. The list of vascular plants inferres the human impact in the Pieniny region. On the Jarmuta Hill, 23 species which are antropophytes established in the Polish flora and 4 cultivated species were described [18] (see Appendix 1). This group of plants represents about 4% of species occurring in Poland.

Moss investigations in Pieniny Range started in the 19th century thanks to Antoni Rehmann, Maximilian Kuhn, Tytus Chałubiński and Józef Krupa. The following century brought further research of this group of plants. Much data can be gathered from the publications of Flora Lilienfeldówna, Bronisław Szafran, Jerzy Szweykowski, Kazimierz Karczmarz, Ryszard Ochyra and Adam Stebel. Currently, the list of mosses consists of 320 taxa of mosses [115-119] and 96 taxa of hornwort and liverworts [120]. The number of mosses which was noted on the Jarmuta Hill constitutes about 20% of taxa occurring in Poland or 44% of the number of taxa of Pieniny Zachodnie, Pieniny Centralne and Małe Pieniny, respectively. In the case of liverworts and hornworts, it is 26 species, which equals about 9% of taxa in

relation to the total number of species in Poland. Among bryophytes, only *Porella platyphylla* is a strictly protected species, but 25 species are partially protected by the law [113]. Comparing to all Polish protected species of bryophytes, about 10% of the species were noted on the Jarmuta Hill. The lower percentage are threatened species. Among these, there were only 2 observed (Fig. 2): *Porella platyphylla* (category E) and *Anomodon rugelii* (category V), which constitutes ca 0.6% of all threatened bryophytes in Poland [121, 122].

Other interesting species

During the exploration of the adit Bania w Jarmucie, two representatives of butterflies were found (order Lepidoptera): *Triphosa dubitata* L. and *Scoliopteryx libatrix* L. There occurred a rove beetle (family *Staphylinidae*) *Quedius mesomelinus mesomelinus* (Marsh.), (*leg.* Piotr Chachuła, *det.* Andrzej Melke), which was not recognized in the Pieniny Range hitherto. This speces lives in corridors, mines or caves [123].

Bats are a very interesting group of mammals. They hibernate in the adit called Bania in Jarmuta. Five species of bats were observed (Fig. 2), especially *Rhinolophus hipposideros* [124, 125].

Plant communities

The Jarmuta Hill was utilized economically since the Modern Period, i.e. since the $17^{th}/18^{th}$ centuries. Human activity left a mark on the natural plant communities. The location of the Jarmuta Hill in the lower forest belt on the brown soils which makes a natural community is the mosophilous beech forest *Dentario glandulosae-Fagetum* (*Querco-Fagetea* class) in different variants. Small springs cover communities by *Cratoneurion commutati* (*Montio-Cardaminetea* class). The actual vegetation depicting the human activity is more varied, though most species do not conform to the habitat. Forest communities are represented by small patches of Carpathian beech forest in the eastern part of the hill. However, the area is generally dominated by communities *Alnus incana* and *Picea abies*, which are the result of planting carried out in the 20^{th} century [37].

The non-forest communities were developed as a result of long-term, extensive farming or mining activity. The abandoned meadows occur in the southern part of the Jarmuta Hill (surroundings of Klimontowska Pass), the central part (Andrzejówka glade and Siodełko glade), in the western part (Dolina Bednarzowska glade). There are also some meadows in the northern part of hill (Szczawnica, settlement Na Potoku and Szlachtowa, settlement Malinów). The agricultural use of the mowed or arable grounds is continued on the land in the northern part of the Jarmuta Hill, the closest to the houses (Szczawnica, settlement Na Potoku and Szlachtowa, settlement Malinów). The remains of mining can be seen in the quarry, which exposed the rocks, giving the possibility for the chasmophitic and epilitic vegetation to grow. Nearby Klimontowska Pass, there are patches of transformed mires which constitute a community with *Scirpus sylvaticus* or *Juncus inflexus* at present. The vegetation occurs only in a few places, mainly in the western part of Jarmuta, and forms a community with *Palustriella commutata*.

Conclusions

The Jarmuta Hill contains the evidence of regional heritage of Małe Pieniny. The field researches showed that the hill was located within the settlement of the Bronze Age. However, it seems that the modern times have changed the terrain image significantly (juxtaposition Fig. 5, 6). The excavation of rock raw materials led to a transformation of the relief the area. Later, the agricultural use of land significantly the image of the Jarmuta Hill changed further. Nowadays, the agricultural landscape vanished. The slopes are covered by forest and thicket. The remains of former human activity are the closed old quarries.

The Jarmuta Hill has a virtue of industrial and culture landscape. A part of the present foundations can be used by tourists. Tourists often appreciate the historic values of the place which they choose [131]. An additional factor enhancing the tourist value is that the adit on the Jarmuta Hill is included in the potential list of sites to appear in the Pieniny Range geopark [126]. The entrance to the tunnel is easily available [39], which makes attractive for tourists. In addition, the disused quarries can be special attractions for tourists as well [127]. According to the light field surface survey, it seems that the quarry "Pod Bukami" is suitable to become an attraction as it is an unconverted and undamaged place.

