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Dear Readers,

We present you with the fourth issue of the journal *Annales Universitatis Paedagogiceae Cracoviensis Studia Naturae*. This year's issue contains twelve original scientific articles in the fields of botany, algology and mycology, zoology, experimental biology, environmental biology and conservation.

In the current issue, two articles have been posted in the botany, algology and mycology field. One of them describes plant inspirations in the decorative motifs of St. Mary's Basilica in Krakow, the second presents vascular plants around Pilzno in south-eastern Poland. One article is classified in the zoology field about the construction of hummingbird nests and their defensive strategies in the deciduous forests of Mexico. In the experimental biology field there have been published as many as four articles with the following topics: assessment of earthworm activity based on biomass uptake, the concentration of bio-flavonoids in the vine cultivar from Georgia, the role of seed coat in germination and early stages of growth beans in the presence of chickweed and the impact of magnesium salts on germination and cucumber growth. One article on selected environmental issues of shale landscape in the Czech Republic has been presented in the field of environmental biology and conservation. The last field of various includes four articles about plants as a source of fragrances and their use in the perfume industry, methods of protection against ticks and measures to obtain a stable agricultural system in sustainable agriculture, cyanobacteria and cyanometabolites used in the pharmaceutical and medical industry. This part also presents reports from five scientific meetings.

We hope that the current issue will meet your interest and encourage you to publish articles in the next issues of the journal, which this year has been included in the journal base – Google Scholar.

Yours sincerely,
Editors of *Annales Universitatis Paedagogiceae Cracoviensis Studia Naturae*

Szanowni Czytelnicy,
Przekazujemy w Państwa ręce czwarty numer czasopisma *Annales Universitatis Paedagogiceae Cracoviensis Studia Naturae*. Tegoroczny numer zawiera dwanaście oryginalnych artykułów naukowych z zakresu botaniki, algologii i mykologii, zoologii, biologii eksperymentalnej, biologii środowiska i ochrony przyrody.

W bieżącym numerze w dziale botaniki, algologii i mykologii zamieszczono dwa artykuły. Jeden opisuje inspiracje roślinne w motywach zdobniczych Bazyliki Mariackiej w Krakowie, a drugi rośliny naczyniowe okolic Pilzna w południowo-wschodniej Polsce. Do działu zoologia zaklasyfikowano jeden artykuł, dotyczący budowy gniazd kolibrów i ich strategii obronnych w lasach liściastych Meksyku. W dziale biologii eksperymentalnej znalazły się aż cztery opracowania obejmujące następującą tematykę: ocena aktywności dżdżownic na podstawie pobrania biomasy, koncentracja bio-flawonoidów z gruzińskiej odmiany winorośli, rola łupiny nasiennej w kiełkowaniu i wczesnych stadiach wzrostu fasoli w obecności gwiazdnicy pospolitej oraz oddziaływanie soli magnezu na kiełkowanie i wzrost ogórka. W dziale biologii środowiskowej i ochrony zamieszczono jeden artykuł na temat wybranych zagadnień środowiskowych krajobrazu łupków ilastych w Czechach. W ostatnim dziale Varia znalazły się cztery artykuły, dotyczące roślin jako źródła substancji zapachowych oraz ich zastosowania w przemyśle perfumeryjnym, metod ochrony przed kleszczami, środków służących do uzyskania stabilnego systemu rolnego w zrównoważonym rolnictwie, cyjanobakterii i cyjanometabolitów stosowanych w przemyśle farmaceutycznym oraz medycznym. W tym dziale uwzględniono także sprawozdania z pięciu spotkań naukowych.

Mamy nadzieję, że bieżący numer spotka się z Państwa zainteresowaniem i zachęci do publikowania artykułów w kolejnych zeszytach czasopisma, które w tym roku zostało włączone do bazy czasopism – Google Scholar.

Z wyrazami szacunku,
Redakcja *Annales Universitatis Paedagogiceae Cracoviensis Studia Naturae*

# Botany & Algology, Mycology

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# Inspirations by plant in the decorative motifs of St. Mary's Basilica in Kraków (Poland)

## Introduction

Plants, especially flowers, have been used as an element of various types of decorations since the beginning of civilisation (Schwarz, Szober, 1974). Plant motifs from ancient times appeared in art, especially related to *Sacrum* (Latin) – the sphere of holiness. Religious symbols of various artists have abundant symbolism, which appeal to a specific audience in a specific and intended way. At present, many monographic studies relating to the religious symbolism of plants can be found in the literature. Examples include the "Atlas of Biblical Plants" by B. Szczepanowicz (2003) or "In the World of the Bible Flora" by J. Picka (1998). These studies contain a list of species mentioned in the Bible and they are particularly useful in explaining the meaning of plant religious symbols.

For believers, God was the first Being who cared for the earthly garden. Therefore, throughout the Bible, illustrating the history of the world, there are plants that have a specific symbolism describing the relationship between man and God. Human is also compared to the plant: (...) "*Planted in the house of the Lord, they will flourish in the courtyards of our God. They will bear fruit even in old age, full of juices and always alive* (Ps. 92.14)". As many as eighty species of plants are listed in the Bible that have not survived to their full extent. Plants are part of the panorama of biblical events, from the Old Testament to the history of Christ. Biblical plant species are fascinating and attractive to many people, precisely because of the symbolism they carry. Hence, they were often an inspiration in various artists studies (Szczepanowicz, 2003; Włodarczyk, 2004; Lengiewicz, 2008).

The arch-presbytery church of the Assumption of the Blessed Virgin Mary in Kraków, also called the St. Mary's Church, the Basilica of the Assumption of the Blessed Virgin Mary or St. Mary's Basilica, is the subject of many studies and publications,

as it belongs to the "*treasury of Polish culture*". It is one of the most important and one of the greatest architectural monuments of Kraków. For centuries it was under the care of wealthy middle-class families, thanks to which today it is included in Poland in the group of buildings of masterful sacred composition (Bujak, Rożek, 1987). The beginnings of the creation of this building, its reconstruction and other history were described in the first volume of the monograph "*Sacred Art of Krakow in the 19th Century*" by Bałus et al. (2004). The aim of this study is to identify plant motifs found in the interior decorations of the Archpriestal Church of the Assumption of the Virgin Mary in Kraków and to analyse their symbolism.

## Characteristics of the object

### Location and architecture

St. Mary's Basilica is located in the north-east corner of the Main Square in Kraków, on the spacious St. Mary's Square (50°03′42″ N, 19°56′21″ E). The sanctuary is located on the route of the Lesser Poland road of Saint James leading to Tyniec. The church is located obliquely in relation to the axis of the Main Square. This is due to its location before establishment of the city. St. Mary's Square was established only in 1257, when the city was located under Magdeburg Law. The foundations of St. Mary's Church date back to the years 1221–1222 (Adamczewski, 1986; Bałus et al., 2004; Komorowski, Sudacka, 2008).

### External architecture (Appendix 1: Fig. 1)

The facade of the temple shows two towers differing in height and a church porch (Fig. 1a–c). The higher tower „*Ekxcubarium*" reaches 81 meters. It is crowned with a Gothic helmet from 1478, whose author is Maciej Heringk. In 1666 year a golden crown was erected on the spire, which was funded by the Italian merchant Piotr Antoni Pestaloci from Vicency. In the Middle Ages it had a defensive function, i.e. it was a guardroom. It was also called '*hejnalica*'. The lower tower (Fig. 1b) reaches a height of 69 meters and has been used as a belfry for centuries. The mannerist helmet of the tower was covered in the second half of the 16th century. It is covered by an elliptical dome placed on an octagonal drum. In its corners there are four smaller domes, located on four-sided bases. In the belfry tower, five bells are hung (Fig. 1b) – including four liturgical ones, which are the largest and oldest bells set in medieval Poland. The fifth bell is a clock dulcimer, because it does not work with the clock located on the higher tower. The belfry of the tower is occupied by a Renaissance chapel dedicated to St. Paweł, which was funded by the Kauffmann family. From the outside, right next to the chapel window, under the roof there is a bell 'for those dying' (Fig. 1g) – it was used to ring when a human died (Rożek, 1974, 1994, 2012).

The walls of the temple are decorated with ogival windows with numerous floral motifs, and the gables of the arches are figural sculptures with symbolic themes. The outer cornice of the temple surrounds 21 figures. Walls of the chapel St. Jan Nepomucen is decorated with a sundial made in 1954 by Tadeusz Przypkowski. On the eastern wall of the chapel there is a sculptural composition designed by Czesław Dźwigaj. It depicts the crucified Christ with the Mother of God and Saint John the Evangelist, as well as smaller statues of saints (Rożek, 2012). To the inside of the temple from the front side leads a baroque polygonal church porch (Fig. 1c). It was created in 1750–1752, according to a design by the Italian architect and sculptor Franciszek Placidi. From the north side of the church there is a small annex of the ecclesiastic treasury from the end of the 16th century. Next to it is a Gothic sacristy. The northern entrance to the church is opened by a huge gate with bas-reliefs depicting the history of Christ and Mary (Rożek, Gondkowa, 2003; Rożek, 2012).

## Internal architecture

The interior of the St. Mary's Church built on a cross plan (Fig. 2) from the floor to the vault is tightly covered with Matejko's paintings. Among them we find various ornamental motifs, angel figures, Marian prayers texts and other religious inscriptions. The vault throughout the church is covered with intensely blue pigment with golden stars. The whole gives the impression of a starry sky (Rożek, 1997; Bałus, 2007).

The main altarpiece was the largest cosmetic and artistic undertaking in St. Mary's Basilica. It was commissioned by city councillors to be implemented by master Wit Stwosz who arrived from Nuremberg. The altar was made in the years 1477–1489. It is considered a top-class work of sacred art from the Middle Ages. The Gothic pentaptic altar consists of a central wardrobe, two fixed wings and two movable wings and a crown. The scene of the Dormition of the Virgin Mary surrounded by the Apostles is the main idea and artistic accent of the altar. Above the central scene of falling asleep, Stwosz placed the Assumption, and at the peak – Mary's coronation. The author of the altar accurately recreated the smallest elements and details, revealed in the life of Mary and Christ scenes, placed in the quarters of the wings. The Wit Stwosz Altar is the greatest achievement of European sculpture of the Middle Ages (Dobrowolski, 1980).

The presbytery is also covered with paintings by Jan Matejko. On the walls are various floral and heraldic motifs: Loreto litanies placed on bands, Marian prayers and angels in dynamic poses. The wall paintings are in very intense and vivid colours. Most of them are red, gold, purple, and blue is on the vaults. Four carved keystones were made according to Matejko's design and they symbolise: the coat of arms of Odrowąż, the Piast eagle, the monogram of the Blessed Virgin Mary, and the coat of arms of the city of Kraków. The windows in the nave and in the presbytery are three-parted (Bałus, 2007).

The cyborium is authored by Jan Maria Padovan. Its execution was completed in 1536. The print consists of three floors. The central part of the cyborium is divided by four pilasters with Corinthian capitals into three niches, based on the theme of the triumphal arch. The cyborium contains the tempietta and tabernacle in which the Blessed Sacrament is. The top is finished with a dome. The golden door on the tabernacle was decorated with a stylised rose and olive tree. It was reconstructed in 1745. Vases, finials and cartouches from the Baroque era were placed here (Wolańska, Bałus, 2010).

There are 11 chapels funded by rich Kraków families such as: Bonerowie, Montelupi and Salomonowie. On the north side of the nave there are the following chapels: Transfiguration, Loreto, St. Lawrence's, St. Anthony's, St. John the Baptist's and St. Michael Archangel's. On the south side of the nave there are chapels: Guardian Angels, St. Valentine's, St. Lazaurus's, St. John Nepomucene's and Our Lady of Częstochowa (Wolańska, Bałus, 2010).

## The analysed material

The material used to analyse plant inspirations in the interior decorative motifs of St. Mary's Basilica in Kraków, in the form of 100 photographs in the years 2017/2018 was collected and developed. In this study some photographs were included as documentation. In the Basilica, 18 sectors (positions) were designated and numbered to simplify the description of the location of plant motifs (Fig. 2). The study omitted the wardrobe and wings of the main altar, made by Wit Stwosz, because they had already been the subject of botanical research (Szafer, 1934, 1958), and the focus was on other parts of the church. The documentation of the study refers to decorative motifs in the following forms: wall painting, sculpture (including scagiola and decorating the dress in paintings) with polychrome, stained glass. The study identifies plant taxa whose mappings were found in the above-mentioned ornamental forms. To identify species and genera the following studies, among others, were used: Szafer et al. (1986), Macků and Krejča (1989), Červenka et al. (1990), Krzyściak-Kosińska and Kosiński (2007), Halarewicz (2014).

In the case of ambiguous identification of the genus or species of the plant, an analysis was made of the entire context of the decoration in which the motif was considered. The context was helpful when the symbolic meaning of the plants used in decorating was taken into account (Wolańska, Bałus, 2010). In the interpretation of Christian symbolism were used, among others, studies of Szczepanowicz (2003), Włodarczyk (2004, 2011) and others.

All plants identified in ornamental motifs were catalogued alphabetically according to systematics with belonging to families. Nomenclature of genera and species, as well as belonging to families was adopted according to the study by Mirek et al. (2002)

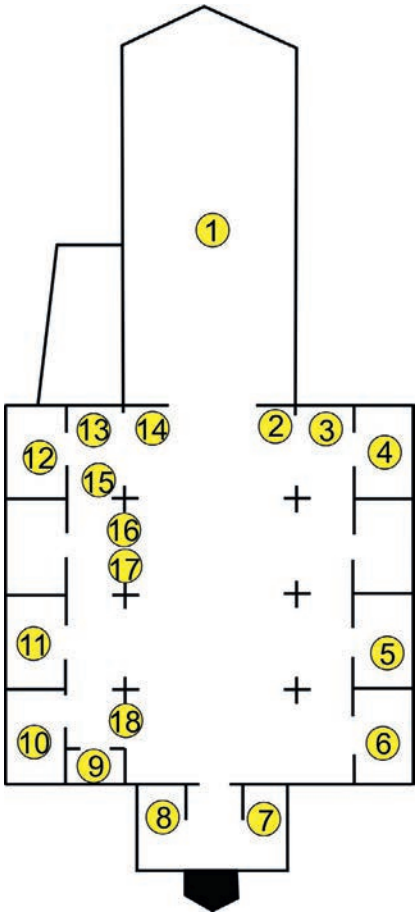


**Fig. 2.** Diagram of the distribution of the analysed sectors (stands) on the St. Mary's Church (Photo. Adriana Brišová);
1 – Presbytery, 2 – Cyborium, 3 – Altar with the crucifix of Wit Stwosz, 4 – Chapel of St. John Nepomucene, 5 – Chapel of St. Valentine, 6 – Chapel of St. Lazaurus, 7 – Chapel of Our Lady of Częstochowa, 8 – Chapel of St. Anthony, 9 – Chapel of Our Lady of Loreto, 10 – Chapel of St. John the Baptist, 11 – Chapel of St. Lawrence, 12 – Chapel of the Transfiguration, 13 – Altar of St. Stanislaw bishop, 14 – Altar with the painting of the Annunciation 15 – Epitaph of Prelate James Januszowicz, 16 – Altar of St. Sebastian, 17 – Fogelweder Stalls, 18 – Altar of St. Simon and St. Jude Thaddaeus

and Polish flora (www.atlas-roslin.pl). At each identified taxa, the following information is summarised: name of the genus or species (if possible), location of the motif in St. Mary's Church according to the numbering of positions in the diagram (Fig. 2), artistic form in which the motif with the given plant appeared (Sg – stained glass, WP – wall painting, Sc – sculpture, P – polychrome), plant parts (f – leaf, c – flower, p – fruit, b – branch) and presentation (st. – stylised, r. – realistic, sy. – symbolic). For example, the abbreviated entry: 1 – WP st. f means that at stand no. 1 (Presbytery) in wall painting a stylised leaf motif of a given plant appears.

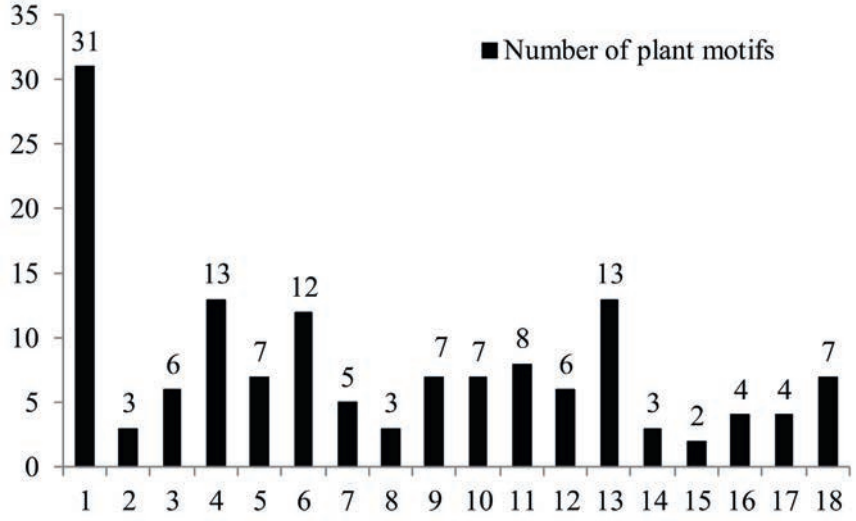


**Fig. 3.** Comparison of the number of plant motifs in individual research sectors of St. Mary's Basilica; 1 – Presbytery, 2 – Cyborium, 3 – Altar with the crucifix of Wit Stwosz, 4 – Chapel of St. John Nepomucene, 5 – Chapel of St. Valentine, 6 – Chapel of St. Lazaurus, 7 – Chapel of Our Lady of Częstochowa, 8 – Chapel of St. Anthony, 9 – Chapel of Our Lady of Loreto, 10 – Chapel of St. John the Baptist, 11 – Chapel of St. Lawrence, 12 – Chapel of the Transfiguration, 13 – Altar of St. Stanislaw bishop, 14 – Altar with the painting of the Annunciation 15 – Epitaph of Prelate James Januszowicz, 16 – Altar of St. Sebastian, 17 – Fogelweder Stalls, 18 – Altar of St. Simon and St. Jude Thaddaeus

## Results

Alphabetical list includes 43 plants found in the ornamental motifs of the St. Mary's Basilica in Kraków, including 29 taxa of genus and 14 taxa of species (Tab. 1 – Appendix 2). Most plant motifs concerned taxa from the following families: Rosaceae (9), Asteraceae (5), Liliaceae (3), Papaveraceae (2), Malvaceae (2). The most common motif appearing is the acanthus (*Acanthum* sp.), which was found in 15 positions. The next most frequent depictions are lilies (*Lilium* sp.) which occur in 11 positions, then roses (*Rosa* sp.) appearing at 9 points of the examined object (Fig. 3).

The unique motifs are hibiscus (*Hibiscus* sp.), gloriosis (*Gloriosa* sp.) and lingonberry (*Vaccinium vitis-idaea* L.) (Tab. 1 – Appendix 2). As for the manner of presentation, in all of the analysed artistic forms (WP, Sc, Sg) stylised performances dominate (Fig. 4). Selected, more interesting decorative motifs are presented in figures 5–8 – Appendix 1. Many floral motifs refer to the symbolism of Mary, due to the fact that the Basilica is for Mary's call (Tab. 2 – Appendix 2).

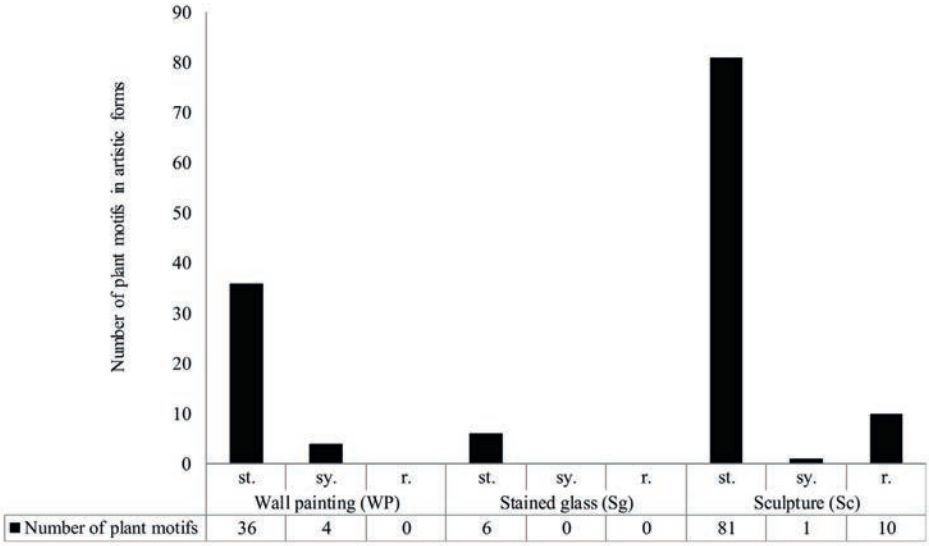


**Fig. 4.** Comparison of the number of performances (st. – stylised, sy. – symbolic, r. – realistic) of floral motifs in the analysed artistic forms

## Discussion

Plants presented in decorative motifs were very often the result of a kind of fashion. Sometimes, the artists created using patterns directly from the nature, but this required some botanical knowledge. That is why they more often used templates or herbaria, i.e. medical books showing plant pictures. They even sometimes copied from other creators and this phenomenon was very common. In various artistic forms created around 1500, such unusual and unreal plants appear, and at the same time so similar to each other that they were certainly copied. However, it can be said that, more or less since the 1660s, the artists tried to faithfully and realistically render the appearance of plants (Włodarczyk, 2011).

The floral motifs in art have always been accompanied by various types of stylisations, which in some cases led to partially or completely unrealistic representation a given ornamental motif. In St. Mary's Basilica, many decorative motifs were found, both in stained glass, wall painting and sculpture, which are difficult to attribute to any plant, although the inspirations of the world of plants are clearly noticeable here. These types of motifs include: branch, thorns (Fig. 5 a–b), pods (Fig. 5c), triple leaves (Fig. 8a), whether rosettes formed from them (Fig. 5d) or stylised flowers (Fig. 5e) – Appendix 1. Often, these motifs have a clear symbolic meaning, and it was probably the main artistic intention (Tab. 2 – Appendix 2). For example, thorns are associated with the crown of thorns and the passion of Christ. According to F. N. Hepper,

J. Maillat and S. Maillat (botanists dealing with biblical plants), there are several species from which branches a crown of thorns could be made, e.g. the thorn of Christ (*Ziziphus spina-christi* (L.) Willd.), Jerusalem thorn (*Paliurus spina-christi* Mill.), or prickly (*Sarcopoterium spinosum* (L.) Spach). However, there is no agreement about this (Włodarczyk, 2011). In religion, the significance of thorns is associated with unhappiness, pain and suffering. Thorns also symbolise the curse that resulted from Adam's disobedience to God. A crown of thorns placed on the head of Christ (Fig. 5a – Appendix 1), means not only torture, but also redemption from the sin of Adam's entire family (Szczepanowicz, 2003; Lengiewicz, 2008).

In the analysed sacred object, the most common appearing method of presentation is a stylised motif. Only in a few cases, the performances are symbolic or realistic – this applies to all three examined artistic forms (Tab. 1 – Appendix 2; Fig. 4). These styles are very different – from small, almost real representations, to significantly changed motifs. Their identification was possible only through the analysis of the whole decorative context. A good example of this are daisies placed in wall painting around the figure of the Mother of God in the Chapel of St. Jan Nepomucen (Fig. 6c – Appendix 1). Their stylisation is far advanced and they also look different from real plants. However, the context of Mary, accompanied by lilies, a symbol of purity, roses and dahlias as an attribute of virginity, peonies symbolising innocent embarrassment. White and pink daisies are a symbol of eternal youth and fit into Marian context (Szczepanowicz, 2003; Lengiewicz, 2008). Similarly, the figures of angels in the Presbytery placed in different poses with instruments and with the text of the Lorean litanies, set on lily flowers, which can be identified only from the context of the presence of angels as the personification of purity, expressed by the presence of these extremely stylised, fancy and colourful lilies. Right next to it, as if for comparison, the artist posted white lilies that are easy to identify because the stylisation is insignificant here.

Among the 18 analysed sectors of St. Mary's Basilica (Fig. 2), the most identified plant motifs were found in the presbytery: 21 in wall painting, 8 in sculpture and 2 in stained glass, and in the Chapel of St. John Nepomucene: 9 in wall painting, 2 in sculpture, 2 in stained glass (Tab. 1 – Appendix 2; Fig. 3). The most common floral motifs appearing in the Basilica decorations are: acanthus (*Acanthum* sp.) – 15 positions, lilies (*Lilium* sp.) – 11 positions, roses (*Rosa* sp.) – 9 positions, cinquefoils (*Potentilla* sp.) and chrysanthemums (*Dendranthema* sp.) – 8 positions each. Unique motifs are hibiscus (*Hibiscus* sp. Fig. 6f–g – Appendix 1) and gloriosis (*Gloriosa* sp.), placed in the wall painting of the Presbytery and lingonberry (*Vaccinium vitis-idaea* L.), which is part of the decorating the vault of the Chapel of St. John the Baptist.

The decorative element, in the form of a stylised acanthus leaf, was already used in architecture in ancient Greece and Rome. This motif was also popular in the Renaissance, Baroque and Classicism periods. Its symbolic meaning is not so important, but

above all it was a favourite decorative element in various artistic forms. In St. Mary's Basilica, it was found in as many as 16 examined sectors of the church (Tab. 1–2 – Appendix 2; Fig. 7a–d – Appendix 1). It is considered a symbol of the tree of life, the impermanence and fragility of life, the passing of the world and human life. On the other hand, as a symbol of suffering and pain, while the leaves themselves as a symbol of moral virtues (Szczepanowicz, 2003; Lengiewicz, 2008; Będkowska, Zemanek, 2016).

In the studied Basilica a very common plant decoration are lily and rose. It is probably associated with the Virgin Mary, who is the patron of this church (Tab. 2 – Appendix 2). Its attributes are, among others, flowers. The lilies appear here in real, stylised and symbolic form. Most often the lily is presented in a stylised form, but also in the form of the so-called Bourbon lily as a symbol of power and majesty. From the 11th century, this flower was part of the Bourbon dynasty coat of arms. It is a kind of stylised lily, heraldic figure, being the symbol of Mary in the Catholic Church (Szczepanowicz, 2003). For example, in the St. Jan Nepomucene's Chapel Mary and the Child, depicted in wall painting, are surrounded by small, golden Bourbon lilies, decorating a navy blue background. This motif also appears in their crowns (Fig. 6c – Appendix 1). Lilies also occur in the St. Anthony's Chapel for whom lily is also an attribute.

In turn, the rose indicates the love of the Mother of God, both for people and for God (Tab. 2 – Appendix 2). It is also a symbol of her beauty: physical and spiritual. In the past, theologians wrote that roses in paradise had no thorns. Our Lady is to be this rose without thorns, which refers to her immaculate conception. The rose kept in the hands of the saints, in turn, can be a symbol of martyrdom. In the Scriptures, roses appear several times, but they do not actually refer to the genus *Rosa* L., but to completely different plants, which do not even belong to the rosa family (Rosaceae). Many local biblical plants named 'Jericho rose' or 'Sharon rose' are the work of medieval monks who loved Bible stories and created gardens with plants they gave biblical names to. They did not have basic botanical knowledge about biblical plants. They themselves identified the flowers and gave them names that they thought were adequate or similar to some biblical species. To this day, many of these names have become part of botanical knowledge (Garrett, 2008). Hence, species that have nothing to do with the rose, e.g. hibiscus (*Hibiscus* sp., Fig. 6f – Appendix 1) or peony (*Paeonia* sp.), may have similar Christian symbolism as a rose. This is analogous to the lily described above, which has been confused with the tulip (*Tulipa* sp.) and, such as: diced chessboard (*Fritillaria meleagris* L.).

Jesse's tree is an interesting plant motif occurring in the Presbytery of St. Mary's Basilica. It was a frequent motif used in art from the 11th to the 17th century. It is an artistic presentation of the family tree of Christ, which in the analysed object resembles a vine (*Vitis vinifera* L.). Jesse was the father of David, king of Israel. In prophecy from the Isaiah book are mentions about the arrival of the Messiah, a descendant of Jesse

or Jesus Christ. In the presentations of this tree, Jesse rests on the ground, from which a trunk with numerous branches springs; on them are images of the Jewish kings and other ancestors of Christ (Śliwa, 2017). The vine motif can also be seen here in several other decorations (Fig. 8g–h – Appendix 1).

There were many reasons for placing specific plant motifs in decorations. Certainly religious symbolism played an important role in this respect, which was to be legible to everyone. It was supposed to raise the majesty and dignity of the temple, which was mentioned earlier. The placement of intricate floral motifs also played an important aesthetic role, which is also very important for religious sites. Thus, decorative motifs with lilies, roses, dahlias and other beautiful flowers, in addition to the symbolic and religious meaning, also fulfilled the decorative functions of this Basilica.

## Conclusion

In the analysed object it is not possible to identify all representations of decorative motifs inspired by the world of plants. It is also difficult to determine the exact functions of all depictions. One can only consider suppositions on this topic and formulate hypotheses. Sometimes, however, it is worth considering the mapped species or type of plant, because it may carry some symbolic content. It happens above all on artistic forms depicting the Mother of God, as well as on those on which Maria, Christ or the saints hold flowers or fruits in their hands. The inspiration for many of these appearances was certainly the well-known symbolism of certain species. Some of these species are recognised only because of their symbolic significance in religious context, because they are not a natural component of our region's flora. An example would be the well-known olive, acanthus or pomegranate. Therefore, such representations also have a certain cognitive aspect.

**Conflict of interest**

The author declares no conflict of interest related to this article.

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**Fig. 1.** Selected elements of the external architecture of St. Mary's Basilica;
a – main facade, b – lower tower (belfry), c – porch, d – board dedicated to Saint. John Paul II, e – epitaph of Stanislaw Chudzicz, f – Renaissance porch, g – bell 'for dying', h – southern entrance for visitors (Photo. A. Brišová, 2017)


**Fig. 5.** Plant motifs in the decorations of St. Mary's Basilica; artistic forms: Sc – sculpture, P – polychrome, WP – wall painting, Sg – stained glass; way of presenting the plant motif: r – realistic, sy. – symbolic, st. – stylised; 1 – 18 sector numbers as per figure 2
thorns: a – 6 Sc (sy.), b – 12 WP (sy.); pods: c – 2 Sc (st.); rosettes with trifoliate elements: d – 1 WP (sy.) flowers: e – 1 WP (st.) (Photo. A. Brišová, 2018)


**Fig. 6.** Plant motifs in the decorations of St. Mary's Basilica (cont.); artistic forms: Sc – sculpture, P – polychrome, WP – wall painting, Sg – stained glass window; way of presenting the plant motif: r. – realistic, sy. – symbolic, st. – stylised; 1–18 sector numbers as per figure 2
oak (*Quercus* sp.): a – 1 WP (st.); carnation (*Dianthus* sp.): b – 6 Sc (r.); peony (*Paeonia* sp.): c – 4 WP (st.), other: roses, dahlias, lilies and bourbon lilies, daisies; mallow (*Alcea* sp.): d, e – 17 Sc / P (st.), other: bells, apple tree, peony; hibiscus (*Hibiscus* sp.): f – 1 WP (st.), other: acanthus leaves; g – real plant (Photo. A. Brišová, 2018)

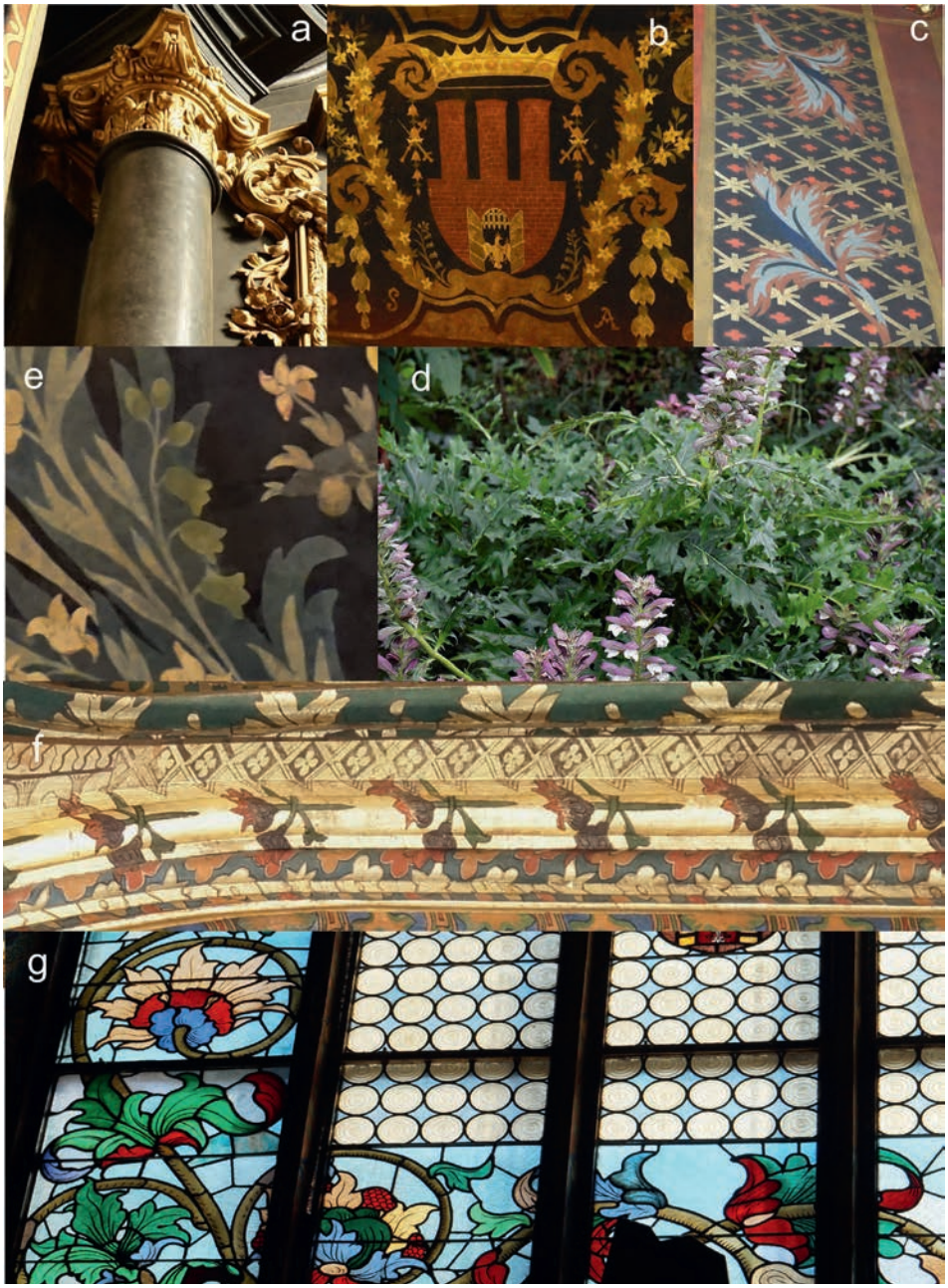


**Fig. 7.** Plant motifs in the decorations of St. Mary's Basilica (cont.); artistic forms: Sc – sculpture, P – polychrome, WP – wall painting, Sg – stained glass; way of presenting the plant motif: r. – realistic, sy. – symbolic, st. – stylised; 1–18 numbers sectors as per figure 2
acanthus (*Acanthus* sp.): a – 5 Sc (st.), b – 18 Sc (st.), c – 12 WP (st.), d – real plant; bell (*Campanula* sp.): e – 13 Sc (st.), f – 1 WP (st.); chrysanthemum (*Dendranthema* sp.): g – 1 Sg (st.) (Photo. A. Brišová, 2018)


**Fig. 8.** Plant motifs in the decorations of St. Mary's Basilica (cont.); Sc – sculpture, P – polychrome, WP – wall painting, Sg – stained glass; way of presenting the plant motif: r. – realistic, sy. – symbolic, st. – stylised; 1–18 sector numbers as per figure 2
clover (*Trifolium* sp.): a – 1 WP (st.); linum (*Linum* sp.): b – realistic plant, c – 16 Sc (st.); geranium (*Pelargonium* sp.): d – 1 WP (st.); proper grenade (*Punica granatum*): e – 1 WP (st.); f – real plant; proper vine (*Vitis vinifera*): g – 9 Sc (st.), h – 9 WP (st.) (Photo. A. Brišová, 2018)

**Tab. 1.** List of all plant taxa recorded in the decorations of the sectors of St. Mary's Basilica;
1–18 – sectors / positions numbers according to figure 2; artistic forms: Sc – sculpture, P – polychrome, WP – wall painting, Sg – stained glass; way of presenting the floral motif: r. – realistic, sy. – symbolic, st. – stylised; plant parts: f – leaf, c – flower, p – fruit, b – branches

| | Plant motifs | Presbitery | Cyborium | Altar with a crucifix | Chapel of St. John Nepomucene | Chapel of St. Valentine | Chapel of St. Lazaurus | Chapel of Our Lady of Częstochowa | Chapel of St. Anthony | Chapel of Our Lady of Loreto | Chapel of St. John the Baptist | Chapel of St. Lawrence | Chapel of the Transfiguration | Altar of St. Stanislaw | Altar with a painting of the Annunciation | Epitaph of bishop James Januszowicz | Altar of St. Sebastian | Fogelweder Stalls | Altars of St. Simon and St. Jude Thaddaeus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | **Cupressaceae** | | | | | | | | | | | | | | | | | | |
| 1. | *Thuja* sp. | Sc st. b | – | – | – | – | – | – | – | – | – | WP st. b | – | – | – | – | – | – | – |
| | **Papaveraceae** | | | | | | | | | | | | | | | | | | |
| 2. | *Chelidonium majus* L. | Sg st. f | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 3. | *Papaver* sp. | WP st. c | – | Sc st. c | WP st. c | Sc r. c | – | – | – | – | – | WP st. c | Sc st. c | – | – | – | Sc st. c | – | – |
| | **Lauraceae** | | | | | | | | | | | | | | | | | | |
| 4. | *Laurus nobilis* L. | – | – | – | – | Sc st. f | – | – | – | Sc st. f | WP sy. f | Sc st. f | – | – | – | – | – | – | – |
| | **Fagaceae** | | | | | | | | | | | | | | | | | | |
| 5. | *Quercus* sp. | WP st. b, f; Sg st. f | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

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| | **Caryophyllaceae** | | | | | | | | | | | | | | | | | | | |
| 6. | *Dianthus* sp. | – | – | – | – | – | Sc r. c | – | – | – | – | – | – | Sc r. c | – | – | – | – | Sc r. c |
| | **Paeoniaceae** | | | | | | | | | | | | | | | | | | | |
| 7. | *Paeonia* sp. | – | – | – | WP st. c | – | – | – | – | – | – | – | – | – | – | – | – | Sc/P st. c | – |
| | **Malvaceae** | | | | | | | | | | | | | | | | | | | |
| 8. | *Alcea* sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Sc/P st. c | – |
| 9. | *Hibiscus* sp. | WP st. c | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | **Buxaceae** | | | | | | | | | | | | | | | | | | | |
| 10. | *Buxus* sp. | – | – | – | WP st. b | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | **Ericaceae** | | | | | | | | | | | | | | | | | | | |
| 11. | *Vaccinium vitis–idaea* L. | – | – | – | – | – | – | – | – | – | WP st. p | – | – | – | – | – | – | – | – |
| | **Rosaceae** | | | | | | | | | | | | | | | | | | | |
| 12. | *Armeniaca vulgaris* L. | – | – | – | – | – | – | – | – | – | – | – | – | Sc st. p | – | – | – | – | – |
| 13. | *Cerasus* sp. | – | – | – | – | – | Sc st. p | – | – | – | – | – | – | Sc st. p | – | – | – | – | Sc st. p |
| 14. | *Crataegus* sp. | WP st. f | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 15. | *Malus* sp. | WP st. p | – | – | – | – | Sc st. p | – | – | – | – | – | – | Sc st. p | – | – | – | Sc/P st. p | – |
| 16. | *Persica vulgaris* Mill. | – | – | – | – | – | Sc st. p | – | – | – | – | – | – | Sc st. p | – | – | – | – | – |
| 17. | *Potentilla* sp. | WP st. f. | – | Sc st. c | WP st. c | – | – | – | Sc st. c | Sc st. c | WP st. c | – | Sc st. c | – | Sc st. c | – | – | – | – |

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| 18. | *Prunus* sp. | – | – | – | – | – | – | – | – | – | – | – | – | Sc st. p | – | – | – | – | – |
| 19. | *Pyrus* sp. | – | – | – | – | – | – | – | – | – | – | – | – | Sc st. p | – | – | – | – | – |
| 20. | *Rosa* sp. | Sg st. c; Sc st. c | – | Sc st. c | WP st. c | Sc r. c | Sc st. c | – | – | – | WP st. c | Sc st. c | – | – | – | – | Sc st. c | – | Sc st. c |
| 21. | *Rubus idaeus* L. | – | – | – | – | – | – | – | – | – | WP st. p | – | – | – | – | – | – | – | – |
| | | | | | | | **Fabaceae** | | | | | | | | | | | | |
| 22. | *Trifolium* sp. | WP st. f | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | | | | | | | **Linaceae** | | | | | | | | | | | | |
| 23. | *Linum* sp. | – | – | Sc st. c | – | – | Sc st. c | – | – | – | – | – | – | – | – | – | Sc st. c | – | – |
| | | | | | | | **Geraniaceae** | | | | | | | | | | | | |
| 24. | *Pelargonium* sp. | WP st. f, c; Sc st. f | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | | | | | | | **Lythraceae** | | | | | | | | | | | | |
| 25. | *Punica granatum* L. | WP st. p | – | – | – | – | Sc st. p | – | – | – | – | – | – | Sc st. p | – | – | – | – | – |
| | | | | | | | **Vitaceae** | | | | | | | | | | | | |
| 26. | *Vitis vinifera* L. | WP, Sc st. f, p | – | Sc st. f, p | – | – | – | – | – | Sc st. f, p | – | – | – | – | – | – | – | – | – |
| | | | | | | | **Oleaceae** | | | | | | | | | | | | |
| 27. | *Olea europaea* L. | – | Sc r. f, p | – | – | – | Sc st. f, p | – | – | – | – | – | – | – | – | – | – | – | – |

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| | **Gentianaceae** | | | | | | | | | | | | | | | | | | |
| 28. | *Gentiana* sp. | Sc st. c | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | **Caprifoliaceae** | | | | | | | | | | | | | | | | | | |
| 29. | *Viburnum* sp. | WP st. p | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | **Boraginaceae** | | | | | | | | | | | | | | | | | | |
| 30. | *Myosotis* sp. | WP st. c | – | – | WP st. c | – | – | – | – | – | WP st. c | WP st. c | – | – | – | – | – | – | – |
| | **Acanthaceae** | | | | | | | | | | | | | | | | | | |
| 31. | *Acanthus* sp. | WP, Rz st. f | Sc st. f | Sc st. f | Sc st. f | Sc st. f | Sc st. f | Sc st. f | Sc st. f | Sc st. f | – | Sc, W st. f | Sc st. f | Sc st. f | Sc st. f | Sc st. f | Sc st. f | – | Sc st. f |
| | **Campanulaceae** | | | | | | | | | | | | | | | | | | |
| 32. | *Campanula* sp. | WP st. c | – | – | – | – | Sc st. c | – | – | – | – | – | – | Sc st. c | – | – | – | Sc/P st. c | Sc st. c |
| | **Asteraceae** | | | | | | | | | | | | | | | | | | |
| 33. | *Bellis perennis* L. | – | – | – | WP st. c | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 34. | *Dahlia* sp. | – | – | – | WP st. c | – | – | – | – | – | – | – | – | Sc st. c | – | – | – | – | – |
| 35. | *Dendranthema* sp. | WP st. f, c | – | – | Sg st. f, c; Sc st. f | – | – | Sc st. c | – | – | – | – | | – | – | – | – | | – |
| 36. | *Helichrysum bracteatum* (Vent.) Andrews | – | – | – | – | – | Sc st. c | – | – | – | – | – | – | – | – | – | – | – | – |
| 37. | *Leucanthemum vulgare* Lam. s. str. | – | – | – | – | Sc r. c | – | Sc st. c | – | Sc st. c | – | – | – | – | – | – | – | – | – |
| | **Colchicaceae** | | | | | | | | | | | | | | | | | | |
| 38. | *Glorioza* sp. | WP st. c | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

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| | | | | | | | | **Liliaceae** | | | | | | | | | | | | |
| 39. | *Fritillaria meleagris* L. | – | – | – | – | – | – | Sc st. c | – | – | – | – | – | – | – | – | – | – | – | |
| 40. | *Lilium* sp. | WP sy., st. c; Sc st. c | – | – | Sg st. C; WP sy., st. c | Sc sy. c | Sc st. c | Sc st. c | Sc r. c | Sc st. c | WP sy. c | WP st. c | – | – | Sc st. c | – | – | – | Sc st. c | |
| 41. | *Tulipa* sp. | WP st. c) | – | – | – | – | – | – | – | Sc st. c | – | – | – | Sc r. c | – | – | – | – | Sc st. c | |
| | | | | | | | | **Poaceae** | | | | | | | | | | | | |
| 42. | *Triticum* sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Sc r. o | – | – | – | |
| | | | | | | | | **Arecaceae** | | | | | | | | | | | | |
| 43. | Phoenix dactylifera L. | Sc st. b | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | |
| | | | | | | | | Motifs of different parts of plants | | | | | | | | | | | | |
| | Nr sektorów/ stanowisk | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
| 1. | thorns | – | – | Sc sy. | – | – | Sc sy. | – | – | – | – | WP sy. | WP sy. | – | – | – | – | – | – | |
| 2. | tree | Sc st. | – | – | – | – | – | – | – | – | WP st. | – | – | – | – | – | – | – | – | |
| 3. | flower | WP st. | – | – | WP st. | Sc st. | Sc st. | – | – | – | – | – | – | – | – | – | – | – | – | |
| 4. | pods | – | Sc r. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | |
| 5. | triple leaf | WP sy. | – | – | WP sy. | – | – | – | – | – | – | – | – | – | Sc sy. | – | – | – | – | |

**Tab. 2.** Christian symbolism of plants noticed in the ornamental motifs of St. Mary's Basilica in Kraków

| Successive number | Plants | Christian symbolism |
|---|---|---|
| 1. | *Thuja* sp. | Branches are considered a symbol of happiness and longevity. |
| 2. | *Chelidonium majus* L. | It is not known. |
| 3. | *Papaver* sp. | Symbol of sleep, death, shed blood. |
| 4. | *Laurus nobilis* L. | The laurel wreath is a victory and a dignity of power; the wreath with the monogram of Christ means triumph over death. |
| 5. | *Quercus* sp. | The habit of the tree and the durability of wood is a symbol of strength; it also means a place sanctified by God's presence and God's great power – it is a tree of life and immortality. |
| 6. | *Dianthus* sp. | Carnations mean purity and motherly love as well as the spiritual relationship between Christ and Mary; the red flower is a symbol of Christ's passion and pure and true love. |
| 7. | *Paeonia* sp. | The flower is a symbol of Mary or St. Jan; considered a symbol of embarrassment and innocence. |
| 8. | *Alcea* sp. | It means pain, mercy, a request for forgiveness. |
| 9. | *Hibiscus* sp. | In Christian symbolism, it has a similar meaning as a rose. |
| 10. | *Buxus* sp. | In Christianity, it symbolises the hope of salvation and immortality. |
| 11. | *Vaccinum vitis-idaea* L. | Fruits are a reflection of offspring, the virtues of interior life. |
| 12. | *Persica vulgaris* Mill. | The fruit symbolises the virtues of the interior life, Christ, the artistic work of man, the offspring of mankind. |
| 13. | *Cerasus* sp. | Like the fruit of blueberry, raspberry, hawthorn, peach and apricot. |
| 14. | *Crataegus* sp. | Like the fruit of blueberry, raspberry, cherry, peach and apricot. |
| 15. | *Pyrus* sp. | Like the fruit of blueberry, raspberry, cherry, peach and apricot. |
| 16. | *Malus* sp. | An apple fruit symbolises Christ, overcoming sin, eternity, marriage, and in the mouth of the snake or the hands of the devil means sin and even death. |
| 17. | *Rubus idaeus* L. | Like the fruit of blueberry, cherry, peach and apricot, hawthorn. |
| 18. | *Armeniaca vulgaris* Lam. | Like the fruit of blueberry, cherry, peach and apricot, hawthorn. |
| 19. | *Potentilla* sp. | A flower with 5 petals of the crown is five wounds of Christ; occurs in the descriptions of the crucifixion of Christ. |
| 20. | *Rosa* sp. | Flower means fiery love; a white rose hung from the ceiling meant silence; is the attribute of the Virgin Mary; is an image of the shed blood of Christ; 5 rose petals symbolise (like a cinquefoil) the 5 wounds of Christ. |
| 21. | *Prunus* sp. | The branches of plum are made of thorns crowns, which are a symbol of the passion of Christ, as well as suffering and hope. |
| 22. | *Trifolium* sp. | The leaf is a symbol of the Holy Trinity; it also means happiness and life. |
| 23. | *Linum* sp. | Flower is patience, purity, innocence, steadfastness of customs, simplicity and even holiness. |

| | | |
|---|---|---|
| 24. | *Pelargonium* sp. | It is not known. |
| 25. | *Punica granatum* L. | The pomegranate is synonymous with resurrection, purity and compassionate love; red means – flaming love, a sign of blood and death, cracked fruit – emblem of "*bonus frater*" monks, clay fruit on the tombs – this is the hope of future life, the fruit crowning the column – it is rebirth, power and life. |
| 26. | *Vitis vinifera* L. | Vine shoots are a symbol of heavenly bliss, leaves are life, Eucharist grapes, paradise; grape juice is the blood of Christ, and the grape on the bush means Christ on the cross. |
| 27. | *Olea europaea* L. | Mother of God attribute and in the scenes of the Annunciation; means blessing and harvesting a time of peace, a just man, a holy tree, eternal wisdom, the chosen people, reconciliation, peace and forgiveness; the olive branch is a symbol of Christ's merciful love, reconciliation and peace. |
| 28. | *Gentiana* sp. | It is a symbol of bitterness and regret. |
| 29. | *Viburnum* sp. | The viburnum shrub is a symbol of rebirth, fruit like blueberry hawthorn and others. |
| 30. | *Myosotis* sp. | Sincere love, faithful memory and naive simplicity. |
| 31. | *Acanthus* sp. | Acanthus thorns is a symbol of suffering and pain, and the leaves themselves for moral virtues, impermanence and fragility of life, the passing of the world and human life. |
| 32. | *Campanula* sp. | Bell flowers are called the hats or thimbles of the Mother of God; combined with the Mother of God, and mean persistence. |
| 33. | *Dendranthema* sp. | Flower for the 'dead'; symbol of faith and hope in the resurrection. |
| 34. | *Dahlia* sp. | The red flower is the equivalent of a rose, hence it has a similar symbolism as a rose. |
| 35. | *Helichrysum bracteatum* (Vent.) Andrews | It means immortality and perseverance. |
| 36. | *Bellis perennis* L. | Eternal youth. |
| 37. | *Leucanthemum vulgare* Lam. | A symbol of great joy, but also the suffering and death of Christ and martyrs. |
| 38. | *Gloriosa* sp. | It means wonderful, full of glory, hence the symbolism similar to that of lilies. |
| 39. | *Lilium* sp. | Mary's most important attribute; emphasizes virtues and innocence, means the Body of Christ, purity, soul striving for God, faithful soul, virginity, royal dignity, Church of the Blessed Virgin Mary, transience, the word of God, light. |
| 40. | *Fritillaria meleagris* L. | Similar like a lily. |
| 41. | *Tulipa* sp. | Similar like a lily; also means good name. |
| 42. | *Triticum* sp. | The ear of grain is God's Kingdom, the mysteries of Jesus and the resurrection; Christ is likened to an ear; threshing and sieving grain symbolises the Last Judgment; the seed means Christ and the resurrection, and the ear of the Blessed Virgin Mary. |
| 43. | *Phoenix dactylifera* L. | The palm branch symbolizes the tree of life, eternal award, triumph, sign of adoration, victory, Christ's victory over hell, a life that does not die, and the branch on the tombstone means martyrdom. |

**Abstract**

The aim behind this analysis was to identify the plants which are the floristic motifs of ornaments inside of Church of Our Lady Assumed into Heaven in Kraków. The art techniques used in ornaments submitted to the analysis were: paintings, sculptures and stained glass-works. The analysis was based on the photographs of various parts of the St. Mary's Basilica taken between 2017 and 2018. Identified species of plants were presented in the table. In the analysis performed here, the author was focused on the symbolism of chosen floral art motifs, since the artist's botanical knowledge was not the only inspiration for utilising such decorations. Due to its symbolism, the motif of flowers was commonly used in the religious art, highlighting the dignity and majesty of this beautiful place of worship. Even though the meaning of plants as a symbol often depends on the cultural basis in which the work is done, there are some examples of plants that are widely known as religious symbols by everyone.

**Key words:** floral motifs, wall painting, stained glass, sculpture, plant symbols

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## Inspiracje roślinne w motywach zdobniczych Bazyliki Mariackiej w Krakowie (Polska)

**Streszczenie**

Celem niniejszej analizy była identyfikacja motywów roślinnych występujących w wewnętrznych zdobieniach Kościoła Archiprezbiterialnego Wniebowzięcia Najświętszej Marii Panny w Krakowie. Ujęto tu następujące formy artystyczne: malowidła, rzeźby, witraże. Przegląd przeprowadzono w oparciu o fotografie wykonane w różnych częściach Bazyliki Mariackiej w latach 2017/2018. Zidentyfikowane gatunki roślin zostały zestawione tabelarycznie. W przeprowadzonej tu analizie skupiono się również na znaczeniu symbolicznym wybranych motywów roślinnych, ponieważ nie tylko wiedza botaniczna artystów była inspiracją w umieszczaniu tego rodzaju zdobień. Częstym bodźcem była powszechnie stosowana w religii symbolika roślin, co jeszcze bardziej podkreślało powagę i majestat tego pięknego miejsca kultu religijnego. Mimo, iż symbolika roślin zależy ogólnie od podstaw kulturowych, w których dzieło powstało, to niektóre rośliny są powszechnie znanymi i czytelnymi dla wszystkich symbolami religijnymi.

**Słowa kluczowe:** motywy roślinne, malarstwo ścienne, witraże, rzeźba, symbole roślin

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# Vascular plants of Pilzno surroundings (South-Eastern Poland)

## Introduction

An extensive monographic study on the flora and geobotanical relations of the Strzyżów Foothills was created at the end of the last century (Towpasz, 1987, 1990). The flora of the Ciężkowice Foothills was analysed in a similar period (Kornaś et al., 1996). Later, only a few petty floristic publications were created to complement the flora of the Strzyżów Foothills (Oklejewicz et al., 2004; Wójcik, 2011; Towpasz, 2013). The natural environment of Pilsen surroundings has been recently presented in a monographic study (Towpasz, 2018). The aim of this study is floristic valorisation of the southern part of the Pilzno commune (South-Eastern Poland).