The number of identified macrofungi is small and certainly does not represent fully the list of species. However, 7 new species were described for the Pieniny Range and 6 species were included in the Red List of Macrofungi in the Polish Carpathians. A greater number of species is represented by the vascular plants flora, which constitute 12% of the species found in Poland; among them, 6% of protected species and 4% of endangered species are described. An interesting group of plants are bryophytes, which constitute about 20% taxa occurring in Poland. In the case of liverworts and hornworts, there are 26 species, which equals about 9% taxa of the total number of species in Poland. The endangered bryophytes are only 0.6 % of the threatened taxa in Poland. Plant communities are characteristic of different habitats of Polish Carpathians, although the impact of human activity is visible in them. The wealth of plants, funghi and specific human activities is the result of the complex geological substrate of the Jarmuta Hill on a small area of Polish Carpathians. As a result of the conducted investigations, the authors point to the most valuable areas in the studied area called as special areas (Figure 6). The limited fragments of the Jarmuta Hill raise the importance of the hill in preserving the biodiversity of the area and its cultural heritage.

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APPENDIX 1
List of species

Fungi, Macromycetes

Ascomycota

1. Annulohypoxylon multiforme (Fr.) Y.M. Ju, J.D. Rogers & H.M. Hsieh, wood, *C. avel.,*
2. Hypoxylon howeanum Peck, wood, *C. avel.,*
3. Kretzschmaria deusta (Hoffm.) P.M.D. Martin, coniferous wood,
4. Lasiosphaeria ovina (Pers.) Ces. & De Not., wood, *C. avel.,*
5. Mollisia cinerea (Batsch) P. Karst., deciduous wood,
6. Xylaria carpophila (Pers.) Fr., fruit of *F. sylv.*,
7. Xylaria hypoxylon (L.) Grev., wood, *F. exc*.
8. Xylaria polymorpha (Pers.) Grev., wood, *F. exc*.

Basidiomycota

9. Agrocybe praecox (Pers.) Fayod, ground,
10. Amylostereum areolatum (Chaillet ex Fr.) Boidin, wood, *P. ab.*
11. Auricularia auricula-judae (Bull.) Quél., wood, *S. nigra*.
12. Bjerkandera adusta (Willd.) P. Karst., wood, *C. avel.,*
13. Calocera cornea (Batsch) Fr., wood, *C. avel.,*
14. Calyptella capula (Holmsk.) Quél., **CL P - R**, on the stem *Chaerophyllum hirsutum*, thicket *C. avel*. with single individuals of *P. ab*. and *C. sang*., 49°24’57.2”N; 20°30’35.8”E; 571m a.s.l., 21.06.2015,
15. Cerioporus varius (Pers.) Zmitr. & Kovalenko, wood, *C. avel*.
16. Climacocystis borealis (Fr.) Kotl. & Pouzar, **CL P - R**, trunk *P. ab*., forest with *F. sylv*. and *P. ab*., 49°24’39.1”N; 20°30’50.9”E; 670m a.s.l., 20.09.2015,
17. Coprinellus domesticus (Bolton) Vilgalys, Hopple & Jacq. Johnson, wood, *F. exc*.
18. Daedaleopsis confragosa (Bolt.) J. Schröt., wood, *S. cap*.
19. Dichomitus campestris (Quél.) S. Domański & Orlicz, **CL P - V, CL K – R**, wood, *C. avel*., thicket of *C. avel*. with single individuals of *P. ab*. and *C. sang*., 49°24’46.2”N; 20°30’27.8”E; 716m a.s.l., 21.06.2015,
20. Exidia glandulosa (Bull.) Fr., wood, *C. sang*.,
21. Fomitiporia punctata (P. Karst.) Murrill, wood, *C. avel*. and *S. cap*.
22. Fomes fomentarius (L.) Fr., wood, *C. avel*.,
23. Fuscoporia ferruginosa (Schrad.) Murrill, **CL K – R**, wood, *C. avel*.
24. Ganoderma applanatum (Pers.) Pat., wood, *C. avel*.,
25. Gloeophyllum odoratum (Wulf.) Imaz., wood, *P. ab*.
26. Hypholoma fasciculare (Huds.) P. Kumm., deciduous wood,
27. Ischnoderma benzoinum (Wahlenb.) P. Karst., **CL P - V, CL K – R**, on the lying log of *P. ab*., forest with *F. sylv*. and *P. ab*., 20.09.2015,
28. Junghuhnia nitida (Pers.) Ryvarden, **CL K – R**, wood, *C. sang*, *det*. Dariusz Karasiński,
29. Lenzites betulina (L.) Fr., wood, *F. sylv*.,
30. Marasmius wettsteinii Sacc. & P. Syd., plant litter of *P. ab*.,
31. Mycena tenerrima (Berk.) Quél., **CL P - E**, on the nut of *C. avel*.,
32. Mycena crocata (Schrad.) P. Kumm., **CL P - R**, on the leaves of *F. sylv*., nearby the quarry „Pod Bukami”, 20.09.2015,
33. Mycena renati Quél., CL P - V, wood, *C. avel*., forest with *F. sylv*. and *P. ab*., 20.09.2015,
34. Panellus serotinus (Pers.) Kühner, wood, *A. inc*.
35. Panellus stypticus (Bull.) P. Karst., wood, *C. avel*. and *S. cap*.
36. Phallus impudicus L., ground,
37. Pseudochaete tabacina (Sowerby) T. Wagner & M. Fisch., **CL K – R**, wood, *C. avel*.,
38. Pycnoporus cinnabarinus (Jacq.) P. Karst., **CL P - R, CL K – R**, wood *C. avel*., forest with *F. sylv*. and *P. ab*., 20.09.2015,
39. Schizophyllum commune Fr., wood, *C. avel*.,
40. Schizopora paradoxa (Schrad.) Donk, wood, *A. inc*.,
41. Skeletocutis nivea (Jungh.) Jean Keller, wood, *S. cap*.,
42. Steccherinum ochraceum (Pers.) Gray, wood, *C. avel*.,
43. Stereum hirsutum (Willd.: Fr.) Gray, wood, *S. cap*.,
44. Stereum rugosum Pers., wood, *C. avel*.,
45. Tomentella ellisii (Sacc.) Jülich & Stalpers, **RR**, coniferous wood, *det*. Dariusz Karasiński, 12.06.2015,
46. Xerocomellus porosporus (Imler ex Bon) Šutara, RR, thicket with *C. avel*., 20.09.2015.

Abbreviation: ***A***. ***inc***. – *Alnus incana*, ***C***. ***sang***. – *Cornus sanguinea*, ***C***. ***avel***. – *Corylus avellana*, ***F***. ***exc***. – *Fraxinus excelsior*, ***F***. ***sylv***. – *Fagus sylvatica*, ***P***. ***ab***. - *Picea abies,* ***S***. ***cap***. – *Salix caprea*, ***S***. ***nigra***. – *Sambucus nigra*, **CL P** – Red-list of macrofungi of Poland (Wojewoda, Ławrynowicz 2006) [13], **CL K** – Red-list of macrofungi of Polish Carpathians (Wojewoda 1990 [100]), **R** – rare species, **V** – vulnerable species, **E** – endangered species, **RR** – very rare species in Poland.

Bryophytes

1. *Abietinella abietina* (Hedw.) M.Fleisch. **[ch]**
2. *Aloina rigida* (Hedw.) Limpr. - [115]
3. *Amblystegium juratzkanum* Schimp.
4. *Amblystegium serpens* (Hedw.) Schimp.
5. *Andreaea rupestris* Hedw. var. *rupestris* - [115] **[ch]**
6. *Anomodon attenuatus* (Hedw.) Huebener **[ch]**
7. *Anomodon rugelii* (Müll.Hal) Keissl.- [128] **[ch] [V]**
8. *Anomodon viticulosus* (Hedw.) Hook. & Taylor **[ch]**
9. *Atrichum undulatum* (Hedw.) P.Beauv.
10. *Barbilophozia attenuata* (Mart.) Loeske - [128]
11. *Barbilophozia barbata* (Schmidel *ex* Schreb.) Loeske
12. *Barbilophozia lycopodioides* (Wallr.) Loeske - [128]
13. *Barbula convoluta* Hedw.
14. *Barbula unguiculata* Hedw.
15. *Blepharostoma trichophyllum* (L.) Dumort. (MM, GV)
16. *Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen
17. *Brachythecium glareosum* (Bruch & Spruce) Schimp.
18. *Brachythecium mildeanum* (Schimp.) Schimp.
19. *Brachythecium rivulare* Schimp.
20. *Brachythecium rutabulum* (Hedw.) Schimp.
21. *Brachythecium salebrosum* (Hoffm. *ex* F.Weber & D.Mohr) Schimp.
22. *Bryoerythrophyllum recurvirostrum* (Hedw.) P.C.Chen
23. *Bryum argenteum* Hedw. - [128]
24. *Bryum caespiticium* Hedw. var. *caespiticium*
25. *Bryum klinggraeffii* Schimp.
26. *Bryum pseudotriquetrum* (Hedw.) P.Gaertn., B.Mey. & Scherb. var. *pseudotriquetrum*
27. *Bucklandiella heterosticha* (Hedw.) Bednarek-Ochyra & Ochyra - [129]
28. *Bucklandiella microcarpa* (Hedw.) Bednarek-Ochyra & Ochyra - [130]
29. *Callicladium haldanianum* (Grev.) H.A.Crum - [128]
30. *Calliergonella cuspidata* (Hedw.) Loeske **[ch]**
31. *Calypogeia azurea* Stotler & Crotz
32. *Campyliadelphus chrysophyllus* (Brid.) R.S.Chopra - [37]
33. *Campylium stellatum* (Hedw.) Lange & C.E.O.Jensen var. *protensum* (Brid.) Bryhn
34. *Cephalozia bicuspidata* (L.) Dumort. - [128]
35. *Ceratodon purpureus* (Hedw.) Brid.
36. *Chiloscyphus pallescens* (Ehrh. *ex* Hoffm.) Dumort. (MM, GV)
37. *Chiloscyphus polyanthus* (L.) Corda - [128]
38. *Cirriphyllum piliferum* (Hedw.) Grout
39. *Climacium dendroides* (Hedw.) F.Weber & D.Mohr **[ch]**
40. *Conocephalum salebrosum* Szweykowski, Buczkowska & Odrzykoski
41. *Cratoneuron filicinum* (Hedw.) Spruce
42. *Ctenidium molluscum* (Hedw.) Mitt. **[ch]**
43. *Dichodontium pellucidum* (Hedw.) Schimp.
44. *Dicranella heteromalla* (Hedw.) Schimp.
45. *Dicranella schreberiana* (Hedw.) Dixon
46. *Dicranella varia* (Hedw.) Schimp.
47. *Dicranodontium denudatum* (Brid.) E.Britton - [128]
48. *Dicranum polysetum* Sw. *ex* anon. - [128] **[ch]**
49. *Dicranum scoparium* Hedw. **[ch]**
50. *Didymodon fallax* (Hedw.) R.H.Zander var. *brevifolius* (Dicks.) Ochyra