## General characteristics of the study area vegetation

The study area belongs to the Western Outer Carpathians and is located within the macroregion of the Central Beskids Foothills and two mesoregions: Ciężkowice Foothills (Pogórze Ciężkowickie) and Strzyżów Foothills (Pogórze Strzyżowskie) (Fig. 1). The landscape is dominated by arable fields, locally meadows and pastures (Appendix 1A–B). Forests occupy a small area and are preserved in places unfavorable to agriculture. Rare protected plants grow within them, among others: *Matteucia struthiopteris*, *Staphyllea pinnata* (Appendix 1C–D), or *Scilla bifolia*.

Meadows, arised and maintained on this area as a consequence of constant human intervention, such as: mowing, grazing, fertilisation. Depending on the degree of soil moisture, the following types of meadows are distinguished in this area: constantly and periodically moist and fresh meadows. On this area, pastures occupy a smaller area compared to meadows. For example, the association of water lilies is very rare in local ponds and oxbow lakes. Xerothermic vegetation develops here on dry, sunny slopes of hills and river valleys, mainly at southern exposure. Synanthropic communi-

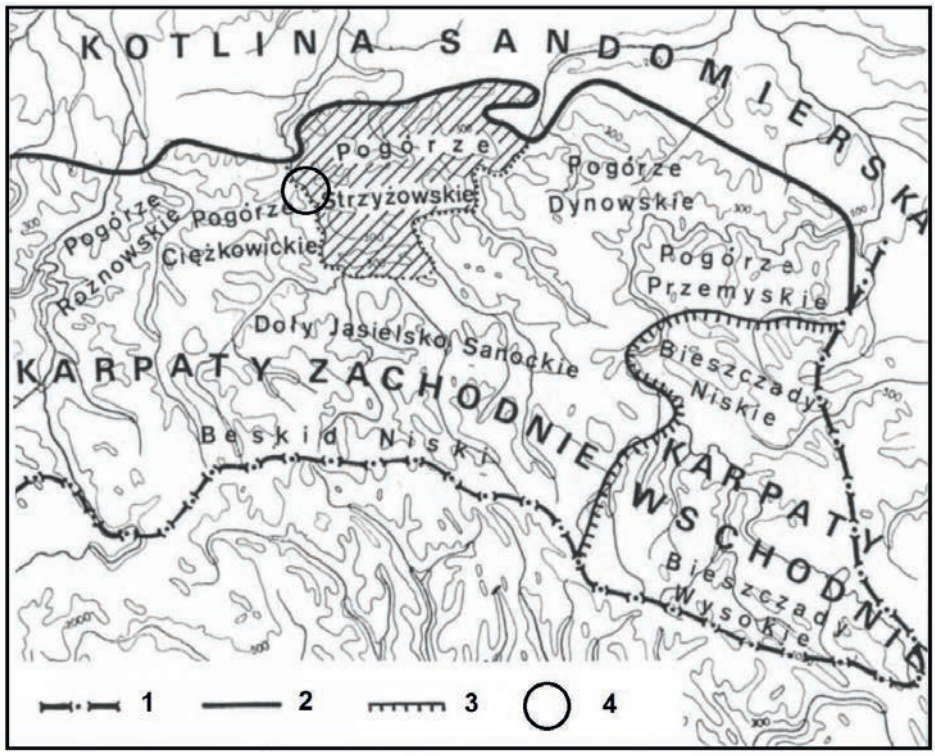


**Fig. 1.** Localisation of the study area against the regional divisionof the Eastern part of the Polish Carpathians (according Kondracki, 1978): 1 – state boundary, 2 – the northern limits of the Carpathians, 3 – boundary between the Western ana Eastern Carpathians, 4 – study region

ties, related to human activity, are creating among other as segetal vegetation in fields and gardens, and as ruderal vegetation accompanying human settlements, communication lines or industrial centers.

## Research methods

A detailed monographic studies of the vascular plant flora of the Strzyżów and Ciężkowice Foothills dates from the end of the 20th century (Towpasz, 1987, 1990; Kornaś et al., 1997). In connection with the elaboration of a chapter on the natural environment of Pilzno (Towpasz, 2018), some of the materials contained in these studies related to the occurrence of vascular plants in the Pilzno commune were used, after their updating and verification in the field in recent years. To complement the flora of the Strzyżów Foothills, earlier studies were also used (Oklejewicz et al., 2004; Wójcik, 2011; Towpasz, 2013).

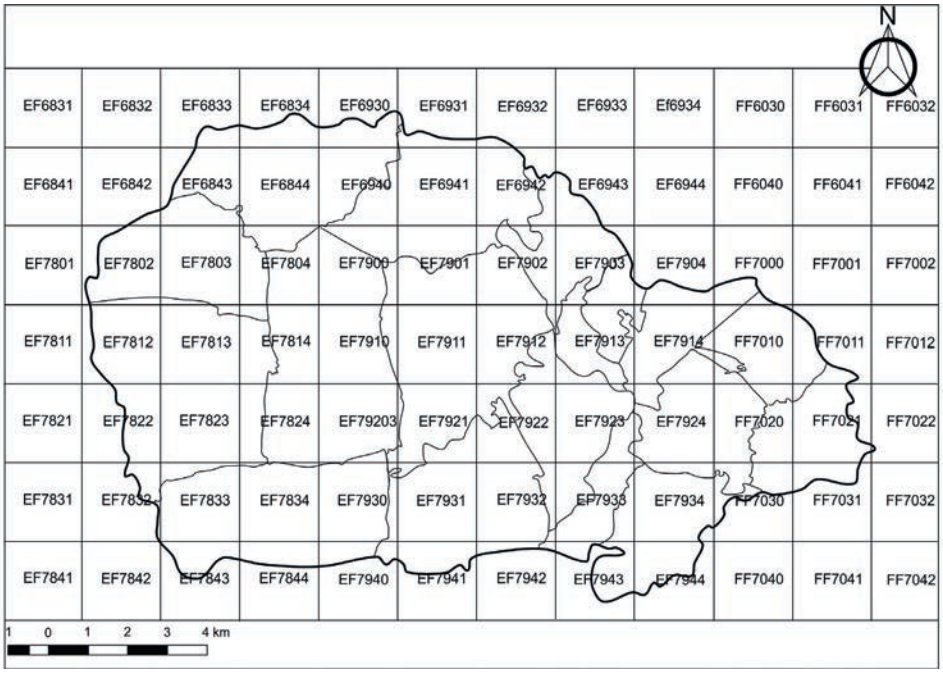


**Fig. 2.** Distribution of ATPOL grid squares in the area of Pilzno commune

The order of the species is given in alphabetical sequence, and their nomenclature is consistent with Mirek et al. (2002). All localities listed here were located in the ATPOL – the Polish geobotanical grid, 2 km long, in accordance with the methodology proposed by Zając (1978). Distribution of ATPOL grid squares in the area of Pilzno commune is shown in figure 2. Alien origin plants, mountain species (Pawłowski, 1925, 1972) and protected plants (*Regulation of the Minister of the Environment of October 9* (…), 2014) are indicated in the list. Classification of alien species was adopted according to the atlas Zając and Zając (2001) and supplemented based on the study by Tokarska-Guzik et al. (2012). For alien species, found in semi-natural and natural habitats (agriophytes), their belonging to the group of invasive plants in the studied area is given in accordance with the work (Zając, Zając, 2015).

In the prepared floristic list, the following marks and abbreviations have been used: * – alien species, Grn. – Górne, Dln – Dolne, CF – Ciężkowice Foothills, SF – Strzyżów Foothills.

## Glossary of geographical names in the Pilzno commune

The list includes geographical coordinates for the villages and signatures of the ATPOL grid squares.

Bielowy 49°56′46″N 21°19′36″E (EF 79 33) – village, 6 km SE from Pilzno (CF)
Dęborzyn 49°55′07″N 21°18′59″E (EF 79 44) – village, about 7 km SE from Pilzno (CF)
Dobrków 49°59′19″N 21°20′01″E (EF 79 04) – village, 1.5 km N from Gołęczyna (SF)
Dulczówka 49°58′43″N 21°17′29″E (EF 79 12) – village, 1 km W from Pilzno (CF)
Gołęczyna 49°58′38″N 21°20′36″E (EF 79 14) – village, about 3 km SE from Pilzno (SF)
Jaworze Dolne 49°57′18″N 21°21′08″E (EF 79 24) – village in the Wisłoka Valley, 8 km SE from Pilzno (SF)
Jaworze Górne 49°55′59″N 21°20′52″E (EF 79 34) – village, 2 km S from Jaworze Dolne (SF)
Łęki Górne 49°58′26″N 21°10′48″E (EF 78 13) – village, 4 km W from Pilzno (CF)
Mokrzec 49°58′38″N 21°19′36″E (EF 79 13) – village, 1 km E from Gołęczyna (SF)
Parkosz 50°00′13″N 21°18′50″E (EF 69 43) – village in the Wisłoka Valley, 3 km NE from Pilzno (SF)
Pilzno 49°58′43″N 21°17′29″E (EF 79 02; 79 03; 79 12) – city by the Tarnów – Dębica road, on the border of the Rożnów Foothills and the Strzyżów Foothills (CF, SF)
Podgrodzie 50°00′42″N 21°20′54″E (EF 69 44) – village, 6 km NE from Pilzno (SF)
Rędziny 49°56′51″N 21°18′08″E (EF 79 22) – hamlet of Strzegocice (CF)
Słotowa 49°56′43″N 21°17′16″E (EF 79 31) – village, 2 km W from Strzegocice (CF)
Strzegocice 49°56′51″N 21°18′08″E (EF 79 22) – village, 5 km S from Pilzno (CF)
Zagórze 49°55′19″N 21°18′05″E (EF 79 33) – village, 1 km NW from Dęborzyn (CF)
Zwiernik 49°56′24″N 21°12′34″E (EF 78 34) – village, 3 km S from Łęki Górne (CF)

## Results – list of species

1. ***Abies alba*** Mill. – Higher montane zone species. In deciduous forests (oak-hornbeam forests, beech forests) and mixed forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Zagórze (EF 79 33).

2. ***Acer campestre*** L. – In deciduous forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

3. ***A. platanoides*** L. – In deciduous forests: Parkosz (EF 69 43), Zwiernik (EF 78 34), Gołęczyna (EF 79 14).

4. ***A. pseudoplatanus*** L. – Higher montane zone species. In deciduous forests: Parkosz (EF 69 43), Łęki Grn. (EF 78 13).

5. ***Achillea millefolium*** L. – In the meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

6. ***Acinos arvensis*** (Lam.) Dandy – Balks and dry slopes: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

7. ***Actaea spicata*** L. – Oak-hornbeam forest over the stream: Podgrodzie (EF 69 44).

8. ***Adoxa moschatellina*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

9. ***Aegopodium podagraria*** L. – Thickets over stream, roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

10. ****Aethusa cynapium*** L. subsp. ***agrestis*** (Wallr.) Dostál – Archaeophyte. Fields: Pilzno (EF 79 02).

11. ***Agrimonia eupatoria*** L. – Roadsides, balks: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

12. ****Agrostemma githago*** L. – Archaeophyte. Fields: Bielowy (EF 79 33).

13. ***Agrostis capillaris*** L. – In meadows and fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 02), Gołęczyna (EF 79 14), Bielowy (EF 79 33).

14. ***A. gigantea*** Roth – Fields: Parkosz (EF 69 43), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

15. ***A. stolonifera*** L. – On stones of the Wisłoka River banks: Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

16. ***Ajuga reptans*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13).

17. ***Alchemilla acutiloba*** Opiz – Pastures: Łęki Grn. (EF 78 13).

18. ***Alisma plantago-aquatica*** L. – In water reservoir and in drainage ditche: Parkosz (EF 69 43).

19. ***Alliaria petiolata*** (M. Bieb.) Cavara & Grande – In alluvial forests of the Wisłoka River: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 02, EF 79 12), Jaworze Dln. (EF 79 24).

20. ***Allium oleraceum*** L. – Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

21. ***A. scorodoprassum*** L. – On edges of thickets: Jaworze Dln. (EF 79 24).

22. ***Alnus glutinosa*** (L.) Gaertn. – Oak-hornbeam forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

23. ***A. incana*** (L.) Moench – Higher montane zone species. In alluvial forests: Podgrodzie (EF 69 44).

24. ***Alopecurus geniculatus*** L. – Wet meadows: Pilzno (EF 79 02), Parkosz (EF 79 03).

25. ***A. pratensis*** L. – Meadows: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Mokrzec (EF 79 13).

26. ***Alyssum alyssoides*** (L.) L. – On sandy fallow lands on the Wisłoka River: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

27. ****Amaranthus retroflexus*** L. – Epoecophyte. In fields, in root crops: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

28. ****Anagallis arvensis*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Zwiernik (EF 78 34), Pilzno (EF 79 02), Mokrzec (EF 79 13).

29. ****Anchusa officinalis*** L. – Archaeophyte. On fallow lands and on ruderal habitats: Podgrodzie (EF 69 44), Mokrzec (EF 79 13).

30. ***Anemone nemorosa*** L. – In deciduous forests: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Parkosz (EF 79 03).

31. ***Angelica sylvestris*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

32. ***Anthemis arvensis*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34).

33. ***Anthriscus nitida*** (Wahlenb.) Hanzl. – Wet forest: Pilzno (EF 79 12).

34. ***A. sylvestris*** (L.) Hoffm. – In thickets of the Wisłoka River: Pilzno (EF 79 12), Strzegocice (EF 79 22).

35. ***Anthyllis vulneraria*** L. – In grasslands on slopes: Jaworze Dln. (EF 79 24).

36. ***Antoxanthum aristatum*** Boiss. – Holoagiophyte. On sandy dune in pine forest: Jaworze Dln. (EF 79 24).

37. ***A. odoratum*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14).

38. ***Apera spica-venti*** (L.) P. Beauv. – Archaeophyte. Fields: Parkosz (EF 69 43), Zwiernik (EF 78 34), Pilzno (EF 79 03).

39. ***Aphanes arvensis*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

40. ***Aposeris foetida*** (L.) Less. – Higher montane zone species. In deciduous forests: Bielowy (EF 79 33).

41. ***Arabidopsis thaliana*** (L.) Heynh. – On ruderal habitats: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13).

42. ***Arabis glabra*** (L.) Bernh. – On dry slopes: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

43. ***Arctium lappa*** L. – Roadsides: Parkosz (EF 69 43), Pilzno (EF 79 02).

44. ***A. minus*** (Hill) Bernh. – Roadside and alluvial forests of the Wisłoka River: Parkosz (EF 69 43), Dobrków (EF 79 04).

45. ***A. tomentosum*** Mill. – Roadside: Podgrodzie (EF 69 44).

46. ***Arenaria serpyllifolia*** L. – Roadsides: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

47. ***Armoracia rusticana*** P. Gaertn., B. Mey. & Schreb. – Archaeophyte. Roadside: Pilzno (EF 79 02).

48. ***Arrhenatherum elatius*** (L.) P. Beauv. ex J. Presl. & C. Presl. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Bielowy (EF 79 33).

49. ***Artemisia campestris*** L. – Sand dunes and fallow land: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln.(EF 79 24).

50. ***A. vulgaris*** L. – Roadside: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 12).

51. ***Asarum europaeum*** L. – Partially protected species. In deciduous forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

52. ***Asplenium ruta-muraria*** L. – On walls: Pilzno (EF 79 12), Strzegocice (EF 79 22).

53. ***A. trichomanes*** L. – In oak-hornbeam thickets: Jaworze Dln. (EF 79 24).

54. ***Aster novi-belgii*** L. – Hemiagriophyte. Invasive species. Roadside: Podgrodzie (EF 69 44).

55. ***Astragalus glycyphyllos*** L. – On balks and roadsides: Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

56. ***Athyrium filix-femina*** (L.) Roth – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

57. ****Atriplex patula*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Zwiernik (EF 78 34).

58. ****Avena fatua*** L. – Archaeophyte. Fields: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

59. ****Ballota nigra*** L. – Archaeophyte. Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12).

60. ***Barbaraea vulgaris*** R. Br. – Roadside and meadow: Parkosz (EF 69 43).

61. ***Batrachium aquatile*** (L.) Dumort. – In water reservoir: Jaworze Dln. (EF 79 24).

62. ***Bellis perennis*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13).

63. ***Berteroa incana*** (L.) DC. – Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

64. ***Berula erecta*** (Huds.) Conville – In drainage ditches: Jaworze Dln. (EF 79 24).

65. ***Betula obscura*** Kotula – In forests: Parkosz (EF 69 43), Dobrków (EF 79 04).

66. ***B. pendula*** Roth – In forests: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14).

67. ****Bidens frondosa*** L. – Hemiagriophyte. Invasive species. On banks of drainage ditches: Dobrków (EF 79 04), Pilzno (EF 79 12).

68. ***B. tripartita*** L. – On banks of rivers and streams: Parkosz (EF 69 43), Zwiernik (78 34), Pilzno (EF 79 12).

69. ***Brachypodium sylvaticum*** (Huds.) P. Beauv. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

70. ****Brassica nigra*** (L.) W. D. J. Koch – Epoecophyte. Roadside: Pilzno (EF 79 02).

71. ***Briza media*** L. – Meadows: Słotowa (EF 79 31), Jaworze Dln. (EF 79 24).

72. ****Bromus carinatus*** Hook. & Arn. – Epoecophyte. On lawns and roadsides: Pilzno (EF 79 12), Jaworze Grn. (EF 79 34).

73. ***B. hordeaceus*** L. – Meadows: Parkosz (EF 69 43), Łęki Górne (EF 78 13), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

74. ***B. inermis*** Leyss. – On dry slopes and roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04), Pilzno (EF 79 12).

75. ****Bunias orientalis*** L. – Epoecophyte. On ruderal habitats: Jaworze Dln. (EF 79 24).

76. ***Calamagrostis arundinacea*** (L.) Roth – In pine forests: Jaworze Dln. (EF 79 24).

77. ***C. epigejos*** (L.) Roth – On balks, in thinned forests and on their outskirts: Podgrodzie (EF 69 44), Słotowa (EF 79 11), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

78. ***Calluna vulgaris*** (L.) Hull – On edges of forests: Parkosz (EF 69 43), Gołęczyna (EF 79 14), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

79. ***Caltha palustris*** L. – Wet meadows, banks of streams: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24), Podgrodzie (EF 69 44).

80. ***Calystegia sepium*** (L.) R. Br. – In alluvial forests of the Wisłoka River: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12).

81. ***Camelina microcarpa*** Andrz. – On sandy fallow lands: Jaworze Dln. (EF 79 24).

82. ***Campanula glomerata*** L. – Dry slopes: Jaworze Grn. (EF 79 34).

83. ***C. patula*** L. – Meadows: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

84. ***C. persicifolia*** L. – In thickets of the Wisłoka River: Podgrodzie (EF 69 44).

85. ***C. rapunculoides*** L. – On cereal fields: Parkosz (EF 69 43), Pilzno (EF 79 02), Gołęczyna (EF 79 14).

86. ***C. trachelium*** L. – In thickets: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

87. ***Capsella bursa pastoris*** (L.) Medik. – Roadsides: Podgrodzie (EF 69 34), Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 02).

88. ***Cardamine amara*** L. – On the banks of streams: Parkosz (EF 69 43), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

89. ***C. impatiens*** L. – In deciduous forest: Jaworze Dln. (EF 79 24).

90. ****Cardaria draba*** (L.) Desv. – Epoecophyte. Roadside: Mokrzec (EF 79 13).

91. ****Carduus acanthoides*** L. – Archaeophyte. On balks and roadsides: Podgrodzie (EF 69 34), Parkosz (EF 69 43), Mokrzec (EF 79 13).

92. ***C. crispus*** L. – Fields: Pilzno EF 79 02), Dobrków (EF 79 04).

93. ***Carex brizoides*** L. – Oak-hornbeam forests: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

94. ***C. caryophyllea*** Latourr. – On lawn at Wisłoka's stone banks: Podgrodzie (EF 69 44).

95. ***C. cuprina*** (I. Sándor ex Heuff.) Nendtv. ex A. Kern. – Wet meadows: Parkosz (EF 69 43), Strzegocice (EF 79 22).

96. ***C. digitata*** L. – In forest: Podgrodzie (EF 69 44).

97. ***C. flacca*** Schreb. – Pasture: Jaworze Dln. (EF 79 24).

98. ***C. gracilis*** Curtis – On banks of drainage ditches: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

99. ***C. hirta*** L. – Pastures: Parkosz (EF 69 43), Gołęczyna (EF 79 14).

100. ***C. nigra*** Reichard – Wet meadows: Łęki Grn. (EF 78 13), Strzegocice (EF 79 22).

101. ***C. ornithopoda*** Wild. – On stones of stream banks and on slope grassland: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

102. ***C. ovalis*** Gooden. – Meadows: Podgrodzie (EF 69 44), Pilzno (EF 79 12).

103. ***C. pallescens*** L. – Meadow: Podgrodzie (EF 69 44).

104. ***C. panicea*** L. – Wet meadows: Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

105. ***C. paniculata*** L. – Wet meadow: Jaworze Dln. (EF 79 24).

106. ***C. pendula*** Huds. – Lower montane zone species. In alluvial forest over stream: Podgrodzie (EF 69 44).

107. ***C. pilosa*** Scop. – In forest: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

108. ***C. remota*** L. – Over stream: Dobrków (EF 79 04).

109. ***C. spicata*** Huds. – On roadside embankment: Pilzno (EF 79 12).

110. ***C. sylvatica*** Huds. – Oak-hornbeam forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

111. ***C. vesicaria*** L. – Wet meadows: Parkosz (EF 69 43), Dobrków (EF 79 04).

112. ***C. vulpina*** L. – Wet meadows: Parkosz (EF 69 43), Zwiernik (EF 78 13), Strzegocice (EF 79 22).

113. ***Carlina vulgaris*** L. – Dry meadow: Parkosz (EF 69 43).

114. ***Carpinus betulus*** L. – In deciduous forests, mainly in oak-hornbeam forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Słotowa (EF 79 11), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

115. ***Carum carvi*** L. – On meadows and balks: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Słotowa (EF 79 11), Jaworze Dln. (EF 79 24).

116. ****Centaurea cyanus*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

117. ***C. jacea*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

118. ***C. scabiosa*** L. – Balks: Podgrodzie (EF 69 44), Słotowa (EF 79 12), Jaworze Dln. (EF 79 24).

119. ***Centaurium erythraea*** Rafn – Partially protected species. Dry meadows: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

120. ***Cephalanthera longifolia*** (L.) Fritsch – Protected species. Oak-hornbeam forest: Dęborzyn (EF 79 44).

121. ***Cerastium arvense*** L. – Fields: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

122. ***C. glomeratum*** Thull. – Field: Strzegocice (EF 79 22).

123. ***C. holosteoides*** Fr. emend. Hyl. – Meadows: Parkosz (EF 69 43), Łęki Grn. (EF 78 13).

124. ***C. semidecandrum*** L. – On sandy dunes: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

125. ***C. sylvaticum*** Waldst. & Kit. – Lower montane zone species. Oak-hornbeam forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

126. ***Cerasus avium*** (L.) Moench – Oak-hornbeam forest: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

127. ***Ceratophyllum demersum*** L. – In water reservoir: Mokrzec (EF 79 13).

128. ***Cerinthe minor*** L. – On dry slopes: Jaworze Dln. (EF 79 24).

129. ***Chaenorrhinum minor*** (L.) Lange – Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02: EF 79 12).

130. ***Chaerophyllum aromaticum*** L. – Thickets: Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

131. ***Ch. hirsutum*** L. – Wet forest: Jaworze Dln. (EF 79 24).

132. ***Chamaenerion angustifolium*** (L.) Scop. – Thickets edge: Zwiernik (EF 78 34).

133. ****Chamomilla suaveolens*** (Pursh) Rydb. – Epoecophyte. Fields and roadsides: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 02), Parkosz (EF 79 03), Dobrków (EF 79 04), Słotowa (EF 79 31).

134. ***Chelidonium maius*** L. – Roadsides: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 03), Słotowa (EF 79 11), Gołęczyna (EF 79 14).

135. ***Chenopodium album*** L. – Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 02, EF 79 12), Jaworze Dln. (EF 79 24).

136. ***Ch. glaucum*** L. – Field: Podgrodzie (EF 69 44).

137. ****Ch. hybridum*** L. – Archaeophyte. On ruderal habitats: Podgrodzie (EF 69 44), Parkosz (EF 69 43).

138. ***Ch. polyspermum*** L. – Fields: Podgrodzie (EF 69 44), Dobrków (EF 79 04), Mokrzec (EF 79 13).

139. **** Ch. strictum*** Roth – Epoecophyte. On ruderal habitat: Jaworze Dln. (EF 79 24).

140. ***Chimaphila umbellata*** (L.) W. P. C. Barton – In pine forests: Jaworze Dln. (EF 79 24).

141. ***Chrysosplenium alternifolium*** L. – In deciduous forests: Zwiernik (EF 78 24), Jaworze Dln. (EF 79 24), Podgrodzie (EF 79 44).

142. ****Cichorium intybus*** L. – Archaeophyte. Roadsides: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Słotowa (EF 79 11), Jaworze Dln. (EF 79 24).

143. ***Circaea lutetiana*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

144. ***Cirsium arvense*** (L.) Scop. – Fields: Parkosz (EF 69 43), Pilzno (EF 79 02, EF 79 12), Gołęczyna (EF 79 14).

145. ***C. oleraceum*** (L.) Scop. – Wet meadow: Dobrków (EF 79 04).

146. ***C. palustre*** (L.) Scop. – In balk: Podgrodzie (EF 69 44).

147. ***C. rivulare*** (Jacq.) All. – Wet meadows: Łęki Grn. (EF 78 13), Parkosz (EF 69 43), Strzegocice (EF 79 22).

148. ***C. vulgare*** (Savi) Ten. – Roadsides and pastures: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Gołęczyna (EF 79 14), Strzegocice (EF 79 22).

149. ***Clinopodium vulgare*** L. – On dry slopes and balks: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Zagórze (EF 79 33) ), Parkosz (EF 79 43).

150. ****Consolida regalis*** Gray – Archaeophyte. Fields: Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

151. ***Convallaria majalis*** L. – In oak-hornbeam forests: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

152. ***Convolvulus arvensis*** L. – Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 02, EF 79 12).

153. ***Conyza canadensis*** (L.) Cronquist – Epoecophyte. Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Mokrzec (EF 79 14).

154. ***Cornus sanguinea*** L. – Thickets: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

155. ***Coronilla varia*** L. – In balks and on dry slopes grasslands: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dolne (EF 79 24).

156. ***Corydalis solida*** (L.) Clairv. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

157. ***Corylus avellana*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

158. ***Corynephorus canecens*** (L.) P. Beauv. – On roadside and on sandy fallow lands: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

159. ***Crataegus monogyna*** Jacq. – In thickets of balks: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04), Mokrzec (EF 79 13), Strzegocice (EF 79 22).

160. ***C. rhipidophylla*** Gand. var. ***lindmanii*** (Hrabětová) K. I. Chr. – In thickets of balk: Jaworze Grn.(EF 79 34).

161. ***C. rhipidophylla*** Gand. var. ***rhipidophylla*** – Thickets over the Wisłoka River: Podgrodzie (EF 69 44).

162. ***C. subsphaericea*** Gand. – In thickets of balk: Jaworze Dln. (EF 79 24) (Oklejewicz i in. 2004).

163. ***Crepis biennis*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

164. ***C. capillaris*** (L.) Wallr. – Meadow: Jaworze Dln. (EF 79 24).

165. ***C. paludosa*** (L.) Moench – In meadow and riparian forest: Parkosz (EF 69 43), Zwiernik (EF 78 34), Dobrków (EF 79 04).

166. ***C. tectorum*** L. – On sandy fallow area: Jaworze Dln. (EF 79 24).

167. ***Cruciata glabra*** (L.) Ehrend. – On balk: Jaworze Dln. (EF 79 24).

168. ***Cucubalus baccifer*** L. – In wicker over the Wisłoka River: Podgrodzie (EF 69 44).

169. ***Cuscuta epithymum*** (L.) L. – On meadow plants: Strzegocice (EF 79 23).

170. ***C. europaea*** L. – On meadow plants: Parkosz (EF 69 43).

171. ***Cynoglossum officinale*** L. – On gravels of the Wisłoka River: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

172. ***Cynosurus cristatus*** L. – Meadows: Podgrodzie (EF 69 44), Dobrków (EF 79 04).

173. ***Cystopteris fragilis*** (L.) Bernh. – On a stone wall: Strzegocice (EF 79 22).

174. ***Dactylis glomerata*** L. – Meadows: Parkosz (EF 69 43), Łęki Grn. (EF 78 13).

175. ***D. polygama*** Horv. – In meadow and oak-hornbeam forest: Parkosz (EF 69 43), Dobrków (EF 79 04).

176. ***Dactylorhiza majalis*** (Rchb.) P. F. Hunt & Summerh. – Partially protected species. Wet meadows: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Strzegocice (EF 79 22), Jaworze Dln. (EF 79 24).

177. ***Daphne mezereum*** L. – Partially protected species. In deciduous forests: Parkosz (EF 69 43), Dobrków (EF 79 04), Dęborzyn (EF 79 43).

178. ****Datura stramonium*** L. – Epoecophyte. Field: Gołęczyna (EF 79 14).

179. ***Daucus carota*** L. – Meadows: Podgrodzie (EF 69 44), Dobrków (EF 79 04).

180. ***Dentaria glandulosa*** Waldst. & Kit. – Higher montane zone species. Oak-hornbeam forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

181. ***Deschampsia caespitosa*** (L.) P. Beauv. – Meadows: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24), Zagórze (EF 79 33).

182. ****Descurainia sophia*** (L.) Webb ex Prantl – Archaeophyte. On ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02).

183. ***Dianthus deltoides*** L. – On sandy grasslands: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

184. ****Digitaria ischaemum*** (Schreb). H. L. Mühl. – Archaeophyte. On fallow area: Jaworze Dln. (EF 79 24).

185. ****D. sanguinalis*** (L.) Scop. – Archaeophyte. On ruderal habitat: Podgrodzie (EF 69 44).

186. ****Diplotaxis muralis*** (L.) DC. – Epoecophyte. Roadside: Pilzno (EF 79 02).

187. ***Dipsacus laciniatus*** L. – On stones of the Wisłoka River bank: Pilzno (EF 79 12), Strzegocice (EF 79 22).

188. ***D. sylvestris*** Huds. – On stones of the Wisłoka River bank: Podgrodzie (EF 69 44), Pilzno (EF 79 12), Mokrzec (EF 79 13).

189. ***Dryopteris carthusiana*** (Vill.) H. P. Fuchs – In forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Dęborzyn (EF 79 44), Gołęczyna (EF 79 14).

190. ***D. dilatata*** (Hoffm.) A. Gray – All-mountain species. In forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34).

191. ***D. filix-mas*** (L.) Schott – In forests: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

192. ***D. expansa*** (C. Presl) Fraser-Jenk. & Jermy – In forest: Jaworze Dln. (EF 79 24).

193. ****Echinochloa crus-galli*** (L.) P. Beauv. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

194. ****Echinocystis lobata*** (F. Michx.) Torr. & A. Gray – Holoagriophyte. Invasive species. It grows in alluvial forests: Mokrzec (EF 79 13).

195. ***Echium vulgare*** L. – Roadsides: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

196. ***Eleocharis palustris*** (L.) Roem. & Schult. – On banks of ditches: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

197. ***Elymus caninus*** (L.) L. – In thickets of rivers and streams: Podgrodzie (EF 69 44), Pilzno (EF 79 12).

198. ***E. repens*** (L.) Gould – In field communities and roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Zwiernik (EF 78 34), Gołęczyna (EF 79 14).

199. ***Epilobium hirsutum*** L. – On edge of ditch: Podgrodzie (EF 69 44).

200. ***E. parviflorum*** Schreb. – On banks of streams: Podgrodzie (EF 69 44). Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

201. ***E. roseum*** Schreb. – On stones of the Wisłoka River bank: Pilzno (EF 79 12).

202. ***Epipactis helleborine*** (L.) Crantz – Partially protected species. Oak-hornbeam forests: Jaworze Dln. (EF 79 24), Jaworze Grn. (EF 79 34), Dęborzyn (EF 89 04).

203. ***E. purpurata*** Sm. – Protected species. Oak-hornbeam forest: Dęborzyn (EF 79 44).

204. ***Equisetum arvense*** L. – In forests, fields, meadows, roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 02, EF 79 03), Jaworze Dln. (EF 79 24).

205. ***E. fluviatile*** L. – In reeds on water reservoirs banks: Parkosz (EF 69 43), Łęki Grn. (EF 78 13).

206. ***E. hyemale*** L. – Oak-hornbeam forest: Podgrodzie (EF 69 44).

207. ***E. palustre*** L. – On banks of ditches: Łęki Grn. (EF 78 13), Dobrków (EF 79 04).

208. ***E. pratense*** Ehrh. – Wet oak-hornbeam forest: Łęki Grn. (EF 78 13).

209. ***E. ramosissimum*** Desf. – On stones of river banks: Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

210. ***E. sylvaticum*** L. – In pine forests: Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

211. ***E. telmateia*** Ehrh. – Lower montane zone species. In wet forests and on banks of streams: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

212. ***Erigeron acris*** L. – Roadsides: Parkosz (EF 69 43), Zagórze (EF 79 33).

213. ***Eriophorum angustifolium*** Honck.– Wet meadows: Parkosz (EF 69 43), Dęborzyn (EF 79 44).

214. ***E. latifolium*** Hoppe – Wet meadow: Łęki Grn. (EF 78 13).

215. ***Erodium cicutarium*** (L.) L'Hér. – On ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

216. ***Erophila verna*** (L.) Chevall. – On grasslands and dry slopes, fields: Parkosz (EF 69 43), Gołęczyna (EF 79 14).

217. ***Erysimum cheiranthoides*** L. – In fields and ruderal habitats: Pilzno (EF 79 12), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

218. ***Euonymus europaea*** L. – In forests: Zwiernik (EF 78 34), Parkosz (EF 69 43), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

219. ***E. verrucosa*** Scop. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Dln. (EF 79 42), Jaworze Dln. (EF 79 24).

220. ***Eupatorium cannabinum*** L. – In thickets above streams: Podgrodzie (EF 69 44). Jaworze Dln. (EF 79 24).

221. ***Euphorbia amygdaloides*** L. – In deciduous forests: Parkosz (EF 69 43), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

222. ***E. cyparissias*** L. – On balks, pastures and dry meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14).

223. ***E. dulcis*** L. – Oak-hornbeam forest: Zwiernik (EF 78 34).

224. ***E. esula*** L. – On dry meadows, balks and pastures: Podgrodzie (EF 69 44), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

225. * ***E. helioscopia*** L. – Archaeophyte. Fields and roadsides: Podgrodzie (EF 69 44), Pilzno (EF 79 02), Mokrzec (EF 79 13).

226. ***E. serrulata*** Thull. – Higher montane zone species. In thickets and on stones of rivers: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

227. ***Euphrasia rostkoviana*** Hayne – On balk: Dobrków (EF 79 04).

228. ***Fagus sylvatica*** L. – In deciduous forests: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

229. ****Fallopia convolvulus*** (L.) Á. Löve – Archaeophyte. Fields: Parkosz (EF 69 43), Pilzno (EF 79 02), Dobrków (EF 79 04), Jaworze Grn. (EF 79 34).

230. ***F. dumetorum*** (L.) Holub. – In thickets on the Wisłoka River: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

231. ***Festuca gigantea*** (L.) Vill. – In forests and thickets above streams: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24), Zagórze (EF 79 33).

232. ***F. ovina*** L. – Meadows: Parkosz (EF 69 43), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

233. ***F. pratensis*** Huds. – Meadows: Strzegocice (EF 79 22), Jaworze Dln. (EF 79 24).

234. ***F. rubra*** L. – Meadows: Parkosz (EF 69 43), Słotowa (EF 79 31), Jaworze Dln. (EF 79 24).

235. ***Ficaria verna*** Huds. – In the forests, on roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 03).

236. ***Filipendula ulmaria*** (L.) Maxim. – Wet meadows: Parkosz (EF 69 43), Dobrków (EF 79 04).

237. ***Fragaria vesca*** L. – In forests, thickets and dry meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

238. ***Frangula alnus*** Mill. – Forests and thickets: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

239. ***Fraxinus excelsior*** L. – In moist and wet forests: Parkosz (EF 69 43), Dobrków (EF 79 04).

240. ***Gagea lutea*** (L.) Ker Gawł. – Forests and thickets: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

241. ***Galega officinalis*** L. – On edges of thickets and on meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Strzegocice (EF 79 22).

242. ***Galeobdolon luteum*** Huds. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

243. ***Galeopsis bifida*** Boenn. – In forests: Parkosz (EF 69 43), Słotowa (EF 79 31).

244. ****G. ladanum*** L. – Archaeophyte. Field: Parkosz (EF 69 43).

245. ***G. pubescens*** Besser – In forests and on ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

246. ***G. speciosa*** Mill. – In forests and thickets: Podgrodzie (EF 69 44), Dobrków (EF 79 04).

247. ***G. tetrahit*** L. – In forests: Gołęczyna (EF 79 14), Jaworze Grn. (EF 79 34).

248. ****Galinsoga ciliata*** (Raf.) S. F. Blake – Epoecophyte. In ruderal habitats and on fields: Parkosz (EF 69 43), Pilzno (EF 79 12).

249. ****G. parviflora*** Cav. – Epoecophyte. In ruderal habitats and on fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12).

250. ***Galium aparine*** L. – In forestss, thickets and on fields: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 02, EF 79 12).

251. ***G. mollugo*** L. – On meadows and balks: Łęki Grn. (EF 78 13), Zagórze (EF 79 43).

252. ***G. odoratum*** (L.) Scop. – In forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

253. ***G. palustre*** L. – Banks of ponds and wet meadows: Parkosz (EF 69 43), Bielowy (EF 79 33).

254. ***G. rivale*** (Sibth. & Sm.) – On banks of ditches: Parkosz (EF 69 43).

255. ***G. schultesii*** Vest – In forests and thickets: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

256. ***G. verum*** L. – Meadows and forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Strzegocice (EF 79 22).

257. ***Gentianella ciliata*** (L.) Borkh. – In grassland of dry meadow: Dobrków (EF 79 04).

258. ****Geranium dissectum*** L. – Archaeophyte. Fields: Podgrodzie (EF 69 44), Mokrzec (EF 79 13), Bielowy (EF 79 33).

259. ***G. palustre*** L. – Wet meadows: Strzegocice (EF 79 22), Jaworze Dln. (EF 79 24).

260. ***G. phaeum*** L. – All-mountain species. In riparian forest over the Wisłoka River: Parkosz (EF 69 43).

261. ***G. pratense*** L. – Meadows: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 11), Bielowy (EF 79 33).

262. ****G. pusillum*** Burm. F. ex L. – Archaeophyte. Fields: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

263. ***G. robertianum*** L. – In forest: Jaworze Dln. (EF 79 24).

264. ***G. sanguineum*** L. – On edge of thickets: Jaworze Dln. (EF 79 24).

265. ***Geum urbanum*** L. – Wet forests: Łęki Grn. (EF 78 13), Parkosz (EF 69 43), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

266. ***Glechoma hederacea*** L. – Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Zwiernik (EF 78 34), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

267. ***G. hirsuta*** Waldst. & Kit. – In forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

268. ***Glyceria maxima*** (Hartm.) Holub. – On banks of pond and over the Wisłoka River: Parkosz (EF 69 43). Podgrodzie (EF 69 44).

269. ***Gnaphalium uliginosum*** L. – Wet fields: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

270. ***Gymnocarpium dryopteris*** (L.) Newman – In forest: Jaworze Dln. (EF 79 24).

271. ***Hedera helix*** L. – Protected species. In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Dobrków (EF 79 04).

272. ***Helianthus tuberosus*** L. – Holoagriophyte. Invasive species. In alluvial forests over the Wisłoka River: Pilzno (EF 79 12).

273. ***Heracleum sphondylium*** L. – Meadows and roadsides: Podgrodzie (EF 69 44), Pilzno (EF 79 03), Dobrków (EF 79 04).

274. ***Hieracium lachenalii*** C. C. Gmel. – In forests: Bielowy (EF 79 33), Jaworze Dln. (EF 79 24).

275. ***H. murorum*** L. – In forests: Zwiernik (EF 78 34), Gołęczyna (EF 79 14).

276. ***H. pilosella*** L. – Dry meadows and pastures: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

277. ***H. piloselloides*** Vill. – Dry meadows: Strzegocice (EF 79 22).

278. ***H. sabaudum*** L. – In forests: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

279. ***H. umbellatum*** L. – In forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

280. ***Holcus lanatus*** L. – Meadows: Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

281. ***Holosteum umbellatum*** L. – In slope of grassland: Słotowa (EF 79 31).

282. ****Hordeum murinum*** L. – Archaeophyte. Roadside: Jaworze Dln. (EF 79 24).

283. ***Humulus lupulus*** L. – In alluvial forests over rivers and streams: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

284. ***Hypericum hirsutum*** L. – In forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

285. ***H. humifusum*** L. – Pasture: Podgrodzie (EF 69 44).

286. ***H. maculatum*** Crantz – Wet meadow: Słotowa (EF 79 31).

287. ***H. perforatum*** L. – Meadows and roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12), Gołęczyna (Ef 79 14).

288. ***H. tetrapterum*** Fr. – Wet meadows: Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

289. ***Hypochoeris radicata*** L. – Meadows and pastures: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

290. ****Impatiens glandulifera*** Royle – Holoagriophyte. Invasive species. In alluvial forest: Dobrków (EF 79 04).

291. ***I. noli-tangere*** L. – Wet forests: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

292. ****I. parviflora*** DC. – Holoagriophyte. Invasive species. In ruderal habitat: Pilzno (EF 79 12).

293. ***Inula britannica*** L. – Meadows: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

294. ****I. helenium*** L. – Hemiagriophyte. On edges of thickets: Bielowy (EF 79 33).

295. ***Iris pseudacorus*** L. – On banks of ditches: Strzegocice (EF 79 22).

296. ***Isopyrum thalictroides*** L. – In forest: Podgrodzie (EF 69 44).

297. ***Jasione motana*** L. – On sandy dunes and fallow lands: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

298. ***Juglans regia*** L. – Holoagriophyte. Currently in study area it settled on balks and in forests: Rędziny (EF 79 22), Jaworze Dln. (EF 79 24).

299. ***Juncus articulatus*** L. emend. K. Richt. – Meadows: Podgrodzie (EF 69 44), Pilzno (EF 79 12).

300. ***J. bufonius*** L. – In wet fields and ditches: Podgrodzie (EF 69 44), Dobrków (EF 79 04), Pilzno (EF 79 12).

301. ***J. conglomeratus*** L. emend. Leers – Meadows: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

302. ***J. inflexus*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

303. ****J. tenuis*** Willd. – Hemiagriophyte. Invasive species. On roadsides and pastures: Podgrodzie (EF 69 44), Bielowy (EF 79 33).

304. ***Juniperus communis*** L. – Thickets: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

305. ***Knautia arvensis*** (L.) J. M. Coult. – Medow: Słotowa (EF 79 31).

306. ****Lactuca serriola*** L. – Archaeophyte. Roadside: Podgrodzie (EF 69 44).

307. ****Lamium album*** L. – Archaeophyte. Roadsides: Łęki Grn. (EF 78 13), Parkosz (EF 69 43), Pilzno (79 12), Jaworze Dln. (EF 79 24).

308. ****L. amplexicaule*** L. – Archaeophyte. Fields: Jaworze Dln. (EF 79 24).

309. ***L. maculatum*** L. – On roadsides and ruderal habitats and in thickets above streams: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12), Zagórze (EF 79 33).

310. ****L. purpureum*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 03), Jaworze Dln. (EF 79 24).

311. ***Lapsana communis*** L. – Fields and roadsides: Zwiernik (EF 78 34), Pilzno (79 12), Mokrzec (EF 79 13).

312. ***Lathyrus pratensis*** L. – Meadows: Rędziny (EF 79 22), Bielowy (EF 79 33).

313. ****L. tuberosus*** L. – Archaeophyte. On cereal fields: Parkosz (EF 69 43), Pilzno (EF 79 12), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

314. ***L. vernus*** (L.) Bernh. – In forests: Podgrodzie (EF 69 44), Parkosz (EF 69 43 Dobrków (EF 79 04).

315. ***Lavathera thuringiaca*** L. – In thickets over the Wisłoka River: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

316. ***Lembotropis nigricans*** (L.) Griseb. – On edge of pine forest: Gołęczyna (EF 79 14).

317. ***Lemna minor*** L. – In pond: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

318. ***L. trisulca*** L. – In pond: Parkosz (EF 69 43).

319. ***Leontodon autumnalis*** L. – Meadows: Strzegocice (EF 79 22).

320. ***L. hispidus*** L. – Roadsides and meadows: Podgrodzie (EF 69 44), Strzegocice (EF 79 22), Jaworze Dln. (EF 79 24).

321. ****Leonurus cardiaca*** L. – Archaeophyte. On ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

322. ***Lepidium campestre*** (L.) R. Br. – Archaeophyte. On ruderal habitat: Jaworze Dln. (EF 79 24).

323. ***L. ruderale*** L. – Archaeophyte. On ruderal habitat: Pilzno (EF 79 12).

324. ***Leucanthemum vulgare*** Lam. – Meadows: Parkosz (EF 69 43), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

325. ***Ligustrum vulgare*** L. – In xerothermic thickets in balks and in thickets over the Wisłoka River: Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

326. ***Lilium martagon*** L. – Protected species. In oak-pine forest: Jaworze Dln. (EF 79 24).

327. ***Linaria vulgaris*** Mill. – On balks: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 12), Bielowy (EF 79 33).

328. ***Lithospermum arvense*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

329. ***Lolium multiflorum*** Lam. – Epoecophyte. In meadows and fields in cereal crops: Parkosz (EF 69 43), Pilzno (EF 79 02, EF 79 12), Bielowy (EF 79 33).

330. ***L. perenne*** L. – Meadows and pastures: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Pilzno (EF 79 12).

331. ***Lonicera xylosteum*** L. – In deciduous forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

332. ***Lotus corniculatus*** L. – Meadows: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Bielowy (EF 79 33).

333. ***L. uliginosus*** Schkuhr. – Wet meadow: Parkosz (EF 69 43).

334. ***Luzula campestris*** (L.) DC. – Meadows: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Słotowa (EF 79 31).

335. ***L. multiflora*** (Retz.) Lej. – Meadows: Gołęczyna (EF 79 14), Bielowy (EF 79 33).

336. ***L. pilosa*** (L.) Willd. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

337. ***Lychnis flos-cuculi*** L. – Bank of pond: Parkosz (EF 69 43), Bielowy (EF 79 33).

338. ***Lycium barbarum*** L. – Epoecophyte. Roadsides: Parkosz (EF 69 43), Pilzno (EF 79 12), Strzegocice (EF 79 22).

339. ***Lycopus europaeus*** L. – On banks of streams: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Dobrków (EF 79 04).

340. ***Lysimachia nemorum*** L. – Higher montane zone species. In forest: Jaworze Dln. (EF 79 24).

341. ***L. nummularia*** L. – Meadows: Parkosz (EF 69 43), Łęki Górne (EF 78 13), Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

342. ***L. vulgaris*** L. – Wet meadows and fields: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

343. ***Lythrum salicaria*** L. – Over banks of ditches: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

344. ***Maianthemum bifolium*** (L.) F. W. Schmidt – In deciduous forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04), Gołęczyna (EF 79 14).

345. ***Malva neglecta*** Wallr. – Archaeophyte. On ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

346. ***M. sylvestris*** L. – Archaeophyte. Roadsides: Podgrodzie (EF 69 44), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

347. ***Matricaria maritima*** L. subsp. ***inodora*** (L.) Dostál – Archaeophyte. Fields and roadsides: Parkosz (EF 69 43), Mokrzec (EF 79 13), Bielowy (EF 79 33).

348. ***Matteucia struthiopteris*** (L.) Tod. – Lower montane zone species and partially protected. W olszynie nad potokiem: Jaworze Dln. (EF 79 24).

349. ***Medicago falcata*** L. – On balks: Parkosz (EF 69 43), Gołęczyna (EF 79 14).

350. ***M. lupulina*** L. – Meadows: Parkosz (EF 69 43), Pilzno (EF 79 12), Strzegocice (EF 79 22).

351. ***M. sativa*** L. – Hemiagriophyte. On meadows, balks and on roadsides: Parkosz (EF 69 43), Pilzno (EF 79 02), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

352. ***M. ×varia*** Martyn – Epoecophyte. On balk: Pilzno (EF 79 12).

353. ***Melampyrum arvense*** L. – On thermophilic meadows, fields: Parkosz (EF 69 43), Pilzno (EF 79 12).

354. ***M. nemorosum*** L. – In deciduous forests and thickets: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34).

355. ***Melandrium album*** (Mill.) Garcke – Archaeophyte. Meadows: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 02, EF 79 12), Gołęczyna (EF 79 14).

356. ***Melica nutans*** L. – In deciduous forests: Parkosz (EF 69 43), Zwiernik (EF 78 34).

357. ***Melilotus alba*** Medik. – On stones of rivers and on roadsides: Podgrodzie (EF 69 44), Dulczówka (EF 79 12), Jaworze Grn. (EF 79 34).

358. ***M. officinalis*** (L.) Pall. – On stones of rivers and on balks: Podgrodzie (EF 69 44), Jaworze Grn. (EF 79 34).

359. ***Mentha aquatica*** L. – On banks of ditches and ponds: Parkosz (EF 69 43), Dobrków (EF 79 04), Jaworze Dln.(EF 79 24).

360. ***M. arvensis*** L. – Fields and roadsides: Parkosz (EF 69 43), Pilzno (EF 79 02), Mokrzec (EF 79 13).

361. ***M. longifolia*** (L.) L. – On banks of streams, ditches and in wet forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn.(EF 78 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

362. ***Mercurialis perennis*** L. – In deciduous forests: Jaworze Dln. (EF 79 24), Zagórze (EF 79 43).

363. ***Milium effusum*** L. – In deciduous forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln.(EF 79 24).

364. ***Moehringia trinervia*** (L.) Clairv. – In forests and in thickets over the Wisłoka River: Podgrodzie (EF 69 44), Bielowy (EF 79 33).

365. ***Moneses uniflora*** (L.) A. Gray – In pine forest: Jaworze Dln. (EF 79 24).

366. ***Monotropa hypopitys*** L. – In pine forest: Jaworze Dln. (EF 79 24).

367. ***Mycelis muralis*** (L.) Dumort. – In forest: Parkosz (EF 69 43), Dobrków (EF 79 04).

368. ***Myosotis arvensis*** (L.) Hill – Archaeophyte. On fields in cereal and root crops: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Strzegocice (EF 79 22).

369. ***M. palustris*** (L.) L. emend. Rchb. – On wet meadows and on banks of ditches: Parkosz (EF 69 43), Zwiernik (EF 78 34), Dobrków (EF 79 04), Bielowy (EF 79 33).

370. ***M. sparsiflora*** Pohl. – In wet oak-hornbeam forest: Podgrodzie (EF 69 44).

371. ***M. stricta*** Link ex Roem. & Schult. – Fields: Podgrodzie (EF 69 44), Bielowy (EF 79 33), Jaworze Dln. (EF 79 24).

372. ***M. sylvatica*** Ehrh. Ex Hoffm. – In wet oak-hornbeam forest: Pilzno (EF 79 12).

373. ***Myosoton aquaticum*** (L.) Moench – On stones of the Wisłoka River: Podgrodzie (EF 69 44).

374. ***Myriophyllum spicatum*** L. – In water reservoir: Jaworze Dln. (EF 79 24).

375. ***Nepeta cataria*** L. – Archaeophyte. Pastures: Parkosz (EF 69 43), Gołęczyna (EF 79 14).

376. ***Nuphar lutea*** (L.) Sibth. & Sm. – In pond: Parkosz (EF 69 43).

377. ***Nymphaea candida*** C. Presl – Partially protected species. In water reservoir: Rędziny (EF 79 22).

378. ***Odontites serotina*** (Lam.) Rchb. – Pastures: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

379. * ***O. verna*** (Bellardi) Dumort. – Archaeophyte. Fields: Parkosz (EF 69 43), Pilzno (EF 79 02).

380. ***Oenanthe aquatica*** (L.) Poir. – On banks of ponds: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

381. ***Oenothera biennis*** L. – On banks of rivers and roadsides: Podgrodzie (EF 69 44), Mokrzec (EF 79 13), Gołęczyna (EF 79 14).

382. ***Ononis arvensis*** L. – On balks and stones of the Wisłoka River: Podgrodzie (EF 69 44), Dobrków (EF 79 04), Słotowa (EF 79 31).

383. ***Onopordum acanthium*** L. – Archaeophyte. On ruderal habitats: Podgrodzie (EF 69 44).

384. ***Origanum vulgare*** L. – On balks: Podgrodzie (EF 69 44), Mokrzec (EF 79 13), Słotowa (EF 79 31).

385. ***Oxalis acetosella*** L. – In forest: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

386. ***O. fontana*** Bunge – Epoecophyte. Fields: Parkosz (EF 69 43), Pilzno (EF 79 02, EF 79 12).

387. ***Padus avium*** Mill. – In moist forests and thickets: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13).

388. ***Papaver argemone*** L. – Epoecophyte. Fields: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

389. ***P. rhoeas*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 02), Bielowy (EF 79 33).

390. ***Paris quadrifolia*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

391. ***Parthenocissus inserta*** (A. Kern.) Fritsch – Holoagriophyte. Invasive species. In alluvial forests on rivers and streams: Gołęczyna (EF 79 14), Jaworze Dln.(EF 79 24).

392. ***Pastinaca sativa*** L. – Archaeophyte. Meadows: Podgrodzie (EF 69 44).

393. ***Petasites albus*** (L.) Gaertn. – Higher montane zone species. In forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

394. ***P. hybridus*** (L.) P. Gaertn., B. Mey. & Scherb. – Over rivers and streams: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12).

395. ***Peucedanum oreoselinum*** (L.) Moench – On edges of pine forests: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

396. ***Phalaris arundinacea*** L. – In reeds over banks of streams and ditches: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12).

397. ***Phegopteris connectilis*** (Michx.) Watt – In forests: Jaworze Dln. (EF 79 24).

398. ***Phleum pratense*** L. – Meadows: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

399. ***Phragmites australis*** (Cav.) Trin. ex Steud. – Over banks of drainage ditches: Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

400. ***Picea abies*** (L.) H. Karst. – In forests, as an admixture: Zwiernik (EF 78 34), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 34).

401. ***Pimpinella maior*** (L.) Huds. – Meadow: Zwiernik.(EF 78 34).

402. ***P. saxifraga*** L. – On balks: Podgrodzie (EF 69 44), Strzegocice (EF 79 22).

403. ***Pinus sylvestris*** L. – In forests: Parkosz (EF 69 43), Słotowa (EF 79 31), Jaworze Dln. (EF 79 24).

404. ***Plantago intermedia*** Gilib. – Fields: Parkosz (EF 69 43), Pilzno (EF 79 02, EF 79 12).

405. ***P. lanceolata*** L. – Meadows, pastures and roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13).

406. ***P. major*** L. – Meadows, pastures and roadsides: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 03), Jaworze Dln. (EF 79 24).

407. ***P. media*** L. – On dry meadows and balks: Parkosz (EF 69 34), Podgrodzie (EF 69 44), Dobrków (EF 79 04).

408. ***Platanthera bifolia*** (L.) Rich. – Partially protected species. In forests: Dobrków (EF 79 04), Bielowy (EF 79 33).

409. ***Poa annua*** L. – Pastures and roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

410. ***P. compressa*** L. – On balks and on dry slopes of grasslands: Parkosz (EF 69 43), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

411. ***P. nemoralis*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

412. ***P. palustris*** L. – On alluvial of rivers and over banks of ponds: Parkosz (EF 69 43), Pilzno (EF 79 12).

413. ***P. pratensis*** L. – On meadows, balks and roadsides: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Strzegocice (EF 79 22), Jaworze Dln. (EF 79 24).

414. ***P. trivialis*** L. – Wet meadows and thickets: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Strzegocice (EF 79 22).

415. ***Polygala comosa*** Schkuhr – On dry slopes of grasslands and in balks: Latoszyn (EF 69 44), Dobrków (EF 79 04).

416. ***P. oxyptera*** Rchb. – On dry and barren grasslands: Zagórze (EF 79 33).

417. ***P. vulgaris*** L. – Dry meadows: Parkosz (EF 69 43), Dobrków (EF 79 04).

418. ***Polygonatum multiflorum*** (L.) All. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

419. ***Polygonum amphibium*** L. – On wet meadows and over banks of waters: Parkosz (EF 69 43), Pilzno (EF 79 12), Bielowy (EF 79 33).

420. ***P. aviculare*** L. – Fields and pastures: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 02), Bielowy (EF 79 33).

421. ***P. bistorta*** L. – Wet meadows: Parkosz (EF 69 43).

422. ***P. hydropiper*** L. – Fields: Parkosz (EF 69 43), Zagórze (EF 79 33).

423. ***P. lapathifolium*** L. subsp. ***brittingeri*** (Opiz) Rech. F. – On ruderal habitats: Podgrodzie (EF 69 44), Pilzno (EF 79 12).

424. ***P. lapathifolium*** L. subsp. ***lapathifolium*** – Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12).

425. ***P. lapathifolium*** L. subsp. ***pallidum*** (With.) Fr. – Fields, ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02), Mokrzec (EF 79 13), Bielowy (EF 79 33).

426. ***P. minus*** Huds. – On wet fields and over banks of ditches: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

427. ***P. mite*** Schrank – Over ditches and on fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

428. ***P. persicaria*** L. – Ruderal habitats, fields: Parkosz (EF 69 43), Pilzno (EF 79 02), Mokrzec (EF 79 13).

429. ***Polypodium vulgare*** L. – In forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24), Zagórze (EF 79 33).

430. ***Populus alba*** L. – In alluvial forests over the Wisłoka River: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12).

431. ***P. nigra*** L. – In alluvial forests over the Wisłoka River: Pilzno (EF 79 12), Strzegocice (EF 79 22).

432. ***P. tremula*** L. – In forests: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Słotowa (EF 79 31).

433. ***Potamogeton crispus*** L. – In still waters: Jaworze Dln. (EF 79 24).

434. ***P. natans*** L. – In bends of the Wisłoka River: Jaworze Dln. (EF 79 24).

435. ***P. nodosus*** Poir. – In bends of the Wisłoka River: Jaworze Dln. (EF 79 24).

436. ***P. pusillus*** L. – In bends of the Wisłoka River: Jaworze Dln. (EF 79 24).

437. ***Potentilla anserina*** L. – On fields, pastures and roadsides: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Pilzno (EF 79 03), Bielowy (EF 79 33).

438. ***P. argentea*** L. – Pastures: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Słotowa (EF 79 11).

439. ***P. erecta*** (L.) Raeusch. – On edges of forests: Bielowy (EF 79 33).

440. ***P. pusilla*** Host – Higher montane zone species. On stones of the Wisłoka River: Parkosz (EF 69 43).

441. ***P. reptans*** L. – Meadows and roadsides: Parkosz (EF 69 43), Pilzno (EF 79 02, EF 79 12), Jaworze Dln. (EF 79 24).

442. ***P. supina*** L. – Pastures: Parkosz (EF 69 43).

443. ***Primula elatior*** (L.) Hill – Partially protected species. In wet forests and meadows: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

444. ***Prunella vulgaris*** L. – Meadows and pastures: Parkosz (EF 69 43), Dobrków (EF 79 04).

445. ***Prunus spinosa*** L. – In thickets and on balks: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

446. ***Pteridium aquilinum*** (L.) Kuhn – In mixed forests, in cutting places and balks: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

447. ***Pulmonaria obscura*** Dumort. – In deciduous forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

448. ***Pyrola chlorantha*** Sw. – Partially protected species. In pine forest: Jaworze Dln. (EF 79 24).

449. ***P. minor*** L. – Partially protected species. In pine forest: Jaworze Dln. (EF 79 24).

450. ***P. rotundifolia*** L. – Partially protected species. In pine forest: Jaworze Dln. (EF 79 24).

451. ***Pyrus communis*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

452. ***P. pyraster*** (L.) Burgsd. – On balks and in thickets: Parkosz (EF 69 43), Dobrków (EF 79 04), Mokrzec (EF 79 13).

453. ***Quercus petraea*** (Matt.) Liebl. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

454. ***Q. robur*** L. – In forests: Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

455. ****Q. rubra*** L. – Holoagriophyte. Invasive species. In forests: Dobrków (EF 79 04), Mokrzec (EF 79 13).

456. ***Ranunculus acris*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Zwiernik (EF 78 34), Pilzno (EF 79 03), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

457. ***R. arvensis*** L. – Archaeophyte. In cereal crops: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

458. ***R. auricomus*** L. – Wet meadows: Parkosz (EF 69 43), Strzegocice (EF 79 22).

459. ***R. cassubicus*** L. – In forest: Parkosz (EF 69 43).

460. ***R. flammula*** L. – On banks of water reservoirs: Parkosz (EF 69 43).

461. ***R. lanuginosus*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

462. ***R. polyanthemos*** L. – Dry meadows: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

463. ***R. repens*** L. – In meadows and ruderal habitats: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 12).

464. ***R. sardous*** Cranz – Pastures: Parkosz (EF 69 43), Dobrków (EF 79 04).

465. ****Raphanus raphanistrum*** L. – Archaeophyte. Fields: Parkosz (EF 69 43).

466. ***Reseda lutea*** L. – Roadsides: Podgrodzie (EF 69 44), Pilzno (EF 79 02), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

467. ****Reynotria japonica*** Houtt. – Holoagriophyte. Invasive species. In forests and on ruderal habitats: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

468. ***Rhamnus cathartica*** L. – In thermophilic thickets on balks: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

469. ***Rhinantus serotinus*** (Schönh.) Oborný – Meadows and fields: Parkosz (EF 69 43).

470. ***Ribes spicatum*** E. Robson – In forests: Jaworze Dln. (EF 79 24), Gołęczyna (EF 79 14).

471. ****Robinia pseudoacacia*** L. – Holoagriophyte. Invasive species. In forests: Parkosz (EF 69 43), Mokrzec (EF 79 13).

472. ***Rorippa* ×*armoracioides*** (Tausch) Fuss – On edge of thickets: Jaworze Dln. (EF 79 24).

473. ***R. austriaca*** (Cranz) Besser – Over the Wisłoka River: Pilzno (EF 79 12).

474. ***R. palustris*** (L.) Besser – Over the Wisłoka River: Pilzno (EF 79 12).

475. ***R. sylvestris*** (L.) Besser – Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02), Gołęczyna (EF 79 14).

476. ***Rosa canina*** L. – In thickets, on balks and on edges of forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33), Jaworze Grn. (EF 79 34).

477. ***R. rubiginosa*** L. – In thickets over the Wisłoka River: Jaworze Grn. (EF 79 34).

478. ***Rubus bifrons*** Vest – On edge of thickets: Podgrodzie (EF 69 44).

479. ***R. caesius*** L. – Thickets: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Słotowa (EF 79 31).

480. ***R. hirtus*** Waldst. & Kit. – Forests and thickets: Pilzno (EF 79 12), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

481. ***R. idaeus*** L. – Forests and thickets: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

482. ***R. montanus*** Lib. ex Lej. – Thickets: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

483. ***R. plicatus*** Weihe & Nees – In thickets over the Wisłoka River: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

484. ****Rudbeckia laciniata*** L. – Holoagriophyte. Invasive species. In alluvial forests: Łęki Grn. (EF 78 13), Dulczówka (EF 79 12).

485. ***Rumex acetosa*** L. – Meadows: Podgrodzie (EF 69 44), Słotowa (EF 79 31), Jaworze Dln. (EF 79 24).

486. ***R. acetosella*** L. – Fields: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

487. ***R. aquaticus*** L. – On bank of ditch: Strzegocice (EF 79 22).

488. ***R. conglomeratus*** Murray – In ditches and on wet meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

489. ***R. crispus*** L. – Meadows: Łęki Grn. (EF 78 13), Dobrków (EF 79 04).

490. ***R. obtusifolius*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

491. ***R. sanguineus*** L. – Wet forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

492. ***R. thyrsiflorus*** Fingerh. – On meadows and on roadside slopes: Parkosz (EF 69 43), Pilzno (EF 79 12).

493. ***Sagina procumbens*** L. – Wet meadows: Jaworze Dln. (EF 79 24).

494. ***Salix alba*** L. – In alluvial forests over the Wisłoka River: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Słotowa (EF 79 31).

495. ***S. caprea*** L. – Thickets: Podgrodzie (EF 69 44), Strzegocice (EF 79 22).

496. ***S. cinerea*** L. – In riparian forest over stream: Strzegocice (EF 79 22).

497. ***S. fragilis*** L. – In riparian forests over streams: Łęki Grn. (EF 78 13), Parkosz (EF 69 43).

498. ***S. purpurea*** L. – In riparian forests over streams: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

499. ***S. triandra*** L. – In alluvial forests over the Wisłoka River: Parkosz (EF 69 43), Pilzno (EF 79 12), Strzegocice (EF 79 22).

500. ***S. viminalis*** L. – In riparian forests over rivers: Łęki Grn. (EF 78 13), Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

501. ***Salvia glutinosa*** L. – Higher montane zone species. In forests: Podgrodzie (EF 69 34), Parkosz (EF 69 43), Gołęczyna (EF 79 14).

502. ***Sambucus ebulus*** L. – On balks: Dobrków (EF 79 04), Bielowy (EF 79 33).

503. ***S. nigra*** L. – Forests and thickets: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33), Jaworze Grn. (EF 79 34).

504. ***S. racemosa*** L. – Higher montane zone species. In forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

505. ***Sanguisorba minor*** Scop. – On dry slope: Jaworze Dln. (EF 79 24).

506. ***Sanicula europaea*** L. – In forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Grn. (EF 79 34).

507. ***Saponaria officinalis*** L. – Roadsides: Podgrodzie (EF 69 44), Pilzno (EF 79 12), Gołęczyna (EF 79 14).

508. ***Sarothamnus scoparius*** (L.) W. D. J. Koch – On edge of forest: Jaworze Dln. (EF 79 24).

509. ***Scilla bifolia*** L. – All-mountain species, partially protected. In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44).

510. ***Scirpus sylvaticus*** L. – On wet meadows and over banks of ditches: Podgrodzie (EF 69 44), Dobrków (EF 79 04), Bielowy (EF 79 33).

511. ****Scleranthus annuus*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Mokrzec (EF 79 13), Gołęczyna (EF 79 14), Zagórze (EF 79 33).

512. ***S. perennis*** L. – On sandy dunes and fallow lands: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

513. ***S. polycarpos*** L. – On sandy fallow land: Gołęczyna (EF 79 14).

514. ***Scrophularia nodosa*** L. – Thickets: Parkosz (EF 69 43).

515. ***S. umbrosa*** Dumort. – Over banks of pond: Jaworze Dln. (EF 79 24).

516. ***Sedum acre*** L. – On stones of the Wisłoka River: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

517. ***S. maximum*** (L.) Hoffm. – On roadside slopes and balks: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

518. ***S. sexangulare*** L. – On stones of the Wisłoka River: Podgrodzie (EF 69 44), Parkosz (EF 69 43).

519. ***Selinum carvifolia*** (L.) L. – On edge of forest: Strzegocice (EF 79 22).

520. ***Senecio barbaraeifolius*** (Krock.) Wimm. & Grab. – Wet meadows: Jaworze Dln. (EF 79 24), Dęborzyn (EF 79 44).

521. ***S. fluviatilis*** Wallr. – In thickets on the Wisłoka River: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 12), Mokrzec (EF 79 13).

522. ***S. jacobaea*** L. – Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04).

523. ***S. ovatus*** (P. Gaertn., B. Mey. & Schreb.) Willd. – Higher montane zone species. In forests and on cutting places: Zwiernik (EF 78 34), Jaworze Grn. (EF 79 34).

524. ***S. sylvaticus*** L. – On cutting places: Jaworze Dln. (EF 79 24).

525. ****S. vernalis*** Waldst. & Kit. – Epoecophyte. Roadside: Jaworze Dln. (EF 79 24).

526. ***S. viscosus*** L. – On stones of the Wisłoka River: Podgrodzie (EF 69 34).

527. ****S. vulgaris*** L. – Archaeophyte. On ruderal habitats: Pilzno (EF 79 12).

528. ***Seseli annuum*** L. – In pine forests: Jaworze Dln. (EF 79 24).

529. ****Setaria pumila*** (Poir.) Roem. & Schult. – Archaeophyte. Fields: Parkosz (EF 69 43) Pilzno (EF 79 02).

530. ***S. viridis*** (L.) P. Beauv. – Archaeophyte. Fields: Parkosz (EF 69 43). Podgrodzie (EF 69 44), Dobrków (EF 79 04), Pilzno (EF 79 12), Jaworze Dln. (EF 79 24).

531. ***Sherardia arvensis*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Pilzno (EF 79 02), Dobrków (EF 79 04), Bielowy (EF 79 33).

532. ***Silene nutans*** L. subsp. ***nutans*** – Dry meadow: Jaworze Dln. (EF 79 24).

533. ***S. vulgaris*** (Moench) Garcke – Meadows and roadsides: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

534. ***Sinapis arvensis*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Pilzno (EF 79 02, EF 79 12).

535. ***Sisymbrium officinale*** (L.) Scop. – Archaeophyte. In fields and ruderal habitats: Parkosz (EF 69 43), Zwiernik (EF 78 34), Pilzno (EF 79 12).

536. ***Solanum dulcamara*** L. – Wet forests: Dobrków (EF 79 04), Jaworze Dln. (EF 79 24).

537. ***S. nigrum*** L. emend. Mill. – Archaeophyte. Roadsides: Parkosz (EF 69 43), Pilzno (EF 79 12), Mokrzec (EF 79 13).

538. ***Solidago gigantea*** Aiton – Holoagriophyte. Invasive species. In alluvial forests over rivers and on roadsides: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Mokrzec (EF 79 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

539. ***S. virgaurea*** L. – In mixed forests: Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

540. ***Sonchus arvensis*** L. – Fields and roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02), Dobrków (EF 79 04), Słotowa (EF 79 31).

541. ***S. asper*** (L.) Hill – Archaeophyte. In fields of root crops and in ruderal habitats: Parkosz (EF 69 43), Dobrków (EF 79 04).

542. ***S. oleraceus*** L. – Archaeophyte. In fields of root crops: Dobrków (EF 79 04).

543. ***Sorbus aucuparia*** L. emend. Hedl. – Forests and thickets: Parkosz (EF 69 43), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

544. ***Spergula arvensis*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Słotowa (EF 79 31), Jaworze Dln. (EF 79 24).

545. ***S. morisonii*** Boreau – On sand dune: Jaworze Dln. (EF 79 24).

546. ***Spergularia rubra*** (L.) J. Presl & C. Presl – On sandy fallow lands: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

547. ***Spirodela polyrhiza*** (L.) Schleid. – In pond: Mokrzec (EF 79 14).

548. ***Stachys palustris*** L. – On bank of pond: Parkosz (EF 69 43).

549. ***S. sylvatica*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

550. ***Staphyllea pinnata*** L. – Protected species. In oak-hornbeam forest: Podgrodzie (EF 69 44).

551. ***Stellaria graminea*** L. – Meadows: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Dobrków (EF 79 04), Pilzno (EF 79 12).

552. ***S. holostea*** L. – In oak-hornbeam forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04), Bielowy (EF 79 33).

553. ***S. media*** (L.) Vill. – In forests and thickets and in fields and ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 02), Słotowa (EF 79 31).

554. ***S. nemorum*** L. – In forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

555. ***S. uliginosa*** Murray – Wet meadows: Zwiernik (EF 78 34).

556. ***Symphytum officinale*** L. – On moist meadows, banks of ditches and on roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02).

557. ***S. tuberosum*** L. – In oak-hornbeam forests and alluvial forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24), Słotowa (EF 79 31).

558. ****Syringa vulgaris*** L. – Holoagriophyte. In thickets: Parkosz (EF 69 43).

559. ****Tanacetum parthenium*** (L.) Sch. Bip. – Epoecophyte. Roadsides: Dobrków (EF 79 04), Mokrzec (EF 79 13).

560. ***T. vulgare*** L. – On pastures, roadsides and in ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 03), Strzegocice (EF 79 22).

561. ***Taraxacum officinale*** F. H. Wigg. – Meadows, fields and roadsides: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 02, EF 79 03), Dobrków (EF 79 04), Gołęczyna (EF 79 14).

562. ***Teesdalea nudicaulis*** (L.) R. Br. – On sandy fields: Parkosz (EF 69 43), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

563. ****Telekia speciosa*** (Schreb.) Baumg. – Holoagriophyte. In alder forest above the stream: Jaworze Dln. (EF 79 24).

564.****Thlaspi arvense*** L. – Archaeophyte. In fields and in ruderal habitats: Parkosz (EF 69 43), Pilzno (EF 79 03, EF 79 12).

565. ***Thymus pulegioides*** L. – On dry meadows and balks: Parkosz (EF 69 43), Pilzno (EF 79 03), Dobrków (EF 79 04).

566. ***T. serpyllum*** L. emend. Fr. – In pine forests: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

567. ***Torilis japonica*** (Houtt.) DC. – In thickets over the Wisłoka River: Podgrodzie (EF 69 44), Mokrzec (EF 79 13).

568. ***Tragopogon orientalis*** L. – Meadows: Jaworze Grn. (EF 79 34).

569. ***Trientalis europaea*** L. – In pine forests: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

570. ***Trifolium arvense*** L. – Roadsides: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

571. ***T. aureum*** Pollich – On balks: Parkosz (EF 69 43), Dobrków (EF 79 04).

572. ***T. campestre*** Schreb. – In grasslands on dry slopes and in meadows: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

573. ***T. dubium*** Sibth. – Meadows: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 12).

574. ***T. fragiferum*** L. – On wet meadows and pastures: Podgrodzie (EF 69 44), Dobrków (EF 79 04).

575. ***T. hybridum* L.** subsp. ***hybridum*** – Wet meadows. Parkosz (EF 69 43), Dobrków (EF 79 04), Słotowa (EF 79 31).

576. ***T. medium*** L. – On balks and dry meadows: Parkosz (EF 69 43), Dobrków (EF 79 04).

577. ***T. pratense*** L. – On stones of the Wisłoka River and on meadows: Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Dulczówka (EF 79 12).

578. ***T. repens*** L. – Meadows: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

579. ***Trisetum flavescens*** (L.) P. Beauv. – Meadows: Łęki Grn. (EF 78 13), Jaworze Dln. (EF 79 24).

580. ***Tussilago farfara*** L. – In fields, balks and ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02, EF 79 03), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

581. ***Typha latifolia*** L. – In water reservoirs: Parkosz (EF 69 43), Dobrków (EF 79 04), Dulczówka (EF 79 12), Mokrzec (EF 79 13), Jaworze Dln. (EF 79 24).

582. ***Ulmus glabra*** Huds. – Oak-hornbeam forests: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

583. ***U. laevis*** Pall. – Oak-hornbeam forests: Parkosz (EF 69 43), Słotowa (EF 79 31).

584. ***Urtica dioica*** L. **–** In moist deciduous forests and ruderal habitats: Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Pilzno (EF 79 03), Jaworze Dln. (EF 79 24).

585. * ***U. urens*** L. – Archaeophyte. On ruderal habitats: Parkosz (EF 69 43), Mokrzec (EF 79 13), Gołęczyna (EF 79 14).

586. ***Vaccinium myrtillus*** L. – In mixed forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Gołęczyna (EF 79 14).

587. ***V. vitis-idaea*** L. – In mixed forests: Podgrodzie (EF 69 44), Dobrków (EF 79 04), Gołęczyna (EF 79 14).

588. ***Valeriana simplicifolia*** Kabath – Wet meadows: Parkosz (EF 69 43), Dobrków (EF 79 04), Bielowy (EF 79 33).

589. ***Valerianella dentata*** (L.) Pollich – Archaeophyte. Fields: Pilzno (EF 79 02), Dobrków (EF 79 04).

590. ***V. rimosa*** Bastard – Archaeophyte. Fields: Parkosz (EF 69 43).

591. ***Verbascum densiflorum*** Bertol. – On gravels of the Wisłoka River: Parkosz (EF 69 43), Jaworze Dln. (EF 79 24).

592. ***V. phlomoides*** L. – Roadsides: Podgrodzie (EF 69 44).

593. ***V. thapsus*** L. – On dry slope: Parkosz (EF 69 43).

594. ***Verbena officinalis*** L. – Archaeophyte. On ruderal habitats: Mokrzec (EF 79 13).

595. ***Veronica anagallis-aquatica*** L. – On banks of streams and drainage ditches: Podgrodzie (EF 69 44), Dobrków (EF 79 04).

596. ***V. arvensis*** L. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Strzegocice (EF 79 22), Jaworze Dln. (EF 79 24).

597. ***V. beccabunga*** L. – On banks of streams: Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

598. ***V. chamaedrys*** L. – Roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 03), Gołęczyna (EF 79 14).

599. ***V. hederifolia*** L. – Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

600. ***V. montana*** L. – Oak-hornbeam forests: Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Jaworze Dln. (EF 79 24).

601. ***V. officinalis*** L. – In forests, on their outskirts and in fallow areas: Zwiernik (EF 78 34), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Jaworze Grn. (EF 79 34).

602. * ***V. persica*** Poir. – Epoecophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 02), Strzegocice (EF 79 22).

603. * ***V. polita*** Fr. – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Dobrków (EF 79 04).

604. ***V. serpyllifolia*** L. – Fields: Podgrodzie (EF 69 44), Strzegocice (EF 79 22).

605. ***V. spicata*** L. – On sand dune: Podgrodzie (EF 69 44).

606. ****V. triphyllos*** L. – Archaeophyte. Fields: Podgrodzie (EF 69 44), Gołęczyna (EF 79 14).

607. ***Viburnum opulus*** L. – In alluvial forests: Podgrodzie (EF 69 44), Parkosz (EF 69 43), Łęki Grn. (EF 78 13), Dobrków (EF 79 04).

608. ****Vicia angustifolia*** L. – Archaeophyte. In field communities: Parkosz (EF 69 43), Podgrodzie EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 12), Gołęczyna (EF 79 14).

609. ***V. cracca*** L. – Meadows, fields and roadsides: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13), Pilzno (EF 79 12), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

610. ****V. dasycarpa*** Ten. – Epecophyte. Fields: Parkosz (EF 69 43), Pilzno (EF 79 02), Dobrków (EF 79 04), Bielowy (EF 79 33).

611. ****V. hirsuta*** (L.) Gray – Archaeophyte. On cereal fields. Parkosz (EF 69 43), Podgrodzie (EF 69 44), Zwiernik (EF 78 34), Pilzno (EF 79 12), Gołęczyna (EF 79 14).

612. ***V. sepium*** L. – Thickets: Parkosz (EF 69 43), Zwiernik (EF 78 34), Pilzno (EF 79 12).

613. ****V. tetrasperma*** (L.) Schreb. – Archaeophyte. On cereal fields: Łęki Grn. (EF 78 13), Gołęczyna (EF 79 14), Słotowa (EF 79 31).

614. ****V. villosa*** Roth – Archaeophyte. On cereal fields: Parkosz (EF 69 43), Mokrzec (EF 79 13).

615. ***Vinca minor*** L. – Oak-hornbeam forests over the Wisłoka River: Podgrodzie (EF 69 44).

616. ****Viola arvensis*** Murray – Archaeophyte. Fields: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Pilzno (EF 79 02), Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24).

617. ***V. canina*** L. – On edges of forests: Gołęczyna (EF 79 14), Jaworze Dln. (EF 79 24), Bielowy (EF 79 33).

618. ***V. hirta*** L. – In thickets over the Wisłoka River: Podgrodzie (EF 69 44).

619. ***V. odorata*** L. – In riparian forests and wet oak-hornbeam forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Łęki Grn. (EF 78 13).

620. ***V. reichenbachiana*** Jord. ex Boreau – Oak-hornbeam forests: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Jaworze Dln. (EF 79 24).

621. ***V. riviniana*** Rchb. – Oak-hornbeam forest: Parkosz (EF 69 43).

622. ***V. rupestris*** F. W. Schmidt – On sandy fallow area: Jaworze Dln. (EF 79 24).

623. ***V. tricolor*** L. – In cereals on sandy fields: Gołęczyna (EF 79 14), Bielowy (EF 79 33).

624. ****Xanthium albinum*** (Widder) H. Scholz – Hemiagriophyte. On the Wisłoka River alluvials: Parkosz (EF 69 43).

625. ****X. strumarium*** L. – Epoecophyte. On ruderal habitats: Parkosz (EF 69 43), Podgrodzie (EF 69 44), Mokrzec (EF 79 13), Jaworze Dln. (EF 79 24).

## Summary

The list of vascular plants presented above has 625 taxa, of which 514 are native and the remaining 111 are alien taxa. Within them 70 are archaeophytes, 21 are epoecophytes, 6 are classified as hemiagriophytes, and 14 are holoagriophytes. (Appendix 1E–G). Thirteen alien species have the status of invasive plants. Among native plants, 19 mountain species were found: 4 lower montane zone species, 12 higher montane zone species and 3 all-mountainous. Eleven protected species have been reported on study area, among others orchids: *Cephalanthera longifolia*, *Epipactis purpurata* (complete protection), or *Dactylorhiza majalis* (partial protection).

**Conflict of interest**

The author declares no conflict of interest related to this article.

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# Appendix 1


Dulczówka near Pilzno, agricultural landscape – A; alluvial forest over the Wisłoka River – B; protected species: *Staphyllea pinnata* L. – C, *Matteucia struthiopteris* (L.) Tod. – D; invasive holoagriophytes: *Impatiens glandulifera* Royle – E, *Solidago gigantea* Aiton – F, *Echinocystis lobata* (F. Michx.) Torr. & A. Gray – G, (Photo. K. Towpasz)

## Abstract

The paper presents the occurrence of vascular plant species in the southern part of the Pilzno commune based on monographic studies from the area of Ciężkowice and Strzyżów Foothills (Western Carpathians). The study contains a list of plant species, both native and of alien origin. For each species its habitat and sites in the ATPOL network were given.

**Key words:** vascular plants, distribution, Pilzno commune, Ciężkowice Foothills, Strzyżów Foothills

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## Rośliny naczyniowe okolic Pilzna (Południowo-Wschodnia Polska)

**Streszczenie**

W pracy przedstawiono występowanie gatunków roślin naczyniowych na obszarze południowej części gminy Pilzno w oparciu o opracowania monograficzne z terenu Pogórzy Ciężkowickiego i Strzyżowskiego (Karpaty Zachodnie). Artykuł zawiera wykaz roślin, zarówno rodzimych, jak i obcego pochodzenia. Dla każdego gatunku podano jego siedlisko i lokalizację w sieci ATPOL.

**Słowa kluczowe:** rośliny naczyniowe, rozmieszczenie, gmina Pilzno, Pogórze Ciężkowickie, Pogórze Strzyżowskie

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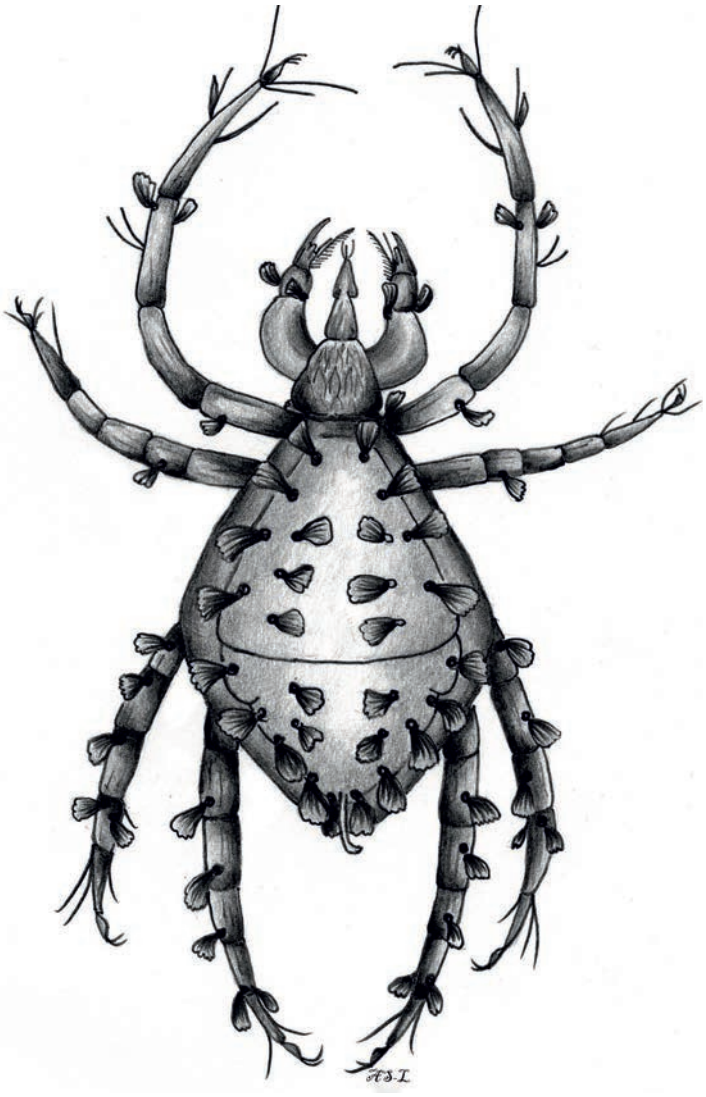
# Zoology



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# Construction of the nest of *Amazilia rutila* De Lattre (Trochillidae) and its anti- predatory defensive strategy in a medium deciduous forest in Campeche, Mexico

## Introduction

The construction of nests by birds is a natural behavior, its size and composition varies depending on the species, and the selection of materials is opportunistic (Deeming, Mainwaring, 2015). In some cases, birds select fresh leaves of plants that have antimicrobial properties or that allow the abatement of ectoparasites in their nests (Dubiec, Mazgajski, 2013). As for the selection of habitats, birds that nest in the soil to achieve reproductive success tend to look for sites with heterogeneous vegetation and dense foliage, which also helps them counteract predation (Martin et al., 1997). But nests with reproductive success depend on factors such as the availability of food and the presence of other individuals of the same species (Danchin et al., 2004).

In the case of hummingbirds, reproductive success can be affected by the isolation and fragmentation of vegetation, resulting in the reduction of their populations (Feinsinger et al., 1987). However, predation in nests is common in ecosystems, being the main factors that cause reproductive failure, affecting population density and affecting abundance at the community level (Angelstam, 1986; Martin, 1988; Buler, Hamilton, 2000; Jokimäki, Huhta, 2000). In this sense, hummingbirds are used as indicator species of disturbance in tropical ecosystems; for example, in the Yucatan Peninsula (YP), Mexico, the diversity of hummingbirds is related to a greater abundance of tree species (Navarro et al., 2016). In the YP there are 12 species of hummingbirds, among these the cinnamon hummingbird *Amazilia rutila* De Lattre (Trochillidae), which is distributed in the Pacific slope from the northeast of Mexico to Costa Rica and the Atlantic slope in the portion north and east of the YP and in Belize; this species is found from tropical forests, urban areas, bushes to savannas (BirdLife International,

2016). In the Official Mexican Standard (DOF-2010) and the BirdLife International (2016) it is categorised as Least Concern (LC).

In general, hummingbirds are considered as flags because of their diversification of plumage colours and flight capabilities (Sánchez-Jasso, Cebrián-Abellán, 2015; Medina- van Berkum et al., 2016), these species function as symbols to attract governmental and non-governmental support, as well as a flag for the implementation of conservation programs (Noss, 1990; Andelman, Fagan, 2000; Carignan, Villard, 2002; Caro et al., 2004; Isasi-Catalá, 2011). With the aim of contributing to the knowledge of the biology and reproductive strategies of *A. rutila*, the architecture, dimensions and vegetative materials of plants used for the construction of their nests and the hosts used as possible adaptations to counteract predation are described.

## Material and methods

### Study area

The first nest of *Amazilia rutila* was located in the Native Flora Conservation Unit of the Yucatan Peninsula (NFCUYP) at the Instituto Tecnológico de Chiná in Campeche, Mexico (19°46′10.44″ N, 90°30′16.24″ W) (Cetzal-Ix et al., 2017) (Fig. 1–2). The second nest was located at the residential farms Cholul (RFC), Campeche, Mexico (19°42′56.44″ N, 90°23′6.59″ W) 14.3 km southeast of the NFCUYP in Chiná, Campeche, Mexico (Fig. 3). Both sites have medium deciduous forest (Pérez et al., 2017) with a sub humid warm climate (Aw) and an annual precipitation of 1141 mm (García, 1988). However, RFC site has a vegetation disturbed by agriculture and livestock, restricted to agro-crops, citrus and pasture (Fig. 2–3).

### Observations and identification of materials for the construction of the nest

Observations of behavioral activities in the hummingbird nests were made at time intervals of 12 to 23 minutes during each hour, between 8:00 a.m. to 1:00 p.m. (diurnal) and 8:00 p.m. to 12:00 p.m. (nocturnal) during 16 days, of 14 from March to April 1, 2019. The characterisation of the nests was made according to Hansell (2000) and with a millimeter precision Vernier. In the Laboratory of Agroecosystems and Conservation of Biodiversity, the identification of the host plants and the materials used for the construction of the nest was made, through specialised literature and illustrated guides of flora of the Yucatan Peninsula (Yucatán) (Carnevali et al., 2010; Cetzal-Ix et al., 2017).

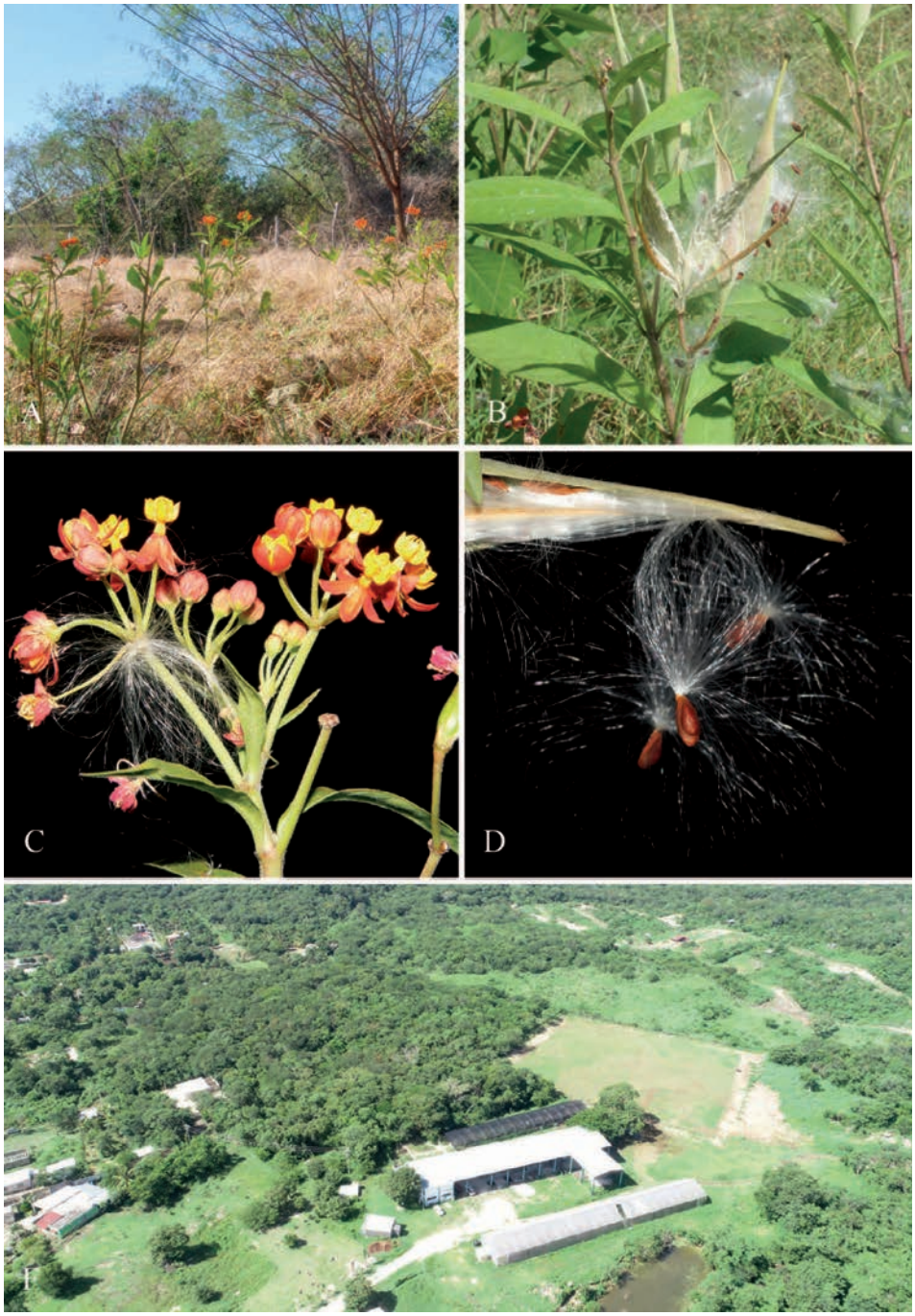


**Fig. 1.** Plant material for nest and study area: A – *Asclepias curassavica* L.; B – seeds; C – flowers and seeds; D – pappus with seeds; E – Native Flora Conservation Unit of the Yucatan Peninsula (NFCUYP) at the Instituto Tecnológico de Chiná in Campeche, Mexico (Photo. W. Cetzal-Ix)

## Results and discussion

The nest of hummingbird located in the NFCUYP presented a female of *A. rutila* with two eggs, one hatched (and the brood was not found) and the other did not hatch after 16 days of observation, due to the abandonment of the adult female (Fig. 1). On the other hand, the hummingbird nest located in RFC presented an adult individual and a juvenile chick. Regarding the sizes of nest, both presented a concave cup-shaped symmetric shape, but differed in their sizes (Fig. 3); the NFCUYP nest has an external length of 61.27 mm, a cup diameter of 24.62 mm, an internal diameter of 23 × 23 mm and a depth of 19.76 mm. The RFC nest had an external length of 52.49 mm, a cup diameter of 40.89 mm, an internal diameter of 23.37 × 26.07 mm and a depth of 27.94 mm.

The main vegetative material identified for the construction of the nests in both locations, were made from pappus from *Asclepias curassavica* L. (Apocynaceae) (Fig. 2A–D). The pappus is a thin and cottony filament that possesses the seeds for the dispersion (Toro, Briones, 1995). Approximately between 10 and 14 m away from the host plants of the nests, respectively, *A. curassavica* was observed growing as a herbaceous from 0.5 to 1 m in height, in disturbed sites and without vegetation. In addition, we observed in both nests the presence of lichens in the lateral parts of the same and covered with cobweb, which gives them greater rigidity and support. The web possibly belongs to *Peucetia viridans* Hentz, which was registered in the same host plants, in both sites (Fig. 1E).

In the NFCUYP, the identified plant-host where the hummingbird nest was found was Chaya bush *Cnidoscolus acotinifolius* (Mill.) I.M. Johnst. (Euphorbiaceae), known in the YP as "Chaya de monte" which are shrubs with abundant white latex, trichomes in the form of sharp hairs and thorns (Fig. 1). This species is native to the YP and is widely distributed in the northern portion of the region, mainly in deciduous and medium-sized sub-deciduous forest (Carnevali et al., 2010). The nest in the host plant was found 1.45 m above the ground, at 37.76 mm in diameter of the main branch, 12.50 mm in diameter of the support branch, placed 10 branches of the host plant, 45 cm away from the stem of the host plant; the percentage of coverage of the leaves that provide the nest was 80% and with a percentage of 70% visibility, based on the criteria of observations indicated by Ralph et al. (1996). Stinging trichomes and the latex that possesses *C. acotinifolius* have been reported to act as defensive mechanisms for the plant (Torres-González, García-Guzmán, 2014). In this sense, they can also represent a defense and protection mechanism for the nests of *A. rutila*, particularly during periods of drought (January to May) when the greatest loss of leaves (40–60%) occurs in the low and medium deciduous and sub caducifolious forests, respectively.

The nest registered in RFC, was found in a mango tree *Mangifera indica* L., a species cultivated and used for agriculture in tropical areas, the nest was observed at

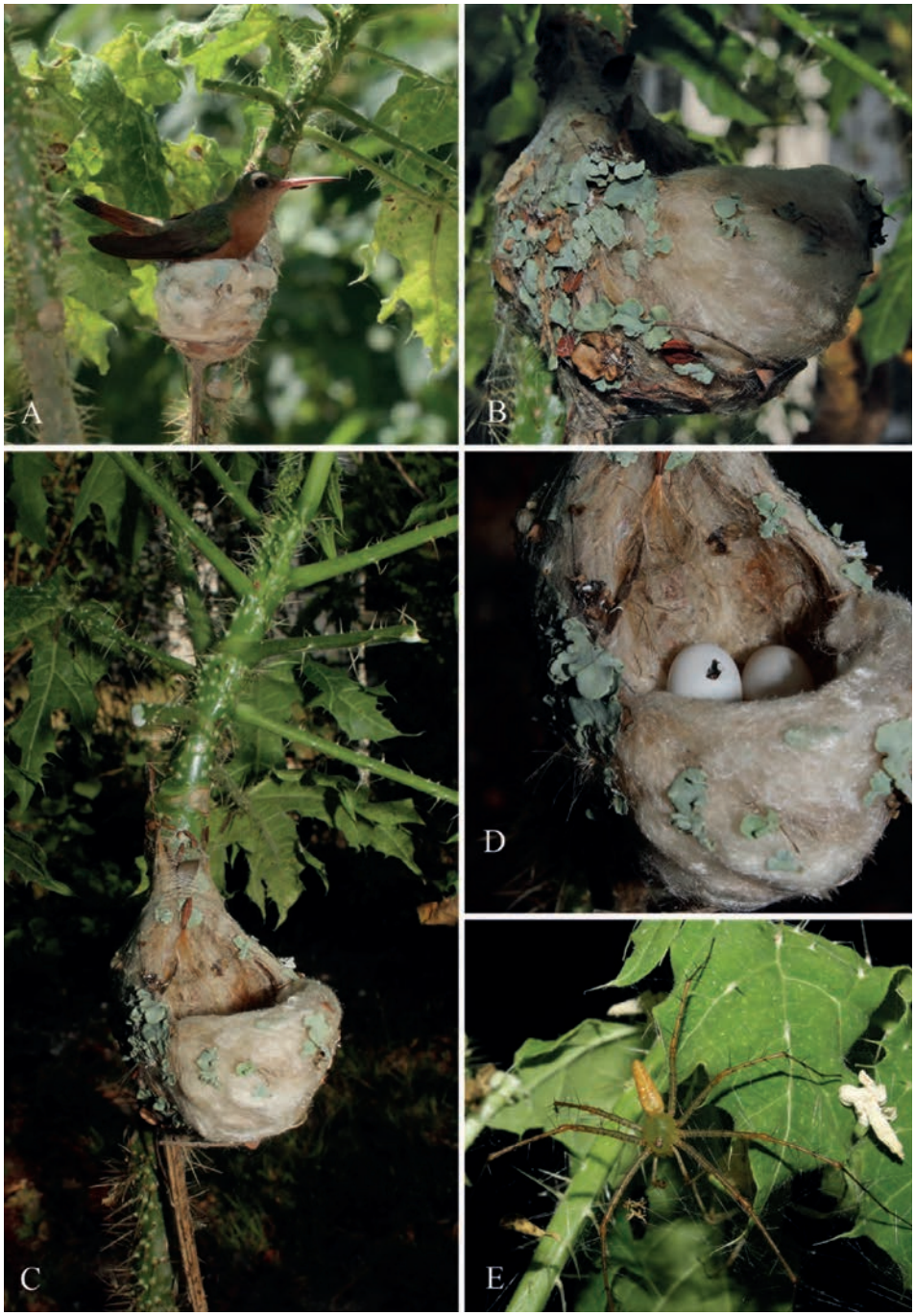


**Fig. 2.** Cinnamon hummingbird and host plant: A – *Amazilia rutila* De Lattre in nest; B – nest, C – nest in *Cnidoscolus aconitifolius* (Mill.) I.M. Johnst.; D – nest eggs; E – *Peucetia viridans* Hentz in *C. aconitifolius* (Photo. H.M.J. López-Castilla)

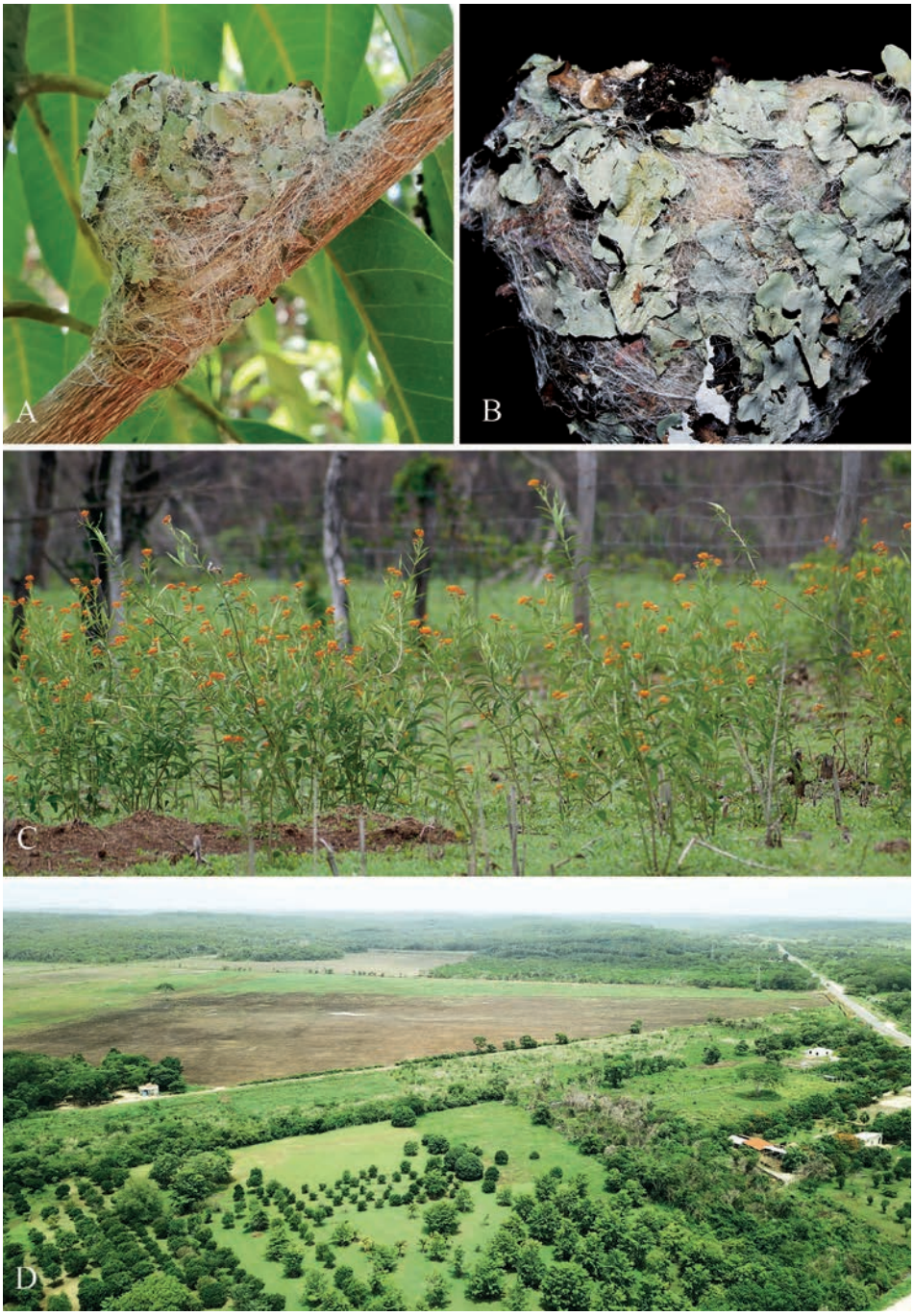


**Fig. 3.** Nest and study area: A – nest on *Mangifera indica* L.; B – nest with lichen and cobwebs; C – plants of *Asclepias curassavica* L. near the nest; D – Residential farms Cholul (RFC) in Chiná, Campeche, Mexico (Photo. H.M.J. López-Castilla)

1.70 meters from the ground, at 37.76 mm in diameter of the main branch, 12.50 mm in diameter of the support branch, placed 10 branches of the host plant, 45 cm away from the stem of the host plant; the percentage of coverage of the leaves that provide the nest was 80% and with a percentage of 70% visibility. The mango tree is widely cultivated in the YP and they do not lose their foliage during the seasons of the year, therefore, they do not expose the hummingbird nests. These dimensions and data on host plants can be considered for further studies on nesting patterns in hummingbirds.

Different species of birds use a wide variety of materials for the construction of their nests, from dry grasses (Mainwaring et al., 2014) or dry leaves of *Pinus patula* Schltdl. & Cham. (Pinaceae) (Morales-Rozo et al., 2009) to cigarette butts in urban species as *Haemorhous mexicanus* Müll. and *Passer domesticus* L. (Suárez- Rodríguez et al., 2013). In some hummingbirds, recorded is the use of branches and dry leaves of *Calea urticifolia* (Mill.) DC. (Asteraceae) for the construction of the nest (Ortiz-Pulido et al., 1998), which are decorated with lichens of the genus *Parmotrema* sp. (García, Botero, 2013) or mosses such as *Ancistrodes genuflexa* (C. Müll.) Cros. and *Weymouthia cochlearifolia* (Schwägr.) Dixon (Meteoriaceae) (Torres-Dowdall et al., 2007). Generally, the materials used for the construction of the nest are adhered with cobwebs (Ortiz-Pulido et al., 1998; García, Botero, 2013). Although plant materials for nest construction are described in some bird species, information on various groups of birds is still scarce (Deeming, Mainwaring, 2015; Biddle et al., 2018; Wesołowski, Wierzcholska, 2018). As well as the identity of the plant species used and if they are selected for some function in the nest, as for example by their antimicrobial properties to counteract ectoparasites (Dubiec, Mazgajski, 2013). For example, in *Amazilia violiceps* Gould we reported the use of dry branches of plants (not determined species plants) for the construction of the outer part of the nest and whitish fibers of the fruit of *Ceiba aesculifolia* (Kunth) Britt. & Baker f. tree for the inner part of the nest; interwoven with cobwebs of possibly *Nephila* sp. (DeSucre-Medrano et al., 2016).

On the other hand, *Amazilia cyanocephala* Lesson records the use of small grasses, small pieces of leaves and flowers of *Mimosa* sp.; likewise, scales of the stems of the fern *Alsophila firma* (Baker) D.S. Conant, *Cyathea bicrenata* Liebm. and *Cyathea* aff. *fulva*) (Cyatheaceae); seeds of *Tillandsia deppeana* Steud. (Bromeliaceae) and horse hairs. The nests are decorated with pieces of liverworts *Calypogeia* spp. (Calypogeiaceae) and adhered with the cobweb of *Peucetia viridans* (Ornelas-Rodríguez, 2010). This same species of spider was identified in *Amazilia rutila*, with which it also adheres the materials to the nest. Previous studies identified as host plants of hummingbird nests species represent species like *Phyllostachys* Siebold & Zucc. (Poaceae) (Ornelas-Rodríguez, 2010), *Heliocarpus terebinthinaceus* (DC.) Hochr. (Malyaceae) (DeSucre-Medrano et al., 2016) and *Citrus limon* (L.) Osbeck (Rutaceae) (García, Botero, 2013). The knowledge of nesting species of the genus *Amazilia* is far from complete

(Ornelas-Rodríguez, 1995). Although *A. rutila* is permanently resident in the YP, its reproductive habits, composition and structure of its nests have not yet been fully studied.

## Conclusion

The cinnamon hummingbird individuals located at the two sites of Campeche were selective-opportunistic with the vegetative materials used for the construction of their nests, because they collect plants that are close to where they establish their nests within their habitat. On the other hand, they select exclusively the pappus from the seeds of *Asclepias curassavica* for the construction of the nest walls, and provide rigidity and support with lichen and cobwebs of *Peucetia viridans* that are also living in the same host plant. The selection of the host plant occurs selectively and opportunistically for periods of drought when the eggs in the nests are mostly exposed to predation. The location of materials for the construction of the nest and host plants can help understand the composition and architecture of nests for the survival of tropical bird species.

**Conflict of interest**

The authors declare no conflict of interest related to this article.

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## Abstract

The Yucatan peninsula (YP) is part of a biogeographical area characterised by its diversity of flora and fauna, among which are the birds, mainly hummingbirds, which are indicators of the state of conservation of the ecosystems. In birds, the site establishment and construction of nest plays a fundamental role for reproduction and survival rate, the selection of materials occurs opportunistically, but birds tend to use fresh leaves of plants with antimicrobial properties or that allow the depletion of ectoparasites in their nests. In this sense, for the first time we recorded for the cinnamon hummingbird (*Amazilia rutila* De Lattre), the materials used for the construction of its nest and the site of establishment of the nest in the host plants in two sites of a medium sub-deciduous forest in, Mexico. We recorded the construction of nests of *A. rutila* in two locations in Campeche; in the first site the nest was found in a chaya bush *Cnidoscolus aconitifolius* (Mill.) I.M. Johnst. (Euphorbiaceae); most possibly as an anti-predatory strategy for trichomes in the form of sharp hairs and spines that the plants possess in their stems and leaves. In the second site, the nest was found in a mango tree *Mangifera indica* L. (Anacardiaceae). The main vegetative material identified for the construction of the nests in both locations, were made from *pappus* (thin and cottony filament that possess the seeds for the dispersion) from *Asclepias curassavica* L. (Apocynaceae).