51. *Didymodon fallax* (Hedw.) R.H.Zander var. *fallax*
52. *Didymodon ferrugineus* (Schimp. *ex* Besch.) M.O.Hill
53. *Didymodon rigidulus* Hedw.
54. *Ditrichum flexicaule* (Schwägr.) Hampe
55. *Dryptodon hartmanii* (Schimp.) Limpr.
56. *Dryptodon pulvinatus* (Hedw.) Brid. - [128]
57. *Encalypta streptocarpa* Hedw.
58. *Encalypta vulgaris* Hedw. - [115]
59. *Eurhynchium angustirete* (Broth.) T.J.Kop. **[ch]**
60. *Fissidens adianthoides* Hedw. - [128]
61. *Fissidens bryoides* Hedw.
62. *Fissidens dubius* P.Beauv. var. *dubius* - [128]
63. *Fissidens dubius* P.Beauv. var. *mucronatus* (Breidl. *ex* Limpr.) Karttunen, Hedenäs & Söderström
64. *Fissidens osmundoides* Hedw. - [128]
65. *Fissidens taxifolius* Hedw.
66. *Fissidens viridulus* (Sw. *ex* anon.) Wahlenb.
67. *Frullania dilatata* (L.) Dumort. **[ch]**
68. *Funaria hygrometrica* Hed.
69. *Guembelia ovalis* (Hedw.) Müll.Hal. - [128]
70. *Hedwigia ciliata* (Hedw.) P.Beauv. var. *ciliata*
71. *Herzogiella seligeri* (Brid.) Z.Iwats.
72. *Homalothecium sericeum* (Hedw.) Schimp. - [128]
73. *Homomallium incurvatum* (Schrad. *ex* Brid.) Loeske
74. *Hygrohypnum luridum* (Hedw.) Jenn. var. *luridum*
75. *Hylocomiadelphus triquetrus* (Hedw.) Ochyra & Stebel **[ch]**
76. *Hylocomium splendens* (Hedw.) Schimp. **[ch]**
77. *Hymenoloma crispulum* (Hedw.) Ochyra - [115]
78. *Hypnum cupressiforme* Hedw. var. *cupressiforme*
79. *Hypnum cupressiforme* Hedw. var. *filiforme* Brid.
80. *Hypnum cupressiforme* Hedw. var. *lacunosum* Brid. - [128]
81. *Hypnum lindbergii* Mitt.
82. *Hypnum pallescens* (Hedw.) P.Beauv.
83. *Isothecium alopecuroides* (Lam. *ex* Dubois) Isov.
84. *Lepidozia reptans* (L.) Dumort.
85. *Leptobryum pyriforme* (Hedw.) Wilson - [128]
86. *Leskella nervosa* (Brid.) Loeske
87. *Leucodon sciuroides* (Hedw.) Schwägr.
88. *Lophocolea bidentata* (L.) Dumort.
89. *Lophocolea heterophylla* (Schrad.) Dumort.
90. *Lophocolea minor* Nees
91. *Lophozia ventricosa* (Dicks.) Dumort. *emend*. H.Buch (MM, GV)
92. *Marchantia polymorpha* L. subsp. *ruderalis* Bischl. & Boisselier
93. *Metzgeria furcata* (L.) Dumort. var. *furcata*
94. *Mnium marginatum* (Dicks.) P.Beauv.
95. *Mnium stellare* Reichard *ex* Hedw.
96. *Neckera complanata* (Hedw.) Huebener - [115] **[ch]**
97. *Niphotrichum canescens* (Hedw.) Bednarek-Ochyra & Ochyra - [128]
98. *Orthodicranum montanum* (Hedw.) Loeske
99. *Orthotrichum affine* Schrad. *ex* Brid.
100. *Orthotrichum pallens* Bruch *ex* Brid.
101. *Orthotrichum pumilum* Sw. *ex* anon.
102. *Orthotrichum speciosum* Nees
103. *Orthotrichum stramineum* Hornsch. *ex* Brid.
104. *Oxyrrhynchium hians* var. *hians* (Hedw.) Loeske
105. *Palustriella commutata* (Hedw.) Ochyra var. *commutata* **[ch]**
106. *Paraleucobryum longifolium* (Ehrh. *ex* Hedw.) Loeske var. *longifolium*
107. *Pedinophyllum interruptum* (Nees) Kaal.
108. *Pellia endiviifolia* (Dicks.) Dumort.
109. *Pellia epiphylla* (L.) Corda
110. *Pellia nessiana* (Gottsche) Limpr. - [128]
111. *Plagiochila asplenioides* (L. *emend*. Taylor) Dumort. **[ch]**
112. *Plagiochila porelloides* (Torrey *ex* Nees) Lindenb.
113. *Plagiomnium affine* (Blandow *ex* Funck) T.J.Kop.
114. *Plagiomnium cuspidatum* (Hedw.) T.J.Kop.
115. *Plagiomnium elatum* (Bruch & Schimp.) T.J.Kop.
116. *Plagiomnium rostratum* (Schrad.) T.J.Kop.

Bryophytes (cont.)

117. *Plagiomnium undulatum* (Hedw.) T.J.Kop.
118. *Plagiothecium cavifolium* (Brid.) Z.Iwats.
119. *Plagiothecium curvifolium* Schlieph. *ex* Limpr.
120. *Plagiothecium denticulatum* (Hedw.) Schimp.
121. *Plagiothecium laetum* Schimp.
122. *Plagiothecium nemorale* (Mitt.) A.Jaeger
123. *Platygyrium repens* (Brid.) Schimp.
124. *Pleurozium schreberi* (Willd. *ex* Brid.) Mitt. **[ch]**
125. *Pogonatum aloides* (Hedw.) P.Beauv.var. *aloides*
126. *Pogonatum urnigerum* (Hedw.) P.Beauv. - [115]
127. *Pohlia nutans* (Hedw.) Lindb. subsp. *nutans*
128. *Pohlia wahlenbergii* (F.Weber & D.Mohr) A.L.Andrews var. *wahlenbergii*
129. *Polytrichastrum formosum* (Hedw.) G.L.Sm.
130. *Polytrichum commune* Hedw. - [128] **[ch]**
131. *Polytrichum juniperinum* Hedw.
132. **[***Porella platyphylla* (L.) Pfeiff. **CH] [E]**
133. *Pseudoleskea incurvata* (Hedw.) Loeske
134. *Pseudoleskeella catenulata* (Brid. *ex* Schrad.) Kindb. - [115]
135. *Pseudoscleropodium purum* (Hedw.) M.Fleisch. *ex* Broth. **[ch]**
136. *Pterigynandrum filiforme* Hedw.
137. *Ptilidium pulcherrimum* (Weber) Vain. - [128]
138. *Pylaisia polyantha* (Hedw.) Schimp.
139. *Radula complanata* (L.) Dumort.
140. *Rhizomnium punctatum* (Hedw.) T.J.Kop.
141. *Rhodobryum roseum* (Hedw.) Limpr. - [115]
142. *Rhynchostegium murale* (Hedw.) Schimp.
143. *Rhytidiadelphus squarrosus* (Hedw.) Warnst. **[ch]**
144. *Rhytidium rugosum* (Ehrh. *ex* Hedw.) Kindb. **[ch]**
145. *Rosulabryum capillare* (Hedw.) J.R.Spence
146. *Rosulabryum elegans* (Nees) Ochyra
147. *Rosulabryum moravicum* (Podp.) Ochyra & Stebel
148. *Sanionia uncinata* (Hedw.) Loeske
149. *Schistidium crassipilum* H.H.Blom
150. *Schistidium lancifolium* (Kindb.) H.H.Blom - [115]
151. *Sciuro-hypnum oedipodium* (Mitt.) Ignatov & Huttunen - [115]
152. *Sciuro-hypnum populeum* (Hedw.) Ignatov & Huttunen
153. *Sciuro-hypnum reflexum* (Starke) Ignatov & Huttunen - [115]
154. *Syntrichia calcicola* J.J.Amann
155. *Syntrichia montana* Nees - [115]
156. *Syntrichia ruralis* (Hedw.) F.Weber & D.Mohr
157. *Taxiphyllum wissgrillii* (Garov.) Wijk & Margad.
158. *Tetraphis pellucida* Hedw.
159. *Thuidium assimile* (Mitt.) A.Jaeger **[ch]**
160. *Thuidium delicatulum* (Hedw.) Schimp. - [37] **[ch]**
161. *Thuidium tamariscinum* (Hedw.) Schimp. **[ch]**
162. *Tortella tortuosa* (Hedw.) Limpr.
163. *Tortula acaulon* (With.) R.H.Zander
164. *Tortula muralis* Hedw. var. *muralis*
165. *Tortula truncata* (Hedw.) Mitt.
166. *Trichostomum tenuirostre* (Hook. & Taylor) Lindb.
167. *Tritomaria quinquedentata* (Huds.) H.Buch - [128]
168. *Weissia controversa* Hedw. - [128]

Abbreviation: CH – strictly protected species (1 species), ch – partially protected species [113] (25 species), E – endangered species (1 species), V – vulnerable species [121] (1 species).