**Key words:** *Asclepias curassavica*, *Cnidoscolus aconitifolius*, hummingbird, *Mangifera indica*, Yucatan peninsula

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## Budowa gniazda *Amazilia rutila* De Lattre (Trochillidae) i jego anty-drapieżna strategia obronna w lasach liściastych w Campeche w Meksyku


### Streszczenie

Półwysep Jukatan (YP) jest częścią obszaru biogeograficznego charakteryzującego się różnorodnością flory i fauny. Wśród fauny licznie występują ptaki, głównie kolibry, będące wskaźnikami stanu zachowania ekosystemów. Dla ptaków zakładanie i budowa gniazda odgrywa podstawową rolę w rozmnażaniu i przeżywalności. Wybór materiałów na gniazda odbywa się oportunistycznie, ale ptaki zwykle używają świeżych liści, o właściwościach przeciwdrobnoustrojowych lub pozwalających na odstraszenie pasożytów zewnętrznych z ich gniazd. W tym kontekście, dla kolibra cynamonowego (*Amazilia rutila* De Lattre) po raz pierwszy opisaliśmy materiały użyte do budowy gniazda oraz miejsce założenia gniazda w roślinach żywicielskich, w dwóch lokalizacjach lasu liściastego w Meksyku. Obserwowaliśmy budowę gniazd *A. rutila* w dwóch lokalizacjach w Campeche. W pierwszym miejscu gniazdo znaleziono w zaroślach Chaya *Cnidoscolus aconitifolius* (Mill.) I.M. Johnst. (Euphorbiaceae); ostre włoski i kolce, które mają rośliny z tego rodzaju na swoich łodygach i liściach, najprawdopodobniej występują tu jako anty-drapieżna strategia dla włosieni. W drugim miejscu gniazdo znaleziono na drzewie mango *Mangifera indica* L. (Anacardiaceae). Główny materiał roślinny zidentyfikowany do budowy gniazd w obu lokalizacjach został wykonany z puchu – *pappus* (cienkiego i bawełnianego filamentu służącego do dyspersji nasion) z *Asclepias curassavica* L. (Apocynaceae).


**Słowa kluczowe:** *Asclepias curassavica*, *Cnidoscolus aconitifolius*, koliber, *Mangifera indica*, Półwysep Jukatan

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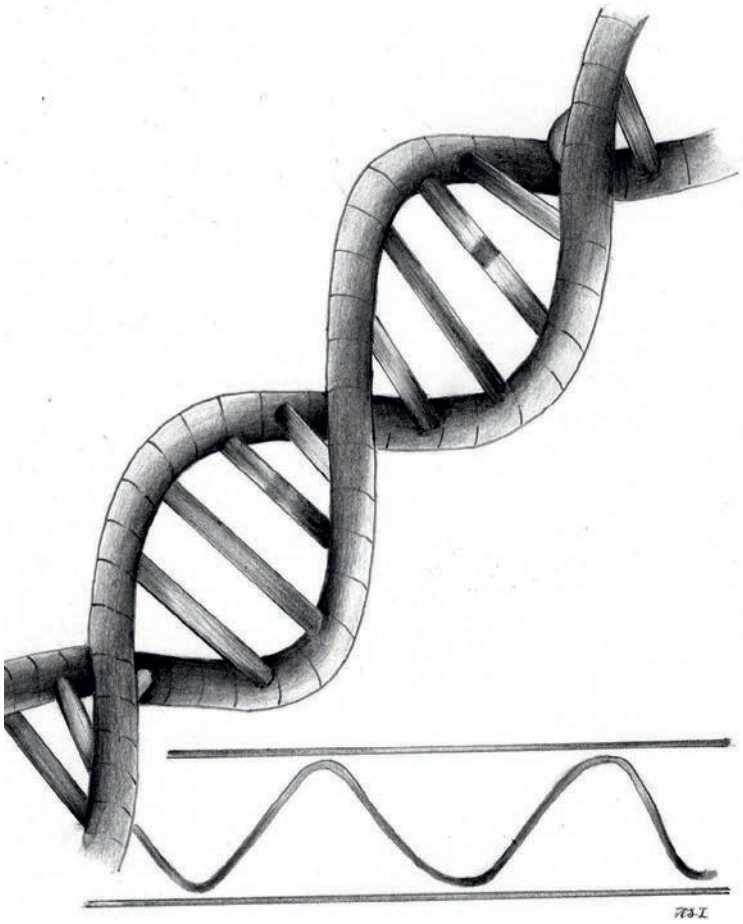
# Experimental Biology



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# Assessment of earthworms activity based on eaten biomass from selected catch crops

## Introduction

In order to preserve the homeostasis of the soil environment and increase its fertility, the presence and activity of soil mesofauna, especially earthworms, is an essential factor (family Lumbricidae Rafinesque-Schmaltz, 1815). By feeding on plant and animal residues, as well as microorganisms, earthworms form resources of soil organic matter that are permanently associated with the soil's mineral phase (Wu et al., 2018). A network of corridors formed by individual ecological groups of earthworms contributes to the regulation of water-air relations in soil. According to Bouché (1972), three main ecological groups of earthworms can be distinguished in the soil profile: anecic, endogeic and epigeic. For agroecosystems, the first two play a key role. Anecic species (e.g. *Lumbricus terrestris* L.) live deep in the soil profile (up to several meters) and form corridors with a further to the vertical slope, which communicate earthworms with a substantial food source, i.e. with plant debris left on the ground (e.g. in the form of mulch). However, their basic component of the diet is the mineral part of the soil, which they eat while drilling corridors. Their activity contributes to better water infiltration and the creation of 'fertile' corridors on the walls of which reside bacteria in the organic matrix left by earthworms (coprolytes, body's excrement). They are also weed seed vectors, which enriches the soil seed bank located at deeper levels. Endogeic species from the second ecological group intensify their activity in the arable soil layer, near plant roots (up to 30 cm deep) and create galleries with a horizontal slope, contributing to the formation of proper humus reservoir in the plant rhizosphere. Also these species are vectors of microorganisms and seeds in the inhabited area (Clause et al., 2017). They are also species that prefer a large proportion of organic remains in addition to the mineral part of the soil.

The presence and activity of earthworms in the cultivated field can be limited by the intensification of cultivation treatments (Briones, Schmidt, 2017) and the use of herbicides (Kostecka, 1999; Pelosi et al., 2014). The introduction of plant biomass into the field, for example in the form of catch crops, is an additional source of food and can contribute to an increase in the earthworm population. The presence and activity of earthworms increases the fertility of the soil habitat, which creates favourable conditions for the growth and development of crop plants.

Each animal selects, *per se*, the most rich in content – optimal food that it needs. For earthworms these are: plant and animal debris, living and dead soil organisms (bacteria, fungi, protozoa, algae, nematodes, amoebas) (Curry, Schmidt, 2007), as well as excrements of various living organisms, minerals, ions in the free state in soil solution. Penetrating the soil profiles of almost every square meter of soil on the Earth's surface, earthworms, when drilling corridors and taking food, decide what and in what quantity will be collected and processed by them. However, this fascinating mechanism of food preferences in earthworms is not yet fully understood. The first work on the trophic behaviourism of earthworms appeared in ancient times (Li et al., 2010), and the deliberations were continued with considerable publicity by Charles Darwin, who devoted the last 30 years of his life to studying the life and functions of earthworms in the process of forming soil organic matter. When food is consumed by the earthworm, a decisive role is played by a part of the neural ganglion, which is stimulated by chemical receptors located in the prostomium (above-mouth lobe) and from receptors on the entire body surface of the earthworm. These receptors provide the earthworm with information about the environment in which it is currently located. Generally, the trophic mechanism in the earthworm consists in collecting through the mouth, then swallowed pieces pass through pharynx, the esophagus and enter the crop, in which they are temporarily kept and mixed with a concentrated suspension of calcium carbonate produced by calciferous gland's secretory cells localised at the end of the esophagus. Next, the food goes to a heavily muscled stomach (gizzard), then passes into the intestine, from where it is excreted in the form of casts through the anus. Despite the absorption of nutrients by the body of the earthworm, droppings are a valuable and rich component of soil matrix and remain compact for a long time. It is interesting that despite high concentrations of phenolic compounds in plant material and their adverse effect on the precipitation of proteins in living organisms, plant biomass remains the main substrate for earthworms. The research of Liebeke et al. (2015) shows that drillodefensins (surface active lipophilic ions 259.1013 Da, which *m/z* are consistent with a molecular formula of $C_{12}H_{19}O_4S^-$) are produced in the earthworm body, which are produced in the foregut section of earthworms and help them digest phenolic-rich residues plant.

One way to assess the trophic activity of earthworms is to quantify their ability to eat food per unit of time. The aim of the study was to evaluate the possibility of processing food (mixed with soil catch crop residues from white mustard (*Sinapis alba* L.), buckwheat (*Fagopyrum esculentum* Moench) and tansy phacelia (*Phacelia tanacetifolia* Benth.) and crop biomass which was spring triticale (×*Triticosecale* Wittm. ex A.Camus) by earthworms of the species *Lumbricus terrestris* L. regard to control object (soil from the field). An interesting further question concerned examining whether any of the plants can be preferred (more willingly taken) by earthworms, thus may supposedly contribute to an increase in their numbers in the field.

## Material and methods

### Study material

The model organism in the experiment were individuals of *Lumbricus terrestris*, a species from the anecic group, which are known for drawing plant organic matter from the soil surface into their corridors reaching 2 meters deep into the soil (Bogdanowicz et al., 2004), and that while burrowing corridors, they also pass a significant amount of the mineral part of the soil through the gastrointestinal tract (Rouse, 2016).

### Assessment of food intake by earthworms

The assessment of food intake by earthworms was performed in laboratory conditions in experiment with Petri dishes. Earthworms were purchased from a commercial supplier (Ekagro) and kept for 4 hours in the dark (15°C) in a container with wet tissue paper to empty their digestive tract. Then 1 *L. terrestris* individual (average weight 4.99 g) was placed in one Petri dish (Ø 11 cm), in seven replications, and was incubated in a vegetation chamber (darkness, 18°C) in a completely randomised system. The food material (20 g per Petri dish) was air-dried fragmented plant biomass (7% w/w) sieved through a Ø 1 mm sieve and mixed with soil sterilised at 105°C which was sieved through a Ø 2 mm sieve and brought to field humidity (approx. 35%). The amount of food eaten by each individual was assessed after 12 h, 24 h and 63 h with an accuracy of 0.0001 g.

Before measuring each dish with food (7 replicates), the earthworm and wet paper were removed, then excrements and coprolites left on the Petri dish during the animal's activity were wiped with paper, and then the together with food was weighed (later subtract the weight of each dish). All results were corrected for values resulting from natural weight loss of food recorded simultaneously for objects without earthworms.

### Statistical analysis

The results regarding the food intake of earthworms were analysed based on ANOVA with repeatable measurements and a grouping factor (food material) or one-way ANOVA (C and N content; ratio of food intake) and subjected to the Tukey HSD test at $\alpha = 0.05$.

## Results and discussion

The dynamics and amount of food intake at 12-hour intervals (Fig. 1 A–B) indicates that this geophages species prefer soil as food. However, among the plant biomass supplements, earthworms most often took white mustard (*Sinapis alba* L.) (0.80 g after the first 12 hours). These food tendencies of earthworms remained until the end of the experiment, and this is all the more surprising because plants of the *Brassicaceae* Burnett family have thioglycosides of volatile mustard oils in their tissues, which after being subjected to mechanical grinding and under the influence of the enzyme myrosinase, may decompose in white mustard to toxic and irritating soft tissues p-hydroxybenzyl isothiocyanate (Sawicka, Kotiuk, 2007).

**Tab. 1.** Nitrogen (N) and carbon (C) content in the biomass of analysed plants and in soil

| Object | N [%] | C [%] | C/N ratio |
|---|---|---|---|
| *Phacelia tanacetifoli*a Benth. | 1.81 ±0.018 b | 40.04 ±0.004 c | 22.1 |
| *Sinapis alb*a L. | 1.94 ±0.032 a | 42.18 ±0.170 a | 21.8 |
| *Fagopyrum esculentu*m Moench | 1.57 ±0.040 c | 40.27 ±0.083 c | 25.7 |
| ×*Triticosecale* Wittm. ex A.Camus (spring) | 1.83 ±0.021 b | 41.68 ±0.077 b | 22.8 |
| soil (control) | 0.08 ±0.003 d | 0.64 ±0.023 d | 8.54 |

mean values ±SD, n = 3; different letters next to values indicate different homogenous group, HSD Tukey test, $\alpha = 0.05$

The third measurement, after more than 3-times a further exposure (63rd hour of the experiment), revealed even greater discrepancies in soil uptake (15.13 g) and soil with the addition of plant biomass (1.37 g on average). At 63rd hour of the study, there was a disruption in the metabolism of earthworms in the form of a secreted white substance in a facility with tansy phacelia (*Phacelia tanacetifolia* Benth.), which resulted in a lower uptake of eaten food than assessed after 24 hours and this also became the basis for the termination of the experiment.

The dynamics of food intake showed acceleration of consumption for some objects and exposure times, and sometimes earthworms took food constantly (Fig. 1). For example, tansy phacelia are characterised by increased intake dynam-

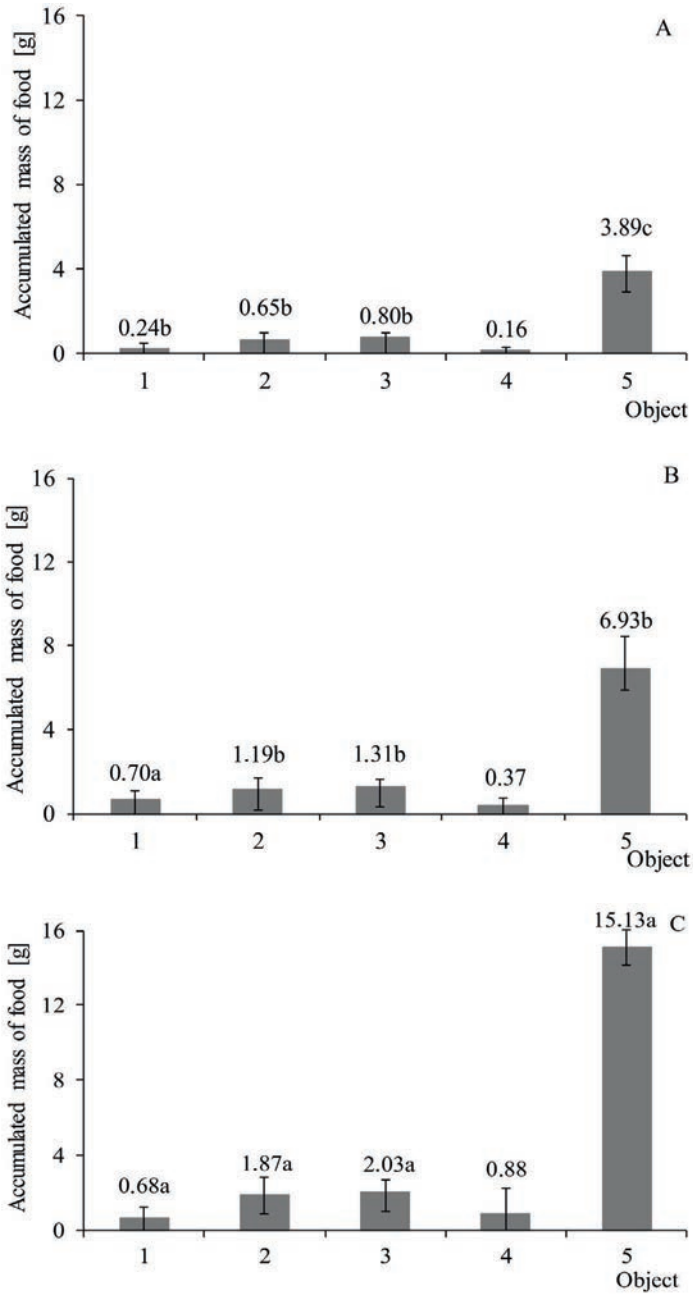


**Fig. 1.** Accumulated mass of food eaten by earthworms *Lumbricus terrestris* L. (A) after 12 hours, (B) after 24 hours, (C) after 63 hours, (n = 7); different letters next to values indicate different homogenous group inside the one object with a time, HSD Tukey test, α = 0.05; ** for ×*Triticosecale* p-value = 0.360579; object: 1 – *Phacelia tanacetifolia* Benth., 2 – *Fagopyrum esculentum* Moench, 3 – *Sinapis alba* L., 4 – ×*Triticosecale* Wittm. ex A.Camus, 5 – soil (control)

ics between 12 and 24 hours of exposure (190%), just as triticale between 12 and 24 hours (131%) and 24–63 hours (138%). White mustard and buckwheat were taken changeless at both time intervals, with more dynamic (though less quantitatively) uptake of buckwheat (83 and 57%, respectively) and balanced uptake dynamics for white mustard (57 and 55%, respectively).

Earthworms, as a biological component that increases soil fertility, are particularly valuable in soil and plant cultivation systems, in which it is not possible to increase this fertility by introducing fertilisers and soil conditioners into the system. This is the case in the organic farming system. Non-use of plant protection products and a larger amount of organic matter going back to the field mean that this system has a greater biodiversity, quantity and biomass of earthworms, although the plough tillage is a decisive factor (Bilalis et al., 2009; Munro et al., 2002). In this context, the conducted research may allow the identification of species-specific trophic behaviour of earthworms (food processing capability, intake dynamics) and estimation of the impact of the earthworm population and their trophic behaviourism on the positive (or negative) effect on the growth and development of plants in organic crops.

It should be noted, that the practice of leaving plant residues in the form of mulch on the soil surface has been known in agriculture for a long time and it is used now, especially in organic farming. Although, according to Jodaugiene et al. (2010) the largest amount and biomass of earthworms is concentrated under grass mulches (av. 185 number per $m^{-2}$ and 42.5 $g \times m^2$ respectively), the selection of plants was not accidental in this experiment, because tansy phacelia, white mustard and buckwheat belongs to the plants widely used in organic farming, at least because of their phytosanitary properties in relation to commercial crops (Majchrzak et al., 2005).

Plants used in the food material used in the experiment were subjected to biochemical analysis for nitrogen and carbon content (Tab. 1). The data show that white mustard, which the earthworms took the most, also had the highest C/N ratio (25.7), while in spring triticale, whose intake was the most dynamic during the whole experiment, this ratio was at the level of 22.8.

A good estimator of the quantitative and qualitative food intake by earthworms is the ratio of the weight of food taken (per day) to the average body weight of the earthworm – F24/AWE (Tab. 2). Based on the obtained results, it was observed that the activity of earthworms increased more than threefold in objects with an addition of catch crop biomass in relation to spring triticale.

**Tab. 2.** Comparison of the ratio of food intake from various plant species during the 24 hours to the average body weight of the earthworm (*Lumbricus terrestris* L.); AWE – average weight of the earthworm, AWFT – average weight of food taken in total after 24 hours, F24/AWE – ratio of food intake per 24 hours to the average weight of the earthworm

| Plant species | AWE [g] | AWFT [g] | F24/AWE |
|---|---|---|---|
| *Phacelia tanacetifolia* Benth. | 5.00 ±1.022 | 0.70 ±0.365 | 0.14 b |
| *Fagopyrum esculentum* Moench | 4.93 ±1.555 | 1.19 ±0.545 | 0.24 b |
| *Sinapis alba* L. | 4.86 ±1.614 | 1.31 ±0.348 | 0.27 b |
| ×*Triticosecale* Wittm. ex A.Camus (spring) | 5.21 ±1.197 | 0.37 ±0.340 | 0.07 b |
| soil (control) | 4.93 ±0.965 | 6.93 ±1.982 | 1.41 a |
| mean value for plants | 5.00 ±1.375 | 0.89 ±0.557 | 0.18 |

average means ±SD, n = 7; different letters next to values indicate different homogenous group, HSD Tukey test, α = 0.05

It is estimated that in maize cultivation in temperate climate, 100 individuals of *L. terrestris* species per 1 m$^2$ process on average 840 kg of litter per year (Bohlen et al., 1997). In this experiment, a new indicator, the decomposition rate, was used, which tells how many kilograms of food used (mixture of soil and plant biomass) pass through the digestive tract of 100 individuals per year, in this case *L. terrestris* (Fig. 2). It can be useful in estimating the contribution of individual soil fauna species to the transformation processes of the organic substance of the agroecosystem in a time interval. Estimation through this indicator gives the opportunity to assess the impact of a particular species, taking into account its synecology (population ecology), living in a given ecosystem and the ability to compare the effectiveness of organisms (including earthworms) in various crops. However, it is advisable to collect the organisms before calculating the decomposition index in order to estimate their real number in the studied area.

The most effective crops in terms of processing of plant biomass by earthworms of the species *L. terrestris* (assessment based on the calculated decomposition rate) would be white mustard and buckwheat (the highest values in figure 2). On the other hand, in quantitative terms, the biomass of cereal plants represented by spring triticale was almost three times less processed compared to other tested plants.

To correctly assess the impact of the earthworm population on the plant biomass cycle in the agroecosystem, it should be taken into account that earthworms as burrowers require more space for their activities, so that the spatial stress factor does not inhibit them from activity. Therefore, field experiments in the mesocosm system are the most commonly used in this type of research. On the other hand, laboratory experiments are short and reflect the food preferences of individuals quite well.

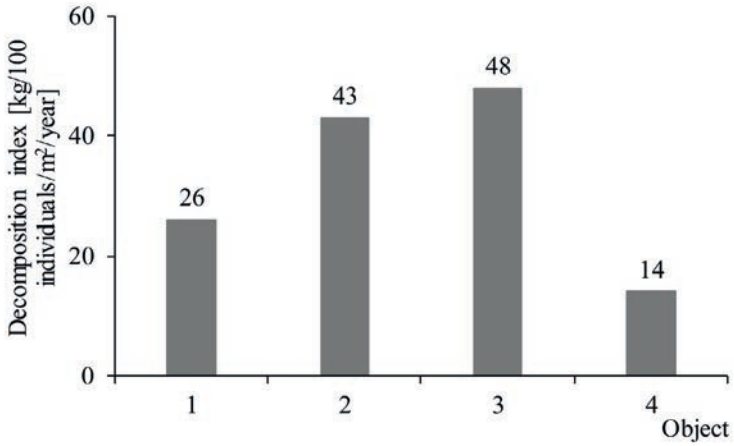


**Fig. 2.** Estimated average mass of food eaten by 100 individuals (*Lumbricus terrestris* L.) based on the results of a laboratory experiment; 1 – *Phacelia tanacetifolia* Benth., 2 – *Fagopyrum esculentum* Moench, 3 – *Sinapis alba* L., 4 – ×*Triticosecale* Wittm. ex A.Camus

## Conclusion

The conducted analyses show that *Lumbricus terrestris* shows food preferences in relation to crop biomass, as the eurybiont of many habitats in temperate climate. During the 63 hour experiment, soil (15.1 g) constituted the most food material collected by earthworms, and among the plant components – the one with the addition of *Sinapis alba* (2.03 g). However, the object with the addition of ×*Triticosecale* spring was characterised by the highest consumption dynamics (the average of 135%). Food material with the addition of tansy phacelia was taken up the fastest in the first 24 hours (190%), but later it fell sharply until changes in animal metabolism were recorded.

The ratio of food intake per day to the average body weight of one earthworm exceeded the unity threshold (1.41) only in the case of the soil object. In other cases (non-cereal plants) it oscillated around 0.22 and only in triticale reached three times lower (0.07). The most favorable decomposition rate was recorded for white mustard, whose estimated amount of food eaten by earthworms (with a local population of 100 individuals) would be approximately 48 kg/m$^2$/year in the field. The assessment of the possibility of food processing by earthworms, as well as the determination of their population in the field, can be very helpful in the organic farming system, where the biological component plays a key role in increasing soil fertility.

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**Conflict of interest**

The authors declare no conflict of interest related to this article.

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## Abstract

The trophic activity of soil mesofauna, especially earthworms (the Lumbricidae family), is a key element in increasing the fertility of agroecosystems. The food strategies that earthworms use as part of the trophic networks in soil, and especially their food preferences, are still unknown. Much is known about what is the food substrate of earthworms, but the food preferences of individual species, as well as the possibilities and dynamics of food processing are not fully understood. The aim of the experiment was to observe the amount and dynamics of food uptake by the earthworms of the species *Lumbricus terrestris* L., which is a common species of soil *Oligochaeta* in agricultural areas, as well as to propose a new decomposition rate measuring the strength of the earthworm population and its contribution to the mechanism of processing plant organic matter.

**Key words:** agroecosystem, Lumbricidae, cover crops

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## Ocena aktywności dżdżownic na podstawie pobrania biomasy z wybranych międzyplonów

### Streszczenie

Aktywność troficzna mezofauny glebowej, zwłaszcza dżdżownic (rodzina Lumbricidae), stanowi kluczowy element w podnoszeniu żyzności agroekosystemów. Strategie pokarmowe jakie stosują dżdżownice będące częścią sieci troficznych w glebie, a zwłaszcza ich preferencje pokarmowe są wciąż niepoznane. Wiele wiadomo na temat tego co jest substratem pokarmowym dżdżownic, to jednak nie do końca poznano preferencje pokarmowe poszczególnych gatunków, a także możliwości i dynamikę przerobienia pokarmu. Celem eksperymentu było zaobserwowanie ilości oraz dynamiki poboru pokarmu przez dżdżownice z gatunku *Lumbricus terrestris* L., będącej powszechnie występującym gatunkiem skąposzczetów glebowych na obszarach użytkowanych rolniczo, a także zaproponowanie nowego wskaźnika dekompozycji, mierzącego siłę i wkład populacji dżdżownic w proces przerabiania roślinnej materii organicznej.

**Słowa kluczowe:** agroecosystem, Lumbricidae, międzyplony

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# The bio-flavanoid concentrate of *Vitis vinifera* L. 'Red Aladasturi'

## Introduction

Flavanoids are the largest group of phenolic compounds, and owing to their high biological activity, they are often referred to as bioflavanoids. Deficiency of flavonoids in the human body manifests with the following symptoms: the general weakness and chronic fatigue, nasal hemorrhage, reduced immunity recurrent colds and infections, the formation of hematomas and vesication, the reduction in vascular conductance and elasticity, pains in the upper and lower extremities during movement, and so on (Kurkin et al., 2013; Yilmaz, Toledo, 2004; Gvinianidze et al., 2019).

There is extensive literature on high antioxidant activity of bioflavonoid-rich coloured grape seed and skin hydrophilic extract and red and white wine produced from it, as well as on inactivation of free radcals (Demrow et al., 1995; Gvinianidze, Gvinianidze, 2018). In 2011, the VITAL (Fred Hutchinson Cancer Research Center, Seattle, Washington) published a study on prostate cancer, and 35.239 men aged 50–76 volunteered for this study. It was found that patients regularly consuming grape-seed hydrophilic extracts were 41% less likely to suffer from prostate cancer than patients taking other drugs such as chondroitin, coenzyme Q10, fish oil, ginseng, ginkgo biloba, garlic, and glucosamine and palmetto (Zharskaya et al., 2014).

*Vitis vinifera* L. 'Red Aladasturi' is a Georgian, aboriginal, late-ripening, industrial cultivar, mostly common in the viticulture and winemaking zones of Imereti and Guria. Grapes ripen in late October and early November, and in full maturity, sugar content reaches 19.5–24.5%, and titrable acidity varies in the range of 8.0–9.3 g/dm$^3$ (Ketskhoveli et al., 1960).

It has been established that grape raw materials grown in different micro-zones differ in their sensory characteristics, uvological and chemical composition, as well as in antioxidant, antiradical and antimicrobial properties (Darra et al., 2012; Kvesitadze et al., 2019). Secondary resources accrued from the processing of coloured grapes (in

the form of skin and stone), by the contents of biologically active compounds have barely analogs in the autotrophic organisms, and they are not of less value products than wine itself. Only 9–12% of the total amount of phenolic compounds is contained in grape juice and pulp, accounting for 75–81% of the total mass of raceme, while the remaining 88–91% of phenolic compounds is mostly localised in the skin and stone, the mass of which is only 18–25% of raceme. This clearly shows how rich the biologically active compounds are in the solid parts of colored grapes, as well as how big is their role in the production of powerful antioxidant polyphenolic concentrates. Accordingly, research in this field is of high relevance.

The aim of the study was to investigate a polyphenolic complex and antioxidant activity of secondary resources remained after the initial processing of *V. vinifera* 'Red Aladasturi' grapes growing in Imereti and different micro-zones, as well as to explore the possibilities of using them for the production of drastic, antioxidant polyphenolic concentrates. The solid parts of colored grapes, with the content of biologically active compounds are the best raw materials for the production of therapeutic extracts and concentrates to treat various pathologies (Gvinianidze et al., 2017, 2018; Morandi Vuolo et al., 2019).

## Materials and methods

### Object of study

Research covered the raw materials of *Vitis vinifera* 'Red Aladasturi' grape from different vineyards of the Imereti viticulture and winemaking zone, particularly: sample N1 – Lifnari vineyards (Rokhi Village, Baghdati district, 120–160 m above sea level), sample N2 – Sviri vineyards (Sviri Village, Zestafoni district, 230–250 m above sea level) and sample N3 – Bagineti vineyards (Bagineti Village, Vani district, 580–600 m above sea level).

Research also covered hydrophilic extracts of grape skin and stone thickened by the vacuum of 'Aladasturi' coloured grapes raw materials, as well as the concentrates produced from their composition.

### Research Methods

For research, there were used gravimetric, extractive, spectral and chromatographic methods (Singleton et al., 1999; Palomino et al., 2000; Giusti, Ronald, 2001; Mensor et al., 2001; Kammerer et al., 2004; Prior et al., 2005; Gómez-Alonsoet al., 2007; Rajha et al., 2013; Benmeziane et al., 2016; Gvinianidze et al., 2018). In test samples, we determined: the moisture and solid matter contents by heat-gravitational (GOST 28561-90) and refractometric methods.

### Quantitative analysis of total phenols

Quantitative analysis of total phenols was performed spectrophotometrically, by Folin-Ciocalteu reagent. In particular, we extracted the crushed test samples with 75–81% ethyl alcohol at the temperature of 72–75°C and under conditions of periodic stirring for 6–7 hours. 1 ml of extract obtained, we placed into a 25 ml flask and added 0.5 ml of $H_2O$, 1 ml of Folin-Ciocalteu reagent, and settled for 8 minutes at room temperature, then we added 10 ml of 7% $Na_2CO_3$, filled the flask with $H_2O$, and settled it for 2 hours at room temperature.

The determination was carried out at 750 nm. As a control, we took 1 ml of the appropriate extracting agent and went through the same process. Calculation of the data obtained from the determination was carried out on the calibration curve of gallic acid.

The total phenol content shall be calculated in accordance with the formula:

$$X = (D \times K \times V \times F) \times 1000 /m,$$

where X – the total phenol content, mg/kgმ; D – optical density; K – gallic acid conversion factor; F – solubility; V – the total volume of extract, ml; m – raw materials mass taken for extraction, g.

### Antioxidant activity

Antioxidant activity in test samples was determined by one of the most common methods – DPPH method. DPPH is a rapid, simple and accurate test method for determining antioxidant activity. DPPH – ($C_{18}H_{12}N_5O_6$ M = 394.33) is a stable free radical with maximum absorption at 515–517 nm, and purple-violet coloration of its methanol extracts changes to bright yellow as a result of the recovery. The reaction occurs in accordance with the following pattern:

$$DPPH. + AH \rightarrow DPPH\text{-}H + A. \quad DPPH. + R. \rightarrow DPPH\text{-}R,$$

where AH is an antioxidant and R is a free radical.

Quantification of total flavonoids was carried out with $AlCl_3$ reagent by spectral method – test sample was extracted with 80% ethyl alcohol at the temperature of 70–75°C. 1 ml of extract obtained from the total volume was placed into a 10 ml flask, then we added 5 ml of $H_2O$, 0.3 ml of 5% $NaNO_2$ was settled for 5 minutes, and then we added 0.3 ml of 10% $AlCl_3$ and settled for 6 minutes, then we added 2 ml of 1N NaOH- R and the determination was performed at 510 nm. As a control, we took 1 ml of the appropriate extracting agent and then went through the same process.

Calculation of the data obtained from the determination was carried out on the rutin calibration curve. The total flavonoid content shall be calculated in accordance with the formula:

$$X = (D \times K \times V \times F) \times 1000 / m;$$

where X – the total flavonoid content, mg/kg; D – optical density; K – rutin conversion factor; F – solubility; V – the total volume of extract, ml; m – raw materials mass taken for extraction, g.

### Monomeric anthocyanins

The course of the pH-differential method for quantification of monomeric anthocyanins was as follows: we take test sample from 1 to 5 grams and carry out extraction with 45% ethyl alcohol. The volume of extract was reduced to 50 or 100 ml according to the extraction quality. From the total volume of extract, we take in two test-tubes 1 ml of extract in each, and add 4 ml of buffer solution in each. In one test-tube, we add 0.025 M of potassium chloride, and in the other test-tube, we add 0.4 M of sodium acetate, and 20 minutes later, we determine the optical density of the test solutions at 520 nm and 700 nm.

### Quantification of leucoanthocyanins and catechins by spectral method

Quantification of leucoanthocyanins and catechins by spectral method – extraction of test sample was carried out with 80% ethyl alcohol at the temperatures of 70–75°C. 1 ml taken from the total volume of extract was added with 3 ml of vanillin reagent and, 3 minutes later, we determine the optical density of red test sample at 500 nm. As a control, we shall take 1 ml or 3 ml of vanillin reagent. Calculation of the data obtained from the determination was carried out on the (+)catechin calibration curve. The catechin content shall be calculated in accordance with the formula: $X = (D \times K \times V \times F) \times 1000 / m$; where X – the catechin content, mg/kg; D – optical density; K – 35.0 (+) catechin conversion factor; F – solubility; V – the total volume of extract, ml; m – raw materials mass taken for extraction, g.

### Results and discussion

*Vitis vinifera* 'Red Aladasturi' is a late-ripening colored grape cultivar with a very special aroma that reaches full maturity in the second half of November, and the range of aromatic compounds in it increases in proportion with the increase in the sugar content (Ketskhoveli et al., 1960). The area of our concern was represented by polyphenolic compounds, and we were less interested in the sugar and aroma compound contents. Accordingly, the grape raw materials

were taken during the period of their technical maturity, while phenolic compounds were present in grapes to the extent possible. Grape samples were taken on 16 October 2018. The analysis of the uvological characteristics of individual samples of grape raw materials is given in table 1.

**Tab. 1.** Uvological characteristics of individual samples of grape raw materials

| Characteristics | | | Samples | | |
|---|---|---|---|---|---|
| | | | N1 | N2 | N3 |
| Parts of the cluster of grapes [%] | Juice and flesh | | 78.60 | 79.67 | 79.83 |
| | Grape | stalk | 4.71 | 4.74 | 4.69 |
| | | skin | 11.87 | 10.85 | 10.82 |
| | | stone | 4.48 | 4.44 | 4.39 |
| Number of seeds in the grain | | | | 1–4 | |
| Solid remains (grape stalk + grape skin + grape stone) | | | 21.06 | 20.03 | 19.90 |
| Structural indicator | | | 3.74 | 3.98 | 4.02 |

The study of the uvological characteristics of selected samples showed that structural indicators of all three samples of grapes (the ratio of flesh and juice to solid waste), at both stages of the grape harvest, were almost similar (relatively smaller for sample N1, and relatively larger for sample N3), indicating small differences in the quantitative phenolic complex contents in these samples (Gvinianidze et al., 2018).

We processed samples of grapes raw materials according to the following pattern: (1) identifying qualitative indicators of grapes raw materials; (2) passing grapes raw materials through the DMCSI-type grape clustercomb divider; (3) pressing-out the comb-less must in a basket press and separation of juice; (4) vacuum sublimation drying of juice-less sweet pomace with an initial moisture content of 45–65% to a final moisture content of 9–10%; (5) separation of the 'Aladasturi' cultivar's skin and stone dried to the moisture content of 9–10%, using tea sorting machine; (6) crushing separately the skin and stone in a micro-mill (TP2 Hammer Mill) until the fraction of 50–100 μm. The crushed grape-stone was extracted by two different methods.

The first method (Grape-stone I – extract): as an extracting agent for extraction of the grape-stone micropowder, we have selected a complex hydrophilic solvent – ethanol containing 40% volumetric alcohol, which was diluted with mineral drinking water "Borjomi" whose pH = 3.6–6.3 and mineralisation is in the range of 7–14 g/dm$^3$. This mineral water contains sodium (potassium) hydrogen carbonate and boric acid. Preliminary experiments have demonstrated that the extracting agent of ethanol diluted with mineral water can successfully replace the extracting agent diluted with water of ethanol containing 40% volumetric alcohol, which is oxidised by hydrochloric acid.

**Tab. 2.** Biologically active compounds of the grape-stone fluid extract

| B.A.C. [mg / 100 g/ dry weight basis] | Stages of superfluid extraction | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| Sample N1 | | | | | | | | | |
| Phenolic compounds | 131.6 | 977.66 | 782.9 | 395.9 | 344.6 | 114.1 | 137.5 | 95.1 | 2979.3 |
| Flavonoids | 290.8 | 505.6 | 421.9 | 310.3 | 243.6 | 144.6 | 219.4 | 89.0 | 2225.2 |
| Flavan-3-ols | 120.6 | 293.7 | 414.4 | 284.9 | 192.5 | 104.2 | 100.4 | 84.5 | 1594.2 |
| Leukoanthocyanins | – | 123.4 | 253.0 | 148.37 | – | – | – | – | 524.7 |
| Sample N2 | | | | | | | | | |
| Phenolic compounds | 123.8 | 943.0 | 762.1 | 382.7 | 332.4 | 184.9 | 129.5 | 87.9 | 2946.3 |
| Flavonoids | 289.6 | 500.2 | 418.1 | 308.7 | 243.4 | 146.4 | 219.6 | 91.8 | 2217.8 |
| Flavan-3-ols | 118.0 | 287.6 | 406.0 | 279.0 | 188.4 | 101.8 | 97.2 | 82.6 | 1560.6 |
| Leukoanthocyanins | – | 130.6 | 257.7 | 153.2 | – | – | – | – | 541.5 |
| Sample N3 | | | | | | | | | |
| Phenolic compounds | 132.4 | 953.3 | 764.2 | 388.7 | 343.9 | 201.9 | 142.0 | 99.8 | 3026.1 |
| Flavonoids | 292.9 | 501.1 | 421.8 | 310.5 | 247.7 | 149.9 | 219.3 | 98.5 | 2242.7 |
| Flavan-3-ols | 119.7 | 288.6 | 403.8 | 271.1 | 190.4 | 105.6 | 101.1 | 86.6 | 1566.9 |
| Leukoanthocyanins | – | 114.3 | 249.1 | 147.9 | – | – | – | – | 511.3 |

We have determined experimentally the mass ratio of the extracting agent and the grape-stone microdispersed powder, which is 5 l/kg. We have also determined experimentally the extraction parameters: temperature 54–57°C, duration 180–210 minutes, pulsation 4 $sec^{-1}$ and the pulsation amplitude 2–3 mm. Grape-stone ethanol extract at the initial stage, at the temperature of 4–5°C, is subject to sedimentation for 7–9 hours, removal from sediment and filtration with a wine filter with plates.

**Tab. 3.** Biologically active compounds and antioxidant activity of grape-stone extracts with 61–63% of solid matter content

| Composition of hydrophilic extracts | | Biologically active compounds [mg / 100 g on dry weight basis] | | | | AOA [%] (F = 100) |
|---|---|---|---|---|---|---|
| | | Phenolic compounds | Flavonoids | Flavan-3-ols | Leukoanthocyanins | |
| Sample | N1 | 3043.76 | 2293.94 | 1643.90 | 567.20 | 51.50 |
| | N2 | 3014.78 | 2276.10 | 1597.70 | 585.90 | 50.60 |
| | N3 | 3181.23 | 2308.65 | 1603.80 | 549.80 | 52.30 |

The second method (Grape-stone II – extract): extraction of a bioflavanoid complex from the grape-stone micro-powder was carried out using a supercritical super-fluid extractor (SFE – 100-2-C10) produced by Water Corporation, where the extracting agent was present together with $CO_2$ ethyl alcohol. For maximal extraction of the bioflavanoid complex, we have determined experimentally the optimal fluid

extraction parameters: pressure –95 bar, $CO_2$ delivery rate – 6.5 kg/h. In addition, the extraction quality was also affected by 72% ethanol as co-solvent, whose ratio to $CO_2$ was 21–22%. Grape-stone fluid extract at the initial stage, at the temperature of 4–5°C, is subject to sedimentation for 7–9 hours, removal from sediment and filtration with a wine filter with plates. The data of the studies of biologically active compounds of the grape-stone superfluid extract are shown in table 2. We have blended the grape-stone extracts obtained by both methods at a ratio of 1:1. The filtered extract contained 5.2–6.3% of solid matters, and it was concentrated using a vacuum-rotary evaporator at the temperature of 54–57°C to the solid matter content of 63%.

The composition of the concentrated grape-stone hydrophilic exracts was pumped over into the enameled collecting tank, from which test samples have been taken for the analysis on the biologically active compound content and antioxidant activity (Tab. 3). From the crushed grape skin, we obtained a hydrophilic liquid extract rich in bioflavonoids in accordance with the following technological scheme (grape skin extract): to effectively carry out extraction of anthocyanins from the grape skin, we processed the grape skin micropowder in advance to 0.4% with potassium metabisulphate.

As an extracting agent, we selected 36–45% volumetric ethanol processed by 2% citric acid. The optimal ratio of microdispersed raw materials and the extracting agent we determined experimentally at 3 l/kg.

We determined experimentally the extraction optimal parameters: temperature 54–57°C; duration 180–210 minutes; the extraction mass pulsation 4 minutes; the amplitude 5 mm. Prior to sedimentation and filtration, the obtained grape skin ex-

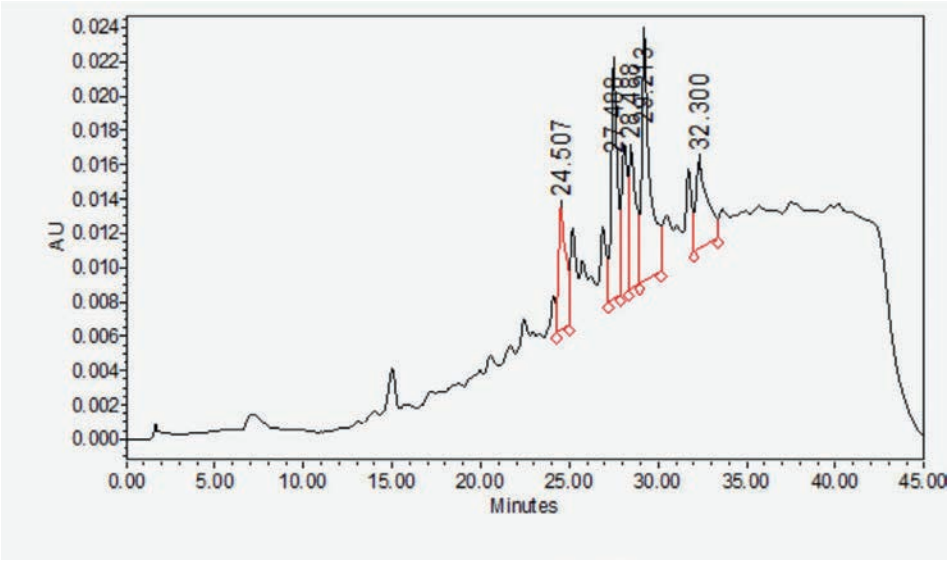


**Fig. 1.** Chromatogram of anthocyanins (sample N1)

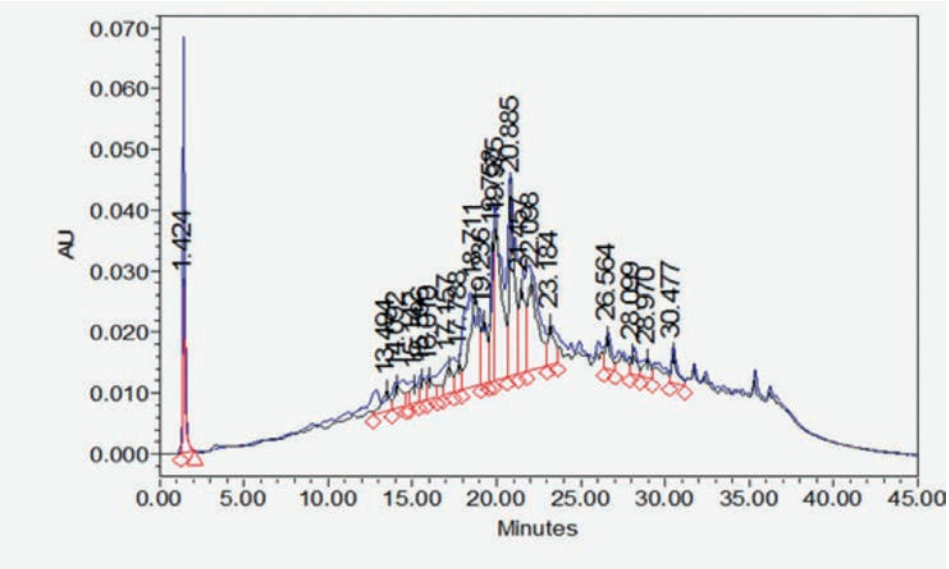


**Fig. 2.** Chromatogram of flavonoids (sample N1)

tract was processed by potassium bicarbonate ($KHCO_3$ – Potassium bicarbonate) for correcting 0.7–0.9 g/dm$^3$ excessive acidity.

**Tab. 4.** Biologically active compounds and antioxidant activity of grape-skin hydrophilic extracts

| Grape skin hydrophilic extract | | Biologically active compounds [mg / 100 g on dry weight basis] | | | | AOA [%] (F = 100) |
|---|---|---|---|---|---|---|
| | | Phenolic compounds | Flavonoids | Flavan-3-ols | Leukoanthocyanins | |
| Sample | N1 | 3178.5 | 646.9 | 1295.9 | 2106.1 | 46.6 |
| | N2 | 3098.8 | 396.0 | 1484.5 | 1302.4 | 45.3 |
| | N3 | 3265.3 | 520.6 | 1667.8 | 1954.8 | 47.1 |

The obtained extract, at the temperature of 4–5°C, is subject to sedimentation for 7–9 hours, removal from sediment and filtration with a wine filter with plates. The composition of the filtered grape skin exracts contained 4.5–5.2% of solid matters, and it was concentrated using a vacuum-rotary evaporator at the temperature of 54–57°C to the solid matter content of 61–63%, and then we assessed biologically active compounds and antioxidant activity (Tab. 4). Figure 1 illustrates the chromatogram of anthocyanins of extract containing 61–63% of solid matters of the micro-dispersed skin of Lifnari's 'Red Aladasturi' cultivar, and figure 2 illustrates the chromatogram of flavonoids.

We have blended the obtained grape-stone ethanol and fluid extracts containing 61–63% of solid maters at an equal ratio (1:1:1) and assessed biologically active compounds and antioxidant activity in this composition (Tab. 5).

**Tab. 5.** Biologically active compounds of grape-stone and skin ethanol and fluid extracts with 61–63% of solid matter content

| Sample number | | Biologically active compounds [mg / 100 g on dry weight basis] | | | | | AOA [%] (F = 100) |
|---|---|---|---|---|---|---|---|
| | | Phenolic compounds | Flavonoids | Flavan-3-ols | Anthocyanins | Leukoanthocyanins | |
| Sample | N1 | 3089.8 | 1746.3 | 1529.1 | 2131.9 | 572.5 | 51.4 |
| | N2 | 3044.7 | 1651.8 | 1562.6 | 1332.7 | 591.0 | 50.3 |
| | N3 | 3210.6 | 1714.2 | 1625.9 | 2011.8 | 554.9 | 52.2 |

The second stage of concentration was implemented by method of vacuum-sublimation or lyophilization to 74–75% of the solid matter content and pumped over into the enameled collecting tank, from which test samples have been taken for the analysis. The results of the assessment of biologically active compounds and antioxidant activity of bio-flavonoid liquid concentrate 'Red Aladasturi' are shown in table 6.

**Tab. 6.** Biologically active compounds and antioxidant activity of *Vitis vinifera* L. 'Red Aladasturi'

| Biologically active compounds [mg / 100 g on dry weight] | Sample | | |
|---|---|---|---|
| | N1 | N2 | N3 |
| Phenolic compounds | 3401.8 | 3351.1 | 3533.3 |
| Flavonoids | 1921.2 | 1808.4 | 1886.7 |
| Flavan-3-ols | 1682.2 | 1719.0 | 1788.9 |
| Anthocyanins | 2348.3 | 1467.9 | 2213.2 |
| Leukoanthocyanins | 578.9 | 597.1 | 560.6 |
| Dry matter [%] | 74–75 | 74–75 | 74–75 |
| AOA, (F = 100) [%] | 56.6 | 55.31 | 57.45 |

The studies have shown that the bio-flavonoid concentrates containing 74–75% solid matters of 'Red Aladasturi' obtained from different samples of colored grapes are slightly different from each other in the biologically active compound contents, but all three samples produce the bio-flavonoid concentrates with high antioxidant activity.

## Conclusion

It has been studied that the grape-stone and skin hydrophilic extracts of 'Aladastur' colored grape cultivar's raw materials taken in the separate viticulture and winemaking micro-zones of Imereti and the liquid bio-flavonoid concentrates are characterised by high antioxidant activity (N1 – 56.60%; N2 – 55.31% and N3 – 57.45%).

The bio-flavanoid liquid concentrates obtained from sample N1 are characterised by a high anthocyanin content, while the conentrates obtained from sample N2, are characterised by a high leucoanthocyanin content, and the bio-flavanoid liquid concentrates obtained from sample N3 are characterised by the content and antioxidant

activity of phenolic compounds and flavan-3-ols. Anthocyanins in samples of 'Red Aladasturi' cultivar are localised in the grape skin.

**Acknowledgement**

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**Conflict of interest**

The authors declare no conflict of interest related to this article.

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## Abstract

This paper dwells on the uvological characteristics of cultivar *Vitis vinifera* L. 'Red Aladasturi' grape raw materials growing in the viticulture and winemaking zone of Imereti (Georgia), as well as biologically active compounds and antioxidant activity of hydrophilic extracts and liquid concentrates of its solid matters (stone and skin). Research also covered hydrophilic extracts of grape skin and stone thickened by the vacuum of 'Red Aladasturi' grapes raw materials, as well as the concentrates produced from their composition. For research, there were used gravimetric, extractive, spectral and chromatographic methods. We processed samples of grapes raw materials according to the following pattern: identifying qualitative indicators of grapes raw materials; passing grapes raw materials through the DMCSI-type grape clustercomb divider; pressing-out the combless must in a basket press and separation of juice; vacuum sublimation drying of juiceless sweet pomace with an initial moisture content of 45–65% to a final moisture content of 9–10%; separation of the 'Red Aladasturi' cultivar's skin and stone dried to the moisture content of 9–10%, using tea sorting machine designed by G. Lominadze; crushing separately the skin and stone in a micro-mill (TP2 Hammer Mill) until the fraction of 50–100 μm. we have blended the obtained grape-stone ethanol and fluid extracts containing 74–75% of solid maters at an equal ratio (1:1:1) and assessed biologically active compounds and antioxidant activity in this composition. It has been established that the bio-flavanoid liquid concentrate 'Red Aladasturi' is strong antioxidant (55.31–57.45%), and one tablespoon or 8–9 ml of it contains 110–127 mg of flavanoids, which is 105–110% of a full day of rations per person per day.

**Key words:** anthocyanins, antioxidant activity, grapes, phenolic compounds, *Vitis vinifera* 'Red Aladasturi'

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## Koncentrat bio-flawonoidów z *Vitis vinifera* L. 'Red Aladasturi'

**Streszczenie**

W artykule omówiono właściwości odmian winogron *Vitis vinifera* L. 'Red Aladasturi', rosnących w strefie uprawy winorośli i winiarstwa w Imereti (Gruzja), a także związki aktywne biologicznie i aktywność przeciwutleniającą ekstraktów hydrofilowych oraz płynnych koncentratów z ich ciał stałych (pestka i skórka). Badania obejmowały również hydrofilowe ekstrakty ze skórki winogron i pestek, zagęszczone przez sublimaty surowca z gron „Aladasturi", a także wytwarzane z nich koncentraty. Do badań wykorzystano metody grawimetryczne, ekstrakcyjne, spektralne i chromatograficzne. Próbki surowców winogronowych przetwarzano według następującego szablonu: identyfikacja wskaźników jakościowych surowców winogronowych; przepuszczanie surowców do produkcji winogron przez dzielnik kombajnu do zbioru winogron typu DMCSI; wyciskanie moszczu w prasie koszowej i oddzielanie soku; sublimacja próżniowa – suszenie słodkich wytłoków bez soku, o początkowej zawartości wilgoci 45–65% do końcowej zawartości wilgoci 9–10%; oddzielenie skórek i pestek odmiany 'Red Aladasturi', wysuszonych do wilgotności 9–10%, za pomocą maszyny do sortowania herbaty, zaprojektowanej przez G. Lominadze; oddzielne mielenie skórek i pestek w mikro-młynie (TP2 Hammer Mill), do frakcji 50–100 μm. Zblendowano otrzymany etanol z pestek winogron i płynne ekstrakty owoców, zawierające 74–75% substancji stałych w równym stosunku (1: 1: 1) i oceniono w tym składzie związki aktywne biologicznie oraz aktywność przeciwutleniającą. Ustalono, że płynny koncentrat bio-flawanoidów 'Red Aladasturi' jest silnym przeciwutleniaczem (55,31–57,45%), a jedna łyżka stołowa lub jego 8–9 ml zawiera 110–127 mg flawanoidów, co stanowi 105–110% pełnej racji żywnościowej dziennie na osobę.

**Słowa kluczowe:** antocyjany, aktywność przeciwutleniająca, winogrona, związki fenolowe, *Vitis vinifera* 'Red Aladasturi'

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# The role of seed coat in the germination and early stages of growth of bean (*Phaseolus vulgaris* L.) in the presence of chickweed (*Stellaria media* (L.) Vill.)

## Introduction

Human activity is one of the main factors affecting soil, water, air and living organisms pollution. Increasing amounts of chemical compounds used in agriculture, construction and industry contribute to the increase of pollution and degradation of the natural environment. Therefore, more and more often production attempts are madein ecological systems, which are an opportunity for sustainable development and protectionof environmental biodiversity. In ecologic farming, synthetic chemical compounds are replaced by natural substances produced by plants, which is why research into the practical use of allelopathy is desirable.

The term 'allelopathy' comes from the Greek language and is a combination of two words allelon (mutual) and pathos (suffer, harm). In present times, allelopathy was described by Hans Molish (1937), who defined the phenomenon as the interaction of adjacent plants (or microorganisms), of both harmful and beneficial biochemical nature (Gniazdowska et al., 2004). During the first World Allelopathy Congress "Allelopathy – a science for the future" in 1996, deliberations were made to create a definition of the phenomenon described, treating allelopathy as any process involving secondary metabolites produced by plants, microorganisms and fungi that affect the growth and development of biological systems and farming, excluding from these transformations animals (Oleszek, 1996; Wójcik-Wojtkowiak et al., 1998). However, the phenomenon of allelopathy cannot be regarded as a form of direct influence of one plant on another, because metabolites secreted into the environment undergo various transformations. The substance in its original form secreted by the donor plant does not always have to reach the acceptor plant. The level of toxicity of allelopathic compounds is determined by retention, transport and transformation processes (Rice, 1984; Oleszek, 1992). Pos-

itive allelopathic interactions can have a practical aspect for plant growth. As part of biological competition, they can also perform a protective function against pests, weeds and diseases, increasing plant resistance (Nowiński, 1961).

A bothersome weed of many crops is the chickweed (*Stellaria media* (L.) Vill.). This species from the family of Caryophyllaceae Juss., is characteristic of weed communities of arable fields and ruderal areas (Matuszkiewicz, 2006). It is an annual or biennial plant, cosmopolitan and nitrophilous. It blooms often all year round and shows germination at low temperatures (van der Vegte, 1978). It grows in segetal areas, landfills, roadside and wastelands. *S. media* propagates both by seeds and vegetatively. It forms low, dense clusters covered with pale yellow leaves and white flowers (Parus, 2015).