Vascular plants

1. *Abies alba* Mill.
2. *Acer platanoides* L.
3. *Acer pseudoplatanus* L.
4. *Achillea millefolium* L.
5. *Aegopodium podagraria* L.
6. *Agrimonia eupatoria* L.
7. *Agrostis capillaris* L.
8. *Agrostis stolonifera* L.
9. *Ajuga reptans* L.
10. *Alchemilla crinita* Buser - [104]
11. *Alchemilla glabra* Neygenf. - [104] **[V]**
12. *Alchemilla plicata* Buser - [104]
13. *Alchemilla xanthochlora* Rothm. - [104] - Malinów
14. *Allium oleraceum* L.
15. *Alnus incana* (L.) Moench
16. *Alopecurus pratensis* L.
17. *Anemone nemorosa* L.
18. *Angelica sylvestris* L.
19. *Anthoxanthum odoratum* L.
20. *Anthriscus nitida* (Wahlenb.) Hazsl.
21. *Anthriscus sylvestris* (L.) Hoffm.
22. *Anthyllis vulneraria* L.
23. *Arabis glabra* (L.) Bernh. - [104] - Malinów
24. *Arabis hirsuta* (L.) Scop.
25. *Arctium minus* (Hill) Bernh.
26. *Arctium tomentosum* Mill.
27. *Arenaria serpyllifolia* L. - [104] - Malinów
28. **Armoracia rusticana* P.Gaertn., B.Mey. & Scherb.
29. *Arrhenatherum elatius* (L.) P.Beauv. *ex* J. Presl & C.Presl
30. *Aruncus sylvestris* Kostel. **[ch]**
31. *Asarum europaeum* L.
32. *Asplenium trichomanes* L.
33. *Astrantia major* L.
34. *Athyrium filix-femina* (L.) Roth
35. *Artemisia vulgaris* L.
36. *Bellis perennis* L.
37. *Betula pendula* Roth
38. *Brachypodium sylvaticum* (Huds.) P.Beauv.
39. *Briza media* L.
40. *Bromus benekeni* (Lange) Trimen
41. **Bunias orientalis* L.
42. *Bupleurum falcatum* L.
43. *Calamagrostis epigejos* (L.) Roth
44. *Calamagrostis varia* (Schrad.) Host
45. *Calluna vulgaris* (L.) Hull - [104]
46. *Caltha palustris* L. subsp. *palustris*
47. *Calystegia sepium* (L.) R.Br.
48. *Campanula patula* L.
49. *Campanula persicifolia* L.
50. *Campanula rapunculoides* L.
51. *Campanula trachelium* L.
52. *Cardamine amara* L. subsp. *amara*
53. *Cardamine flexuosa* With.
54. *Cardamine impatiens* L.
55. *Cardamine pratensis* L.
56. *Cardaminopsis halleri* (L.) Hayek
57. **Carduus acanthoides* L. - [104]
58. *Carduus personata* (L.) Jacq.
59. *Carex digitata* L.

Vascular plants (cont.)

60. *Carex flacca* Schreb.
61. *Carex hirta* L.
62. *Carex lepidocarpa* Tausch - [104]
63. *Carex nigra* Reichard
64. *Carex ornithopoda* Willd. **[V]**
65. *Carex pallescens* L.
66. *Carex panicea* L.
67. *Carex paniculata* L.
68. *Carex pilulifera* L. - [104]
69. *Carex spicata* Huds. (as *C. contigua* - [104])
70. *Carex sylvatica* Huds.
71. *Carlina acaulis* L. **[ch]**
72. *Carum carvi* L.
73. *Centaurea jacea* L.
74. *Centaurea scabiosa* L.
75. *Centaurium erythraea* Rafn. subsp. *erythraea* - [104] **[ch]**
76. *Cerastium holosteoides* Fr. *emend*. Hyl.
77. *Cerastium arvense* L.
78. *Cerasus avium* (L.) Moench
79. *Chaenorrhinum minus* (L.) Lange
80. *Chaerophyllum aromaticum* L.
81. *Chaerophyllum hirsutum* L.
82. *Chamaenerion angustifolium* (L.) Scop.
83. *Chamaenerion palustre* Scop.
84. *Chelidonium majus* L.
85. *Chenopodium album* L.
86. *Chrysosplenium alternifolium* L.
87. *Circaea alpina* L. - [104]
88. *Cirsium arvense* (L.) Scop.
89. *Cirsium erisithales* (Jacq.) Scop. - [104]
90. *Cirsium oleraceum* (L.) Scop.
91. *Cirsium palustre* (L.) Scop.
92. *Cirsium rivulare* (Jacq.) All.
93. [*]*Cirsium vulgare* (Savi) Ten.
94. *Clinopodium vulgare* L.
95. *Colchicum autumnale* L. **[ch]**
96. *Convolvulus arvensis* L.
97. ◊ *Coreopsis verticillata* L.
98. *Coronilla varia* L.
99. *Cornus sanguinea* L.
100. *Corylus avellana* L.
101. *Crataegus* x*macrocarpa* Hegetschw.
102. *Crataegus monogyna* Jacq.
103. *Crepis biennis* L.
104. *Cruciata glabra* (L.) Ehrend.
105. *Cynosurus cristatus* L.
106. *Dactylis glomerata* L.
107. *Dactylorhiza majalis* (Rchb.) P.F.Hunt & Summerh. **[ch]**
108. *Daucus carrota* L.
109. *Deschampsia caespitosa* (L.) P.Beauv.
110. *Digitalis grandiflora* Mill. **[ch]**
111. *Dryopteris affinis* (Lowe) Fraser-Jenk.
112. *Dryopteris carthusiana* (Vill.) H.P.Fuchs
113. *Dryopteris dilatata* (Hoffm.) A.Gray
114. *Dryopteris filix-mas* (L.) Schott
115. *Eleocharis palustris* (L.) Roem. & Schult.
116. *Eleocharis quinqueflora* (Hartmann) O.Schwarz
117. *Elymus caninus* (L.) L.
118. *Elymus repens* (L.) Gould
119. **Epilobium ciliatum* Raf. - [104] - Malinów
120. *Epilobium hirsutum* L.
121. *Epilobium montanum* L.
122. *Equisetum arvense* L.
123. *Equisetum palustre* L.
124. *Euonymus europaea* L.
125. *Eupatorium cannabinum* L.
126. *Euphorbia amygdaloides* L.
127. *Euphorbia cyparissias* L.
128. **Euphorbia helioscopia* L. - [104]
129. *Euphorbia serrulata* Thuill.
130. *Euphrasia rostkoviana* Hayne - [104]
131. *Euphrasia vernalis* List - [104]
132. *Fagus sylvatica* L.
133. *Festuca gigantea* (L.) Vill.
134. *Festuca ovina* L. - [104]
135. *Festuca pratensis* Huds.
136. *Festuca rubra* L.
137. *Filipendula ulmaria* (L.) Maxim.
138. *Fragaria vesca* L.
139. *Frangula alnus* Mill.
140. *Fraxinus excelsior* L.
141. *Galeobdolon luteum* Huds.
142. *Galeopsis pubescens* Besser - [104]
143. *Galeopsis speciosa* Mill.
144. *Galeopsis tetrahit* L. - [104]
145. **Galinsoga ciliata* (Raf.) S.F.Blake
146. *Galium aparine* L.
147. *Galium boreale* L.
148. *Galium mollugo* L.
149. *Galium odoratum* (L.) Scop.
150. *Gentiana asclepiadea* L. **[ch]**
151. *Gentianella ciliata* (L.) Borkh. **[ch]**
152. *Gentianella lutescens* (Velen.) Holub - [104] **[ch]**
153. **Geranium dissectum* L. - [104]
154. *Geranium phaeum* L.
155. *Geranium robertianum* L.
156. *Geum rivale* L.
157. *Geum urbanum* L.
158. *Gladiolus imbricatus* L. **[CH]**
159. *Glechoma hederacea* L.
160. *Glyceria notata* Chevall.
161. *Gnaphalium sylvaticum* L.
162. *Gymnocarpium dryopteris* (L.) Newman
163. *Hedera helix* L.
164. *Heracleum sphondylium* L.
165. *Hieracium pilosella* L.
166. *Helianthemum nummularium* (L.) Mill.
167. *Herniaria glabra* L. - [104]
168. *Homogyne alpina* (L.) Cass.
169. *Hypericum maculatum* Crantz
170. *Hypericum perforatum* L.
171. *Hypochoeris radicata* L.
172. **Impatiens glandulifera* Royle
173. *Impatiens noli-tangere* L.
174. **Impatiens parviflora* DC.
175. *Inula conyza* DC.
176. **Juglans regia* L.
177. *Juncus buffonius* L.
178. *Juncus effusus* L.
179. *Juncus inflexus* L.
180. *Juncus squarrosus* L.
181. *Juniperus communis* L. subsp. *communis*
182. *Knautia arvensis* (L.) J.M.Coult.
183. *Lamium maculatum* L.
184. *Lapsana communis* L.
185. *Larix decidua* Mill. subsp. *decidua*
186. *Lathyrus pratensis* L.
187. *Leontodon autumnalis* L. subsp. *autumnalis*