Beans (*Phaseolus vulgaris* L.) belong to the beans family (Fabaceae Lindl., =Papilionaceae Giseke). It comes from Central and South America. Currently, it is widely grown in more than 200 cultivars on the Old Continent, as well as in Africa and Asia. Its popularity in crops is due to seeds that are rich in protein, contain folic acid, vitamin B6, iron. Bean seed coat is a rich source of biologically active ingredients, among others: amino acids, flavonoids, triterpenes, sugars, steroidal saponins, trace elements, guanidine derivatives, organic acids, vitamins C and E (Kuchanowicz et al., 2017).

The interest in seed germination biotests increases every year, which are easy to observation, easy to perform and does not require large financial outlays. In germination biotests, it is important to determine what concentrations of chemicals adversely affect seed germination, plant growth and development. The aim of the study was to investigate the role of seed coat in the germination process and in the early stages of growth of bean seeds (*P. vulgaris*) in the presence of aqueous extracts from dry shoots of chickweed (*S. media*). The influence of chickweed extracts on the values of germination index of bean seed with seed coat and seed without it was determined (1), the growth inhibition rate of seedlings was determined (2), the values of fresh and dry matter and the percentage of water content in 7 days seedlings of *P. vulgaris*, grown from seeds with seed coats, as well as without them (3).

## Material and methods

### Plant material

Bean seeds (*Phaseolus vulgaris*) from the horticultural company POLAN (Kraków, Poland) were used for the experiments. Herbaceous parts of chickweed (*Stellaria media*) in form of fresh shoots were harvested in southern Poland near Kraków and dried in laboratory conditions. Then they were stored in the dark, so as to avoid microbiological destruction of allelopathic compounds contained in them.

### Extracts preparation

Aqueous extracts from *S. media* dry shoots were prepared in three percentage concentrations: 5, 10 and 15%. Grinded in a grinder (Braun 4045, Germany) shoots of chickweed depending on the concentration were flooded with the appropriate amount of distilled water (5% extract = 5 g dry material + 95 ml cold boiled water, 10% extract = 10 g dry material + 90 ml cold boiled water, 15% extract = 15 g dry material + 85 ml cold boiled water). The extracts prepared in this way were left for 24 hours in the dark at a temperature of about 25°C to extract the chemical compounds contained in them. After one day, extracts from chickweed dry shoots were strained through a double layer of gauze and stored in the refrigerator for the duration of the experiment.

### Seeds germination

Bean seeds, counted 10 for each Petri dishes, were rinsed under running water for 30 minutes, and then 3 times with distilled water and divided into two groups. The first experimental group were beans with seed coats, and the second were seeds without them. In order to easily remove the coat from the seeds, some of them were left for 2–3 hours in distilled water until the coat clearly wrinkled, and then it was removed with a knife so as not to damage the inside of the seed. The seeds of *P. vulgaris* prepared in this way, both with seed coats and without them, were lined with tweezers on Petri dishes, 9 cm in diameter, with a triple layer of filter paper moistened with 5 ml of appropriate aqueous extract from *S. media* shoots, at concentrations of 5, 10 and 15%. The control group consisted of bean seeds, both those with seed coats and seeds without them, put on Petri dishes with filter paper moistened with 5 ml of distilled water. For the duration of the experiment, all seed on Petri dishes were placed in the dark at room temperature. Every 24 h for 7 days the number of germinated seeds was checked. Germinated seeds were those which germinal root was half the size of the seed.

### Germination indexes

After 7 days of the experiment, the effect of aqueous extracts from *S. media* dry shoots on the germination indexes of *P. vulgaris* seeds with and without coats were assessed. These formulas of germination indexes are in table 1.

### Biometric analysis

The length of whole *P. vulgaris* seedlings was measured with a ruler with an accuracy of 1 mm. The impact of *S. media* dry shoots extracts on bean seedling growth on length was determined according to the formula proposed by Islam and Kato-Noguchi (2012): $IP = (1 - (LE/LC)) \times 100$; where: IP – growth inhibition index [%]; LE – seedlings length (mm) treated with emitter data; LC – seedlings length (mm) from the control.

**Tab. 1.** Germination index formulas

| Germination index | Formula | Author |
|---|---|---|
| GP (Germination percentage) | GP = [Number of germinated seeds at everyday/ Total number of seeds sets for bioassay] × 100 | Global method |
| SE (Speed of emergence) | SE = (Number of germinated seeds at the starting day of germination/Number of germinated seeds at the final days of measurement) × 100 | Islam et al. (2009) |
| SVI (Seedling vigour index) | SVI = (Seedling length(mm) × Germination percent)/100 | |

### Fresh and dry mass, water content

The fresh mass of 7-day-old bean seedlings with and without seed coat was determined on the laboratory scale (Ohaus Adventurer Pro, USA). To obtain a dry mass, the plant material was dried for 48 hours at 105°C in an dryer (WAMED SUP 100, Poland) and then weighed. On the basis of the mass values obtained, the percentage water content was determined according to the formula: 100 – [(dry mass × 100) / fresh mass].

### Statistical analysis

The results were developed in Microsoft Excel based on data collected from observations carried out during the experiment. Additionally, statistical analysis was performed using the one-way ANOVA / MANOVA analysis of variance test. Duncan's test at $p \leq 0.05$ was used to assess the significance of differences between the means ± SD tested. The data was analysed in StatSoft, Inc. (2018). STATISTICA (data analysis software system), version 13.1. www.statsoft.com.

## Results

### Germination indexes

Germination capacity of seeds *Phaseolus vulgaris*, with seed coat and without it, in the presence of aqueous extracts of dry shoots of *Stellaria media* with different concentrations of 5, 10, 15% and control conditions was varied (Fig. 1–2).

Among seeds with seed coat, no seeds germinated on the first day of the experiment. On the third day, the highest percentage of germinated seeds was observed on the 10% extract, where the germination value was 40%. Seeds watered with a 5% extract and those from the control sample reached value of 30%, while no seeds germinated in the presence of 15% extract. On the seventh day, the percentage of germinated seeds increased in three cases, reaching the highest value of 80% for seeds

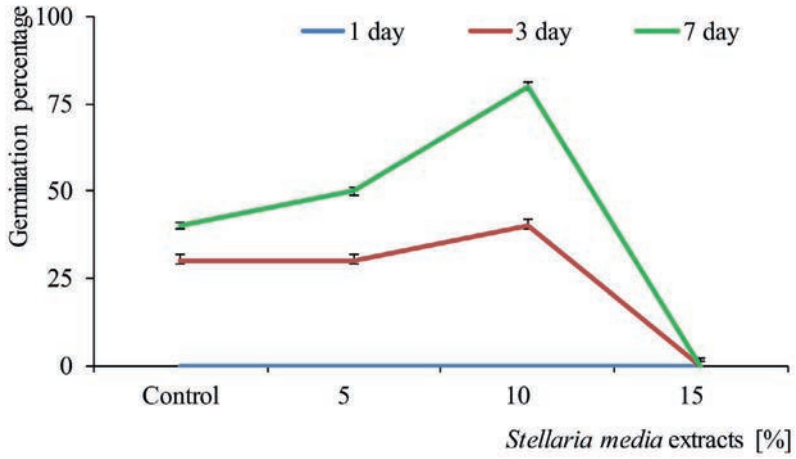


**Fig. 1.** Percent of germinated seeds *Phaseolus vulgaris* L. grown from seed with coat in the presence of aqueous extracts from the dry shoots of *Stellaria media* (L.) Vill. at various concentrations of 5, 10 and 15% and control conditions (distilled water)

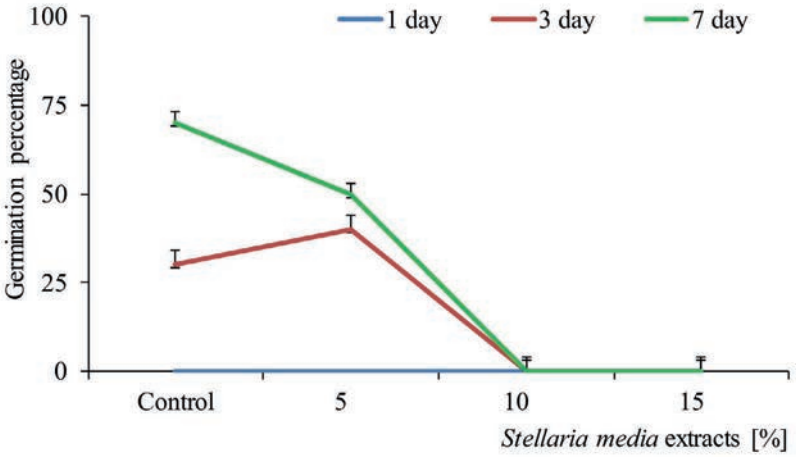


**Fig. 2.** Percent of germinated seeds *Phaseolus vulgaris* L. grown from seed without coat in the presence of aqueous extracts from the dry shoots of *Stellaria media* (L.) Vill. at various concentrations of 5, 10 and 15% and control conditions (distilled water)

germinating in the presence of 10% extract, 50% for seeds watered with 5% extracts, and 40% for the control sample. Only on the 15% extract of chickweed, no germinated seeds were observed (Fig. 1).

For *P. vulgaris* seeds without coat, germination began only on the third day of observation. The largest number of newly germinated bean seeds was on the seventh day of experiment for seeds from the control sample. A slightly smaller number of germinated seed, compared to the control, was observed on dishes with 5% chickweed extract. In the other two cases, in the presence of 10 and 15% extracts, no bean germination was noted until the end of the experiment (Fig. 2).

In the case of seed emergence (SE), the highest, though uneven, results were obtained for bean seeds watered with 5% aqueous extract from *S. media* shoots (at 60% for seeds with coat and 80% for seeds without it). Similar values of SE were achieved by bean seeds with coat watered with distilled water (control test). Lower values of the discussed coefficient apply to seeds of *P. vulgaris* with coat, germinating in the presence of 10% extracts and seeds without seed coat from the control sample. Compared to the control conditions, the extract of 15% from chickweed shoots, regardless of the presence or absence of seed coat, inhibited the germination of bean seeds in 100% (Fig. 3–4).

Seed vigour index (SVI) has a similar values, both for seeds germinating with and without seed coat (Fig. 5–6). In both cases, both on the 3rd and the last 7th day, it was observed that the higher the concentration of the aqueous extract from *S. media*, the higher the seedling viability (up to 10% for seeds with coat and to 5% without coat).

In the studied sample of seed with coat, the highest value of the SVI index was recorded for seedlings *P. vulgaris* watered with 10% extracts, in relation to the control. For seeds without coat, the highest value of this parameter was observed in the case of the control sample. At 15% of the extract concentration, the bean SVI index, for both seed with and without coat, had 0 value.

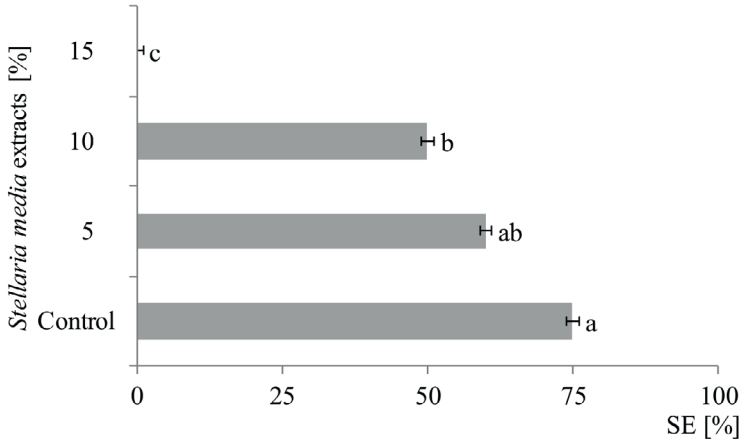


**Fig. 3.** Seed emergence (SE) of seeds *Phaseolus vulgaris* L. grown from seed with coat in the presence of aqueous extracts from dry shoots of *Stellaria media* (L.) Vill. at various concentrations of 5, 10, 15% and control conditions (distilled water); mean values ± SD marked with letters a, b, c differ significantly according to Duncan's test $p \leq 0.05$

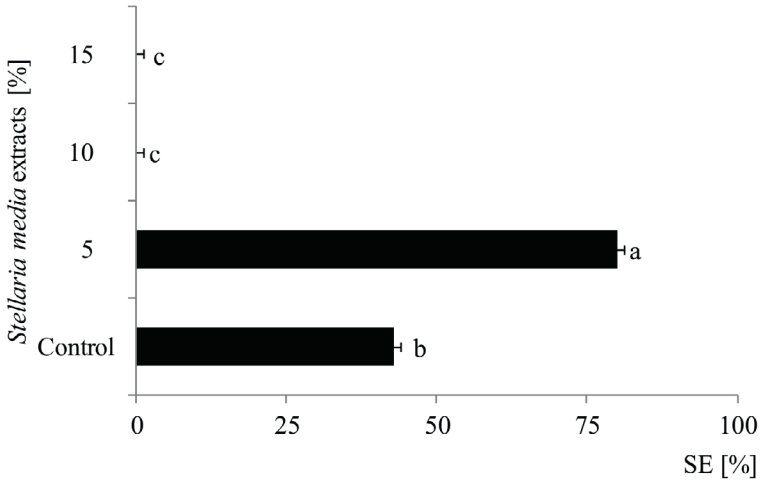


**Fig. 4.** Seed emergence (SE) of seeds *Phaseolus vulgaris* L. grown from seed without coat in the presence of aqueous extracts from dry shoots of *Stellaria media* (L.) Vill. at various concentrations of 5, 10, 15% and control conditions (distilled water); mean values ± SD marked with letters a, b, c differ significantly according to Duncan's test $p \leq 0.05$

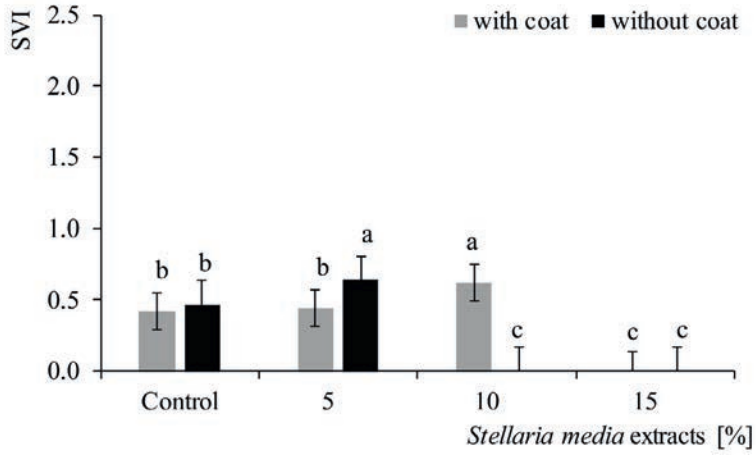


**Fig. 5.** Seed vigour index (SVI) of *Phaseolus vulgaris* L. grown from seeds with and without coat, on the 3th germination day, in the presence of aqueous extracts from dry shoots of *Stellaria media* (L.) Vill. at various concentrations of 5, 10 and 15% and control conditions (distilled water); mean values ± SD marked with letters a, b, c differ significantly according to Duncan's test $p \leq 0.05$

## Biometric analysis

Biometric analysis of *P. vulgaris* seedlings germinated from seed with coat showed that both extracts at 5 and 10% concentrations stimulated the growth of them, compared to control. In the case of bean seeds germinating without coat, the growth inhibition

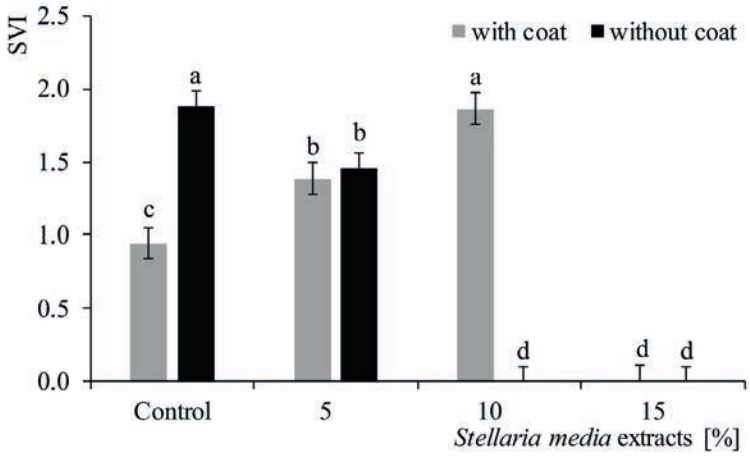


**Fig. 6.** Seed vigour index (SVI) of *Phaseolus vulgaris* L. grown from seeds with and without coat, on the 7th germination day, in the presence of aqueous extracts from dry shoots of *Stellaria media* (L.) Vill. at various concentrations of 5, 10 and 15% and control conditions (distilled water); mean values ± SD marked with letters a, b, c differ significantly according to Duncan's test $p \leq 0.05$

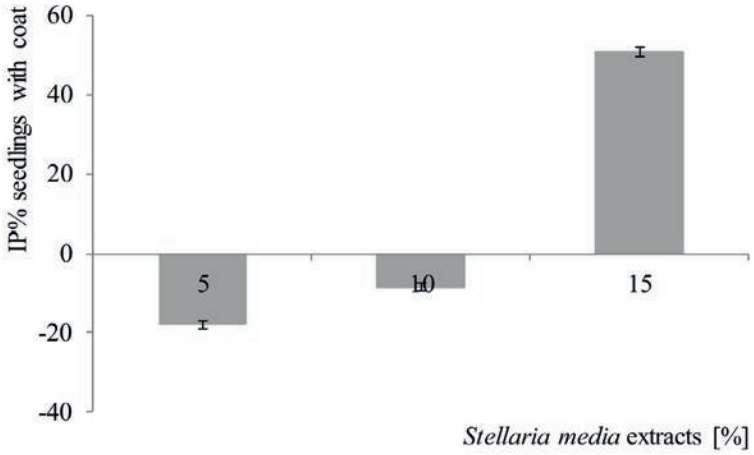


**Fig. 7.** Inhibition percentage index of growth (IP) (expressed as a percentage of control value) of *Phaseolus vulgaris* L. germinated seed with coat in the presence of aqueous extracts from *Stellaria media* (L.) Vill. at various concentrations of 5, 10 and 15% and control (distilled water); a negative (-) value on the Y axis indicates growth, and a positive (+) value indicates growth inhibition

had already occurred in the presence of 10% extracts. Regardless of the presence or absence of seed coat, clear inhibition of the growth in length of *P. vulgaris* seedlings was caused by extracts of 15% concentration from *S. media*, compared to seedlings grown in control (Fig. 7–8).

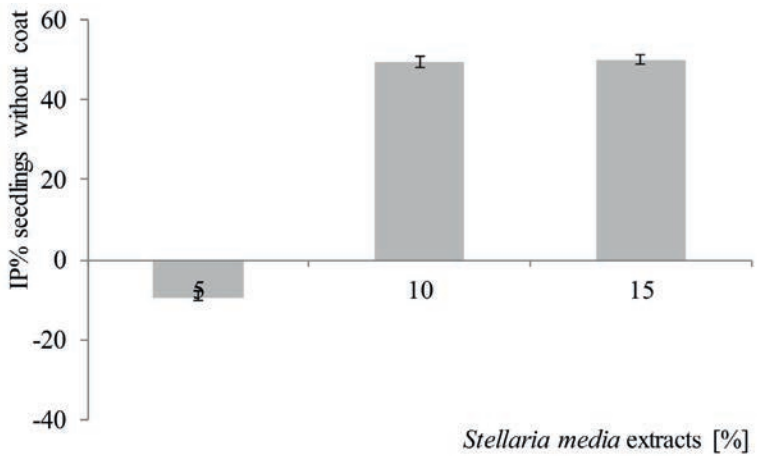


**Fig. 8.** Inhibition percentage index of growth (IP) (expressed as a percentage of control value) of *Phaseolus vulgaris* L. germinated seed without coat in the presence of aqueous extracts from *Stellaria media* (L.) Vill. at various concentrations of 5, 10 and 15% and control (distilled water); a negative (-) value on the Y axis indicates growth, and a positive (+) value indicates growth inhibition

## Fresh and dry mass, water content

Analysing the values of fresh mass of bean seedlings watered with aqueous extracts from *S. media* shoots, significant differences were found compared to the control (Tab. 3). The highest increase in fresh mass was observed in *P. vulgaris* watered with 5% extracts (for seeds with coat) and for seedlings watered with 5 and 10% extracts (for seeds without coat).

In the case of dry mass, the only significant statistical differences in the values of this parameter noticed for bean seedlings grown with seed coat on 5% extracts, compared to the dry mass of seedlings watered with distilled water (Tab. 3). In other cases, regardless of the type of seeds analysed, dry mass values changed slightly.

**Tab. 2.** Changes in the length of *Phaseolus vulgaris* L. seedlings [cm] grown from seeds with seed coat – (A) and without seed coat – (B) in the presence of aqueous extracts from dry shoots of *Stellaria media* (L.) Vill. at different concentrations of 5, 10 and 15% and control (distilled water), marked on different days of the experiment (days 1, 3 and 7)

| Day | *Stellaria media* extract [%] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Control | | 5 | | 10 | | 15 | |
| | A | B | A | B | A | B | A | B |
| 1 | 1.25 b | 1.30 b | 1.45 b | 1.35 b | 1.35 b | 1.25 b | 1.15 b | 1.25 b |
| 3 | 1.40 b | 1.55 b | 1.45 b | 1.60 b | 1.55 b | 1.25 b | 1.15 b | 1.25 b |
| 7 | 2.45 a | 2.55 a | 2.65 a | 2.25 a | 2.00 ab | 1.25 b | 1.15 b | 1.25 b |

mean values ± SD marked with letters a, b, c differ significantly according to Duncan's test $p \leq 0.05$

The percentage of water content in the control samples was 35.37% for bean seed with coat and 44.56% for seed without it. Both in the first and second analysed samples, the value of the parameter increased significantly in seedlings watered with 5% extracts of chickweed extracts, compared to the control sample (Tab. 3). However, as the concentration of allelopathic compounds increased in aqueous extracts from *S. media*, a decrease in the water content of bean seedlings was observed in each of the studied samples.

**Tab. 3.** Fresh and dry mass values and percentage of water content in *Phaseolus vulgaris* L. seedlings grown from seed with seed coat – (A) and without seed coat – (B) in the presence of aqueous extracts from shoots of *Stellaria media* (L.) Vill., with different concentrations of 5, 10 and 15% and control (distilled water)

| Parametr | *Stellaria media* extract [%] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Control | | 5 | | 10 | | 15 | |
| | A | B | A | B | A | B | A | B |
| Fresh mass [g] | 0.2944 b ±0.06 | 0.2534 b ±0.06 | 0.4880 a ±0.11 | 0.4142 a ±0.11 | 0.2187 b ±0.06 | 0.5435 a ±0.15 | 0.2007 b ±0.04 | 0.2229 b ±0.03 |
| Dry mass [g] | 0.1877 bc ±0.04 | 0.1393 a ±0.04 | 0.2041 a ±0.08 | 0.1479 a ±0.04 | 0.1316 c ±0.03 | 0.1600 a ±0.05 | 0.1641 bc ±0.03 | 0.1494 a ±0.04 |
| Water content [%] | 35.37 b ±0.04 | 44.56 c ±0.04 | 59.09 a ±0.08 | 63.68 b ±0.04 | 38.75 b ±0.03 | 70.49 a ±0.05 | 18.25 c ±0.03 | 33.30 cd ±0.04 |

mean values ± SD marked with letters a, b, c differ significantly according to Duncan's test $p \leq 0.05$

## Discussion

Modern agriculture pays great attention to the skilful and environmentally safe increase in the quantity and quality of crops (Górecki et al., 1994). The first important stage in obtaining high-quality crop plants is to provide them with the right conditions for seed germination. Changes occurring during germination are regulated at the molecular, cellular and whole seeds levels (Grzesiuk, Kulka, 1981; Higashiyama et al., 2003). In the first stage of germination an important role is played by the seed coat (Herse, 1982). Seed coat accounts for 12 to 20% of the mass of seeds, and the remaining seed components of the embryo are: cotyledon and germinal root, which constitute respectively 75 to 83% and 5% of the mass (Byszewski, 1972). The chemical composition of the seed coat and embryo is different, depending on the physiological functions performed, and the stage of seed development (Grzesiuk, Kulka, 1981; Niewiadomski, 1990).

The differences in germination process and early stages of *Phaseolus vulgaris* growth observed during the experiment showed the allelopathic properties of *Stellaria media*, as well as the protective effect of the seed coat in the interaction of seeds with allelopathic substances. Previous studies on allelopathic properties of

chickweed show that the presence of this weed causes a decrease of *Brassica napus* L. var. *napus* crops (Lutman et al., 2000), reduced production of *Triticum aestivum* L. grains (Lutman, 2002), and also depending on the concentration of the extract favourably or adversely effects on the germination and growth of different cultivars of *Zea mays* L. (Zandi et al., 2019). However, *S. media* does not affect every plant in the same negative way. This thesis was confirmed by this experiment (Fig. 1–8; Tab. 2–3).

Seed germination is a complex process that includes both catabolic and anabolic reactions and biochemical transformations (Grzesiuk, Kulka, 1981). The seed viability index accepted on an international scale is germination capacity (Dąbrowska, 1998). In this study it was observed that the percentage values of germinated *P. vulgaris* seeds with and without seed coat were the largest for seeds watered with 5% aqueous extracts from *S. media* dry shoots, compared to seeds germinated on distilled water (Fig. 1–2). In addition, a high number of germinated seeds was observed on 10% extracts in the group of bean seeds with seed coat. The opposite effect was for seeds without seed coat, where 10% extracts completely inhibited the germination of bean seeds (Fig. 2).

Seed germination studies that take place in laboratory conditions do not exactly reflect crop conditions (Faligowska et al., 2012). Therefore, the vigour of seeds to additionally assess is proposed (Conreras, Barros, 2005). In this experiment, the seed emergence (SE) index values for both tested samples (seeds with and without coat) were characterised by a various seed reaction to aqueous extracts from *S. media* shoots (Fig. 3–4). In the case of seed with seed coat, the relationship between SE index and the value of the aqueous concentration of *S. media* can be noticed. Compared to the SE from the control, it was observed that the higher concentration of the extract, the faster the SE index values decreased. Compared to the control, in the case of seeds without coat, only 5% extract of chickweed caused an increase in the SE index.

Significantly higher values of seed vigour index (SVI) for bean seeds with seed coat were noted. In contrast, seeds without seed coat were more sensitive to aqueous extracts from *S. media* (Fig. 5–6). Probably, these results were connected with the presence or absence of seed coat. The seed coat has a protective function of the seed against harmful external factors, including: bacterial and fungal infections, as well as drying out, the influence of toxic chemical compounds and mechanical damage (Grzesiuk, Kulka, 1981; Możdżeń, Rzepka, 2016).

Biometric analysis showed the stimulating effect of 5 and 10% aqueous extracts on the growth of 7-day-old *P. vulgaris* seedlings, germinated with seed coat. For seeds without seed coat, quite the opposite results were obtained (Fig. 7–8). Both, in one and the second experimantal group of seeds in the presence of 15% of extracts from *S. media*, a total inhibition of seedlings growth was found (Tab. 2). The results obtained are consistent with the literature data of many authors. For example: Możdżeń et al.

(2016) showed the inhibitory effect of aqueous extracts from *Capsella bursa-pastoris* (L.) Medik. on germination and growth of *Lactuca sativa* L. cv 'Maryna', Puła et al. (2016) studied the effect of aqueous extracts of *Galium aparine* L. on various cultivars of *Zea mays* L., Możdżeń et al. (2018) observed the allelopathic activity of *Galinsoga parviflora* Cav. and *Oxalis fontana* Bunge on early growth stages of different cultivars of *Raphanus sativus* L. var. *radicula* Pers, Zandi et al. (2018) confirmed the allelopathic properties of *S. media* on *R. sativus* var. *radicula* and others.

The increase in fresh and dry mass of bean seedlings, grown from seed with seed coat, was significantly the largest on substrates with 5% extracts, compared to the control (Tab. 3). At 10 and 15% extract concentrations, the mass values were near to the control. The values of fresh mass in seedlings grown from seeds without seed coat were clearly higher in the case of extracts 5 and 10%, in relation to the control. In the case of dry mass, no statistically significant changes were found in the values of this parameter. It can be supposed that the differences in mass increase are due to the disruption by the *S. media* extracts of the capture, transport and use of ions of calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), potassium ($K^{+}$) and water (Das et al., 1997). According to Bieżanowska-Kopeć and Pisulewski (2006), bean seeds have antioxidant properties due to the polyphenols content, which are part of the plant's natural protective ingredients against harmful compounds. Another protective barrier for seeds with a seed coat may be cuticle, which, depending on the thickness and saturation with waxes, is an impermeable barrier to water and gases (Russi et al., 1992; Zeng et al., 2005). The chemical composition of seeds, their size and variety play an important role in mass growth and seed swelling (Rice, 1984).

The percentage of water content increased significantly in seeds without a seed coat – from 44.56 to 63.68% for seeds watered with a 5% extract, up to 70.49% for seeds grown on a 10% extract (Tab. 3). For seeds with seed coat grown in the presence of 5% extract, the percentage increase in water was smaller and amounted to 59.09%. Seed coat protected the seeds against the negative allelopathic effects of the aqueous extract from *S. media* – inhibition of germination was observed only at a concentration of 15%. It also did not allow for high absorption of the aqueous extract, as evidenced by the lower percentage of water in seeds with seed coat. The differences obtained most likely result from the presence in the extracts of chemical compounds that modify the properties of cell membranes and contribute to a low degree of water absorption, thereby reducing the germination rate of seeds (Siwek, 2008). Rut et al. (2012) report that allelopathic compounds inhibit roots hair formation, reducing their active surface, and thus reduce water uptake.

The essence of the allelopathy process is the secretion by the plants (donors) of specific chemical compounds that favourably or adversely affect other plants (acceptors) (Wójcik-Wojtkowiak, Politycka, 1998). Allelopathic reactions of one plant to anoth-

er are the result of interactions of mixtures of different compounds, not just a single substance (Blum, 1996; Veronneau et al., 1997). In crops, the antagonistic effects of various groups of chemical compounds are more pronounced at low concentrations, compared to the action of individual substances. Herb of *S. media* contains oligosaccharides, saponins, flavonoids, proteins, provitamins, vitamins B1, B2, C, E, PP, triterpene glycosides, sugar alcohols and mineral salts (Vanhaecke et al., 2006; Hu et al., 2009), which can cause this kind of complex action. The analysed indexes show clearly that water extracts from dry *S. media* shoots show allelopathic properties for germination and early stages of bean growth. While, seed coat plays an important role in protecting seeds from the effects of aqueous extracts of chickweed. Experiment carried out here confirmed, that seeds throughout the entire life cycle of plants, despite the best protection against various stress factors, during germination become sensitive to any type of stress (Weiqiang et al., 2005).

## Conclusion

(1) Germination indexes for seeds of *Phaseolus vulgaris* showed that seeds without seed coats were more sensitive to aqueous extracts from *Stellaria media* at low allelopathic compounds concentrations the seeds germinated similarly to distilled water, however at higher concentrations of this substances the process of germination was inhibited.
(2) The increase in the length of seedlings grown from seeds with coats and without them decreased with increasing allelopathic substances concentrations; in the presence of 15% of *S. media* extracts, inhibition of seedling growth was observed.
(3) The values of fresh and dry mass and the percentage of water content differed for each of the examined group of seeds, depending on the concentration of the extract used.

**Conflict of interest**

The author declares no conflict of interest related to this article.

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## Abstract

The aim of the study was to determine the role of the seed coat in the presence of aqueous extracts from *Stellaria media* (L.) Vill. on germination and early growth stages of bean seeds *Phaseolus vulgaris* L. Dry shoots of the chickweed aqueous extracts were prepared, with which the bean seeds with coat and without coat were treated. The control group was seeds watered only with distilled water. After 7 days of the experiment, seed germination parameters, seed germination rate (SE), seed vitality index (SVI), seedling growth inhibition index (IP), fresh and dry mass values and percentage water content were determined. The experiment showed the germination capacity of bean seeds was varied, in relation to seeds from the control. With increasing concentrations of extracts, a significant reduction in the seed germination rate was observed, both for those with seed coat and without seed coat. The seed vitality index increased only in seeds with coat, and decreased in each of the applied concentrations of extracts in seeds without seed coat. The seedling growth inhibition index reached negative values in both groups of seeds tested only at a concentration of 5%. In comparison to the control, IP was positive for seedlings watered with 15% extracts. For *P. vulgaris* seedlings grown on 5% of extracts the highest increase in the fresh mass was observed, in relation to the value of control mass. For seedlings grown from seeds with seed coat the differences in the dry mass values primarily were noted. The percentage of water content in bean seedlings varied depending on the group of seeds studied and the concentration of allelopathic substances in the chickweed aqueous extracts. The examined indexes of seed germination and seedling growth showed that in the case of *P. vulgaris* seeds without seed coat

were more sensitive to aqueous extracts from dry shoots of *S. media*. Compared to the control group, in low concentrations of allelopathic substances the seeds germinated similarly to the distilled water, and at higher concentrations, the seeds germination, the seedlings growth and fresh and dry mass values were inhibited.

**Key words:** allelopathy, seed coat, fresh and dry mass, germination indexes

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## Rola łupiny nasiennej w kiełkowaniu i wczesnych stadiach wzrostu fasoli (*Phaseolus vulgaris* L.), w obecności gwiazdnicy pospolitej (*Stellaria media* (L.) Vill.)

### Streszczenie

Celem badań było określenie roli łupiny nasiennej w obecności wodnych ekstraktów z *Stellaria media* (L.) Vill. na kiełkowanie i wczesne etapy wzrostu nasion fasoli żółtostrąkowej (*Phaseolus vulgaris* L.). Przygotowano wodne ekstrakty z suchych pędów gwiazdnicy pospolitej, którymi podlewano nasiona fasoli z łupiną nasienną i bez łupiny nasiennej. Grupę kontrolną stanowiły nasiona podlewane wyłącznie wodą destylowaną. Po upływie 7 dni eksperymentu wyznaczono parametry zdolności kiełkowania nasion, szybkość kiełkowania nasion (SE), wskaźnik żywotności nasion (SVI), wskaźnik hamowania wzrostu siewek (IP), a także określono przyrost świeżej i suchej masy oraz procentową zawartość wody. Eksperyment wykazał zróżnicowaną zdolność kiełkowania nasion fasoli, w stosunku do nasion z próby kontrolnej. Wraz ze wzrostem stężeń ekstraktów obserwowano wyraźne zmniejszenie wartości wskaźnika szybkości kiełkowania nasion, zarówno tych z łupiną nasienną, jak i bez łupiny nasiennej. Wskaźnik żywotności nasion wzrastał jedynie u nasion z łupiną nasienną, a malał w każdym z zastosowanych stężeń wyciągów u nasion pozbawionych łupiny nasiennej. Wskaźnik hamowania wzrostu siewek osiągał wartości ujemne w obu grupach nasion jedynie przy stężeniu 5%. W porównaniu z kontrolą, IP był dodatni w przypadku siewek podlewanych 15% ekstraktami. Największy przyrost świeżej masy, w stosunku do wartości mas z kontroli, zauważono u siewek *P. vulgaris* wyrosłych na podłożach z 5% wyciągami. Różnice w przyroście suchej masy odnotowano dla siewek wyrosłych z nasion z łupiną nasienną. Procentowa zawartość wody w siewkach fasoli zmieniała się w zależności od grupy nasion oraz koncentracji związków allelopatycznych w wodnych wyciągach z gwiazdnicy. Analizowane wskaźniki kiełkowania nasion i wzrostu siewek wykazały, iż w przypadku *P. vulgaris* bardziej wrażliwe na wodne wyciągi z suchych pędów *S. media* były nasiona pozbawione łupiny nasiennej. W niskich stężeniach allelopatin nasiona kiełkowały podobnie jak na wodzie destylowanej, a w wyższych, kiełkowanie, przyrost na długość oraz wartości mas były wyraźnie hamowane.

**Słowa kluczowe:** allelopatia, łupina nasienna, świeża i sucha masa, wskaźniki kiełkowania

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She is interested in an allelopathic interaction between aqueous extracts from weeds and different seeds during germination and growth.

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# The role of magnesium salts in germination and growth of *Cucumis sativus* L.

## Introduction

Fertilisation is an agro-technical treatment that affects both productivity and quality of crop plant. Its purpose is to improve and maintain soil fertility, as well as minimise environmental burden. In recent years, sulphur is one of the necessary macronutrient fertilisers, the deficiency of which is constantly growing (Scherer, 2001; Morris, 2007; Soleymani et al., 2010; Hussain et al., 2011).

Sulphur is commonly found in nature and it is an essential component in the physiological processes of living organisms. It is most often supplied to plants in the form of $SO_4^{2-}$ and incorporated by biosynthesis into organic compounds. Among the sulphur organic compounds, cysteine, methionine, cystine dipeptide, glutathione, sulpholipids, biotin, and glucosinolates dominate. This element plays an important physiological role, protects the plant against diseases and pests. Sulphur cannot be replaced by other elements in oxidoreductive systems that control photosynthesis, chlorophyll synthesis and reduction of nitrates (V) to ammonia. Its deficiency weakens the vigour of plants, resistance to stress and reduces yields (Boreczek, 2000). It is necessary in the initial stages of plant growth, just as nitrogen and phosphorus are (Marska, Wróbel, 2000; Gaj, Klikocka, 2011).

Another important element for plants is carbonate ions. They have a significant impact on soil pH, which is one of the most important indicators of soil suitability for optimal cultivation and fertilisation (Hell, Rennenberg, 1998; Tao et al., 2019). The pH of soil plays an important role in the processes of mobilisation or immobilisation of trace elements in contaminated soils.

Cucumber (*Cucumis sativus* L.) belongs to Cucurbitaceae family. It is creeping vine, probably arises from the wild species *C. hardwickii* (Royle) Alef. (syn. *C. sativus* var. *hardwickii* (Royle) Gabaev), which grows in the Himalayas. In India it was cul-

tivated around 3.000 years ago and was later widely spread. Currently, it is known in all climatic zones, and its berry fruit (lat. *bacca*) is widely used in the cuisine of many countries (Vaughan, Geissler, 2001). Raw fruits are rich in antioxidants, cucurbitacin, and also contain about 97% water and help cleanse the body of toxins (Pudelski, 1971; *Chief Inspector of Protection …*, 2014).

In many countries, the fertilisation does not give good production results, because the ingredients necessary for plants are found in soils in insufficient amounts. As a result, this leads to reduced plant productivity and reduced crop quality. Knowledge of the nutritional needs of plants allows the rational use of fertilisers in various technologies of their production (Wójcik, 2014). The implementation of new measures, treatments and technologies requires numerous and multi-faceted studies (Pruszyński, 2009). The aim of this study was to determine the effect of magnesium sulphate and carbonate on (1) germination capacity, (2) growth of plants and (3) fresh and dry mass parameters of cucumber (*C. sativus*).

## Material and methods

### Plant material and medium modification

*Cucumis sativus* seeds from POLAN company were used in the experiment. Kottke et al. (1987) medium and their modifications were used for the experiments: [1] – pH 5.4, [2] with the addition of $MgSO_4 \times 7H_2O$ – pH 4.8, [3] with the addition of $MgCO_3 \times 3H_2O$ – pH 6.5. The control was performed on distilled water [4].

### Germination

The cleaned seeds, in a 1% solution of acetone and washed with running and distilled water, were put 25 pieces with tweezers on sterile Petri dishes with a triple layer of filter paper moistened with a suitable type of medium and distilled water (control). The Petri dishes with seed were placed in the dark, at room temperature. Every 24 hours the number of germinated seeds was checked. Germinated seeds were considered to be those with sprouts equal to at least 2 mm. After 7 days, germination capacity of cucumber seeds were measured by germination indexes according to Islam and Kato-Noguchi (2014): germination energy (GE), germination as a percentage of control (G%), speed emergence (SE), mean germination time (MGT) were measured.

### Growth of plants

After 3 days, germinated seeds were rinsed with distilled water and planted into pots with sand (10 plants for each series). Plants were grown in a growth chamber (Angelantoni Industrie, Italy) in a 12 / 12h photoperiod, at 25°C / 20°C (day / night) and relative humidity RH% 70–90%.

### Biometric analysis

After 27 days, the length of underground and aboveground organs of cucumber plants was analysed. An inhibition percentage of growth (IP) index for root, hypocotyl, stalk, petioles was measured according to method used by Islam and Kato-Noguchi (2012).

### Fresh, dry mass and turgor water content

Fresh mass of organ plants (root, hypocotyl, stalk, petiole, cotyledons, first leaves, second leaves) were measured on scale (Radwag WPS 120, Poland). Turgor water content (TWC) according to (Mullan, Pietragalla, 2012) was checked. Dry mass after 48 h of drying plant material in dryer (Wamed SUP 100, Poland) at temperature 105°C was measured.

Detailed analyses concerned the assessment of the effect of nutrients on germination, growth on the length, weight increase and water content of cucumber specimens: grown from seeds germinated in distilled water, and watered of the media during growth [I] and specimens grown from seeds germinated on media and also in the growth stage watered with media [II].

### Statistical analysis

The germination experiment was carried out in two series by 25 seeds on Petri dishes for each Kottke medium modification and distilled water. In growth stage in two repetition,10 plants for each treatment of medium were measured. The results were analysed by the ANOVA / MANOVA parametric test using the post hoc Duncan test $p < 0.05$.

## Results

### Germination indexes

Germination energy (GE) for cucumber seeds watered with distilled water and Kottke medium reached similar values. The lowest germination capacity was found for seeds watered with the Kottke medium with the addition of magnesium carbonate (Fig. 1).

Analysis of *Cucumis sativus* seed germination based on germination index expressed as percentage of control showed that the most seeds germinated on Kottke medium, and the lowest on Petri dishes with $MgCO_3$ medium (Fig. 2).

The speed emergence (SE) of *C. sativus* seeds, in the first 3 days of germination, was from 80 to 90%. In the following days it was close to or equal to 100%. Compared to the control, for cucumber seeds watered Kottke medium, the highest values of this parameter were observed. For seeds treatment Kottke medium with carbon oxide, the lowest values of SE was revealed (Fig. 3).

## Biometric analysis

The cucumber root growth was stimulated, regardless of the type of Kottke mediums and the time of their application (Tab. 1).

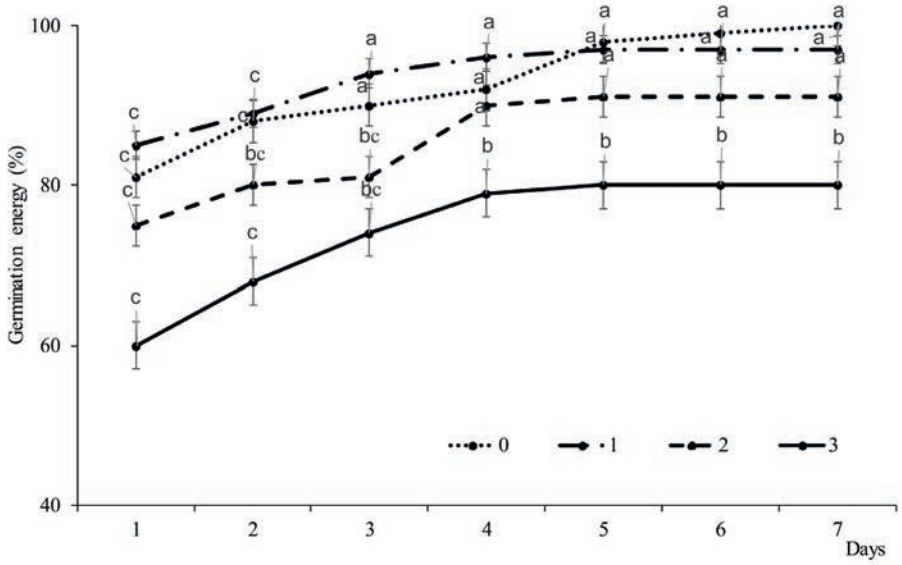


**Fig. 1.** Germination energy(GE) of *Cucumis sativus* L. seeds on: 0 – distilled water, 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$; values marked letter (a, b, c) differ significantly according to Duncan test at $p < 0.05$

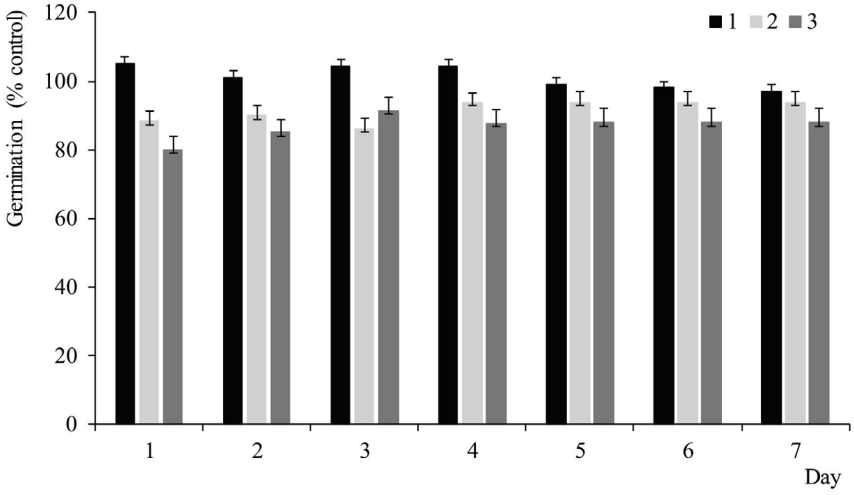


**Fig. 2.**Germination (% of control) of *Cucumis sativus* L. seeds watered with 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$

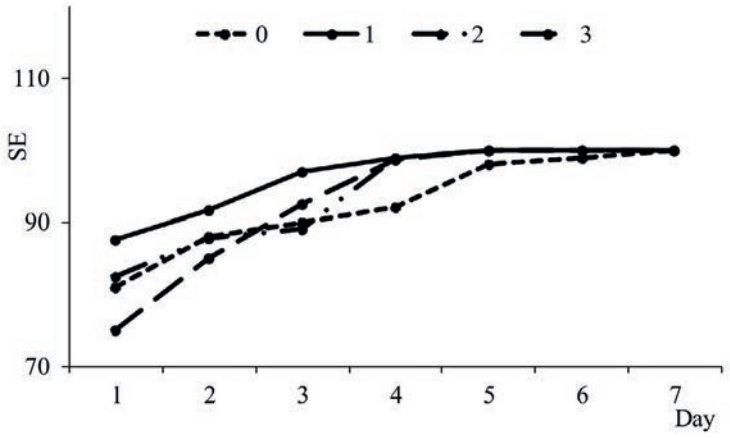


**Fig. 3.** Speed of emergence (SE) of *Cucumis sativus* L. seeds watered with 0 – distilled water, 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$

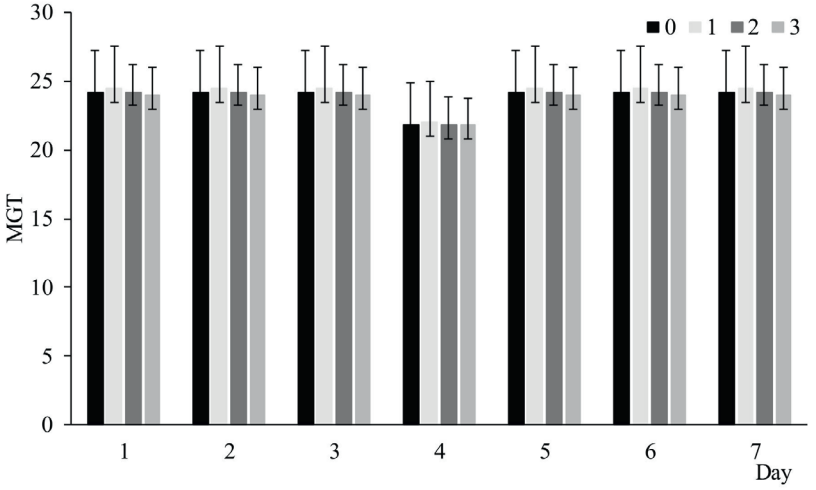


**Fig. 4.** Mean germination time (MGT) of *Cucumis sativus* L. seeds watered with 0 – distilled water, 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$

MGT (mean germination time) reached very similar values regardless of the medium used. Compared to the control, the highest MGT values were found for seeds watered with Kottke medium, and the lowest for those treated with medium with $MgCO_3$ (Fig. 4).

**Tab. 1.** Length of *Cucumis sativus* L. organs watered with 0 – distilled water, 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$ in germination and growth stages

| Organ | 0 | Medium | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | | | 1 | 2 | 3 |
| | | 1 | 2 | 3 | | | |
| root | 13.3 b | 15.0 a | 14.6 a | 16.0 a | 15.0 a | 15.0 a | 16.0 a |
| hypocotyl | 3.7 a | 3.6 a | 3.0 a | 3.4 a | 3.7 a | 2.3 b | 2.7 b |
| stalk | 1.6 b | 1.8 ab | 1.9 a | 1.9 a | 1.9 a | 2.0 a | 2.1 a |
| petiole | 0.6 b | 1.3 a | 1.2 a | 1.2 a | 1.4 a | 1.2 a | 1.0 a |

values marked letter (a, b, c) in rows differ significantly according to Duncan test at $p < 0.05$

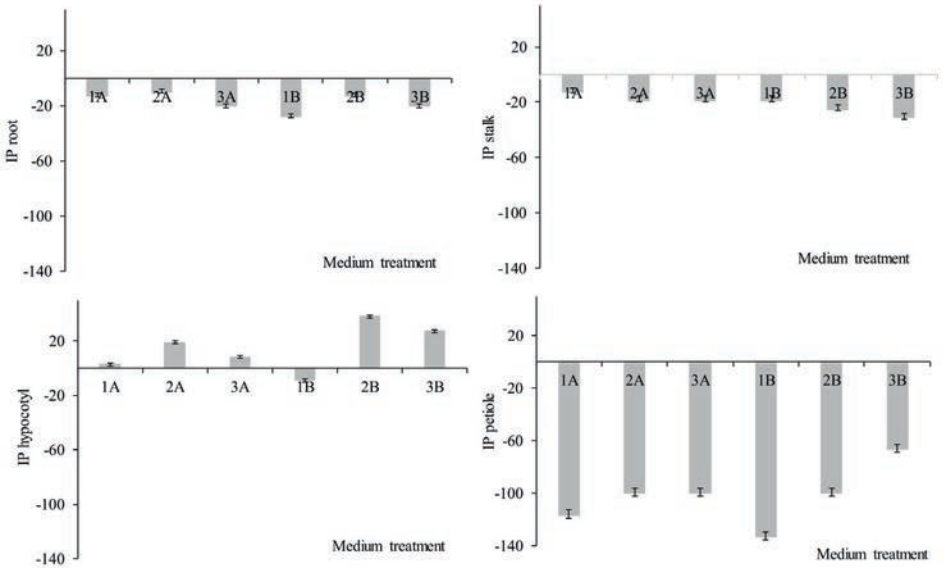


**Fig. 5.** Inhibition percentage (IP) as control % of roots, hypocotyls, stalk and petioles of *Cucumis sativus* L. plants growth (A) watered in germination stage 0 – distilled water and growth stage 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$ and (B) watered in germination and growth stages 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$; a minus (-) value on the Y axis indicates growth, and a plus (+) value indicates growth inhibition

The length of *C. sativus* hypocotyls was clearly inhibited by Kottke medium supplemented with magnesium sulphates and carbonates, which were used to water the plants during both germination and growth. For the stalk, the stimulating effect of each modification of the medium on cucumber growth was demonstrated. Compared to the control, the length of petioles during used the modification of the Kottke mediums was increased by half (Tab. 1).

Analysis of the IP root index showed the stimulating effect of all the media used on the growth of this organ. The highest IP root values of cucumber for plants watered

with mediums, both during germination and growth stages were found. In the case of the IP hypocotyl index, the growth of this organ, in virtually all cases, was inhibited. Only, for hypocotyls of plants watered with Kottke medium during the germination and growth stages inhibiting stimulation of growth was found. For IP stalk index, the lowest values for plants grown from seeds watered with Kottke medium were found. The highest growth of cucumber stalks for plants watered with medium modifications during the germination and growth stages was noted. IP petiole index values were stimulated in each sample tested. Mediums caused 100% or even higher increase in *C. sativus* petioles (Fig. 5).

Compared to the control, the fresh mass of cucumber root was higher in each of the samples studied. For plants watered with Kottke medium both in the germina-

**Tab. 2.** Fresh and dry mass and turgor water content of *Cucumis sativus* L. organs watered with 0 – distilled water, 1 – Kottke medium, 2 – Kottke medium + $MgSO_4 \times 7H_2O$, 3 – Kottke medium + $MgCO_3 \times 3H_2O$

| Organ | 0 | Medium | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | | | 1 | 2 | 3 |
| | | 1 | 2 | 3 | | | |
| | | | Fresh mass [g] | | | | |
| root | 0.505 c | 1.039 a | 0.938 a | 1.063 a | 1.104 a | 0.854 ab | 0.852 ab |
| hypocotyl | 0.117 ab | 0.168 a | 0.138 a | 0.171 a | 0.181 a | 0.110 ab | 0.090 c |
| stalk | 0.032 b | 0.063 a | 0.067 a | 0.067 a | 0.069 a | 0.072 a | 0.068 a |
| petiole | 0.018 c | 0.034 a | 0.029 a | 0.026 a | 0.029 a | 0.032 a | 0.025 ab |
| cotyledons | 0.274 b | 0.352 a | 0.316 a | 0.0319 a | 0.333 a | 0.344 a | 0.311 a |
| 1-st leaves | 0.111 c | 0.239 a | 0.191 ab | 0.178 ab | 0.183 ab | 0.201 a | 0.179 ab |
| 2-nd leaves | 0.042 c | 0.191 a | 0.166 ab | 0.181 a | 0.177 a | 0.203 a | 0.156 ab |
| | | | Dry mass [g] | | | | |
| root | 0.052 c | 0.064 ab | 0.077 ab | 0.072 ab | 0.092 a | 0.081 ab | 0.092 a |
| hypocotyl | 0.007 b | 0.010 a | 0.009 a | 0.010 a | 0.010 a | 0.006 b | 0.006 b |
| stalk | 0.003 b | 0.005 a | 0.006 a | 0.005 a | 0.004 a | 0.004 a | 0.005 a |
| petiole | 0.001 a | 0.002 a | 0.002 a | 0.002 a | 0.002 a | 0.002 a | 0.002 a |
| cotyledons | 0.024 b | 0.030 a | 0.027 a | 0.038 a | 0.035 a | 0.019 c | 0.021 b |
| 1-st leaves | 0.016 b | 0.028 a | 0.030 a | 0.032 a | 0.032 a | 0.018 b | 0.021 ab |
| 2-nd leaves | 0.005 c | 0.019 a | 0.015 a | 0.020 a | 0.014 ab | 0.020 a | 0.016 ab |
| | | | Turgor water content [%] | | | | |
| root | 89.70 | 93.84 | 91.79 | 93.23 | 91.67 | 90.52 | 89.20 |
| hypocotyl | 94.02 | 94.05 | 93.48 | 94.15 | 94.48 | 94.55 | 93.33 |
| stalk | 90.63 | 92.06 | 91.04 | 92.54 | 94.20 | 94.44 | 92.65 |
| petiole | 94.44 | 94.12 | 93.10 | 92.31 | 93.10 | 93.75 | 92.00 |
| cotyledons | 91.24 | 91.48 | 91.46 | 88.09 | 89.49 | 94.48 | 93.25 |
| 1-st leaves | 85.59 | 88.28 | 84.29 | 82.02 | 82.51 | 91.04 | 88.27 |
| 2-nd leaves | 88.10 | 90.05 | 90.96 | 88.95 | 92.09 | 90.15 | 89.74 |

values marked letter (a, b, c) in rows differ significantly according to Duncan test at $p < 0.05$

tion and growth stage and only during growth, the highest increase in the value of this parameter was demonstrated. Also, the medium with the addition of $MgCO_3$ increased the fresh mass of root, by half, in plants watered during growth stage. In other modifications, it was also showed a positive effect of the mediums on the growth of fresh mass of root. In the case of fresh mass of hypocotyls, a positive effect of medium was demonstrated, only Kottke medium with $MgCO_3$ caused a statistically significant decrease in the value of this parameter. The fresh mass values of stalk and petioles increased by half, in each of the measured samples, compared to the control. For the fresh mass of cotyledons, the positive effect of the medium used was also demonstrated. In all modification of Kottke medium, a significant increase in fresh mass of first and second leaves was observed (Tab. 2).

The values of dry mass of roots and all aboveground organs of cucumber plants were significantly higher under the influence of applied modifications of Kottke media, compared to the value of control masses. Turgor water content parameter, in the studied *C. sativus* plant organs, was similar and close to the control values. Generally, Kottke's medium and its modifications increased the water content of the cucumber's organs (Tab. 2).

## Discussion

Crop plants need different mineral substances for proper growth and development. From an agricultural point of view, the most important role is played by available forms of elements, which are determined by many factors (Domska et al., 1998; Kaniuczak, 1999). Currently, the natural soil richness in nutrients does not fully meet their nutritional needs. One of the main reasons for the reduction of soil organic mass is the intensification of agricultural production, including the introduction of simplified crop rotation with a predominance of cereal monocultures. Unquestionable factors for increasing agricultural production are balanced organic and mineral fertilisation, correct crop rotation, plow tillage and pro-ecological activities, which, when used properly, have a positive effect on plant growth and development (Tujak, 2006; Jadczyszyn et al., 2010; Jaskulski et al., 2012).

Magnesium is one of the many substances that condition the proper course of life processes of living organisms. Conducted experiment showed that the presence of magnesium carbonates and sulphates slightly inhibited the germination indexes of cucumber seeds compared to the control. The values of the determined germination indexes showed that the most inhibitory effect on germination capacity had Kottke medium with $MgCO_3 \times 3H_2O$ (Fig. 1–4). The reaction to the acid reaction of the soil is not the same. It depends on the plant species, its variety and other soil properties. The formation of soil pH values is mainly related to their mineralogical composition,

changes and content of organic mass, as well as climatic conditions. Acid cations have a toxic effect on crops, which is revealed in a reduction in the growth and size of the root system.

At the same time, in the soil intensive processes of retarding absorbable phosphorus compounds and reducing the content of basic cations occur. Magnesium uptake by plants occurs in the form of $Mg^{2+}$ ions. To a large extent it depends on the pH of soils, as well as the competitive action of $H^+$, $K^+$, $NH_4^+$ and $Ca^{2+}$ cations. Their high mobility can contribute to the displacement of magnesium from the soil sorption complex, and thus disrupt the proper functioning of plants (Kabata-Pendias, 1999).

Biometric root analysis showed the stimulating effect of the nutrients regardless of the time of watering. Compared to the control, the increase in hypocotyl length was inhibited in the presence of magnesium ions and sulphates (Fig. 5, Tab. 1). The highest growth of stems was observed in plants watered with nutrients supplemented with magnesium salts throughout the experiment. The petiole growth in length was stimulated by all modifications of Kottke media.

Fresh mass values, regardless of the type of medium and the time of its use, were higher in relation to the mass values from the control sample (Tab. 2). Only the fresh mass of hypocotyls watered throughout the experiment with magnesium salts was lower compared to the control. An increase in the dry mass value was demonstrated for all cucumber organs analysed. The percentage of water content was the lowest for the roots and first leaves compared to the control.

The positive effect of magnesium sulphate is most likely due to the presence of sulphur. This chemical element maintains normal physiological parameters that directly affect plant growth and development (Dobermann et al., 1998; Thomas et al., 2003; Hitsuda et al., 2005). The compounds of this element play key roles in many cellular processes (Dubuis et al., 2005). Sulphur is involved in the formation of proteins, carbohydrates, fats, in photosynthesis and in the synthesis of chlorophyll and lignin (Hell, Rennenberg, 1998). The positive effect of magnesium carbonate on plants can be due to the optimal pH of the soil, in which magnesium was easily absorbed. Slightly acidic soils have the best magnesium content. The content of available forms of magnesium decreases on very acidic and alkaline soils (Tao et al., 2019).

Stress conditions induce various biochemical processes in plant cells, as a result of which the metabolic and transport processes change (Konieczna et al., 2018a–b). They lead to a loss of cellular homeostasis, and even to the death of plants (Szatanik-Kloc et al., 2007; Pająk, Durak, 2018). As part of broadly understood 'sustainable agriculture' one should strive to comply with the principles of good practice, which includes, among others, limiting the use of synthetic pesticides and the production of healthy and good quality food.

## Conclusion

(1) Germination indexes of cucumber seeds watered with Kottke medium and its modification reached similar values, compared to the control group (distilled water). For seeds watered with the Kottke medium with the addition of magnesium carbonate the lowest germination capacity was observed.
(2) Kottke mediums and its modifications had positive effect on growth of cucumber plants, regardless the stages which they were used. Only Kottke medium modifications used in both stages had negative effect on the growth of cucumber hypocotyls.
(3) The values of fresh and dry mass and water content increased in plants watered with Kottke mediums and its modifications, compared to the control.

**Conflict of interest**

The authors declare no conflict of interest related to this article.

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## Abstract

The aim of the study was to determine the effect of magnesium sulphate and carbonate on the germination and growth of cucumber seeds (*Cucumis sativus* L.). For the experiment was used (1) Kottke et al. (1987) medium (pH 5.4) and its modification: (2) Kottke medium with the addition of $MgSO_4 \times 7H_2O$ (pH 4.8), (3) Kottke medium with the addition of $MgCO_3 \times 3H_2O$ (pH 6.5) and (4) distilled water (control). Characterisation of the germination capacity of cucumber seeds, under the influence of Kottke medium and its modification, were measured by germination indexes. An attempt was also made to assess the effect of mediums on growth on the length of plants, fresh and dry mass and water content. Germination indexes showed that the presence of magnesium carbonates and sulphates slightly inhibited seed germination, compared to the control. Biometric analysis of *C. sativus* roots showed a stimulating effect of mediums regardless of the time of watering the plants. Compared to the control, the length of hypocotyl was inhibited in the presence of the magnesium and sulphates ions. The highest growth of cucumber stalks in plants watered with mediums supplemented with magnesium salts for all time of experiment was observed. The petiole growth in length was stimulated by all modifications of Kottke medium. Fresh mass values, regardless of the type of medium and the time of its use, were higher in relation to the mass values from the control sample. Only the fresh mass of hypocotyl from plants watered throughout the experiment with magnesium salts was lower compared to the control. For all tested *C. sativus* organs an increase in the dry mass value was demonstrated. The percentage of water content was the lowest for roots and first leaves compared to the control.

**Key words:** fertilisation, germination, mass, organs' length

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## Rola soli magnezu w kiełkowaniu i wzroście *Cucumis sativus* L.

**Streszczenie**

Celem pracy było określenie wpływu siarczanu i węglanu magnezu na kiełkowanie oraz wzrost ogórka gruntowego (*Cucumis sativus* L.). Do doświadczeń użyto (1) pożywki Kottke et al. (1987) (pH 5,4) i jej modyfikacji: (2) pożywka Kottke z dodatkiem $MgSO_4 \times 7H_2O$ (pH 4,8), (3) pożywka Kottke z dodatkiem $MgCO_3 \times 3H_2O$ (pH 6,5) oraz (4) wodę destylowaną (kontrola). Charakterystykę zdolności kiełkowania nasion ogórka, pod wpływem pożywki Kottke i jej modyfikacji, zmierzono za pomocą wskaźników kiełkowania. Podjęto również próbę oceny wpływu pożywek na wzrost na długość, przyrost mas i zawartość wody. Wskaźniki kiełkowania wykazały, że obecność węglanów i siarczanów magnezu nieznacznie hamowała kiełkowanie nasion, w stosunku do kontroli. Analiza biometryczna korzeni roślin wykazała stymulujący wpływ pożywek niezależnie od czasu podlewania roślin. W porównaniu do kontroli, przyrost na długość hipokotyli był hamowany w obecności zastosowanych jonów magnezu i siarczanów. Największy przyrost łodyg ogórka zaobserwowano u roślin podlewanych pożywkami z dodatkiem soli magnezu przez cały okres eksperymentu. Wzrost na długość ogonków liściowych był stymulowany przez wszystkie modyfikacje pożywek Kottke. Wartości świeżej masy niezależnie od rodzaju pożywki i czasu jej stosowania, były wyższe w stosunku do wartości mas z próby kontrolnej. Jedynie świeża masa hipokotyli roślin podlewanych przez cały okres eksperymentu solami magnezu była mniejsza, w porównaniu z kontrolą. Wzrost wartości suchej masy wykazano dla wszystkich badanych organów roślin. Procentowa zawartość wody była najniższa dla korzeni i pierwszych liści, w porównaniu z kontrolą.

**Słowa kluczowe:** nawożenie, kiełkowanie, masa, długość organów

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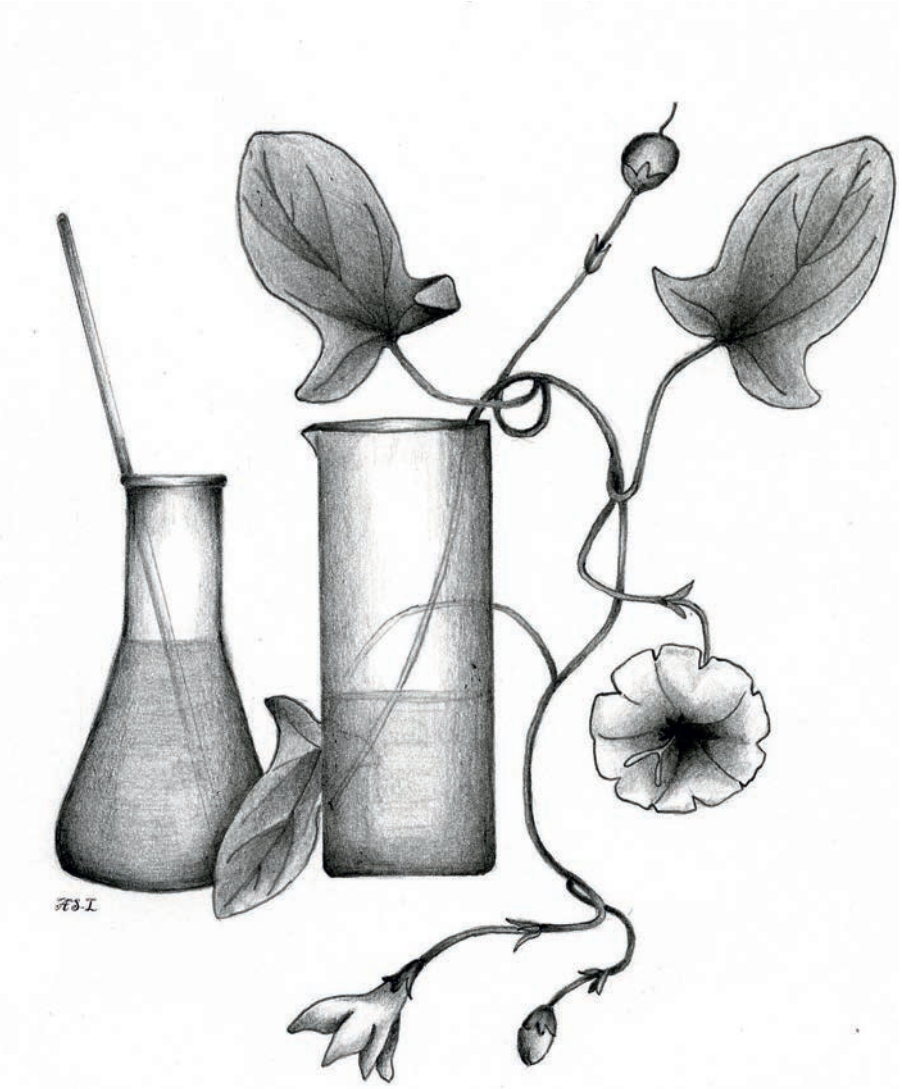
# Ecology & Enviromental Protection



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# Selected environmental issues of the landscape of shale (Nízký Jeseník Mt., Czechia) – preliminary results

## Introduction

For our purposes, we understand the environment as a set of natural, artificial and social components of the world that are (or may be) in direct contact with man. Natural components include, for example, climate, water and soil conditions. The artificial components can include buildings, production and transport facilities, communications and also terrain shapes such as mine heaps. Finally, social components include interpersonal relationships, culture, laws, economic conditions. The interaction between man and (his) environment then occurs in the landscape. The very content of the term landscape then has a very wide range, which can moreover be understood from various points of view. The landscape structure is variable over time and determined by its composition elements, which perform their own functions and are more or less dynamic. In the landscape we can distinguish the primary structure formed by the physical-geographic complex, i.e. natural elements such as geology, climate, water, natural terrain, etc. The secondary structure is the land use and material elements of this use (settlements, communications, mining remains, real vegetation cover, etc.). The tertiary structure of the landscape then includes intangible phenomena that can be reflected in the primary and secondary landscape structures. These include, for example, administrative units, ownership relationships, protection zones and regimes. The tertiary structure can also include the so-called magical places, which are connected with various legends and folklore traditions and the natural and artificial point of view. The primary, secondary and tertiary structure of the landscape is shaped by its typical character. An important landscaping agent are human activities.

The 'shale landscape' is a distinctive environmental and landscape phenomenon that can be seen from many points of view, as already mentioned above. It is located

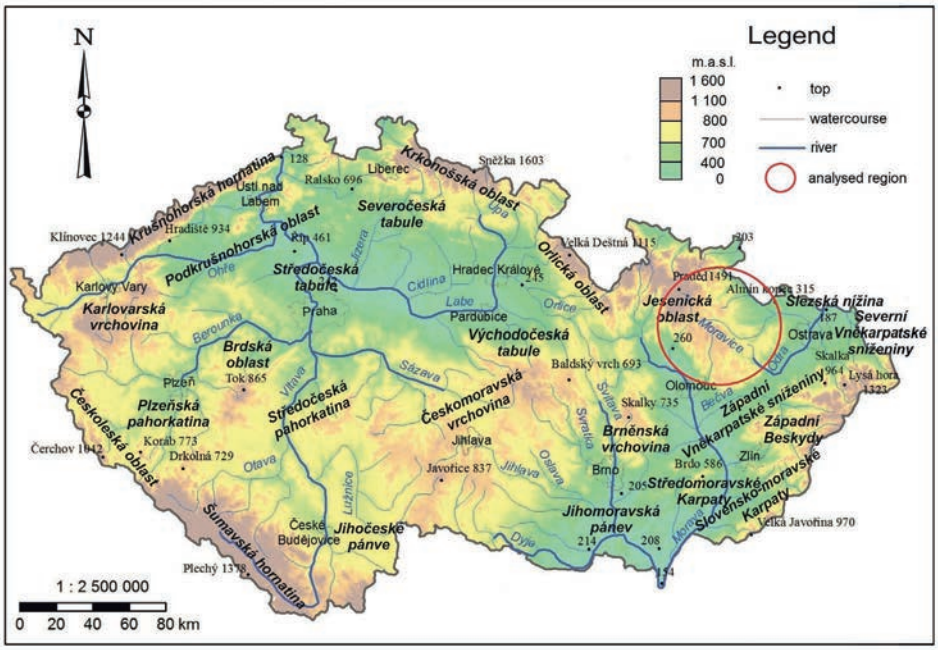


**Fig. 1.** Localisation of analysed region on map of Czechia (Source of map: Czech Environmental Information Agency – changed)

in the geomorphological unit Nízký Jeseník (2.894 km²) (Vencl, Strohalm, 2005). The mining of roofing shale tiles was concentrated in a part of the Lower Carboniferous of the Moravian-Silesian Region in terms of the geological division of the Bohemian Massif (Hrušecký, 1946; Zapletal et al., 1989) – Fig. 1. Here, for more than two centuries, shale mining has also left a distinct mark on local architecture and urbanism. With the resettlement of the original German-speaking population in 1945–1946, not only the roofing shale mining, but also the typical architectural elements that significantly contributed to the landscape character of the area were lost were reduced. Among these typical architectural features of the 'shale landscape' were, in particular, the original roofing – shale tiles attached with copper nails, which is now being replaced by another material or shale from import. The social composition of the population has also changed. New residents of abandoned settlements after the expulsion of Germans can be considered basically the first human colonisers of the territory. They began to transform the landscape and settlement structure, often without a deeper understanding of its specific dynamics and of course without following the ancestors traditions and respect to the genius loci.

We can characterise the 'shale landscape' as a post-industrial landscape; remnants of shale mining as landscape elements of post-industrial landscape. These include quarries and quarry lakes, adits and shafts, mine heaps and remnants of various build-

ings. In total, these elements can be found in the cadastre of more than 50 villages and towns of Nízký Jeseník Mts. An interesting finding of recent decades is the fact that some habitats, which are traditionally perceived as a symbol of degradation of the natural environment (for example abandoned quarries or mine heaps), are inhabited by quite unique communities of plants and animals (Tropek, Řehounek, 2012). In the case of post-mining landscape, it is possible to speak of a biological colonisation, formed by plant and animal communities in various stages of succession and a cultural colonisation, formed by man and his activities.

The subject of our research is a comprehensive understanding of the landscape after shale mining, which includes the colonisation of landscape mining elements by plants, vegetation and animals, including humans.

## Material and methods

The following text presents only some (most important) representatives of animals whose presence in the landscape after shale mining is related to post-mining landscape elements. The fauna survey started here in 2017 and can be divided into two phases. In the first phase, it is an inventory survey, which is focused especially on species protected, endangered or otherwise important from different taxonomic groups. In the second phase selected taxa (e.g. amphibians in quarry ponds, Hymenoptera insects on heaps or bats in underground spaces), the so-called specific zoological survey, are systematically studied.

Various types of methods were used in the inventory survey (observation, shearing using a hard skid net on islets of vegetation, individual collection in heaps of tailings material, etc.). They were in the underground in vertebrates and vertebrates studied by using conventional flashlights while browsing underground space each mine. In this way animals were examined in particular on the walls and ceilings (spiders, butterflies and bats). On the floor animals were surveyed under various objects (stones, remains of timbering, etc.). It was necessary in some taxa to take specimens for accurate determination. Animals were collected using entomological tweezers or exhauster, and fixed in 70% alcohol or killed by vapours of ethyl acetate. In the case of specific zoological research suitable methods were chosen for the study of individual taxa (e.g. aquatic animals net for amphibian studies, Mörick dish for Hymenoptera, bat-detector for bats).

The flora and vegetation survey was launched in 2017 with orientation terrain walks to find out the basic physiognomy of vegetation and the nature of the relief. In the first phase, an inventory survey was carried out focusing on rare and protected species according to Act no. 114/1992 Coll. and the corresponding red lists. Currently a phytosociological survey according to the rules of the Zurich – Montpellier School

(Braun-Blanquet, 1964). In the flatter parts of the heaps, reléves had the shape of 100 $m^2$ squares. On slopes, terraces and trailers, the shape of a rectangle was chosen as the more suitable one to maintain the recommended area. Phytosociological survey was performed at available slopes and exposures. Species were recorded in phytosociological tables during the season.

Due to the abundance of individual localities and sub-areas spread over a large area (including Jakartovice – 49°54′54″ N, 17°41′3″ E, surroundings of Hrubá voda – 49°40′13″ N, 17°26′11″ E, Břidličná – 49°54′42″ N, 17°22′16″ E, Moravice – 49°51′28″ N, 17°43′13″ E, Zálužné – 49°49′23″ N, 17°42′59″ E and others), the phenomenon of 'colonisation' of shale landscape cannot be affected by tramps and campers but at least on the basis of some selected localities to describe the characteristics of this post-industrial colonisation and to outline issues that will be developed in the future. The existing survey is based primarily on published literature, including tramp texts and field research, which included both observation and documentation of informants' statements contacted on the spot and through links to well-known camp organisations in the Ostrava and Opava regions. In the future, it would be possible to use, for example, archival sources for individual localities.

## Preliminary results and discussion

When anthropogenic activity is terminated or significantly reduced, natural processes will prevail and species with specific demands can be encountered at these post-industrial sites (sometimes at industrial sites), including a significant presence of rare and endangered species or the occurrence of organisms, which we consider to be unusual in our nature. In the Czech Republic, some species occur only at post-industrial sites. This is particularly so because post-industrial habitats create specific conditions that are typical to the present Central European landscape. Man has traditionally stopped farming in the landscape. Of course, the most common types of species are less demanding, common. However, in both cases, there are plants and animals that can find optimal conditions at post-industrial sites (Konvička et al., 2005).

Landscape elements after shale mining represent a varied mosaic of micro-sites in terms of both botanical and zoological aspects (Appendix 1A-B). For example, acidophilous grasses and sub-xerothermic plant species grow on the tops of mine heaps: *Hieracium bauhini* Schult. Asteraceae, *Sedum acre* L. Rosaceae and *Potentilla argentea* agg. L. Rosaceae. Some species, such as *Chamaenerion palustre* Scop. (= *Epilobium dodonaei* Vill.) Oenotheraceae, *Filago arvensis* L. Asteraceae or *Lepidium campestre* (L.) R. Br. Brassicaceae, are found directly on the mine heaps created by shale fragments. Some of these taxa belong to species from the red list of vascular plants in the Czech Republic.

For the remains of buildings from indigenous peoples, we can see massive linden trees, or ornamental plants such as dwarf periwinkle (*Vinca minor* L.) Apocynaceae, Poet's narcissus (*Narcissus poeticus* L.) Amaryllidaceae, and yellow figwort (*Scrophularia vernalis* L.) Scrophulariaceae. There are endangered grass annual fescue (*Vulpia myuros* (L.) C. C. Gmel.) Poaceae on dry warm places and the most endangered species round-leaved wintergreen (*Pyrola rotundifolia* L.) Pyrolaceae on unstable, shaded areas of mine heaps.

From the animals, there is a xerothermal snake in the same places – the endangered smooth snake (*Coronella austriaca* Laur.) Colubridae, the endangered green tiger beetle (*Cicindela campestris* L.) Carabidae or rare spider *Ozyptila claveata* Walck Thomisidae (Appendix 1B). Adits represent a significant wintering ground for bats, for example Western barbastelle (*Barbastella barbastellus* Schreb.) Vespertilionidae or very abundant greater mouse-eared bat (*Myotis myotis* Borkh.) Vespertilionidae and lesser horseshoe bat (*Rhinolophus hipposideros* Bech.) Rhinolophidae. In flooded quarry lakes there is a rich population of critically endangered species European crayfish (*Astacus astacus* L.) Astacidae. Amphibians are represented by common toad (*Bufo bufo* L.) Bufonidae, smooth newt (*Lissotriton vulgaris* L. =*Triturus vulgaris* L.) Salamandridae, alpine newt (*Ichthyosaura alpestris* Laur. =*Triturus alpestris* Laur.) Salamandridae and common frog (*Rana temporaria* L.) Ranidae. Interesting findings include the finding of *Niphargus tatrensis* Wrześ. Niphargidae in the leachate of mining galleries. It follows from published and unpublished materials that after the expulsion of the original population, the colonisers of the above-mentioned elements of the mining landscape were campers followed by tramps who, unlike the new permanent residents, approached the landscape with respect and interest, based on the philosophy of the tramp movement. For example, the 49$^{th}$ section of Junák in Ostrava had summer camp in Mokřinky near Melč – 49°51′0″ N, 17°45′28″ E, in 1947 (BVÚ, 2005). New, seemingly temporary and occasional 'residents' came to the country. The landscape features of the mining landscape have played and still play an important role in the life of campers and tramps as "colonisers". One of the possibilities to demonstrate this is the use of tramp toponyms and their spread. Some of the names refer directly to a particular landscape element (for example, a shaft with a tunnel called "Rodriguez's Tomb" on the cadastre of the defunct village of Nové Oldřůvky – 49°45′4″ N, 17°40′38″ E, or a quarry with a quarry pond 'Na špici' in Jakartovice), others include a wider area where several different mining elements are found (for example, a place called 'El Fuego' in the cadastre of the extinct Lesy). Sometimes a name given initially for only one particular landscape element was used for a much wider territory, as is the case with an abandoned quarry with a quarry pond in Jakartovice, which is named 'Horse Mine' and it functions under this name even in the mining register.

Appropriately situated quarry, not flooded or flooded only in part, with various terraces and heaps, provided ideal conditions for establishing a permanent campsite. Often, such a 'romantic' place has become the goal of traditional clubs, and in some cases, the centre of group games. Quarry lakes themselves were attractive for the possibility of their exploration, bathing, or to build rafts and other simple vessels. The walls of operational and other buildings provided a suitable refuge after a minor modification (in some cases, the roof was made of shale tiles), fireplaces and sleeping bunk beds were built. Shale tiles served as 'guestbook sheets' for example to record visitor names or nicknames. From the shale itself were built camp circles and specific fireplaces (stacked to a height of 50 cm or more), various inscriptions visible from above, as well as towers and mounds. An important role was played by the fact that stay in these localities was not significantly regulated (Kupka, Pohunek, 2017).

## Conclusion

The issues presented here are only a brief introduction to the wider elaborate of fauna, flora and vegetation of this region. Analysed colonisation processes, taking place in such a specific post-mining environment, should be considered in spontaneous and induced aspects. In the latter case, an important role is played by anthropopression of a different nature than it used to be, which is currently consequence of the increase in tourism in this area.

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**Conflict of interest**

The authors declare no conflict of interest related to this article.

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## Appendix 1

Preliminary list of plant (A) and animal (B) species recorded in the habitats of the shale post-mining landscape (Jakartovice village 49°54′54″ N, 17°41′3″ E):

Nomenclature of plants: according Polish flora (www.atlas-roslin.pl) and other Internet sources.

**(A) Bryophytes**: *Abietinella abietina* (Hedw.) M.Fleisch., *Amblystegium serpens* (Hedv.) Schimp., *Atrichum undulatum* (Hedw.) P.Beauv., *Brachythecium rutabulum* (Hedw.) Schimp., *B. salebrosum* (Hoffm. ex F.Weber et D.Mohr) Schimp., *Brachytheciastrum velutinum* (Hedw.) Ignatov et Huttunen (= *Brachythecium velutinum* W. P. Schimp.), *Bryum argenteum* Hedw., *Ceratodon purpureus* (Hedw.) Brid., *Cynodontium polycarpon* (Hedw.) Schimp., *Dicranella heteromalla* (Hedw.) Schimp., *D. varia* (Hedw.) Schimp., *Dicranum polysetum* Sw. ex anon., *D. scoparium* Hedw., *Hylocomium splendens* (Hedw.) Schimp., *Hypnum cupressiforme* Hedw., *H. revolutum* (Mitt.) Lindb., *Lophocolea bidentata* (L.) Dumort., *Lophozia ventricosa* (Dicks.) Dumort., *Orthotrichum affine* Schrad. ex Brid., *O. anomalum* Hedw., *Oxyrrhynchium hians* (Hedw.) Loeske (= *Eurhynchium hians* (Hedw.) Sande Lac.), *Plagiomnium affine* (Blandow ex Funck) T.J.Kop., *Plagiothecium denticulatum* (Hedw.) Schimp., *P. succulentum* (Wilson) Lindb., *Pleurozium schreberi* (Willd. ex Brid.) Mitt., *Pohlia nutans* (Hedw.) Lindb., *Polytrichastrum formosum* (Hedw.) G. L. Sm. (= *Polytrichum formosum* Hedw.), *Polytrichum juniperinum* Hedw., *P. piliferum* Hedw., *Pseudoscleropodium purum* (Limpr) M. Fleisch. ex Broth., *Ptilidium ciliare* (L.) Hampe, *P. pulcherrimum* (Weber) Vain., *Racomitrium lanuginosum* (Hedw.) Brid., *Rhizomnium punctatum* (Hedw.) T.J. Kop, *Rhytidiadelphus squarrosus* (Hedw.) Warnst., *Rosulabryum laevifilum* (Syed) Ochyra (= *Bryum moravicum* Podp.), *Sanionia uncinata* (Hedw.) Loeske, *Scapania nemorea* (L.) Grolle, *Schistostega penata* (Hedw.) F.Weber et D.Mohr, *Syntrichia ruralis* (Hedw.) F. Weber et D. Mohr (= *Tortula ruralis* (Hedw.) Gaertn., Meyer, & Scherb.), *Tortula muralis* Hedw.

**Vascular plants**: *Acer campestre* L., *A. platanoides* L., *A. pseudoplatanus* L., *Achillea millefolium* L., *Agrostis stolonifera* L., *Alnus glutinosa* (L.) Gaertn., *Anthriscus sylvestris* (L.) Hoffm., *Arenaria serpyllifolia* L., *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl et C., *Artemisia vulgaris* L., *Athyrium filix femina* (L.) Rot, *Betula pendula* Roth, *Bidens frondosa* L., *Bromus sterilis* L., *Calamagrostis epigejos* (L.) Rot, *Calystegia sepium* (L.) R.Br., *Carex praecox* Schreb., *Carpinus betulus* L., *Centaurea cyanus* L., *Cerasus avium* (L.) Moench (= *Prunus avium* L.), *Chamaenerion palustre* Scop. (= *Epilobium dodonaei* Vill.), *Chelidonium majus* L., *Chenopodium album* agg., *Cirsium arvense* (L.) Scop., *Conyza canadensis* (L.) Cronquist, *Cornus alba* L. (= *Swida alba* (L.) Opiz), *C. sanguinea* L. (= *Swida sanguinea* Opiz), *Corylus avellana* L., *Crataegus monogyna* Jacq., *Crepis biennis* L., *Daucus carota* L., *Digitaria sanguinalis* (L.) Scop., *Dryopteris*

*filix-mas* (L.) Schott, *Echium vulgare* L., *Epilobium adenocaulon* Hausskn. (= *E. ciliatum* Raf.), *Erigeron annuus* (L.) Pers., *Eupatorium cannabinum* L., *Fagus sylvatica* L., *Festuca rubra* L., *Festuca* sp., *Filago arvensis* L., *Fragaria vesca* L., *Fraxinus excelsior* L., *Galeopsis pubescens* Besser, *G. speciosa* Mill., *Galium aparine* L., *Geranium robertianum* L., *Geum urbanum* L., *Glechoma hederacea* L., *Hedera helix* L., *Hieracium bauhini* Schult., *H. murorum* L., *H. sabaudum* L., *Hypericum maculatum* Crantz, *H. perforatum* L., *Impatiens parviflora* DC., *Inula conyza* DC., *Juglans regia* L., *Lepidium campestre* (L.) R. Br., *Ligustrum vulgare* L., *Malus domestica* Borkh., *Matricaria perforata* Mérat (= *Tripleurospermum inodorum* (L.) Sch. Bip.), *Melandrium album* (Mill.) Garcke (= *Silene latifolia* Poir.), *Mycelis muralis* (L.) Dumort., *Myosotis sylvatica* Ehrh. ex Hoffm., *Oenothera biennis* L., *Oxalis acetosella* L., *Padus avium* Mill. (= *Prunus padus* L.), *Pastinaca sativa* L., *Picea abies* (L.) H.Karst., *Picris hieracioides* L., *Pinus nigra* J.F. Arnold, *P. sylvestris* L., *Poa compessa* L., *P. pratensis* L., *Populus tremula* L., *Potentilla argentea* agg. L., *P. erecta* (L.) Raeusch., *Prunus spinosa* L., *Pyrola rotundifolia* L., *Quercus robur* L., *Ribes uva-crispa* L. (= *Grossularia uva-crispa* (L.) Mill.), *Robinia pseudacacia* L., *Rosa* sect. *caninae* DC., *Rubus caesius* L., *R. idaeus* L., *Rumex acetosa* L., *R. acetosella* L., *R. obtusifolius* L., *Salix caprea* L., *S. purpurea* L., *Sambucus nigra* L., *Scrophularia vernalis* L., *Senecio jacobaea* L., *S. ovatus* (P. Gaertn., B. Mey. et Scherb.) Willd., *S. vulgaris* L., *Solidago canadensis* L., *S. gigantea* Aiton, *Sorbus aucuparia* L. em. Hedl., *Stellaria graminea* L., *S. media* (L.) Vill., *Symphytum officinale* L., *Tanacetum parthenium* (L.) Sch. Bip., *Taraxacum* sect. *ruderalia* Kirsch., H.Øllg. & Štěpánek, *Tilia cordata* Mill., *T. platyphyllos* Scop., *Urtica dioica* L., *Verbascum thapsus* L., *Veronica chamaedrys* L., *Viola odorata* L., *Vulpia myuros* (L.) C. C. Gmel.

Nomenclature of animals: according BioLib (https://www.biolib.cz/cz/taxon/), Fauna Europaea (https://fauna-eu.org/) and other Internet sources.

**(B) Snails**: *Aegopinella nitens* Mich. (= *Hyalinia nitens* Mich.), *Alinda biplicata* Mont. (= *Balea biplicata* Mont.), *Arion distinctus* J. Mabil., *Arion vulgaris* Moquin-Tand., *Boettgerilla pallens* Simr., *Cochlicopa lubrica* O. F. Müll., *Deroceras agreste* L., *D. reticulatum* O. F. Müll., *Discus rotundatus* O. F. Müll., *Helix pomatia* L., *Limax cinereoniger* Wolf, *Monachoides incarnatus* O. F. Müll., *Oxychillus glaber* Rossm., *Radix labiata* Rossm.
**Crustaceans**: *Armadillidium vulgare* Latre., *Astacus astacus L., Ligidium hypnorum* Cuv., *Niphargus tatrensis* Wrześ., *Oniscus asellus* L., *Porcellio scaber* Latre.
**Spiders**: *Amaurobius fenestralis* Ström, *Cicurina cicur* Fabr., *Coelotes pabulator* Sim. (= *C. terretris* Wild.), *Drassyllus praeficus* L. Koch, *Meta menardi* Latre., *Ozyptila claveata* Walck., *Pirata hygrophilus* Thor., *Pisaura mirabilis* Cler.
**Grasshoppers and crickets**: *Pseudochorthippus parallelus* Zetter. (= *Chorthippus parallelus* Zetter.), *Gomphocerippus rufus L., Oedipoda caerulescens* L., *Phaneroptera falcata* Poda, *Pholidoptera griseoaptera* De Geer, *Tetrix subulata* L., *Tettigonia cantans Fuess.*

**Butterflies and moths**: *Aglais urticae* L., *Anthocharis cardamines* L., *Apatura ilia* Denis & Schiff., *Aphantopus hyperantus* L., *Araschnia levana* L., *Argynnis paphia* L., *Autographa gamma* L., *Coenonympha pamphilus* L., *Colias hyale* L., *Gonepteryx rhamni* L., *Inachis io* L. (= *Aglais io* L.), *Lasiommata megera* L., *Leptidea reali* Reiss., *Lycaena dispar* Haw., *Maniola jurtina* L., *Melanargia galathea* L., *Nymphalis antiopa* L., *Pararge aegeria* L., *Pieris brassicae* L., *P. napi* L., *P. rapae* L., *Polygonia c-album* L., *Polyommatus icarus* Rottem., *Scoliopteryx libatrix* L., *Thymelicus lineola* Ochsen., *Triphosa dubitata* L., *Vanessa atalanta* L., *V. cardui* L.

**Beetles**: *Cantharis rustica* Fall., *Carabus violaceus* L., *Chrysomela fastuosa* Scop., *Cicindela campestris* L., *Anoplotrupes stercorosus* Scri. (=*Geotrupes stercorosus* L.), *Leptura quadrifasciata* L., *Nicrophorus vespillo* L., *Oiceoptoma thoracicum* L., *Phosphuga atrata* L., *Psyllobora vigintiduopunctata* L., *Rhagonycha fulva* Scop., *Silpha obscura* L., *Staphylinus caesareus* Cederh., *Tachyura parvula* Deje., *Thanatophilus rugosus* L.

**Hymenoptera**: *Agenioideus cinctellus* Spin., *Ammophila sabulosa* L., *Andrena fulva* Müll., *Andrena haemorrhoa* Fabr., *A. minutula* Kir., *A. nigroaenea* Kir., *A. nitida* Müll., *A. strohmella* Stöck., *A. varians* Kir., *Anoplius infuscatus* Van der Lind., *Apis mellifera* L., *Arachnospila anceps* Wesm., *Bombus campestris* Panz., *B. pascuorum* Scop., *B. rupestris* Fabr., *B. terrestris* L., *Halictus maculatus* Smith, *H. tumulorum* L., *Hylaeus signatus* Panz., *Lasioglossum calceatum* Scop., *L. morio* Fabr., *L. pauxillum* Schen., *Melecta albifrons* Foer., *Nomada conjungens* Herrich-Schäf., *N. flavoguttata* Kir., *N. fulvicornis* Fabr., *N. succincta* Panz., *Osmia bicornis* L., *Polistes nimpha* Christ, *Priocnemis perturbator* Harr., *Rhopalum clavipes* L., *Sphecodes gibbus* L., *Trypoxylon minus* Beaum., *Vespula germanica* Fabr., *V. vulgaris* L.

**Amphibians**: *Bufo bufo* L., *Ichthyosaura alpestris Laur. (=Triturus alpestris* Laur.*), Lissotriton vulgaris L. (= Triturus vulgaris L.), Pelophylax esculentus* L., *Rana temporaria L.*

**Reptiles**: *Anguis fragilis* L., *Coronella austriaca* Laur., *Lacerta agilis* L., *Natrix natrix* L.

**Bats**: *Barbastella barbastellus* Schreb., *Myotis emarginatus* É. Geoff., *M. myotis* Borkh., *M. mystacinus* Kuhl, *M. nattereri* Kuhl, *Plecotus auritus* L., *Rhinolophus hipposideros Bech.*

## Abstract

The area of the Nízký Jeseník Mts. is, among other things, well known for its shale roofing tiles since the 18th century. In places where shale was intensively or extensively exploited until 1945, abandoned areas after mining works remained. In general, every mining is perceived as a activity of landscape degradation by the public. However, these indelible traces of shale mining in the form of various mining-related objects (e.g. abandoned quarries, quarry ponds, shafts, drains etc.) are also gradually becoming places that are colonized by unique plant and animal communities. There are very interesting species bond to specific environmental conditions of post-mining landscape, with frequent rare and endangered species. People have also become 'new' colonisers in the case of the shale landscape.

**Key words:** post-industrial landscape, abandoned quarries, mine heaps, fauna colonisation, vegetation colonisation, cultural colonisation

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## Wybrane zagadnienia środowiskowe krajobrazu łupków ilastych (Nízký Jeseník, Czechy) – wstępne rezultaty

### Streszczenie

Obszar gór Niskiego Jesionika znany jest od XVIII wieku, m.in. z łupków dachówkowych. W miejscach, w których łupek był intensywnie lub ekstensywnie eksploatowany do 1945 r., pozostały wyrobiska górnicze. Generalnie, każda działalność wydobywcza jest postrzegana przez społeczeństwo jako działanie degradujące krajobraz. Jednak te nieusuwalne ślady wydobycia łupków ilastych, w postaci różnych obiektów związanych z górnictwem, np. opuszczone kamieniołomy, stawy kamieniołomowe, szyby, dreny itp., również stopniowo stają się miejscami kolonizowanymi przez unikalne ugrupowania roślin i zwierząt. Interesujące gatunki wiążą się ze specyficznymi warunkami środowiskowymi krajobrazu pogórniczego, a często występują tam gatunki rzadkie i zagrożone. W przypadku krajobrazu łupkowego, także sami ludzie stali się „nowymi" kolonizatorami.

**Słowa kluczowe:** krajobraz poprzemysłowy, opuszczone kamieniołomy, hałdy min, kolonizacja fauny, kolonizacja roślinności, kolonizacja kulturowa

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**Jiří Kupka**
The author is focusing on ecological and environmental applications in post-industrial landscape (especially fauna study at post mining sites, including underground spaces), biological researches related to biogeochemistry and environmental geochemistry, brownfields reuse and didactics of natural sciences.

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**Rostislav Poláček**
The author is engaged in research of Hymenoptera insects with a focus on wasps, bumble bees and solitary bees in post-industrial landscape. The research is carried out mainly at localities (heaps) after mining of mineral resources.

# Various

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# Plants as a treasury of fragrant substances for food industry and perfumery

## Introduction

Fragrant substances play an important role in our life. Every day we accidentally or deliberately smell hundreds or even thousands of natural and artificial compounds. Some of them exhibit pleasant aroma like vanilla in ice creams or constituents of top perfumes. Before we start to drink a good wine or whisky our noses are attacked with dozens of volatile chemical molecules preparing our tongues for subsequent flavour experiences. On the other hand sweat components or volatiles released from some mould cheeses or fermented food like '*surströmming*' arouse disgust in some persons but a small amount of very bad smelling organic sulphur compounds like tetrahydrothiophene in natural gas we use in our kitchen can save somebody life in case of gas leakage. It would be difficult to imagine our existence without various aromas.

It seems that eating is one of the biggest pleasures we can experience in our life. Even in the Holy Bible there is a statement "*There is nothing better for a man than taking meat and drink, and having delight in his work*". Eating is a multisensory experience. The very first contact is with eyes, next the senses of taste and smell are engaged. In the paper published in *Science* the authors claim that people are able to recognise more than one trillion of olfactory stimuli (Bushdid et al., 2014). These results are breathtaking and in the strong contrast with many previous statements sometimes not proven by experiments. In popular literature we can still find relatively old information that people can distinguish just about 3.000–10.000 odours (Crocker, Henderson, 1927).

Food technologists very often encounter the problem of destroying food aroma during thermal food processing. The volatile compounds are lost and the flavour of

the resulting product may be different from the starting components. At present due to the fragrant food additives we are able to a certain extent restore these aromas. Addition of some synthetic or natural aromas to food products increases their tastiness and sensory attractiveness. It should be remembered that there are two ways in which we smell – orthonasal and retronasal route (Spence, 2017). This short review is devoted to plant-derived aromatic substances applied as food additives and in some cases as materials for perfume industry as well.

## Essential oils – preparation

Essential oils belong to the natural fragrant materials widely applied in food industry and in pharmaceutical and perfumery ones too. These materials can be obtained in many ways. The most important ones are extractions with various solvents like *n*-hexane $C_6H_{14}$, ethyl acetate $CH_3COOEt$, methylene chloride $CH_2Cl_2$, florasol (1,1,1,2-tetrafluoroethane) or supercritical carbon dioxide. The last solvent is definitely environmental friendly and safe as far as residues in the final product. In food industry it is used for removal of caffeine from coffee beans and green tea (Kim et al., 2010).

Another example is the extraction of essential from *Lavandula ×hybrida* Rever. (Lavandin) flowers with supercritical carbon dioxide. The two most important components of this oil are linalool and linalyl acetate applied in food industry and as biocides as well (Kamali et al., 2015). Supercritical carbon dioxide was also applied in isolation of essential oils from *Flixweed*, *Eucalyptus globulus* Labill., *Mentha ×piperita* L. (Zekovic et al., 2009; Mahdavi et al., 2015; Singh et al., 2016). Other examples can be found in some review papers on this subject (Xu et al., 2011; Capuzzo et al., 2013; Manjare et al., 2019).

The second important method of essential oil isolation is steam distillation. The steam flow is passed through the plant material (bark, flowers, roots, leaves, peel, berries, rhizome) placed in a glass flask or steel container and removes volatile compounds with subsequent condensation. The distillate is collected in receiver and an essential oil is separated from the water phase. The resulted oil can be subjected to fractional distillation and rectification. In some cases the cooling of the resulted oil results in crystallisation of some constituents. Steam distillation process can be supported with microwave heating of the plant material/water mixture for more effective isolation of fragrant material (Chemat et al., 2006; Sahraoui et al., 2008; Moradi et al., 2018). Another group of researchers applied solvent free microwave extraction SFME of essential oils from plant material (Lucchesi et al., 2018). The authors significantly reduced the time of oil extraction in comparison with traditional hydro-distillation method. At present a microwave reactor is a standard tool for chemists. Beside it ultrasound assisted reactions are more and more popular in organic and analytical chemis-

try (Capelo-Martinez, 2009; Cravotto et al., 2018). This technique is a valuable tool for extraction of essential oils and other plant metabolites. The details of this procedure and its application in food industry, cosmetics and pharmacy can be found in a recent review paper (Chemat et al., 2017).

It would be good to mention probably the oldest method of essential oils preparation based on the cold pressing of plant material like olives or citrus peels. The most important products obtained in this way are orange, lemon, grapefruit and bergamot essential oils which are widely employed in food and cosmetic industry.

In case of danger that some constituents of essential oils can be decomposed at the temperature of steam distillation the procedure of maceration can be applied. One of the oldest and very effective though very tedious is *enfleurage*. This method is based on extracting of fragrant compounds from plant material (usually flower petals or whole flowers) with animal fat like lard or tallow and leaving the whole for a few days. After this time the flowers are removed and new ones are mixed with lipids. This procedure is repeated up to the saturation of fat with essential oils. After removing the flowers the fat is mixed with ethyl alcohol. The components of essential oils are dissolved in it and the insoluble fat is separated off. The residue resulted after the evaporation of the alcohol is called an absolute. The technique of enfleurage is almost abandoned and replaced with solvent extraction (Surburg, Penten, 2006). Such an example is jasmine absolute, a very valuable ingredient for perfumery industry. At present it is prepared by double or triple extraction of jasmine blossoms with *n*-hexane. One needs to collect manually 8.000 000 blossoms to obtain 1 kg of jasmine absolute (Konopski, Koberda, 2003).

## The chemical constituents of essential oils

Essential oils applied as food additives or products for fragrant composition in perfume industry are complicated mixtures of many compounds. For example the recent investigations on volatile and semi-volatile compounds in various citrus oils (ex. *Citrus limon* (L.) Burm., *C. sinensis* (L.) Osbeck, *C. medica* L.) based on gas chromatography coupled to mass spectrometry (GC-MS) revealed the presence of 200–400 compounds (Bozkurt et al., 2017; Gonzales-Mas et al., 2019). The essential oils extracted from *Rosa* ×*centifolia* L. or *R.* ×*damescena* Mill. are one of the most expensive ingredients applied in cosmetics industry. The amount of volatile compounds varies depend on the literature source. Some authors reported 32 compounds based on GC and GC-MS chromatography. Among them the most abundant were citronellol, geraniol and nerol (Ahmad et al., 2009). The other group reported 50 volatiles in Damascene rose oil (Naquvi et al., 2014). A recent review on rose essential oil or 'liquid gold' constituents suggests that investigation on this subject is far to be finished (Nunes, Graca, 2017).

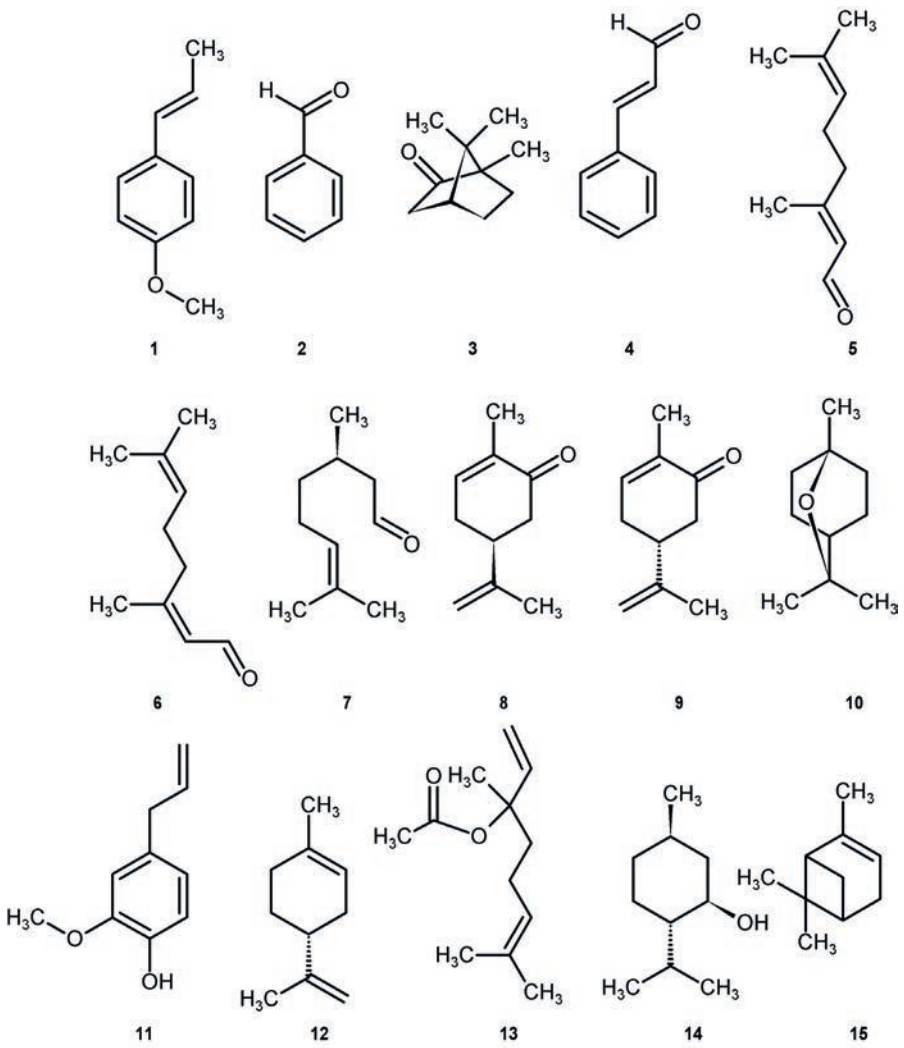


**Fig. 1.** Chemical structures of some isolates from essential oils: 1) anethole, 2) benzaldehyde, 3) camphor, 4) cinnamaldehyde, 5) citral A, 6) citral B, 7) citronellal, 8) (*S*)-carvone, 9) (*R*)-carvone, 10) eucalyptol, 11) eugenol, 12) (*R*)-(+)-limonene, 13) linalyl acetate, 14) menthol, 15) pinene (Source: Rutkowski et al., 2003; Kołodziejczyk, 2013)

In some cases the content of some fragrant materials is quite high so some essential oils are subjected to fractional distillation or crystallisation to obtain valuable materials for food industry, perfumery or organic synthesis. The significant majority of them are terpenes hydrocarbons or their monofunctional derivatives. Beside them we can find esters, aromatic aldehydes, phenols, ketones, ethers and nitrogen, oxygen and sulphur containing heterocycles.

Some important isolates 1–15 from essential oils are listed in figure 1 (Rutkowski et al., 2003; Kołodziejczyk, 2013). The worldly production of anise essential oil is estimated over 400 tonnes and the content of *trans*-anethol 1 is ca. 70–95% depending on the plant source. Anethol can be prepared in a synthetic way too. It is used as a food additive to some alcoholic beverages like absinth, anisette and raki. The last one is an alcoholic drink popular in Turkey (Ashurst, 1999). Benzaldehyde 2 is obtained either synthetically or from natural cinnamaldehyde 4 in the reaction with sodium hydroxide (Wiener, Pittel, 1985; Surburg, Panten, 2006). It can be also prepared from amygdalin extracted from some kernels like apricot or bitter almonds (Passos, Ribeiro, 2010). Cinnamaldehyde 4 is obtained from cinnamon bark *Cinnamomum verum* J.Presl or *C. cassia* (L.) J.Presl through steam distillation. There are some alternative synthetic pathways to prepare this compound like aldol condensation of benzaldehyde and acetic aldehyde but due to the high worldly production of cinnamic bark the isolation is more economic. Benzaldehyde 2 and cinnamaldehyde 4 are applied in food industry as flavours in chewing gums, cakes, bakery aromas or ice creams. Camphor 3 can be isolated from *C. camphora* Ness et Eberm tree grown in China, Vietnam, Japan and Taiwan. As a food additive natural camphor is popular in India (Aguilar et al., 2008). It can be also synthesised from natural pinene 15. Beside it this terpene is used for synthesis of other fragrant substances like terpineol or verbenone. These substances can be prepared either via chemical or microbial oxidation of pinene (Rozenbaum et al., 2006; Praskoso et al., 2018).

Citronella grass *Cymbopogon nardus* (L.) Rendle is a rich source of citral A (geranial) 5, citral B (neral) 6 and citronellal 7. These compounds are used in food industry as lemon, lime and orange flavorings for ice creams, candies and baked goods (Winter, 2009). Geranial and neral were also found in hop essential oil. They are reduced by yeast into geraniol and nerol and in part these compounds are responsible for beer flavour (Tressl et al., 1987). Two carvone enantiomers 8 and 9 are used as food additives, insects repellents and building blocks in asymmetric organic synthesis (Cravalho, Fonesca, 2006). These compounds can be isolated from *Carum carvi* L. and *Mentha spicata* L., respectively. The major application of eucalyptol 10 involves candies, aromatic balms or mouthwash (Cameron, Easton, 2000). Just recently eucalyptol was applied as solvent in synthesis of heterocyclic compounds (Campos et al., 2019). Eugenol 11 is known to possess antiseptic properties and is used in dentistry. Its application as food additive is relatively limited due to the very strong odour. This compound is obtained from oil of clove derived from steam distillation of flower buds, leaves and steam of *Syzygium aromaticum* (L.) Merr. & Perry. Chatterjee and Paramita described investigations on application of eugenol as natural antioxidant in mayonnaise (Chatterje, Bhattacharje, 2015). Moreover it can be a starting material for synthesis of vanillin – a valuable natural fragrant substance (Lampman et al., 1977). (*R*)-(+)-li-

monene 12 is produced on the biggest scale in the world. The annual production of this fragrant compound in Brazil and Florida is estimated at 75.000 t (Taylor, 2002). Due to this abundant amount this compound with the smell of orange or lemon is applied not only in food industry and perfumery but it is used as a solvent for grease removal and a paint stripper too. The bergamot essential oil derived from bergamot oranges contains limonene 12 (30.7%) and linalyl acetate 13 (30.1%), respectively (Sawamura et al., 2006). The last compound found a vast application in perfume industry (Fahlbush et al., 2003). Essential oils from *Mentha arvensis* L. and *M.* ×*piperita* L. contain menthol 14 which found multiple applications in many consumer products like cosmetics, drugs and tobacco flavour additive (Aldadyan, Samet, 2018).