Vascular plants (cont. 2)

188. *Leontodon hispidus* L. subsp. *hastilis* (L.) Rchb.)
189. ◊ *Leucanthemum maximum* (Ramond) DC.
190. *Leucanthemum vulgare* Lam.
191. *Libanotis pyrenaica* (L.) Bourg.
192. **Linaria vulgaris* Mill. - [104]
193. *Linum catharticum* L.
194. *Listera ovata* (L.) R.Br. **[ch]**
195. *Lolium perenne* L.
196. *Lonicera xylosteum* L.
197. *Lotus corniculatus* L.
198. *Luzula campestris* (L.) DC.
199. *Luzula luzuloides* (Lam.) Dandy & Wilmott
200. *Luzula multiflora* (Retz.) Lej. - [104]
201. *Luzula pilosa* (L.) Willd.
202. *Lycopodium clavatum* L. **[ch]**
203. *Lycopus europaeus* L.
204. *Lysimachia nemorum* L.
205. *Lysimachia nummularia* L.
206. *Maianthemum bifolium* (L.) F.W.Schmidt
207. **Malus domestica* Borkh.
208. *Matteucia struthiopteris* (planted) (L.) Tod. **[ch]**
209. *Medicago lupulina* L.
210. *Melandrium rubrum* (Weigel) Garcke
211. *Melica nutans* L.
212. *Melilotus alba* Medik.
213. *Mentha arvensis* L.
214. *Mentha longifolia* (L.) L.
215. *Moehringia trinervia* (L.) Clairv.
216. *Mycelis muralis* (L.) Dumort.
217. **Myosotis arvensis* (L.) Hill
218. *Myosotis palustris* (L.) L. *emend*. Rchb.
219. *Myosotis ramosissima* Rochel - [104]
220. *Myosotis sylvestris* Ehrh. *ex* Hoffm.
221. *Myosoton aquaticum* (L.) Moench - [104] - Malinów
222. *Myricaria germanica* (L.) Desv. - [104] – Malinów **[ch]**
223. *Nardus stricta* L.
224. *Neottia nidus-avis* (L.) Rich. **[ch]**
225. *Ononis arvensis* L.
226. *Orchis mascula* (L.) L. subsp. *signifera* (Vest.) Soó **[CH][V]**
227. *Oxalis acetosella* L.
228. *Padus avium* Mill.
229. **Papaver rhoeas* L. - [104]
230. ◊ *Papaver somniferum* L. - [104]
231. *Paris quadrifolia* L.
232. *Petasites albus* (L.) Gaertn.
233. *Petasites hybridus* (L.) P. Gaertn., B. Mey. & Scherb.
234. *Phegopteris connectilis* (Michx.) Watt - [104]
235. *Phleum pratense* L.
236. *Picea abies* (L.) H.Karst.
237. *Pimpinella major* (L.) Huds.
238. *Pimpinella saxifraga* L.
239. *Pinus sylvestris* L.
240. *Plantago intermedia* Gilib. - [104] - Malinów
241. *Plantago lanceolata* L.
242. *Plantago major* L.
243. *Plantago media* L.
244. *Poa angustifolia* L.
245. *Poa annua* L.
246. *Poa compressa* L.
247. *Poa nemoralis* L.
248. *Poa trivialis* L.
249. *Poa pratensis* L.
250. *Polygala amarella* Crantz - [104]
251. *Polygala comosa* Schkuhr
252. *Polygala vulgaris* L.
253. *Polygonatum verticillatum* (L.) All.
254. *Polygonum aviculare* L.
255. *Polygonum lapathifolium* L. - [104] - Malinów
256. *Polypodium vulgare* L.
257. *Polystichum aculeatum* (L.) Roth **[CH] [V]**
258. *Populus tremula* L.
259. *Potentilla anserina* L.
260. *Potentilla erecta* (L.) Raeusch.
261. *Prenanthes purpurea* L.
262. *Primula elatior* (L.) Hill **[ch]**
263. *Prunella vulgaris* L.
264. **Prunus cerasifera* Ehrh.
265. **Prunus domestica* L.
266. *Prunus spinosa* L.
267. *Pteridium aquilinum* (L.) Kuhn
268. *Pulmonaria obscura* Dumort.
269. **Pyrus communis* L.
270. *Pyrus pyraster* (L.) Burgsd.
271. *Ranunculus acris* L.
272. *Ranunculus lanuginosus* L.
273. *Ranunculus polyanthemos* L.
274. *Ranunculus repens* L.
275. *Ribes alpinum* L.
276. *Ribes uva-crispa* L.
277. *Rosa canina* L.
278. *Rosa tomentosa* Sm.
279. *Rubus caesius* L.
280. *Rubus hirtus* Waldst. & Kit. agg.
281. *Rubus idaeus* L.
282. *Rubus plicatus* Weihe & Nees - [104]
283. *Rubus wimmerianus* (Sprib. *ex* Sudre) Sprib.
284. *Rumex acetosa* L.
285. *Rumex conglomeratus* Murray - [104]
286. *Rumex obtusifolius* L.
287. *Sagina procumbens* L.
288. *Sagina saginoides* (L.) H.Karst. - [104]
289. *Salix alba* L.
290. *Salix caprea* L.
291. *Salix cinerea* L.
292. *Salix fragilis* L.
293. *Salix purpurea* L.
294. *Salix silesiaca* Willd. - [104]
295. *Salvia glutinosa* L.
296. *Salvia verticillata* L.
297. *Sambucus nigra* L.
298. *Sanguisorba minor* Scop.
299. *Sanicula europaea* L.
300. *Scirpus sylvaticus* L.
301. **Scleranthus annuus* L. - [104] - Malinów
302. *Scrophularia nodosa* L.
303. *Scrophularia scopolii* Hoppe
304. *Sedum fabaria* W.D.J. Koch - [104]
305. *Sedum maximum* (L.) Hoffm. - [104]
306. *Sedum sexangulare* L. - [104]
307. *Senecio ovatus* (P. Gaertn., B. Mey. & Scherb.) Willd.
308. *Senecio viscosus* L. - [104] - Malinów
309. **Senecio vulgaris* L. - [104]
310. *Sorbus aucuparia* L. *emend*. Hedl.
311. *Stachys sylvatica* L.
312. *Stellaria graminea* L.

Vascular plants (cont. 3)

313. *Stellaria media* (L.) Vill.
314. *Stellaria nemorum* L.
315. *Symphytum cordatum* Waldst. & Kit. *ex* Willd.
316. *Symphytum officinale* L.
317. *Taraxacum* sect. Ruderalia
318. **Thlaspi arvense* L. - [104] - Malinów
319. ◊ *Thuja plicata* Donn *ex* D.Don
320. *Thymus pulegioides* L.
321. *Tragopogon orientalis* L.
322. *Trifolium aureum* Pollich - [104] - Malinów
323. *Trifolium medium* L.
324. *Trifolium montanum* L.
325. *Trifolium pratense* L.
326. *Trifolium repens* L.
327. *Trisetum flavescens* (L.) P.Beauv.
328. *Tussilago farfara* L.
329. *Urtica dioica* L.
330. *Vaccinium myrtillus* L.
331. *Valeriana simplicifolia* Kabath
332. *Verbascum thapsus* L.
333. *Veronica beccabunga* L.
334. *Veronica chamaedrys* L.
335. **Veronica filiformis* Sm.
336. *Veronica montana* L.
337. *Veronica officinalis* L.
338. *Veronica serpyllifolia* L.
339. *Viburnum opulus* L.
340. *Vicia cracca* L.
341. **Vicia sativa* L. - [104]
342. *Vicia sepium* L.
343. *Vinca minor* L.
344. *Viola hirta* L.
345. *Viola reichenbachiana* Jord. *ex* Boreau
346. *Viola riviniana* Rchb.
347. *Viscaria vulgaris* Röhl. - [104]

Abbreviation: CH – strictly protected species (3 species), ch – partially protected species [113] (14 species), V – vulnerable species [114] (4 species), * - antropophyte established in the Polish flora (23 species), ◊ - cultivated species [18] (4 species).