## Diamonds among fragrant materials

In some essential oils the content of a single fragrant substance can be very high. Such an example is (*R*)-(+)-limonene. In citrus, orange or lemon essential oils its amount varies within 65–90%. On the other hand there are valuable aromatic substances which exist in very small amounts in plant material. Some of them are depicted in figure 2. One of the examples is nootkatone 16 which can be found in grapefruit, orange and mandarin oranges essential oils. It can be isolated from these sources but due to tiny amount of 0.01–0.5% the price of the natural compound is very high and varies between 4.000–6.500 Euro/kg. Pure compound found an application as insect repellent and a food additive approved by FDA (Food and Drug Administration) as well (Jordan et al., 2012). To avoid high costs of natural compound, alternative synthetic methods were developed including biotechnological based ones (Fratz et al., 2009).

Even a more expensive food flavour additive and a diet supplement is raspberry ketone 17. It is a natural compound which can be found in cranberries, blackberries and raspberries. In the last example it occurs in the amount of 1–4 mg/kg so the extraction from natural resources is useless from economical point of view because the estimated price is ca. 20.000$/kg (Beekwilder et al., 2007). There is a big demand for this flavour ingredient as a food additive and a diet supplement as well. Thus raspberry ketone can be synthesised from simple starting materials such as *p*-hydroxbenzaldehyde 22 and acetone 23 resulting chalcone 24 which can be reduced with cheap reagents like nickel boride and hydrogen $Ni_2B/H_2$ under atmospheric pressure yielding the final compound 17 (Fig. 3) (Bandarenko, Kovalenko, 2014).

Unfortunately this product cannot be recognised as natural in spite of the identical properties with the raspberry ketone obtained from natural resources. To fulfil these demands, methods based on natural substrates and preparation processes as natural as possible are in great demand. Joulain and Fuganti published a procedure employing a baking yeast for reduction of a double bond in 4-(*p*-hydroxyphenyl)but-3-en-2-one 24 yielding raspberry ketone 17 in 56% yield (Joulian, Fuganti, 1999). Acetone 23 can

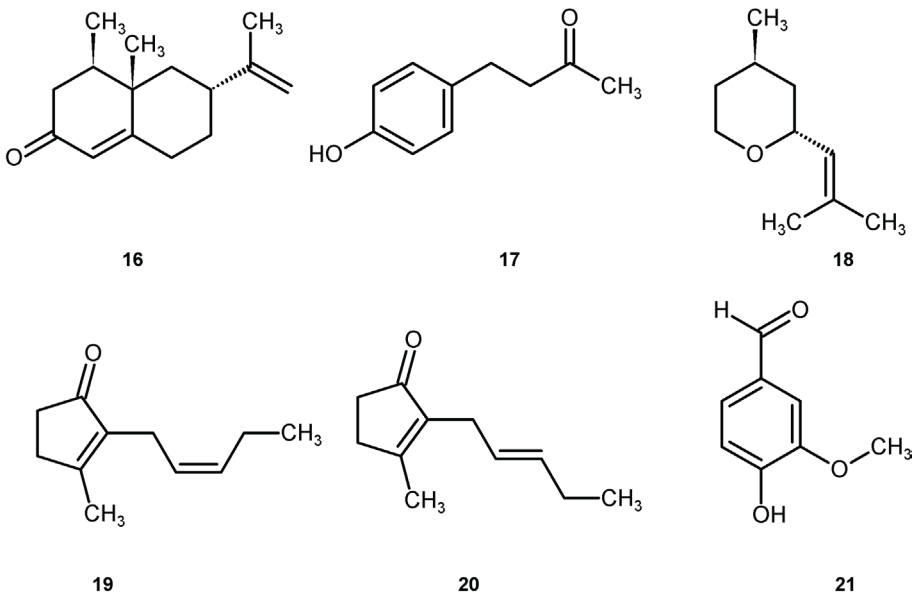


**Fig. 2.** Chemical structures of some expensive fragrant materials: 16) nootkatone, 17) raspberry ketone, 18) rose oxide, 19) *cis*-jasmone, 20) *trans*-jasmone, 21) vanillin (Source: Ruzicka, Pfeiffer, 1933; Berger, 2007; Fratz et al., 2009; Alsters et al., 2010; Bandarenko, Kovalenko, 2014)

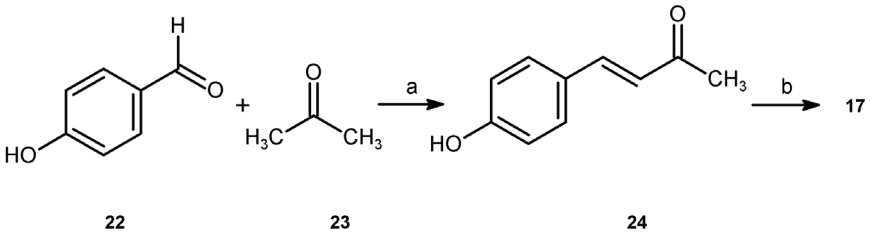


**Fig. 3.** Synthesis of raspberry ketone: a) NaOH, r.t. 24–48 hrs; b) $Ni_2B$ or baker yeast (Source: Joulain, Fugati, 1999; Bandarenko, Kovalenko, 2014)

be obtained from microbial synthesis (Sauer, 2016). Natural *p*-hydroxybenzaldehyde 22 can be extracted from sorghum shoots (*Sorghum vulgare* Pers.) (Bove, Conn, 1961).

Rose oxide 18 is one of the constituent of rose essential oil obtained from *Rosa* ×*damascena* and *R.* ×*centifolia* as well. Due to the very high price of the previously mentioned essential oils, some synthetic procedures were developed to prepare this compound because it is used in contemporary perfume compositions (Alsters et al., 2010). Rose oxide was found also in some Muscat wines and is one of the components responsible for floral-green flavour of those wines (Boelens et al., 1993).

The similar situation is with one of the constituent of the jasmine essential oil namely *cis*-jasmone 19 used in the creation of high quality perfumes. The content of

this compound in jasmine essential oil varies at 2.6–3.4% so the isolation is definitively unprofitable (Clarke, 2008). It was discovered over 100 years ago and since that time many synthetic pathways have been developed to fulfil demand of perfume producers (Hesse, 1899). The synthetic jasmone is frequently a mixture of cis/trans 19/20 isomers (Ruzicka, Pfeiffer, 1933).

The last, but not the least example in this small gallery of natural fragrant materials is vanillin 21. The natural compound can be extracted from *Vanilla planifolia* Andrews grown in Madagascar. Unfortunately the natural resources are not sufficient to satisfy the demands of the market so many synthetic procedures were developed to supply this valuable product for food and perfumery industry. Thus synthetic vanillin can be prepared on industrial scale either from eugenol, guaiacol or from lignin – a side product from cellulose industry (Berger, 2007). There is also a technological procedure of vanillin preparation from cow dung. The author of the procedure – Japanese scientist Mayu Yamamoto was awarded with Ig-Nobel prize for this outstanding achievement in 2008 (Yamamoto et al., 2008). Natural vanillin extracts are expensive so there is a danger that synthetic vanillin can be used to adulteration of natural extract. To avoid these problems numerous analytical techniques are applied including authentication with plant DNA (Philippe et al., 2019).

## Conclusions

This very short review gives a slight glimpse on the application of fragrant substances of plant origin in contemporary food and perfume industry. At present as a whole 2.000–3.000 flavouring chemicals – both natural and synthetic are used commercially. The search and analysis of natural fragrant substances is especially challenging due to the fact that their content in plant or animal material is sometimes on the verge of a homeopathic one. On the other hand the rapid progress in modern analytical techniques gives birth to hope that many new aromatic molecules will be isolated and characterised in the future. Moreover we have to remember that a lot of organic chemists from academic and industrial laboratories constantly modify known structures and synthesise new molecules with interesting fragrant properties which do not exist in nature, so we can expect new olfactory experiences.

**Conflict of interest**

The authors declare no conflict of interest related to this article.

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## Rośliny jako skarbnica substancji zapachowych dla przemysłu spożywczego i perfumeryjnego

**Streszczenie**

Artykuł poświęcony jest niektórym aspektom substancji zapachowych pochodzenia roślinnego, stosowanych jednocześnie w przemyśle spożywczym i perfumeryjnym. Od starożytności opracowano wiele technik ekstrakcji w celu uzyskania olejków eterycznych. Niektóre z nich są nadal stosowane. Nowe ekstrakcje, takie jak: mikrofalowe lub ultradźwiękowe, są coraz bardziej popularne i pozwalają zaoszczędzić czas oraz koszty. Niezależnie od procedury powstałe olejki eteryczne są źródłem wielu związków chemicznych, tzw. izolatów. Mogą one być stosowane jako dodatki do żywności lub jako materiały wyjściowe do syntezy organicznej. Niektóre substancje zapachowe występują w bardzo małych ilościach w materiale roślinnym, dlatego ekstrakcja nie jest opłacalna ekonomicznie, ale po ustaleniu ich struktur chemicznych i opracowaniu procedur syntetycznych, w niektórych przypadkach są one pozyskiwane na skalę przemysłową. Substancje opisane poniżej to tylko niewielka część z 2000–3000 pachnących cząsteczek, które sprawiają, że nasze życie jest przyjemniejsze, zarówno w jedzeniu, jak i perfumach.

**Key words:** essential oils, extraction techniques, food additives, fragrant substances**.**

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# Methods of protection against ticks (Acari: Ixodida)

Ticks are ruthless, dangerous ectoparasites that attack a large host circle. They are in the second place, after mosquitoes, in the rank of dangerous blood-drinking arthropods. The increased pace of urbanization and weather variability in recent decades have created new, convenient conditions for ticks to be found among people and pets. It is particularly dangerous as ticks carry numerous pathogens and spread tick-borne diseases, such as: Lyme borreliosis, tick-borne encephalitis (Fig. 1A–B), babesiosis, granulocytic anaplasmosis.

Depending on the morphological structure, ticks can be divided into proper (hard) (Ixodidae) and Argasidae (soft ticks) (Argasidae). Of the 19 species of ticks permanently found in the Polish fauna, *Ixodes ricinus* L. is – the common tick (Siuda, 1991) is the most common of the hard ticks (Appendix 1A). It occurs in green areas – not only along forest paths, in glades, and forest roads, but also increasingly in home gardens, playgrounds, and recreational places. In addition to the fact that ticks can be found in nature, during trips, picnics, walks, we also cannot feel safe in farm buildings and our own homes, due to the possible occurrence of a soft tick, *Argas reflexus* Fabr., attacking mainly nocturnal rock pigeons in lofts, attics of buildings, on church towers (Appendix 1B).

In terms of location of their occurrence, we can divide ticks into three ecological groups (Siuda, 1991) (Tab. 1): nest-burrow ticks – occurring in lofts, attics, caves, basements, animal cavities and burrows, in the nests of mammals and birds, and in their hollows on trees or in rock shelters. These ticks are usually host-specific species, they spend their entire lives in hideouts, where they can feed on their host who lives, sleeps, breeds and hibernates there. In hidden habitats, there are small fluctuations in climatic conditions; non-nest ticks – found in litter, near bird nests built on trees, among vegetation. They occupy more open environments, feed on busy, migrating

hosts, and are not attached to strictly located whereabouts and breeding of hosts. The survival of a hungry tick in such conditions depends mainly on its tolerance to changing environmental conditions, such as temperature, light, humidity; non-nest-burrow ticks – larvae and nymphs occur at the entrance and inside the burrows of mammals, while adults are non-nest parasites.

The differences in protection against tick attacks are primarily related to our whereabouts, and thus the possibility of encountering this dangerous parasite on its way. There are several options for protection against tick attacks, but there is no 100% effective way to avoid these parasites.

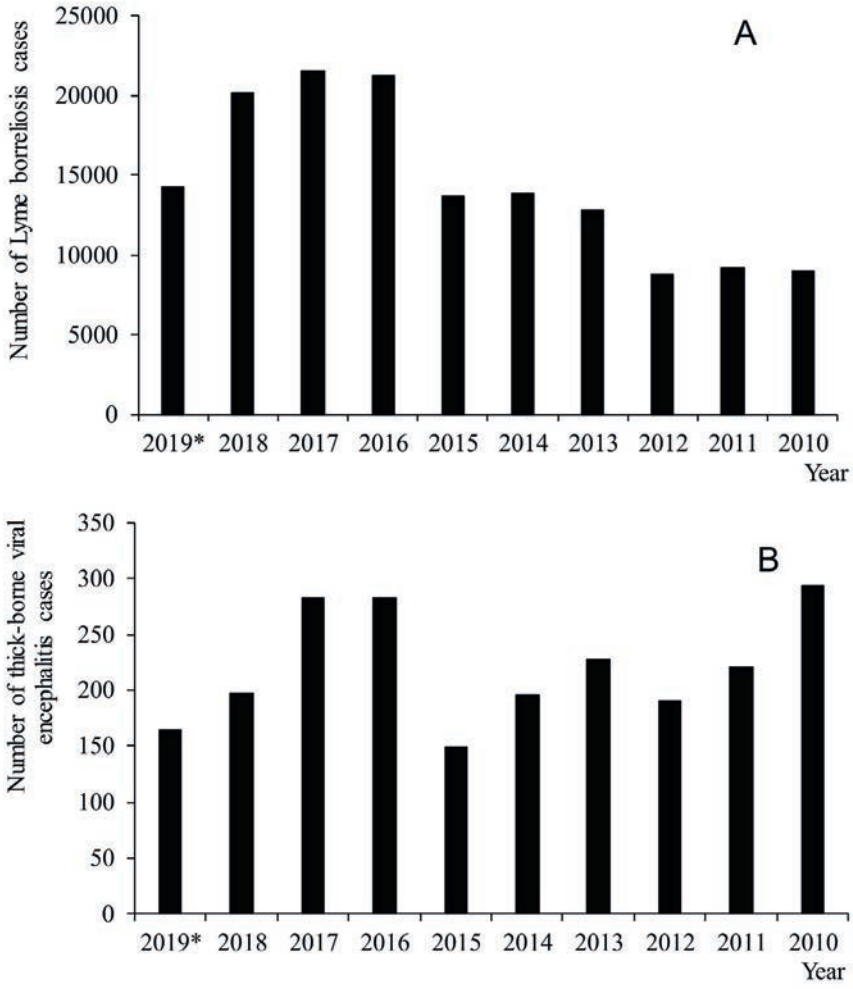


**Fig. 1.** The number of cases of selected tick-borne diseases in Poland; A – Lyme borreliosis, B – Tick-borne viral encephalitis;
*Data for day 30.09.2019 (Source: http://wwwold.pzh.gov.pl/oldpage/epimeld/index_p.html)

**Tab. 1.** Ecological groups of ticks found in Poland

| Ecological group | Tick species |
|---|---|
| nest-burrow | *Argas polonicus* Siuda, Hoogstraal, Clifford et Wassef |
| | *A. reflexus* Fabricius |
| | *Carios vespertilionis* Latreille |
| | *Ixodes apronophorus* Latreille |
| | *I. arboricola* Schulze & Schlottke |
| | *I. caledonicus* Nuttall |
| | *I. crenulatus* Koch |
| | *I. hexagonus* Leach |
| | *I. lividus* Koch |
| | *I. rugicollis Schulze* & Schlottke |
| | *I. simplex* Neumann |
| | *I. vespertilionis* Koch |
| non-nest | *Haemaphysalis concinna* Koch |
| | *H. punctata* Canestrini & Fanzago |
| | *Ixodes frontalis* Panzer |
| | *I. persulcatus* Schulze |
| | *I. ricinus* Linneus |
| | *I. trianguliceps* Birula |
| | *Dermacentor reticulatus* Fabricius – adults form |
| non-nest-burrow | *D. reticulatus* – larvae and nymphs |

Ticks on the host's body are looking for a suitable place, most often they are parts of the body with delicate skin, sweating: under the knees, groin, navel, armpits, at the base of the hair/neck, shoulders or behind the ears. In the case of pets, foraging of ticks is most often found around the neck, head, less often on the back and around the tail/anus (Siuda, 1991).

To defend against tick attacks, the following simple guidelines should be observed: avoid places typical for ticks (forest edges, forest paths, mid-forest clearings, animal trails covered with tall grass and bushes), thus avoid resting on the grass or in places covered with tall grass, lush vegetation, bushes; put on appropriate clothing, suitable for going out into the field, which will prevent ticks from moving onto the naked body: long trousers, with socks rolled out, high shoes, a long-sleeved sweatshirt inserted into trousers, headgear, neck coverage; use tick repellents in the form of sprays, creams, impregnation of things that are exposed to tick attacks, e.g. clothing, tents, blankets, footwear; parasite repellents should also be used for pets/farm animals; check the body for any ticks on clothing or exposed areas of the body; the tick inserted into the body should be removed as soon as possible using hygienic tweezers or special pliers available at pharmacies, pet stores; after returning home, check the body and the removed clothing, because ticks can wander unnoticed on the body or clothing; if we take a dog or a cat out, we also check its whole body after returning home; in addition,

taking a shower and thorough cleaning with a sponge can help get rid of ticks; people who often spend time actively in the nature, on trips or actively working professionally with the forest and green areas should receive protective vaccinations against tick-borne encephalitis after consulting a doctor.

The most commonly used procedures in the human environment aimed at reducing the number of ticks are: draining of wetlands, cutting or moving vegetation; systematic mowing of grass, removal of bushy thickets; limiting access of rodents and other wild animals to human buildings: removal of hideouts, landfills; in the case of soft ticks, systematic disinfection and protection of animal husbandry places: observation of farm animals, in lofts, checking the technical condition of the rooms; not allowing farm animals to move to human housing; rotations of pastures for grazing animals.

In recent years, attempts have been made to use natural organisms to fight ticks. These experiments are currently carried out on selected tick species, they are not long-term studies, so there is no 100% certainty that the given examples of animals eliminating tick populations can be used on a larger scale.

Among the animals, we can mention several examples that can reduce the population of ticks in the environment – ants: fire ant (*Solenopsis invicta* Bur.) (Castellanos et al., 2016); beetles: *Staphylinus caesareus* Ceder. – currently rare due to the use of a large number of spraying (Samish, Alekseev, 2001); bed bugs; butterfly larvae; flies: *Ixodiphagus hookeri* How., a small insect laying eggs in a tick larvae, which then becomes food for the hatched wasp larvae (Collatz et al., 2010) (Appendix 1 C-D); reptiles: sand lizard (*Lacerta agilis* L.); birds: domestic hens (*Gallus gallus domesticus* L.), ducks (*Anas* sp.), turkeys (*Meleagris gallopavo* L.), black grouse (*Lyrurus tetrix* L.), pheasants (*Phasianus colchicus* L.), partridges (*Perdix perdix* L.), helmeted guineafowl (*Numida meleagris* L.) – the fact that guineafowl eat adult ticks was confirmed by scientific research in 1990 in the USA (Duffy et al., 1992), red-billed oxpecker (*Buphagus erythrorhynchus* Stan.) (Bezuidenhout, Stutterheim, 1980), cattle egret (*Bubulcus ibis* L.); rodents: sorex, mice – deer mice (*Peromyscus leucopus* Rafin.) (Shaw et al., 2003), rats (*Rattus* sp. G. Fischer). Researchers (Angelo et al., 2015) inform that also some viruses, bacteria and fungi, e.g. *Metarhizium anisopliae* (Metch.) Sor. and Beauveria *bassiana* (Bals.-Criv.) Vuill. as well as nematodes (Samish et al., 2000), have the ability to reduce and weaken tick populations.

Research conducted by scientists shows that some plant species have deterrent properties and limit the occurrence of ticks in the area of cultivation of these plants, e.g. due to the intense smell caused by the release of specific essential oils into the air. However, it should be kept in mind that these are only experimental ways of fighting ticks so far. The research is carried out on selected species of ticks, on small populations, so this is not a fully proven method of protection against ticks. The plants listed

by scientists in the literature include, among others: tansy (*Tanacetum vulgare* L. – Appendix 1E) which is distinguished by a sharp spicy smell due to the essential oil – it repels not only ticks, but also mosquitoes, flies and aphids (Pålsson et al., 2008); horseradish (*Armoracia rusticana* P.Gaertn., B.Mey. et Scherb.) – an extract from the roots of horseradish not only repels but also kills ticks; catnip (*Nepeta cataria* L.) – contains nepetalactone – a compound that ticks and mosquitoes cannot tolerate (Birkett et al., 2011); sweet flag (*Acorus calamus* L.) – this plant's essential oil contains over 80% of azarone, which is a substance that repels ticks, mosquitoes, ants and flies (Ghosh et al., 2011); onion (*Allium cepa* L.) – according to Russian scientists, dried onion powder is one of the most effective ways to get rid of ticks (Aboelhadid et al., 2013); garlic (*A. sativum* L.) (Aboelhadid et al., 2013); wormwood (*Artemisia absinthium* L.) (Godara et al., 2015); wild garlic (*A. ursinum* L.); narrow-leaved lavender (*Lavandula angustifolia* Mill.) (Pirali-Kheirabadi, Teixeira da Silva, 2010); *Tanacetum cinerariifolium* (Trevir.) Sch. Bip. – the flowers of this plant contain cinerine and pyrethrin – toxic to insects (an extract from them is used in many insecticidal preparations); rosemary (*Rosmarinus officinalis* L. – Appendix 1F) (Martinez-Velazquez et al., 2011).

Repellents on sale are available in various forms: sprays, liquids in atomizers, lotions, gels, creams, wipes impregnated with a repellent substance, bracelets made of polyvinyl chloride (PVC) or silicone, plasters to stick on clothing or other surfaces, devices emitting ultrasonic sounds. In addition, pills, injections and spot-on are used for animals. Repellents may contain active substances of synthetic or natural origin. The most commonly used synthetic active ingredients are: N-N-diethyl-m-toluamide (DEET); ethyl ester of 3-(N-acetyl-N-butyl) amino propionic acid (IR3535); 1-piperidine-carboxylic acid KBR3023 (icaridine) (Przygodzka et al., 2019). In Poland, in 2016, research was carried out to determine the repellent effect of *Dermacentor reticulatus* Fabricius (meadow tick) ticks, products containing DEET, icaridine, IR3535 and a mixture of 3 substances: DEET, IR3535 and geraniol. Studies have confirmed that a repellent containing 30% DEET showed 90% repellence for ticks even after 7 hours from applying the repellent on human skin, while the activity of other substances decreased, the second best repelling compound was: 30% DEET, 20% IR3535 and 0.1% geraniol (60% of ticks not entering the skin after 7 hours). Products containing 20% of icaridine and 12% IR3535 repelled ticks effectively for 1.5 hour (Gliniewicz et al., 2019). However, it should be remembered that the tick species included in the research rarely attack humans, so it is necessary to carry out such experiments on a larger scale on the tick species *I. ricinus* most threatening the human species.

Ticks are very dangerous parasites for humans and animals, which in addition to causing direct effects of foraging (skin damage) can also be the transmitters of tick-borne diseases. Currently, these parasites occupy many convenient habitats, have many hosts and the risk of an attack by ticks throughout Poland is a common phe-

nomenon. Reducing the number of ticks will still remain the most sought after method for preventing these parasites from occurring in human and pet habitats, as well as from spreading dangerous tick-borne diseases. Research on controlling ticks is based mainly on chemical insecticides, which are not completely safe for humans and animals, and long-term tests of the environmental impact of these preparations are needed. There are several species of animals that eliminate the presence of ticks to some extent, and several species of plants that repel these dangerous parasites. However, the most promising method of bio-control so far is the use of fungal pathogens, reducing the number of ticks as well as affecting the movement and efficiency of parasites. All natural ways to prevent the occurrence of ticks are still sought after, improved and implemented in the environment, but it should be kept in mind that such actions do not cause changes in relationships in local trophic networks.

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**Conflict of interest**

The authors declare no conflict of interest related to this article.

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*Ixodiphagus hookeri* Howard: http://www.zeckenhilfe.com/en/all-about-ticks/article/what-are-the-natural-enemies-of-ticks-; *Ixodiphagus hookeri* attacking a fed female tick: https://alchetron.com/Ixodiphagus-hookeri

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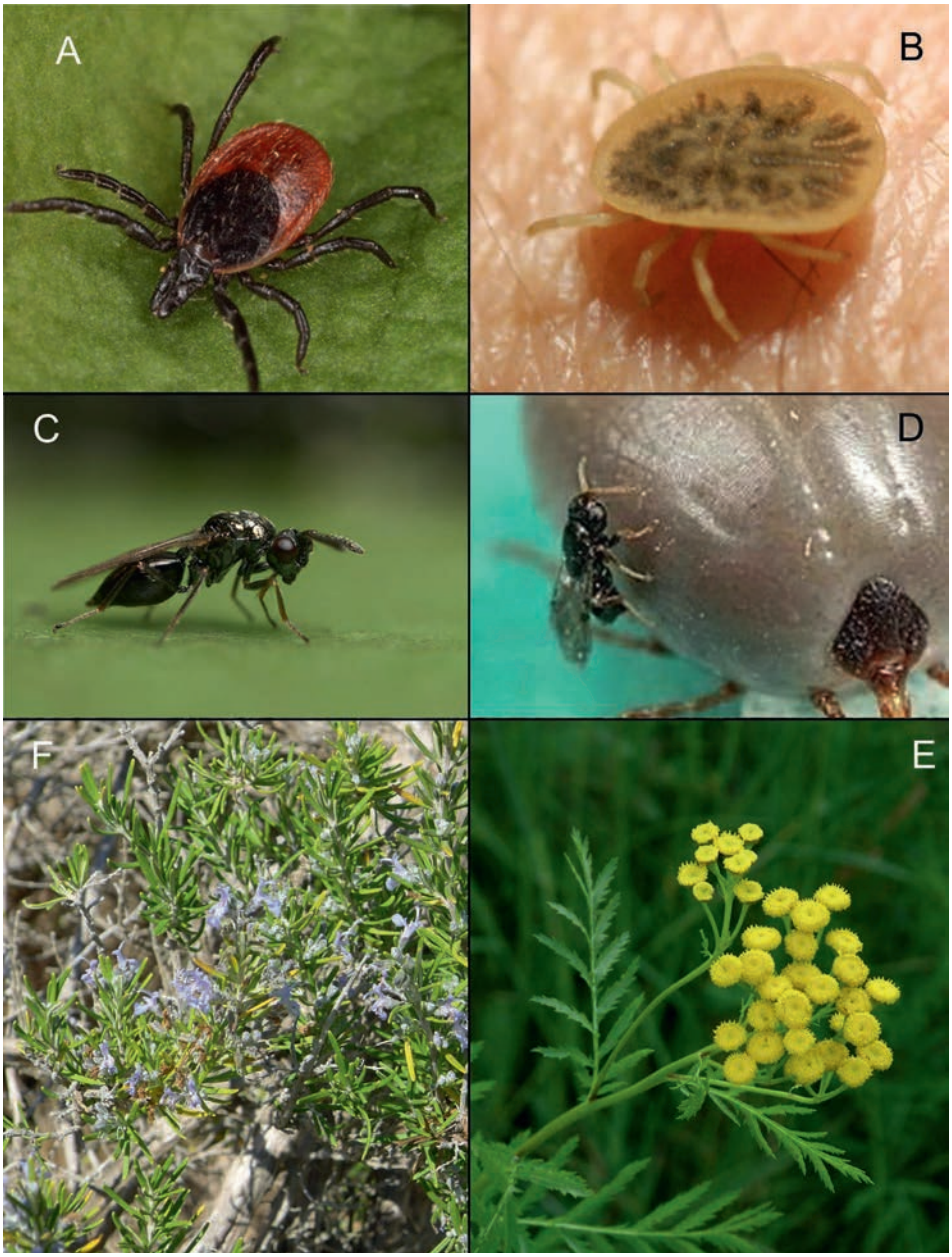
/magnoliopsida/asteraceae/tanacetum/vulgare-2.jpg

*The number of cases of selected tick-borne diseases in Poland. Data for day* 30.09.2019: http://wwwold.pzh.gov.pl/oldpage/epimeld/index_p.html

Appendix 1




A – *Ixodes ricinus* L. female (Source: https://www.gmx.net/magazine/wissen/natur-umwelt), B – *Argas reflexus* Fabricius (Source: https://zeckenrollen.de/zecken/zeckenarten-in-deutschland/), C – *Ixodiphagus hookeri* Howard (Source: http://www.zeckenhilfe.com/en/all-about-ticks/article/), D – *Ixodiphagus hookeri* attacking a fed female tick (Source: https://alchetron.com/Ixodiphagus-hookeri), E – *Tanacetum vulgare* L. (Source: http://www.nic.funet.fi/pub/sci/bio/life/plants), F – *Rosmarinus officinalis* L. (Photo. A. Kocoń)

## Metody ochrony przed kleszczami (Acari: Ixodida)

**Streszczenie**

Kleszcze (Acari: Ixodida) należą do roztoczy, pasożytujących najczęściej na gadach, ptakach i ssakach. Ze względu na znaczenie epidemiologiczne, epizootiologiczne, jak również bezpośrednią szkodliwość wśród ludzi i zwierząt, zaliczają się do jednych z najgroźniejszych pasożytów zewnętrznych. Na całym świecie stwierdzono występowanie około 850 gatunków kleszczy, w Polsce, do tej pory stwierdzono 19 gatunków stale występujących w faunie naszego kraju. Bytują one w różnych siedliskach od terenów nizinnych aż po tereny górskie, zajmując takie miejsca jak: lasy, tereny zieleni, strychy budynków w tym mieszkalnych i gospodarskich, nory, jamy zwierząt, jaskinie. Coraz częstsze występowanie kleszczy w bliskim otoczeniu człowieka i zwierząt przydomowych oraz domowych stwarza idealne warunki do przenoszenia patogenów chorób odkleszczowych. Nie ma wątpliwości, że stale poszukiwane są wszelkie sposoby ochrony osobistej i działania środowiskowe, chroniące przed atakami kleszczy oraz przed konsekwencjami jakie mogą wystąpić po żerowaniu pasożyta.

**Key words:** parasite, tick protection, ticks

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# Measures to achieve a stable farming system in sustainable agriculture – a short review

## Introduction

The rapid increases in human population and exploitative use of non-renewable resources have worsened food shortages (Amini et al., 2012; Esfandiary et al., 2012; Soleymani et al., 2012a–b; Shahrajabian et al., 2017, 2018; Ogbaji et al., 2018; Soleymani, Shahrajabian, 2018; Yong et al., 2018). In the context of improving the global food situation, chemical fertilisers play a dominant role (Yazdpour et al., 2012; Shahrajabian, Soleymani, 2017a–b). Most scientists believe that increasing yield per ha is a major way for increasing crops yield (Soleymani et al., 2016; Soleymani, Shahrajabian, 2017; Yong et al., 2017). Due to high costs and poor accessibility of inorganic fertilisers to resource-poor farmers, other inputs are oftentimes proposed as alternatives (Abedi et al., 2010; Shahri et al., 2011; Soleymani, Shahrajabian, 2012a; Shahrajabian et al., 2013). It is believed that much of deficient plant nutrients could be supplied to soils through organic matters while small shortage are made up with mineral fertilisers (Oluleye, Akinrinde, 2010; Ogbaji et al., 2013).

In forage production, considering chemical position of forage crop is important (Rezaeifard et al., 2010). Farmyard manure (FYM) contains very small amount of major nutrients and involves transportation. But, it maintains the soil physical and chemical condition and improves the overall ecological balance of the crop production system. FYM reduces the external inputs and can on self-regulating ecosystem process.

The aim of this research is to review intercropping, its importance and comparison of fertilisers, organic manures, and green manures.

### Intercropping

Intercropping is known as a practice, which can improve the utilisation of available resources and cause yield advantages and increases yield stability compared to sole

cropping (Soleymani et al., 2011e; Soleymani, Shahrajabian, 2012a). It is a sustainable practice used in many developed and developing countries and an essential element of agricultural sustainability (Singh et al., 2010). In intercropping system, there is normally one main crop and one or more added crops, with the main crop being of primary importance for food and forage production. The most important aim and advantage of intercropping is to produce a higher yield on a given piece of land by appropriate use of the available growth resources that may not be utilised by each single crop grown alone. There are different types of intercropping but the most important types are, row intercropping, strip intercropping, mixed intercropping and relay intercropping. Intercropping system may lead to soil conservation, improvement of soil fertility, and improvement of forage quality, reduction of pest and diseases.

The intercropping systems are old and widespread applications in low-input agricultural systems, and they were common for many countries before the modernisation of agriculture. There are both direct and indirect facilitative interactions of intercropping systems. Intercropping systems can cause more effective use of resources by providing symbiotic nitrogen from legumes or making available inorganic phosphorus fixed in soil because of lowering of pH via nitrogen fixing legumes. Also, more efficient water usage in intercropping systems was suggested by numerous researchers. Intercropping practices are the most productive when intercrops of different growth period are used so that their maximum requirements for growth resources occur at different times. They are the best way of introducing more biodiversity into agro-ecosystems and results have shown that increased crop diversity may increase the number of ecosystem service provided. These practices are the best way to ecological balance, more utilisation of resources, increase in the quantity and quality of agricultural products and significant reduction of damage and loss by pests, diseases and weeds. On the basis of multiple advantages of intercropping especially in the terms of sustainable agriculture and organic farming, it is clear that intercropping is more reasonable than sole cropping systems.

The agricultural use of a living cover crop during a crop growth cycle (relay intercropping) may help to preserve biodiversity, increase soil organic matter content and carbon sequestration and provide nutrient recycling (Shili-Touzi et al., 2010). Leguminous as a cover crops are extensively used in the tropics for soil conservation in plantation crops, maintaining it fertility. These plants have good potential for replacing many unwanted weeds (Olorynmaiye, 2010). For example, in potato and corn intercropping, Land Equivalent Ration (LER) reached 1.58 (Ebwongu et al., 2001). Bekele and Sommartya (2006) noticed that in intercropping of potato with garlic LER was more than one. According to Dua et al. (2005) the intercropping treatments increased yield as compared to sole-cropping. LER was higher than one in the intercropping of potato and pinto bean (Nasrollahzadeh Asl et al., 2009). Ghanbari et al. (2010) reported that

land equivalent ration values were higher in all intercropping systems with different planting ration of maize-cowpea which indicated the yield advantage of intercropping over sole cropping maize. Bilalis et al. (2005) reported that in the maize-bean intercrop system, LER values were statistically higher than in maize-cowpea.

The intercropping shows the beneficial effect on the quality and quantity of growth of crop plants. For example, Soleymani et al. (2012c) reported that in Iran there has been a rapid increase of fertiliser application in recent years to achieve high yields. Mix cropping legumes with cereal and grasses species were used for enhance nutrition value, supply energy and protein on both crops. This mixture offers a sustainable alternative to maintain efficient farming systems with reduced environmental impacts. The studies showed that intercropping causes yield advantage and better nutrition uptake. For suitable ways to animal's grazing were intercropping of berseem clover and forage corn in low input farming system and nitrate accumulation in clover.

The intensive cropping system, heavy input technology, environmental degradation and other related problems again encouraged to use green manuring in plant nutrient supply system. Residue burning accompanied with usage of triticale as a green manure was the best choice to achieve high quality. For obtaining the most fresh forage yield and biological yield of forage corn, triticale plantation can be replaced by barley cultivation. Four weeks of residue retention accompanied by using of barley as green manure led to the highest yield and yield components of forage corn. That is why, the green manuring is an age-old practice used for supplying nitrogen to crop plants.

## Fertiliser

Low-input farming systems such as arable organic farming, often have limited access to nitrogen and decreased the productivity of these systems (Marsalis et al., 2010; Soleymani et al., 2010, 2011e, 2012a; Soleymani, Shahrajabian, 2012b; Abdollahi et al., 2018). The minimal or no fertiliser input causes serious nutrient depletion, which coupled with the low fertility status of soil is the major limiting factor to crop production. Increasing nitrogen supply enhances both growth of shoot and root of plants (Shahrajabian et al., 2011; Soleymani, Shahrajabian, 2011).

To optimise plant production and minimise production cost needed is supplemental nitrogen application (Ahmadi Moghaddam et al., 2010; Kayan, 2010; Soleymani et al., 2013). Inadequate amount of nutrient availability can show deficiency symptom and influence on the quality and quantity of yield of crops. In most commercially available fertilisers, the concentrations of active ingredients rapidly decreased due to chemical, photochemical and biological degradation, volatilisation, leaching, adsorption or immobilisation in soil (Broumand et al., 2010; Xiong et al., 2010).

Farmers often intercrop on soils without adequate knowledge of the right quality of fertilisers to be applied. By human activity nitrate found naturally at moderate

concentrations in many environments often rises to dangerous level. For example, nitrogen fertilisers affect yield and nutritive value of corn (Marsalis et al., 2010). Combined organic and inorganic fertilisation enhances organic matter in soil and increases yield of sweet maize (Efthimiadou et al., 2010). However, the application of excessive amounts of nitrogen can cause the accumulation of toxic levels of nitrate ($NO_3^-$) in plants (Gulmezoglu et al., 2010; Khoshkharam et al., 2010; Soleymani, Shahrajabian, 2013). Nitrate toxicity in forage plants can cause chronic or acute stress in livestock.

## Manure

Organic farming, which evolved in the 1980s, is one way to solve the current farming problems. In this method, manure and green manure is used instead of chemical fertilisers (Soleymani et al., 2011b–d; 2012b). Because of this substitution, the food and environment become safer. Manures are very variable products, often difficult to apply accurately and release nutrients in the soil at a desirable rate. Some studies have shown that farmyard manure applied alone or in combination with inorganic fertilisers was effective in maintaining soil fertility under continuous cultivation. Applying farm manure increased cation exchange capacity (CEC), organic carbon and water holding capacity of the soil and nutrient availability. For example, a dairy manure is an excellent source of nitrogen for crops and can easily fulfil the nitrogen requirement. To get satisfactory results well-composted manure must be used, because it is usually free of weed seeds and has a better nutrient balance. Barmaki et al. (2008) reported that the yields of potato plots in which manure was used were 0.4 kg $m^{-2}$ higher than in plots that receive only chemical fertilisers. It has been noted that application of organic manure has a more lasting beneficial residual effect that can remain significant up to four seasons when compared with inorganic fertilisers whose residual benefit do not last beyond season (Babaji et al., 2010). Liu et al. (2010) reported that sheep manure had no significant effect on rice's characteristics. Long term application of NPK and pig manure together with straw return to field produced highest rice grain yield. Future of agriculture lies in the development of organic based fertilisers.

FYM improves plants production better than mineral fertilisers as the crop is not capable of optimising single application of inorganic fertilisers but prefers slow continuous release of nutrient that is possible with the use of organic manure.

## Green manure

Symbiotic $N_2$ fixation (SNF) in legumes is a fundamental process for maintaining soil fertility continued productivity of organic cropping systems (Singh et al., 2010). It is very often used in inter-row crops. One of the benefits of this kind of crop is having high potential of extrapolation. Cultivation of legumes together with non-legume

plants is a common practice in the world. Mixture of annual legumes and cereals is intensively cultivated in the world as a forage. Recently increasing interest of intercropping as an attempt to substantiate functional biodiversity for agriculture and reduce chemical inputs use was observed. For example, Sulc et al. (1993) concluded that ryegrass-alfalfa mixtures cultivate in North-Central USA can provide a good forage.

The typical organic production is characterised by extended rotations involving leguminous crop green manure and organic amendments utilisation (Soleymani et al., 2011a–b; Soleymani, Shahrajabian, 2012c). Canali et al. (2010) noted that supply of nitrogen from the soil, which consist of nitrogen mineralised from organic soil matter and crop residue is an important and variable contributor of nitrogen to potato crop production. Without organic farming, food security will be hampered (Sarker, Itohara, 2010). Legumes are often grown for incorporation into soil as a green manure providing benefits such as off-season soil cover, stimulated soil biological activity and improved plant nutrition (Soleymani et al., 2011c). Most interest has been attached to the legume's ability to furnish subsequent crops with readily available nitrogen (N). Some plants used for the production of green manure can significantly increase in yield of crops (Singh et al., 2010).

## Conclusion

Sustainable agriculture means a shift from monoculture to intercropping. In other words, intercropping means the agricultural cultivation of two or more crops in the same space and at the same time. Sustainable farming also means self-sustaining, low-input and energy-efficient agricultural systems. Biodiversity is the main key and strategy for sustainable agriculture. Application of organic and synthetic fertilisers to soil would provide multiple benefits for improvement of soil chemical, physical and biological properties leading to improved crop yield. Integrated use of synthetic and organic fertilisers leads to development of sustainable crop production. Also, this may improve the efficiency of synthetic fertilisers and reduce their usage. Integrated use of organic and synthetic fertilisers is a good method to improve crop productivity and sustain soil quality and fertility. In sustainable agricultural system, fertilisers, livestock manure and cover crops are important parameters in productive agricultural systems to have stable food.

**Conflict of interest**

The authors declare no conflict of interest related to this article.

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## Środki służące do uzyskania stabilnego systemu rolnego w zrównoważonym rolnictwie – krótki przegląd

**Streszczenie**

Zrównoważony system rolny jest najlepszym sposobem na zaspokojenie potrzeb dzisiejszych i przyszłych pokoleń. W systemie tym wielkość plonu wzrasta wraz z zastosowaniem upraw międzyrzędowych, poprzez wyższy współczynnik wzrostu roślin, redukcję nasion chwastów, ograniczenie ilości szkodników i chorób oraz bardziej efektywne wykorzystanie zasobów. Uprawa międzyrzędowa jest jednym z najważniejszych sposobów zwiększenia różnorodności w ekosystemie rolniczym. Systemy międzyplonowe mogą być bar-

dziej stabilnymi systemami praktyk rolniczych niż uprawy monokulturowe. Najważniejszymi zaletami uprawy międzyrzędowej są: zwiększenie produkcji rolnej i większe wykorzystanie zasobów środowiska. Zintegrowane stosowanie nawozów syntetycznych i organicznych może również prowadzić do rozwoju zrównoważonej produkcji roślinnej. Metoda ta poprawia wydajność działania nawozów chemicznych i jednocześnie ogranicza ich stosowanie. Zielony nawóz z roślin strączkowych, takich jak: koniczyna, lucerna i inne, które są bogatym źródłem azotu uwalnianego w glebie, jest w stanie zmniejszyć znacząco zapotrzebowanie na azot syntetyczny. Tego rodzaju biologiczne wiązanie azotu odgrywa bardzo ważną rolę w zrównoważonych systemach rolniczych. W zrównoważonym systemie rolnym nawozy, odchody zwierzęce i rośliny uprawne oraz chwasty są ważnymi parametrami dla zapewnienia stabilnej produkcji żywności.

**Key words:** intercropping, chemical fertiliser, manure, sustainable agriculture, stable system

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# Cyanobacteria and cyanometabolites used in the pharmaceutical and medical industry

## Introduction

Cyanobacteria from marine and freshwater habitats are known to produce a diverse array of active compounds (cyanometabolites). These include low molecular weight peptides, polysaccharides, fatty acids, phenols and alkaloids (Burja et al., 2001; Mazur-Marzec et al., 2015). Some of them are a threat to human and environmental health. But many of these natural products possess considerable interest due to their potential applications (Berry et al., 2008; Leão et al., 2012; Almeida et al., 2015). It was estimated that out of the 660 new compounds identified in marine bacteria in the years 1997–2008, till 33% were derived from cyanobacteria (Imhoff et al., 2011). These compounds could be used to obtain commercial algaecides, herbicides, and insecticides. Furthermore, some of these chemical substances demonstrated antifungal, antibacterial, antiviral and even antitumor activity, which could lead to the development of new drugs from them (Berry et al., 2008). Thus, the issue of commercial application of cyanobacteria and their cyanometabolites requires more attention and investigation.

The first discovery of the healing properties of cyanobacteria took place in 1500 B.C. where the *Nostoc* sp. species was used to treat several forms of cancer (Singh et al., 2011). In recent years, many studies have been conducted on the use of cyanobacteria as a potential source of new biologically active substances e.g., microginine, cyanopeptin, aeruginosine and spumigine (Głowacka et al., 2007). The last two can be used to treat hypertension, cardiovascular diseases, and viral infections. In turn, microginine is used to cure hypertension, and cyanopeptin for asthma and viral infections (Singh et al., 2011). Bouillomides A and B from *Lyngbya bouillonii* L.Hoff. & V.Dem. are strong inhibitors of serine protease, elastase, and chymotrypsin (Rubio et al., 2010). Particularly valuable are such compounds that have of antiviral (cyanovirin, scytovirin), antifungal (fischerelin, cryptophycin, calophycin), antibacterial

(microviridine, muscoride, nostocin A), antitumor (apratoxins A and D, dolastine) and antimalar (ambigol C) nature (Wright et al., 2005; Głowacka et al., 2007). In the years 1981–2002, over 60% of anti-cancer and anti-infectious drugs were of natural origin. Currently, due to the high costs of introducing new products to the market by the pharmaceutical industry (500–2000 million dollars), the number of new drugs is decreasing. Currently, drugs are becoming less effective because the resistance of pathogens to antibiotics is increasing. Therefore, it is important to explore new biologically active compounds to produce new drugs (Lam, 2007).

The main aim of this study was to present the knowledge on active compounds of cyanobacteria, which may have potential applications in the pharmaceutical and medical industries. This topic is very important but is still not sufficiently understood. For centuries, human diseases have been treated with natural products because these plant-based, natural drugs are much healthier than their chemical counterparts. In this paper, we showed the positive aspects of cyanobacteria cultivation and possibilities of its commercial use. Algae nomenclature was used here according to *AlgaeBase* (https://www.algaebase.org/) and other microbes from different sources.

## Medical and pharmaceutical use of cyanobacteria

Initial knowledge of the properties of cyanobacteria enabled their application on an industrial, pharmaceutical, and medical scale. They produce many biologically active cyanometabolites which have, among others, anticancer, antifungal, antiviral, anti-inflammatory, and antimalarial properties (Gupta et al., 2013; Fig. 1). Cyanobacteria also contain pigments that can strengthen the immune system, and even reduce the risk of heart disease multiple sclerosis, cataracts, and age-related diseases, as well as prevent cancer. Pigments can be used both as medicines and cosmetics, as well as natural pigments for products including ice cream, sweets, soft drinks, and milk products. Extract from blue pigment, which is phycocyanin, obtained from the species of e.g., *Arthrospira* sp., is used in eye shadow, lipsticks and eyeliner. Moreover, this pigment inhibits pancreatic lipase and also, depending on the dose, the growth of Ehrlich cancer cells (El-Baky, 2003). Carotenoids, which are antioxidants, are also anti-cancer drugs substances (Sheih et al., 2009). Chlorophyll together with pigments such as phycocyanin and phycoerythrin have a protective effect against UV radiation on the skin, thus delaying the aging process. In addition, cyanobacteria produce polysaccharides that have the ability to stabilise emulsions and suspensions, form gels, etc., and these can be used in the cosmetics industry as ingredients in nutrients, creams and many other similar products, as well as in the pharmaceutical industry as ingredients in medicines (Głowacka et al., 2007; Tab.1).

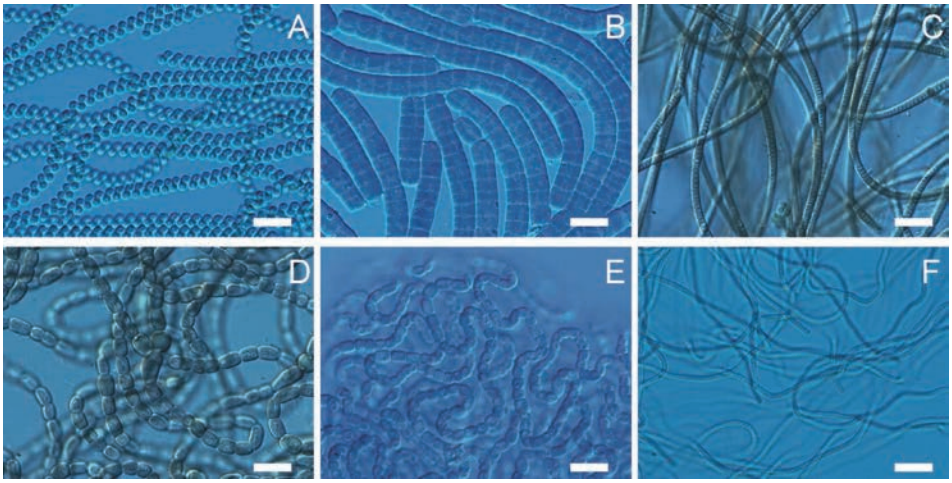


**Fig. 1.** Examples of cyanobacteria as a potential source for commercial applications: *Arthrospira* sp. (A), *Lyngbya* sp. (B), *Leptolyngbya* sp. (C), *Nostoc* cf. *commune* Vauch. ex Born. & Flah. (D), *Nostoc muscorum* C.Ag. ex Born. & Flah. (E), and *Pseudanabaena* sp. (F). Scale bar = 10 μm (Photo. S. Śliwińska-Wilczewska)

## Micro- and macroelements from cyanobacteria

Perhaps, cyanobacteria *Arthrospira platensis* Gomont can be the richest source of vitamins as well as macro- and microelements. They contain nutrients, i.e. *β*-carotene (with antioxidant properties which protect the organism against free radicals), iodine, selenium, zinc, iron, magnesium, manganese, copper and γ-linolenic acid, derived from the group of omega-6 fatty acids, glycolipid H-b2, which is an inhibitor of pancreatic lipase and vitamin B12, which is necessary for the proper functioning of nerve tissue, B1, B2, B3 and E (Klasik et al., 2010; Gupta et al., 2013). Isolated compounds of the *Arthrospira* sp. species have nourishing, strengthening and detoxifying properties, and the extract from its cells has antiallergic, antiviral properties, inhibits carcinogenesis processes, and also reduces blood cholesterol (Głowacka et al., 2007). *Arthrospira* sp. is also rich in proteins – contain their about 60% (Ishimi et al., 2006). It also helps alleviate the occurrence of anemia during pregnancy (Nuhu, 2013).

## Cyanobacteria compounds with antiviral activity

Viral diseases, including HIV, affects many people around the world. According to WHO and UNAIDS, 36.7 million people lived with HIV at the end of 2016, of which 1 million died due to it. Thousands of marine organisms, including cyanobacteria, have been tested for antiviral properties (Yasuhara-Bell, Lu, 2010). Such an antiviral compound is cyanovirin produced by *Nostoc ellipsosporum* Rabenh. ex Born. & Flah.

This protein inhibits proliferation of HIV-1, HIV-2, acquired immunodeficiency virus FIV cats and SIV monkeys (Głowacka et al., 2007). Nostoflan polysaccharide from *N. flagelliforme* (Born. & Flah.) Elen. also has activity against the herpes-1 virus (Singh et al., 2011). Scytovirin isolated from the aqueous extract of *Scytonema varium* Kütz. ex Born. & Flah. is also an antiviral protein. It acts similarly to the already mentioned cyanovirin, because both inhibit the process of virus absorption on the surface of host cells. It has been proven that if scitovirin is given up to 8 hours after infection with the virus, it successively prevents the development of infection (Bokesch et al., 2003). In 2002, water extracts from *Arthrospira maxima* Setchell & N.L.Gardner cells were tested and they were shown to inhibit the development of infections caused by the HSV-2 and HSV-1 herpes virus, CMV cytomegalovirus and the virus causing Aujeszky's PRV disease. Polysaccharides produced by cyanobacteria including *A. platensis*, demonstrated the ability to inhibit the replication of HSV, HIV-1, HIV-3, influenza A, and mumps virus, which were cultured in suspensions of human cell cultures (Głowacka et al., 2007). Zainuddin et al. (2002) researched the aqueous and methanolic extract from cyanobacterial cultures of the genus *Calothrix*, *Microcystis*, *Nodularia*, *Oscillatoria*, *Lyngbya* and *Scytonema* to check their activity against influenza A virus in a dog's kidney cells. The most effective extract turned out to be obtained from cyanobacteria of the genus *Microcystis*. A reduction of approximately 90% in viral replication was observed due to protease inhibiting activity. None of the methanol extracts was cytotoxic. Besides, Lau et al. (1993) tested the ability of aqueous cyanobacterial extracts to inhibit reverse transcriptase RT of the avian myeloblastoma virus AMV and HIV and it was proved that 18 (2.0%) extracts showed this possibility in the range of over 50%. On this basis, it was concluded that cyanobacteria can be a promising source of compounds used for viral therapies.

## Cyanobacteria compounds with antibacterial activity

Kreitlow et al. (1999) studied hydrophilic and lipophilic extracts of cyanobacteria for their antibacterial activity. In the case of Gram (-) bacteria, no inhibitory activity was found. While for Gram (+) seven species of cyanobacteria from twelve (*Anabaena lemmermannii* P.G.Richt., *A. solitaria* Kleb., *Limnothrix* sp., *Microcystis ichthyoblabe* (G.Kun.) Kütz., *Nodularia* sp., *Oscillatoria rubescens* DC ex Gomont, *O. tenuis* C.Ag. ex Gomont) showed high activity against at least one of the bacteria such as: *Bacillus subtilis* Ehren., *Micrococcus flavus* Cohn and *Staphylococcus aureus* F.J. Rosenbach. In terms of antibacterial activity, Oufdou et al. (2001) tested the benthic species of cyanobacteria *Pseudanabaena* sp. and they showed that the extracts secreted by these organisms inhibited the growth of bacteria *Escherichia coli* T. Esch., *Salmonella* sp. and *Staphylococcus aureus*. In turn, antibacterial activity against *Bacillus cereus* Frank. &

Frank., *Escherichia coli* and *Staphylococcus epidermidis* Evans have a compound called noscomin obtained from *Nostoc commune* Vauch. ex Born. et Flah. (Singh et al., 2011). Gutiérrez et al. (2008) isolated two abietane diterpenes from *Microcoleous lacustris* Desikachary and proved that they showed activity against bacteria *Salmonella typhi* (=*S. enterica* (ex Kauff. & Edw.) Le Minor & Popoff serovar Typhi), *Staphylococcus aureus*, *S. epidermidis* and *Vibrio cholerae* Pacini. Another species of cyanobacteria that produces antimicrobial peptides, including microviridine and cavaguchipeptin is *Microcystis aeuroginosa* Kütz. In addition, antibacterial activity was discovered from muscoride isolated from *Nostoc muscorum* C.Ag. ex Born. & Flah., bastadine from *Anabaena basta*, microsporins from *Nostoc commune*, nostocycline A from *Nostoc* sp. and nostocin A from *N. spongiaeforme* C.Ag. ex Born. & Flah. All these metabolites have antibacterial properties because they can destabilise bacterial cell walls (Głowacka et al., 2007).

## Cyanobacteria compounds with antifungal activity

Many cyanobacteria also exhibit properties to inhibit fungal life processes. The methanol extract from *Anabaena solitaria* Kleb. has antifungal activity against *Alternaria alternate* (Fr.) Keissl., *Botrytis cinereal* Pers., and *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. Similarly is with cells from cyanobacteria *Nostoc commune*, which, in addition to the fungi mentioned above, also act against *Fusarium oxysporium* Schltdl., *Phytophthora capsica* Leon., *Pythium ultimum* Trow and *Rhizopus stolonifer* (Ehrenb.) Vuill. (Kim, 2006). The anti-fungal activity was also shown by ambigol A and B from *Fischerella ambigua* (Kütz. ex Born. & Flah.) Gomont (Falch et al., 1995), fischerellin from *F. muscicola* Gomont (Srivastava et al., 1998) and tanicolide cryptophycins, and A-D majuskulamides from *Lyngbya majuscula* Harv. ex Gomont (Głowacka et al., 2007).

## Cyanobacteria compounds with anti-cancer activity

It was found that some cyanometabolites have apoptotic properties. Such type of action have got, among others, dolastine, which was initially isolated from sea hares (family Aplysiidae), but later it was discovered that it is also produced by cyanobacteria (Costa et al., 2012). Thus, this compound can be used to suppress unnecessary and potentially harmful cells. Dolastine 10, a pentapeptide produced by *Symploca* sp., induces apoptosis of human lymphoblastic leukemia cells (Wall et al., 1999) and also has an inhibitory effect on lung cancer cells (Kalemkerian et al., 1999). Apatoxin D isolated from *Lyngbya* sp. has similar cytotoxic properties concerning lung cancer (Gutiérrez et al., 2008). Apratoxin A, extracted from *L. majuscula* Harv. ex Gomont cells, inhibits bone

sarcoma cancer cells (Liu et al., 2009). Microcyclamide from *Microcystis aeuroginosa* has cytotoxic properties on murine P388 leukemia cells (Ishida et al., 2000). Calothrixin from cyanobacteria *Calothrix* sp. inhibits the growth of HeLa cervical cancer cells (Rickards et al., 1999). Majngulamide C from *Lyngbya majuscula* has inhibitory activity against lung cancer, large intestine cancer and glioblastoma cells (Vijayakumar, Menakha, 2015). Coibamide from *Leptolyngbya* sp. is a cyclic depsipeptide that causes cell cycle inhibition in the G1 phase for MDA-MB-435 breast cancer (Costa et al., 2014). Cryptophycin-1 from *Nostoc linckia* Born. ex Born. & Flah. has a cytotoxic effect on cancer cells of the large intestine, prostate, solid tumors, colon cancer HT-29, Caco-2 and GC3, breast cancer MCF-7 and MDA-MB-231, HeLa cervical cancer, and also leukemia U937, CCRF-CEM and HL-60 (Shih, Teicher, 2001; Singh et al., 2011; Vijayakumar, Menakha, 2015). Nodularins and microcystin from cyanobacteria are toxic inhibitors of protein phosphatases PP1 and PP2A therefore, after appropriate chemical modification they can be used to produce analogues of potential drugs used to inhibit the processes leading to the formation of cancer (Łukomska et al., 2002). Costa et al. (2014) tested the anti-cancer activity of marine cyanobacterial strains. Five of them were the most interesting in terms of bioactive compounds: *Leptolyngbya fragilis* (Gomont) Anag. & Kom., *L. halophila* (Hansgirg) Anag. & Kom., *L. mycoidea* (Frémy) Anag., *Nodosilinea nodulosa* (Z.Li & J.Brand) Perkerson & Casamatta and *Synechocystis salina* Wislouch. It was also shown that two of them – *L. fragilis* and *S. salina* – are the most bioactive against cancer cells.

## Cyanobacteria compounds with antiprotozoal activity

Tropical diseases such as malaria, cholera, leishmaniasis, African coma, schistosomiasis caused by protozoa are equally dangerous. According to WHO, over a billion people struggle with one or more of these diseases (Simmons et al., 2008). Cyanobacteria have been found to contain compounds that inhibit protozoa that cause these diseases. Viridamide A is a compound isolated from *Oscillatoria nigrovirdis* Thwaites ex Gomont that acts against *Trypanosoma cruzi* Chagas, *Leishmania mexiana* Garnham, and *Plasmodium falciparum* Schaudinn (Singh et al., 2011). Ambigol C from *Fischerella ambigua* (Kütz. ex Born. & Flah.) Gomont acts against *Trypanosoma rhodesiense* and *P. falciparum* (Wright et al., 2005). In addition, a compound called nostocarboline extracted from *Nostoc* sp. also exhibits activity against protozoa such as *Leishmania donovani* Ross, *P. falciparum*, *Trypanosoma brucei* Plimmer & Bradford and *T. cruzi* Chagas (Singh et al., 2011).

**Tab. 1.** Examples of cyanobacterial with potential use in medicine and pharmaceutical industry

| Cyanobacteria | Effect | References |
|---|---|---|
| *Arthrospira platensis* Gomont | Antiviral activity (HIV type 1, Herpes simplex, Polio) | Głowacka et al. (2007) |
| *Dichothrix baueriana* Born. & Flah. | Antiviral activity (Herpes simplex type 2) | Larsen et al. (1994) |
| *Fischerella muscicola* Gomont | Fungicides | Hagmann and Jüttner (1996) |
| *Lyngbya lagerheimii* (Gomont ex Gomont) Anag. & Kom. | Antiviral activity (HIV type 1) | Gustafson et al. (1989) |
| *Lyngbya* sp. | Antitumor activity | Simmons et al. (2005) |
| *Nostoc* sp. | Cholinesterase inhibitor (Alzheimer's disease) | Blom et al. (2006) |
| *Oscillatoria agardhii* Gomont | Larvicidal activity | Harada et al. (2000) |
| *Phormidium tenue* Gomont | Antiviral activity (HIV type 1) | Gustafson et al. (1989) |
| *Phormidium* sp. | Fungicides (oral candidiasis) | Garima et al. (2013) |
| *Pseudoanabaena* sp. | Antibacterial activity (*E. coli*, *Salmonella* sp.) | Głowacka et al. (2007) |
| *Scytonema ocellatum* Lyngb. ex Born. & Flah. | Fungicides | Patterson and Bolis (1995) |
| *Symploca hydnoides* Kütz. ex Gomont | Antiparasitic activity (malaria, Chagas disease) | Linington et al. (2008) |
| *Westiellopsis* sp. | Larvicidal activity (malaria, meningitis) | Rao et al. (1999) |

## Conclusions

Cyanobacteria have a wide range of occurrences and occupy many habitats, including oceanic areas, freshwater lakes, and even extreme habitats such as deserts, coastal rocks, glacial lakes or hot springs. In eutrophic and hypertrophic waters, cyanobacteria often dominate the phytoplankton in the summer period, creating a massive and harmful bloom. Some cyanobacteria produce toxins that can significantly affect human health. However, even though cyanobacteria contain toxic substances, there are species whose secreted organic compounds can be used as a potential source for commercial applications. The properties of cyanobacteria discussed in this work emphasize how these organisms can be potentially used by humans in many areas of their life. Cyanometabolites can serve as drugs for incurable diseases such as cancer or other diseases caused by bacteria, viruses, fungi or protozoa. However, the composition and functional role of many cyanometabolites remain unknown, therefore, the issue of commercial application of cyanobacteria and their cyanometabolites require more attention and investigation.

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**Conflict of interest**

The author declares no conflict of interest related to this article.

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## Cyjanobakterie i cyjanometabolity stosowane w przemyśle farmaceutycznym oraz medycznym

### Streszczenie

Związki bioaktywne sinic wykazują różnorodne właściwości, które potencjalnie mogą być wykorzystane w wielu sektorach przemysłu. W artykule tym szczególny nacisk położono na wykorzystanie sinic i ich cyjanometabolitów, zarówno w przemyśle farmaceutycznym, jak i medycznym. Scharakteryzowano związki wyizolowane ze szczepów sinic, które można stosować do wytwarzania leków o działaniu przeciwwirusowym, przeciwgrzybiczym, przeciwnowotworowym, przeciwdrobnoustrojowym oraz przeciwbakteryjnym. Pokazano również pozytywne aspekty hodowli sinic i możliwości ich komercyjnego wykorzystania.

**Key words:** applications, blue-green algae, cyanobacteria, cyanometabolites, industry

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# 21st International Symposium "Parasitic and allergic arthropods – medical and sanitary significance" (May 4–6, 2019, Janowiec near Vistula River, Poland)

# XXI Międzynarodowe Sympozjum „Stawonogi pasożytnicze, alergogenne i jadowite – znaczenie medyczne i sanitarne" (4–6 maja 2019, Janowiec nad Wisłą, Polska)

On May 4–6, 2019, in Janowiec near Vistula River, the 21st International Symposium "*Parasitic, allergenic and poisonous arthropods – medical and sanitary significance*" took place. As every year, the organisers of the symposium included the Medical University of Lublin and the Foundation for the Control of Ticks and Prevention in Tick-borne Diseases in Lublin. The aim of these cyclical Symposia is to present current research conducted in domestic and foreign scientific units, on parasitic, allergenic and poisonous arthropods, especially ticks. In this year's edition, Symposium participants also discussed the problems of tick-borne diseases and the search for effective ways to prevent and monitor this type of threats.

On the first day of this year's Congress (May 4), participants were registered and dinner was planned. The official opening of the 21st Symposium by Prof. Alicja Buczek, head of the Department and Faculty of Biology and Parasitology of the Medical University of Lublin, took place in the Oblasówka Guesthouse on May 5. Further proceedings of this year's Symposium were also held there.

W dniach 4–6 maja 2019 roku w Janowcu nad Wisłą, odbyło się XXI Międzynarodowe Sympozjum „*Stawonogi pasożytnicze, alergogenne i jadowite – znaczenie medyczne i sanitarne*". Organizatorami Sympozjum, jak co roku, były następujące jednostki: Uniwersytet Medyczny w Lublinie oraz Fundacja na Rzecz Zwalczania Kleszczy i Profilaktyki w Chorobach Odkleszczowych w Lublinie. Celem tych cyklicznych Sympozjów jest prezentacja aktualnych badań, prowadzonych w krajowych i zagranicznych jednostkach naukowych, dotyczących stawonogów pasożytniczych, alergogennych i jadowitych, w tym szczególnie kleszczy. W tegorocznej edycji uczestnicy Sympozjum dyskutowali również nad problemami chorób odkleszczowych oraz nad poszukiwaniem skutecznych sposobów zapobiegania i monitorowania tego rodzaju zagrożeń.

W pierwszym dniu tegorocznego Zjazdu (4 maja) odbywała się rejestracja uczestników oraz została zaplanowana kolacja. Oficjalne otwarcie XXI Sympozjum przez Prof. dr hab. Alicję Buczek, kierownika Katedry oraz Zakładu Biologii i Parazytologii Uniwersytetu Medycznego w Lublinie, miało


**Fig. 1.** Prof. Branislav Petko during lecture (Photo. A. Kocoń)
**Ryc. 1.** Prof. dr hab. Branislav Petko w trakcie wykładu (Fot. A. Kocoń)

The first paper was presented by Prof. Michał Stanko from the Institute of Parasitology of the Slovak Academy of Sciences, who reported on the many years of research results in monitoring the presence of ticks in Kosice. Then, you could listen to another interesting paper on the impact of the electromagnetic field on the meadow tick *Dermacentor reticulatus* Fabr., delivered by Prof. Branislav Petko from the same scientific centre (Fig. 1).

After a short coffee break, oral presentations continued, among others, by Assoc. Prof. Slawomir Pancewicz from the Medical University of Bialystok discussed the subject of tick-borne diseases in Poland, especially Lyme disease. As a practitioner, he presented many facts about this disease, while dispelling the commonly circulating myths

miejsce w Pensjonacie Oblasówka w dniu 5 maja. Tam również odbywały się dalsze obrady tegorocznego Sympozjum. Pierwszy referat został zaprezentowany przez Prof. dr hab. Michała Stanko z Instytutu Parazytologii Słowackiej Akademii Nauk, który zreferował wieloletnie wyniki badań z monitoringu występowania kleszczy w Koszycach. Następnie można było wysłuchać drugiego ciekawego referatu, dotyczącego wpływu pola elektromagnetycznego na kleszcza łąkowego *Dermacentor reticulatus* Fabr., wygłoszonego przez Prof. dr hab. Branislava Petko z tego samego ośrodka naukowego (Ryc. 1).

Po krótkiej przerwie kawowej kontynuowano prezentacje ustne, m.in. Prof. Dr hab. Sławomir Pancewicz z Uniwersytetu Medycznego w Białymstoku omawiał tematykę

about it. The interesting subject of rickettsiosis dragged from travelling on the example of African tick fever was also discussed by PhD Magdalena Tudrujek-Zdunek from the Medical University of Lublin. While PhD Agnieszka Pawełczyk from the University of Warsaw presented the results of research related to the species diversity of *Borrelia* spirochetes in *Ixodes ricinus* L. ticks collected from humans in 2016–2018.

On the same day (May 5) after dinner, subsequent papers were delivered, among others by PhD students from the Pedagogical University of Krakow: MSc Anna Kocoń presented preliminary results on ticks attacking domestic dogs and cats in southern Poland, and MSc Natalia Malejky-Kłusek presented research on the repellent effect of plants and substances contained in them on selected beetles – pests of stored cereal grain. At the end of this paper session, PhD Grzegorz Kania from the Medical University of Lublin discussed the importance of millipedes in nature, and PhD Elżbieta Rożej-Pabijan from the Pedagogical University of Krakow presented research on changes in the species composition of bees on variable-moist meadows (the *Molinion caeruleae* relation W. Koch 1926).

A poster session took place on the last day of the Symposium (May 6). During this session, Symposium participants could learn about interesting topics explored by PhD students and other scientists from all over Poland. For example, MSc Slawomir Dudek from the Silesian Medical University illustrated the effect of plant extracts on *Borrelia burgdorferi* spirochetes (Johnson et al. emend. Baranton et al.) under *in vitro* con-

chorób odkleszczowych w Polsce, szczególnie boreliozy. Jako lekarz praktyk, przedstawił wiele faktów na temat tej choroby, dementując jednocześnie powszechnie krążące o niej mity. Interesujący temat riketsjoz zawlekanych z podróży na przykładzie afrykańskiej gorączki odkleszczowej został również omówiony przez Dr Magdalenę Tudrujek-Zdunek z Uniwersytetu Medycznego w Lublinie. Natomiast Dr Agnieszka Pawełczyk z Uniwersytetu Warszawskiego przedstawiła wyniki badań związanych z różnorodnością gatunkową krętków *Borrelia* u kleszczy *Ixodes ricinus* L., zebranych z ludzi w latach 2016–2018.

Tego samego dnia (5 maja) po obiedzie, kolejne referaty wygłosili, m.in. doktoranci z Uniwersytetu Pedagogicznego w Krakowie: Mgr Anna Kocoń zaprezentowała wstępne wyniki na temat kleszczy atakujących psy i koty domowe na terenie południowej Polski oraz Mgr Natalia Malejky-Kłusek przedstawiła badania repelentnego wpływu roślin i substancji w nich zawartych na wybrane chrząszcze – szkodniki magazynowanego ziarna zbóż. Na koniec tej sesji referatowej Dr Grzegorz Kania z Uniwersytetu Medycznego w Lublinie omówił znaczenie krocionogów w przyrodzie, a Dr Elżbieta Rożej-Pabijan z Uniwersytetu Pedagogicznego w Krakowie zaprezentowała badania zmian składu gatunkowego pszczół na zmienno-wilgotnych łąkach trzęślicowych (związek *Molinion caeruleae* W.Koch 1926).

W ostatnim dniu Sympozjum (6 maja) odbyła się sesja posterowa. W trakcie tej sesji uczestnicy Sympozjum mogli zapoznać się z ciekawymi tematami eksplorowanymi przez doktorantów i innych naukowców z całej Polski. Na przykład, Mgr Sławomir

ditions, MSc Aleksandra Izdebska presented the topic of repetitive action of anethole on the *Rhyzoptera dominica* F. (Coleoptera: Bostrichidae), MSc Anna Kocoń presented the issue of human safety during sleep – are we sure that we are safe and free from parasites?, and MSc Natalia Malejky-Kłusek depicted the subject of introducing natural enemies affecting harmful warehouse arthropods.

30 people from 10 scientific institutions participated in this year's Symposium. During the entire conference, the participants of this year's edition had the opportunity to present their research results and, as every year, new ideas for cooperation were created, not only with the scientific units in the country, but also abroad.

Dudek z Śląskiego Uniwersytetu Medycznego zilustrował wpływ ekstraktów roślinnych na krętki *Borrelia burgdorferi* (Johnson et al. emend. Baranton et al.) w warunkach *in vitro*, Mgr Aleksandra Izdebska zaprezentowała temat repelentnego działania anetolu na kapturnika zbożowca *Rhyzoptera dominica* F. (Coleoptera: Bostrichidae), Mgr Anna Kocoń przedstawiła zagadnienia bezpieczeństwa człowieka podczas snu – czy na pewno jesteśmy wtedy bezpieczni i wolni od pasożytów?, a Mgr Natalia Malejky-Kłusek zobrazowała tematykę wprowadzania naturalnych wrogów działających na szkodliwe stawonogi magazynowe.

W tegorocznym Sympozjum uczestniczyło 30 osób, z 10 instytucji naukowych. W trakcie całego Zjazdu, uczestnicy tegorocznej edycji mieli możliwość przedstawienia swoich wyników badań i jak co roku utworzyły się nowe pomysły współpracy, nie tylko z jednostkami naukowymi w kraju, ale również za granicą.

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# 58th Polish Botanical Society Congress, "Botany without borders" (July 1–7, 2019, Kraków, Poland)

# 58. Zjazd Polskiego Towarzystwa Botanicznego „Botanika bez granic" (1–7 lipca 2019, Kraków, Polska)

From 1 to 7 of July, the 58th Polish Botanical Society (PBS) Congress under topic "Botany without borders" took place. It had not only nationwide form but also an international scientific conference character. The organisers of this important event for botanists were: Kraków division of the Polish Botanical Society, W. Szafer Institute of Botany (Polish Academy of Science), Institute of Botany of the Jagiellonian University, Institute of Biology of the Pedagogical University of Krakow and Botanical Garden of the Jagiellonian University. All scientific events of the Congress occurred in the main building of the Pedagogical University of Krakow at Podchorążych 2 St. The lectures and poster sessions were delivered in 14 topic related sections: Aerobiological, Bryological, Dendrological, Plant Physiology and Biochemistry, Geobotany and Protection of the Floras, History of Botany, Plant Tissue Cultures, Lichenological, Mycological, Botanical Gardens and Arboreta, Paleobotanical, Pteridological, Plant Structure and Development and Vascular Plants Taxonomy.

On the first day of the Congress (July 1st), organisational meetings were held related

W dniach 1–7 lipca 2019 r. odbył się 58. Zjazd Polskiego Towarzystwa Botanicznego (PTB), pod hasłem „Botanika bez granic", mający tradycyjnie formę nie tylko ogólnopolskiej, ale i międzynarodowej konferencji naukowej. Organizatorami tego ważnego dla botaników wydarzenia były: Oddział krakowski PTB, Instytut Botaniki im. W. Szafera Polskiej Akademii Nauk, Instytut Botaniki Uniwersytetu Jagiellońskiego, Instytut Biologii Uniwersytetu Pedagogicznego w Krakowie oraz Ogród Botaniczny Uniwersytetu Jagiellońskiego. Wszystkie obrady tegorocznego Zjazdu odbywały się w budynkach Uniwersytetu Pedagogicznego, przy ul. Podchorążych 2 w Krakowie. Wystąpienia ustne oraz doniesienia plakatowe prezentowano w 14 sekcjach tematycznych: Aerobiologicznej, Briologicznej, Dendrologicznej, Fizjologii i Biochemii Roślin, Geobotaniki i Ochrony Szaty Roślinnej, Historii Botaniki, Kultur Tkankowych Roślin, Lichenologicznej, Mykologicznej, Ogrodów Botanicznych i Arboretów, Paleobotanicznej, Pteridologicznej, Struktury i Rozwoju Roślin oraz Taksonomii Roślin Naczyniowych.

Pierwszego dnia Zjazdu (1 lipca) odbyły się spotkania organizacyjne, związane


**Fig. 1.** Speech by Vice-Rector of Development of the Pedagogical University of Krakow – Assoc. Prof. Robert Stawarz, during the inauguration of the 58th Congress of the Polish Botanical Society (Photo. D. Węgiel)
**Ryc. 1.** Przemowa Prorektora ds. Rozwoju Uniwersytetu Pedagogicznego w Krakowie – Dr hab. Roberta Stawarza, w trakcie inauguracji 58. Zjazdu Polskiego Towarzystwa Botanicznego (Fot. D. Węgiel)

to the functioning of the Society: a meeting of the Presidium of the Main Council of the PBS, a meeting of the Main Board of PBS and the General Assembly of Delegates. As a result, a number of resolutions important for the Society were adopted and the Chairman and new Presidium of the Main Board of the PBS were elected for the 2019–2022 term. In the late afternoon members of PBS had the opportunity to participate in two outdoor sessions: "*Herbarium murorum cracoviensis – Plants in the architecture of Cracow*" and "*Sightseeing of the Botanical Garden of the Jagiellonian University*".

The next day of the Congress (July 2nd) the official opening of the 58th Polish Botanical Society Congress took place, during

z funkcjonowaniem Towarzystwa: posiedzenie Prezydium Zarządu Głównego PTB, posiedzenie Zarządu Głównego PTB oraz Walne Zgromadzenie Delegatów. W efekcie podjęto szereg ważnych dla Towarzystwa uchwał oraz wybrano Przewodniczącego i nowe Prezydium Zarządu Głównego PTB na kadencję 2019–2022. Natomiast późnym popołudniem miały miejsce dwie sesje plenerowe: „*Herbarium murorum cracoviensis* – Rośliny w architekturze Krakowa" oraz „*Wizyta w Ogrodzie Botanicznym Uniwersytetu Jagiellońskiego*".

Następnego dnia (2 lipca) nastąpiło uroczyste otwarcie 58. Zjazdu PTB, podczas którego swoje wystąpienia wygłosili dotychczasowi przedstawiciele władz Towarzystwa oraz

**Fig. 2.** This year's winners of the Medal of Professor Bolesław Hryniewiecki decorated for disseminating botanical knowledge (Photo. D. Węgiel)
**Ryc. 2.** Tegoroczni laureaci Medalu im. Prof. Bolesława Hryniewieckiego odznaczeni za upowszechnianie wiedzy botanicznej (Fot. D. Węgiel)

which the actual authorities of the Society and invited guests presented their speeches (Fig. 1). Awards and medals for the most active botany scientists were also given (among others: Medal of Prof. Władysław Szafer, Medal of Prof. Bolesław Hryniewiecki (Fig. 2) and Medal of Prof. Zygmunt Czubiński). Next, the Plenary Sessions occurred. During them several lectures of local (Fig. 3) and foreign researchers were presented which highlighted both the history and perspectives of global botany. Particularly worth mentioning is the interdisciplinary and international character of this part of the Congress. In the evening, after the dynamic discussion on the actual trends in the biology and evolution of the plant kingdom, it was time for a mo-

zaproszeni goście (Ryc. 1). Nadano również odznaczenia i medale naukowcom zasłużonym w dziedzinie szeroko pojętej botaniki (m. in.: Medal im. Prof. Władysława Szafera, Medal im. Prof. Bolesława Hryniewieckiego (Ryc. 2) oraz Medal Prof. Zygmunta Czubińskiego). W dalszej kolejności odbyły się obrady Sesji Plenarnych, podczas których przedstawione zostały referaty krajowych (Ryc. 3) oraz zagranicznych wykładowców dotyczące, m. in. porównania dorobku oraz perspektyw ogólnoświatowej botaniki. Na szczególną uwagę zasługuje interdyscyplinarny oraz międzynarodowy charakter tej części Zjazdu. Wieczorem, po burzliwej wymianie poglądów na temat najnowszych trendów w badaniach nad biologią i ewolucją króle-

**Fig. 3.** Plenary session: Professor Martin Kukwa (University of Gdańsk): *Lichenology – where we were, where we are, where we are going* (Photo. D. Węgiel)
**Ryc. 3.** Sesja plenarna: Prof. dr hab. Martin Kukwa (Uniwersytet Gdański): *Lichenologia – gdzie byliśmy, gdzie jesteśmy, dokąd zmierzamy* (Fot. D. Węgiel)

ment of reflection and calm during the Organ Concert at the Church of St. Francis of Assisi in Kraków. Without doubts it was exactly the moment when we all could understand that botany is really a science "without borders" in which there should be a place for everyone who loves the beauty and the scientific significance of plants.

On the third day of the Congress (July 3rd), lectures and poster sessions in the individual PBS Sections began. In addition, at the beginning of the meeting, a benefit dedicated to the activities of Prof. Małgorzata Latałowa took place. It summarised her contribution as an outstanding researcher to the current state of paleobotanical and phytogeographic knowledge. Many hours of deliberations and discussions ended on that day with a gala

stwa roślin, przyszedł czas na chwilę refleksji i wyciszenia podczas Koncertu Organowego w Bazylice Ojców Franciszkanów w Krakowie. Niewątpliwie był to ten moment, w którym wszyscy mogli uzmysłowić sobie, że botanika jest nauką „bez granic", w której powinno być miejsce dla każdego, kto umiłował sobie piękno oraz naukowe znaczenie roślin.

Trzeciego dnia Zjazdu (3 lipca) rozpoczęły się obrady w sesjach tematycznych, referatowych i plakatowych, w poszczególnych Sekcjach PTB. Ponadto na początku tych obrad miał miejsce benefis okolicznościowy, poświęcony działalności Pani Prof. dr hab. Małgorzaty Latałowej, podsumowujący wkład tej wybitnej badaczki w obecny stan wiedzy paleobotanicznej i fitogeograficznej. Wielogodzinne obrady i dyskusje zakończo-

dinner, accompanied by the sounds of music in the Kraków Opera building.

On the fourth day of the conference (July 4th), in the thematic sections the lectures and poster sessions were continued. Due to the very large number of presentations submitted, the meeting time was fully utilised to present the latest achievements and the concept of botanical studies. It was easy to see how far specialisation in individual branches of botany had come. It is important to emphasise the high substantive level and innovation of many of the scientific presentations and reports presented during the Congress.

When the official scientific parts came to an end field excursions begun. They were an opportunity for both the tightening of the cooperation between different institutions and to highlight the natural value of selected areas of Southern Poland. In the program of excursions a special importance was given to the presentation of natural characteristics and nature–human interactions in these ecosystems, which play the most important role in the discussion on the evolution of interdisciplinary methods of nature conservation and innovative use of its resources. On Friday (July 5th), one-day field sessions took place: in the Babiogórski National Park, Niepołomicka Forest, as well as in the Miechowska and Ponidzie Uplands. On Saturday (July 6th), one-day trips to the Gorczański National Park, the Ojców National Park and the Olkusz Ore-bearing Region were organised. The sessions proposed by the organisers were undoubtedly an opportunity for direct contact with nature of primary environments, as well as those in which human activity overlaps with

ne zostały tego dnia uroczystą kolacją, przy dźwiękach muzyki w gmachu Opery Krakowskiej.

W czwartym dniu konferencji (4 lipca) kontynuowane były obrady Sesji referatowych oraz plakatowych w sekcjach tematycznych. Ze względu na bardzo dużą liczbę zgłoszonych wystąpień czas obrad wykorzystany został w pełni na przedstawienie najnowszych osiągnięć oraz koncepcji badań botanicznych. Łatwo było zauważyć to, jak daleko zaszła specjalizacja w poszczególnych gałęziach botaniki. Należy w tym miejscu podkreślić wysoki poziom merytoryczny oraz innowacyjność wielu z przedstawionych podczas Zjazdu wystąpień i doniesień naukowych.

Po zakończeniu wszystkich obrad w sekcjach, przyszedł czas na sesje terenowe, które stały się okazją, zarówno do pogłębienia współpracy pomiędzy przedstawicielami różnych ośrodków naukowych, jak i do zapoznania się z cechami przyrodniczymi wybranych rejonów Polski Południowej. Przygotowując program sesji terenowych położono szczególny nacisk na zaprezentowanie walorów przyrodniczych oraz interakcji przyroda–człowiek tych ekosystemów, które zajmują ważne miejsce w dyskusji nad dalszą ewolucją metod interdyscyplinarnej ochrony przyrody i innowacyjnego wykorzystania jej zasobów. W piątek (5 lipca), odbyły się jednodniowe sesje terenowe: w Babiogórskim Parku Narodowym, Puszczy Niepołomickiej oraz na Wyżynie Miechowskiej i Ponidziu. W sobotę (6 lipca) miały miejsce również jednodniowe sesje w Gorczańskim Parku Narodowym, Ojcowskim Parku Narodowym oraz w Olkuskim Okręgu Rudnym.

the intrinsic rhythms of ecosystems. The diversity of these areas in terms of topography and ecology gave the opportunity to present a wide spectrum of determinants of active and passive protection of natural resources in a gradient of anthropopressure and social expectations. Parallel to the above-mentioned sessions, a three-day field session was also held (from Friday to Sunday, July 5–7th). It covered the topic of vegetation of the Bieszczady Mountains, Sanocko-Turczańskie Mountains and the Przemyśl Foothills. Participation in this event enjoyed particular interest among participants of the Congress.

In total, 450 participants attended the PBS Congress, 200 oral presentations were lectured and 240 posters were delivered. 10 guests from abroad: Czech, Belgium, Slovakia, Switzerland, Ukraine and Great Britain participated in the Congress. The 58th Polish Botanical Society Congress was undoubtedly an occasion to discover the actual trends in the biological and biotechnological plant science, and understand the problems of the conservation of the flora of Southern Poland. The Polish Botanical Society is one of the oldest and biggest scientific associations in Poland. It realises several goals in the field of the promotion of specialised research in the plant biology, ecology, taxonomy and phytogeography, the integration of the scientific society and the popularisation of botany in the society. The cyclical organisation of meetings and conferences, such as the PBS Congress, undoubtedly contributes to the achievement of the above goals. The organisers of the Congress prepared and electronically published the Book of Abstracts of oral presentations

Zaproponowane przez organizatorów sesje były niewątpliwie okazją do bezpośredniego kontaktu z przyrodą środowisk pierwotnych, jak również tych, w których działalność człowieka nakłada się na samoistne rytmy ekosystemów. Zróżnicowanie tych obszarów pod względem topograficznym oraz ekologicznym dało możliwość przedstawienia szerokiego spektrum uwarunkowań ochrony czynnej oraz biernej zasobów przyrodniczych w gradiencie antropopresji i oczekiwań społecznych. Równolegle do powyższych sesji odbyła się także trzydniowa sesja terenowa (od piątku do niedzieli, 5–7 lipca). Obejmowała ona tematykę szaty roślinnej Bieszczadów, Gór Sanocko–Turczańskich i Pogórza Przemyskiego. Udział w tym wydarzeniu cieszył się szczególnym zainteresowaniem wśród uczestników Zjazdu.

Łącznie w 58. Zjeździe PTB brało udział 450 botaników, wygłoszonych zostało 200 referatów i przedstawiono 240 plakatów. Ponadto, w Zjeździe uczestniczyło 10 gości z zagranicy: Czech, Belgii, Słowacji, Szwajcarii, Ukrainy i Wielkiej Brytanii. Zjazd ten stał się okazją do zapoznania się z aktualnymi trendami w naukach dotyczących biologii i biotechnologii roślin, jak również do zrozumienia problemów ochrony szaty roślinnej Polski Południowej. Polskie Towarzystwo Botaniczne jest jednym z najstarszych i najliczniejszych towarzystw naukowych w Polsce, realizującym cele w zakresie promowania specjalistycznych badań nad biologią, ekologią, systematyką i geografią roślin, integrowania środowiska botaników oraz upowszechniania wiedzy botanicznej w społeczeństwie. Cykliczne organizowanie spotkań i konferencji, takich jak Zjazd PTB, niewąt-

and posters (available at: https://hdl.handle.net/20.500.12333/254) and the Guidebook for the excursions (available at: https://hdl.handle.net/20.500.12333/255).

We look forward to the next, equally fruitful meetings of the Polish Botanical Society!

pliwie przyczynia się do osiągnięcia powyższych celów. Na potrzeby tegorocznego Zjazdu przygotowano i opublikowano elektronicznie „Streszczenia referatów i plakatów" (dostępne pod adresem: https://hdl.handle.net/20.500.12333/254) oraz „Przewodnik Sesji Terenowych" (dostępny pod adresem: https://hdl.handle.net/20.500.12333/255).

Z wielką niecierpliwością oczekujemy kolejnych, równie owocnych zjazdów Polskiego Towarzystwa Botanicznego!

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# 28th Meeting of the European Vegetation Survey "Vegetation diversity and global change", September 2–6, 2019, Madrid, Spain

# 28 Spotkanie z europejskimi badaniami nad roślinnością „Różnorodność roślinności i zmiany globalne", 2–6 września 2019, Madryt, Hiszpania

In Madrid, from 2 to September 6, 2019, the 28th International Conference was took place as part of the so-called 28th Meeting of the European Vegetation Survey "Vegetation diversity and global change". The main organiser of the conference was the Institute of Pharmacology, Pharmacognisation and Botany of the Complutense University in Madrid. The members of the scientific committee were: PhD Emiliano Agrillo and PhD Fabio Attorre (Department of Plant Biology, University of La Sapienza in Rome), PhD Andraž Čarni and PhD Jovan Hadži (Institute of Biology, Research Center of the Slovenian Academy of Sciences and Arts of Ljubljana), Prof. Milan Chytrý (Department of Botany and Zoology, University of Brno), PhD Monika Janišová (Institute of Botany, Slovak Academy of Sciences, Banská Bystrica), PhD María Pilar Rodríguez-Rojo (Institute of Environmental Sciences, University of Castilla-La Mancha, Toledo), Prof. John Rodwell (Environmental consultant, Lancaster), Prof. Joop Schaminée (Group for the Protection of Nature and Plant Ecology, University of Wageningen).

W dniach od 2 do 6 września 2019 roku, w Madrycie, odbyła się już po raz 28 Międzynarodowa Konferencja w ramach tzw. spotkań dotyczących badań roślinności, pt. „Różnorodność roślinności i zmiany globalne". Głównym organizatorem konferencji był Instytut Farmakologii, Farmakognozji i Botaniki Uniwersytetu Complutense w Madrycie. Wśród członków komitetu naukowego znaleźli się: Dr Emiliano Agrillo i Dr Fabio Attorre (Zakład Biologii Roślin, Uniwersytet La Sapienza w Rzymie), Dr Andraž Čarni i Dr Jovan Hadži (Instytut Biologii, Centrum Badawcze Słoweńskiej Akademii Nauk i Sztuki z Ljubljana), Prof. Milan Chytrý (Zakład Botaniki i Zoologii, Uniwersytet w Brnie), Dr Monika Janišová (Instytut Botaniki, Słowacka Akademia Nauk, Banská Bystrica), Dr María Pilar Rodríguez-Rojo (Instytut Nauk o Środowisku, Uniwersytet Castilla-La Mancha, Toledo), Prof. John Rodwell (Konsultant ekologiczny, Lancaster), Prof. Joop Schaminée (Grupa Ochrony Przyrody i Ekologii Roślin, Uniwersytet Wageningen).

During the ceremonial opening of the conference (September 3, 2019) plenary lecture entitled "*Linking above and below ground plant community responses: a melting pot of interactions and soil heterogeneity*" as presented by PhD Adrian Escudo (Rey Juan Carlos University of Mostoles). After the official greeting of the guests, the participants were invited to participate in the first lecture session on the subject of "Sand-dune and halophilous Vegetation". The speakers presented, among others, issues from research on coastal dunes ecosystems in central Italy, the conservation status of dune habitats in two contrasting Natura 2000 areas, overview of sandy vegetation of the Pannonian and western Pontic region and a syntaxonomic approach to halophytic communities from Western Europe.

After a short coffee break, in the second session entitled "High mountain vegetation", the speakers discussed issues related to: the differentiation of observational errors and the effects of climate change in long-term monitoring of the composition and abundance of high-mountain plant species, biogeography of alpine plant communities in southern Europe, the coenological and syntaxonomical features of relict populations of two Salix species in the high Apenin zone, with mountain tundra vegetation, as well as the effect of ozone on Mediterranean alpine meadows in the Guadarrama range (central Spain).

In the afternoon, the first poster session took place in which participants presented a wide thematic spectrum in the field of vegetation research. Of particular interest were the issues concerning: development of data-

Podczas uroczystego otwarcia konferencji (3. 09. 2019) wykład plenarny pt. „*Połączenie nad i podziemnych odpowiedzi zbiorowisk roślinnych: tygiel interakcji a hetreogeniczność gleby*" wygłosił Dr Adrian Escudo (Uniwersytet Rey Juan Carlos z Mostoles). Po oficjalnym przywitaniu przybyłych gości, uczestnicy zostali zaproszeni do udziału w pierwszej sesji wykładowej, obejmującej tematykę „Roślinności wydm piaszczystych i halofitów". Prelegenci zaprezentowali, m.in. zagadnienia z badań o ekosystemach wydm przybrzeżnych w środkowych Włoszech, stan ochrony siedlisk wydmowych na dwóch kontrastujących obszarach Natura 2000, przegląd roślinności psamofilnej w regionie panońskim oraz syntaksonomiczne podejście do halofitycznych zbiorowisk z Europy Zachodniej.

Po krótkiej przerwie kawowej, w drugiej sesji pt. „Roślinność wysokogórska", prelegenci omawiali zagadnienia związane: ze różnicowaniem błędów obserwatorskich i skutków zmian klimatu w długoterminowym monitorowaniu składu i liczebności gatunków roślin wysokogórskich, biogeografią zbiorowisk roślin alpejskich w południowej Europie, cechami cenotycznymi i składniowymi reliktowych populacji dwóch gatunków *Salix* w strefie wysokogórskiej Apeninów, z roślinnością tundry górskiej, a także wpływem ozonu na śródziemnomorskie łąki wysokogórskie w paśmie Guadarrama (centralna Hiszpania).

W godzinach popołudniowych, odbyła się pierwsza sesja plakatowa, w której uczestnicy prezentowali szerokie spektrum tematyczne z zakresu badań nad roślinnością. Szczególnym zainteresowaniem cieszyły się

bases for assessing the conservation status of habitats on the example of the "VegFrance" database, how to improve remote sensing research using knowledge of vegetation, classification and ecological diversity, on the example of dry grassland habitats of Ukraine, as well as the development of a new system for describing diversity dry grasslands in Poland.

In the third plenary session entitled "Assessment and conservation of European habitats" the lectures concerned: review of endangered and endemic species associated with different types of habitats in Europe and monitoring the status of Natura 2000 habitats in Flanders. After the coffee break, in the second part of the session presented were: identification of habitats using satellite images, implementation of the Natura 2000 program in Albania and the diversity of plant communities of the Strazhata Hill in central and northern Bulgaria.

The next day of the conference (September 4, 2019) three thematic sessions took place: "Vegetation patterns in the Palaearctic", "Methods and databases for vegetation studies", "Mediterranean and thermophilous forests".

During the lectures presented were, among others, a new method and application for Android as a probabilistic key to identify types of vegetation in the field, modeling the composition of vegetation and their richness in spatial scales and environmental gradients in the Central Apennines, native forest dominance patterns in the Iberian Peninsula, a review of types and habitats of thermophilic vegetation on the edge of Ukrainian forests, as well as floristic and coenotic diversity of Vyatka-Kama (Tatarstan, Russia). On the

zagadnienia dotyczące: opracowania baz danych do oceny stanu zachowania siedlisk na przykładzie bazy "VegFrance", jak ulepszyć badania teledetekcyjne wykorzystując wiedzę o roślinności, klasyfikacji oraz zróżnicowaniu ekologicznym, na przykładzie suchych siedlisk trawiastych Ukrainy, a także opracowania nowego systemu opisu różnorodności suchych muraw w Polsce.

W trzeciej sesji plenarnej zatytułowanej „Ocena i ochrona siedlisk europejskich" referaty dotyczyły: przeglądu zagrożonych i endemicznych gatunków, związanych z różnymi typami siedlisk w Europie oraz monitorowania stanu siedlisk Natura 2000 we Flandrii. Po przerwie kawowej, w drugiej części sesji przedstawiono problematykę: identyfikacji siedlisk za pomocą zdjęć satelitarnych, realizacji programu Natura 2000 w Albanii oraz różnorodności zbiorowisk roślinnych wzgórza Strazhata w środkowej i północnej części Bułgarii.

Następnego dnia konferencji (4. 09. 2019) odbyły się trzy sesje tematyczne: „Wzory wegetacji w palearktyce", „Metody i bazy danych do badań roślinności" oraz „Lasy śródziemnomorskie i ciepłolubne". W trakcie wykładów zaprezentowano, m.in. nową metodę i aplikację na Androida, jako probabilistyczny klucz do identyfikacji typów roślinności w terenie, modelowanie składu roślinności i ich bogactwa w skalach przestrzennych i gradientach środowiskowych w Apeninach Środkowych, rodzime wzorce dominacji lasów na Półwyspie Iberyjskim, przegląd rodzajów i siedlisk roślinności termofilnej na skraju ukraińskich lasów, a także różnorodność

same day, in the second poster session, participants discussed topics such as: the importance of small-leaved forests in the vegetation cover in the central part of the Russian plain, floristic patterns in the altitude gradient in the Mongolian part of Altai, between steppe and high mountain belts, the state of conifers in the eastern Alps and changes in water-peat vegetation in Lower Silesian forests (Poland).

On the penultimate day of the conference (September 5, 2019) in plenary sessions: "Wetlands, Riparian and Aquatic Vegetation" and "Vegetation Dynamics and Succession in Different Habitats" the speakers presented topics related to: the succession of peat bogs in the Engure Lake nature park in Latvia, the MedIsWet project as an opportunity to improve the state of knowledge and methods of protecting wetlands in Sicily and Sardinia, research on vegetation in the Güímar valley in Tenerife (Canary Islands), phenological trends in plant communities dominated by grasses in Mediterranean areas, the impact of drought on the changing composition of Mediterranean forests and plant succession in post-industrial areas. In the evening, after the official closing of the meeting, it was time for a celebratory dinner, during which scientists had the opportunity to make friends with colleagues from various centers, which will certainly result in joint research projects. The dinner ended with a flamenco dance show and good fun.

On Friday morning (September 6, 2019), field sessions were organised for interested conference participants, which became both an opportunity to explore knowledge and to learn about the natural qualities of high mountain areas in the Sierra de Guadarrama

florystyczną i cenotyczną Vyatka-Kama (Tatarstan, Federacja Rosyjska). W tym samym dniu, w drugiej sesji plakatowej uczestnicy dyskutowali, m.in. na temat: znaczenia lasów drobnolistnych w pokrywie roślinności w środkowej części równiny rosyjskiej, wzorów florystycznych w gradiencie wysokościowym w mongolskiej części Ałtaju, między pasami stepowymi a wysokogórskimi, stanu drzew iglastych we wschodnich Alpach oraz zmian roślinności wodno-torfowej w borach dolnośląskich (Polska).

W przedostatnim dniu konferencji (5. 09. 2019) w sesjach plenarnych: „Mokradła, roślinność nadbrzeżna i wodna" i „Dynamika roślinności i sukcesja w różnych siedliskach", prelegenci poruszali tematy związane z: sukcesją torfowisk w parku przyrody Engure Lake na Łotwie, projektem MedIsWet, jako szansą na poprawę stanu wiedzy i metod ochrony mokradeł na Sycylii i Sardynii, badaniami roślinności w dolinie Güímar na Teneryfie (Wyspy Kanaryjskie), trendami fenologicznymi w zbiorowiskach roślinnych zdominowanych przez trawy na obszarach śródziemnomorskich, wpływem suszy na zmieniający się skład lasów śródziemnomorskich oraz sukcesją roślin na terenach poprzemysłowych. Wieczorem, po oficjalnym zakończeniu obrad, przyszedł czas na uroczystą kolację, podczas której naukowcy mieli możliwość nawiązywania nowych znajomości z kolegami z różnych ośrodków, co z pewnością zaowocuje wspólnymi projektami badawczymi. Kolacja zakończyła się pokazem tańców flamenco i wspólną zabawą.

W piątkowy poranek (6. 09. 2019), dla zainteresowanych uczestników konferencji

National Park (central Spain). During this session, various plant communities were admired – from open oak forests with *Quercus rotundifolia* Lam., through shelf formations of limestone or gypsum soils and cliffs in the Miocene sediments near the El Campillo lagoon, to different groups of halophytes in the El Salobral nature reserve. The vegetation of West-Iberian areas was also studied, including oak formations *Q. pyrenaica* Willd. and evergreen *Q. suber* L. and *Q. rotundifolia*.

This year's 28th European meeting on vegetation research was attended by over 170 scientists from various European centres, among others from the Czech Republic, Slovakia, Poland, Ukraine, Lithuania, Latvia, Russia, Italy, France, Spain and Germany. This meeting was certainly an opportunity to present the results of research on the current state of vegetation in Eurasia. It gave the opportunity to exchange views on topics of modern research methodology, collection and processing of phytosociological data in relation to their habitats. For the purposes of this conference, information on the conference has been published in an electronic version at: http://evs2019madrid.es/.

zorganizowano sesje terenowe, które stały się, zarówno okazją do zgłębiania wiedzy, jak i do poznania walorów przyrodniczych terenów wysokogórskich w Parku Narodowym Sierra de Guadarrama (centralna Hiszpania). W trakcie tej sesji, podziwiano różne zbiorowiska roślinne – od otwartych lasów dębowych z *Quercus rotundifolia* Lam., poprzez szelfowe formacje wapiennych lub gipsowych gleb i klifów w osadach mioceńskich w pobliżu laguny El Campillo, do różnych grup halofitów w rezerwacie przyrody El Salobral. Zapoznano się również z roślinnością terenów zachodnio-iberyjskich, w tym m.in. formacjami dębu *Q. pyrenaica* Willd. oraz zimozielonych *Q. suber* L., i *Q. rotundifolia*.

W tegorocznym 28 europejskim spotkaniu, dotyczącym badań roślinności, wzięło udział ponad 170 naukowców z różnych ośrodków Europy, m.in. z Czech, Słowacji, Polski, Ukrainy, Litwy, Łotwy, Rosji, Włoch, Francji, Hiszpanii i Niemiec. Spotkanie to z pewnością było okazją do prezentacji rezultatów badań nad obecnym stanem roślinności w Eurazji. Dało możliwość wymiany poglądów na tematy współczesnej metodyki badań, gromadzenia i przetwarzania danych fitosocjologicznych, w powiązaniu z ich siedliskami. Na potrzeby niniejszej konferencji, informacje dotyczące zjazdu zostały opublikowane w wersji elektronicznej pod adresem: http://evs2019madrid.es/.

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# XXVIII International Conference "The Importance of the Bieszczady National Park for Scientific Research and Ecological Education", September 19–21, 2019, Zatwarnica, Poland

# XXVIII Międzynarodowa Konferencja „Znaczenie Bieszczadzkiego Parku Narodowego dla badań naukowych i edukacji ekologicznej", 19–21 wrzesień 2019, Zatwarnica, Polska

The XXVIII International Conference entitled "*The Importance of the Bieszczady National Park for Scientific Research and Ecological Education*" was held in Zatwarnica from 19th to 21st September. The conference was organized by the Bieszczady National Park in cooperation with the Połoniny National Park (Slovakia). The honorary patronage over the conference was held by the Secretary of State, Chief Nature Conservator Małgorzata Joanna Glińska, Podkarpackie Voivode Ewa Leniart and the Marshal of the Podkarpackie Voivodship Władysław Ortyl. The honorary guest of this year's conference was Prof. Fedir Hamor from the Carpathian Biosphere Reserve (Ukraine).

The conference was opened, on September 19th, by the director of the Bieszczady National Park, PhD Ryszard Prędki, who warmly welcomed all participants of this year's conference, especially guests from Ukraine and Slovakia. After the opening, invited guest Prof. Fedir Hamor delivered a lecture "*On some aspects of scientific activity and ecological education in the Carpathian Biosphere*

XXVIII Międzynarodowa Konferencja pt. „*Znaczenie Bieszczadzkiego Parku Narodowego dla badań naukowych i edukacji ekologicznej*" odbyła się w Zatwarnicy w dniach 19–21 września 2019 roku. Organizatorem konferencji był Bieszczadzki Park Narodowy przy współudziale Parku Narodowego Połoniny (Słowacja). Patronat honorowy nad konferencją objęli Sekretarz Stanu, Główny Konserwator Przyrody Małgorzata Joanna Glińska, Wojewoda Podkarpacki Ewa Leniart oraz Marszałek Województwa Podkarpackiego Władysław Ortyl. Gościem honorowym tegorocznej konferencji był Prof. dr hab. Fedir Hamor z Karpackiego Rezerwatu Biosfery (Ukraina).

19 września br., otwarcia konferencji dokonał dyrektor Bieszczadzkiego Parku Narodowego Dr Ryszard Prędki, który serdecznie powitał wszystkich uczestników tegorocznej konferencji, zwłaszcza gości z Ukrainy i Słowacji. Po otwarciu zaproszony gość Prof. dr hab. Fedir Hamor wygłosił referat „*O niektórych aspektach działalności naukowej i edukacji ekologicznej w*

*Reserve (Ukraine)*" which met with great interest from conference participants. Before the coffee break, two lectures were presented by scientists from Ukraine, among others, Assoc. Prof. Oksana Maryskevych from the Institute of Ecology of the Carpathians NAN of Ukraine "*Prospects for the functioning of the new Ukrainian Bojkiwszczina National Natural Park*".

In the second scientific session, the following papers were presented, among others: "*A network of large protected areas on the northern slope of the Eastern Carpathians and prospects for international cooperation*" – Prof. Platon Tretiak from NAN State Museum of Natural History of Ukraine, "*A synthetic presentation of information on research topics implemented in BdPN in the last decade*" – PhD Eng. Stanisław Kucharzyk from the Bieszczady National Park, "*Diatoms (Bacillariophyta) as indicators of the state of water environments – spring and head-streams of river sections of the rivers of the Bieszczady National Park. The importance of short- and long-term studies*" – Assoc. Prof. Joanna Żelazna-Wieczorek from the University of Lodz. In total, six papers were presented in this session.

In the afternoon, the conference organisers invited all participants to the newly renovated Ecological Education Field Station in Suche Rzeki. The grand opening was executed by the director of the Bieszczady National Park PhD Ryszard Prędki and Prof. Bogdan Zemanek from the Jagiellonian University. The Park Director thanked everyone who have contributed to the renovation of this facility and invited conference participants for refreshments.

*Karpackim Rezerwacie Biosfery (Ukraina)*", który spotkał się z dużym zainteresowanie ze strony uczestników konferencji. Przed przerwą kawową referaty wygłosiło dwóch prelegentów, m.in. Doc. dr Oksana Maryskevych z Instytutu Ekologii Karpat NAN Ukrainy „*Perspektywy funkcjonowania nowego ukraińskiego Przyrodniczego Parku Narodowego Bojkiwszczina*".

W drugiej sesji naukowej, swoje referaty wygłosili, m.in. Prof. dr hab. Platon Tretiak Państwowe Muzeum Przyrodnicze NAN Ukrainy „*Sieć dużych obszarów chronionych na północnym stoku Karpat Wschodnich a perspektywy współpracy międzynarodowej*", Dr inż. Stanisław Kucharzyk Bieszczadzki Parku Narodowy „*Syntetyczna prezentacja informacji o tematach badawczych realizowanych w BdPN w ostatnim dziesięcioleciu*", Dr hab. Joanna Żelazna-Wieczorek Uniwersytet Łódzki „*Okrzemki (Bacillariophyta) jako wskaźniki stanu środowisk wodnych – źródeł i źródłowych odcinków rzek Bieszczadzkiego Parku Narodowego. Znaczenie badań krótko- i długoterminowych*". W tej sesji zaprezentowano w sumie sześć referatów.

Po południu, organizatorzy konferencji zaprosili wszystkich uczestników do nowo wyremontowanej Terenowej Stacji Edukacji Ekologicznej w Suchych Rzekach. Uroczystego otwarcia dokonał dyrektor Bieszczadzkiego Parku Narodowego Dr Ryszard Prędki oraz Prof. dr hab. Bogdan Zemanek z Uniwersytetu Jagiellońskiego. Dyrektor Parku serdecznie podziękował wszystkim osobom, które przyczyniły się do remontu niniejszego obiektu oraz zaprosił uczestników konferencji na niewielki poczęstunek.

In the next scientific session, which was continued in Suche Rzeki, the following papers were presented: "*Ecological education in the Bieszczady National Park*" – PhD Grażyna Holly from the Bieszczady National Park, "*Current activities in the field of environmental education implemented in the LKP Lasy Bieszczadzkie*" – MSc Eng. Mateusz Świerczyński from Cisna Forest District together with MSc Eng. Ewa Wydrzyńska-Scelina from Baligród Forest District, "*Degradation and renaturalisation of soils affected by hiking in the Bieszczady National Park*" – Prof. Marek Drewnik from the Jagiellonian University in Kraków, "*Recreation of water fauna in degraded streams: can nature cope alone?*" – Prof. Krzysztof Kukuła from the University of Rzeszów, "*New Hieracium species (Asteraceae) from BdPN*" – Prof. Zbigniew Szeląg from the Pedagogical University of Krakow and others. Nine papers were presented in this session. After the paper session, there was time for a poster session. During this session, the results of the research were presented: "*The specific architecture of the Bieszczady National Park*" – MSc Łukasz Kielar Cracow University of Technology and "*Beaver's activity and changes in the local flora in the Syhłowaciec stream valley (Western Bieszczady) – preliminary research results*" – MSc Rita Rakowska from the Jagiellonian University in Kraków. After returning to Zatwarnica, the participants took part in the integrative meeting.

The next day, September 20th, in the early morning the conference participants went to Slovakia to participate in a two-day field session. As part of it, they admired the educational qualities of the "Great Rawka-Nova

W kolejnej sesji naukowej, którą kontynuowano w Suchych Rzekach, referaty zaprezentowali: Dr Grażyna Holly Bieszczadzki Park Narodowy „*Edukacja ekologiczna w Bieszczadzkim Parku Narodowym*", Mgr inż. Mateusz Świerczyński Nadleśnictwo Cisna wraz z Mgr inż. Ewa Wydrzyńska-Scelina Nadleśnictwo Baligród „*Obecne działania w zakresie edukacji ekologicznej realizowane na terenie LKP Lasy Bieszczadzkie*", Prof. dr hab. Marek Drewnik Uniwersytet Jagielloński w Krakowie „*Degradacja i renaturyzacja gleb znajdujących się pod wpływem turystyki pieszej w Bieszczadzkim Parku Narodowym*", Prof. dr hab. Krzysztof Kukuła Uniwersytet Rzeszowski „*Odtwarzanie się fauny wodnej w potokach zdegradowanych: czy przyroda może poradzić sobie sama?*", Prof. dr hab. Zbigniew Szeląg Uniwersytet Pedagogiczny w Krakowie „*Nowe gatunki Hieracium (Asteraceae) z BdPN*" i inni. W tej sesji zaprezentowano dziewięć referatów. Po zakończeniu sesji referatowej nastąpił czas na sesję posterową. W jej trakcie wyniki badań zaprezentowali: Mgr Łukasz Kielar Politechnika Krakowska „*Specyficzna architektura Bieszczadzkiego Parku Narodowego*" oraz Mgr Rita Rakowska Uniwersytet Jagielloński w Krakowie „*Działalność bobra a zmiany w lokalnej florze w dolinie potoku Syhłowaciec (Bieszczady Zachodznie) – wstępne wyniki badań*". Po powrocie do Zatwarnicy uczestnicy wzięli udział w wieczorze integracyjnym.

Następnego dnia, tj. 20 września br., uczestnicy konferencji w godzinach wczesno porannych wyjechali na Słowację w celu uczestnictwa w dwudniowej sesji terenowej. W jej ramach podziwiali walory edukacyjne transgenicznej polsko-słowackiej ścieżki

Sedlica" transgenic Polish-Slovak nature path and the "Havesowa" reserve in the Połoniny National Park.

This year's XXVIII International Conference gathered 77 representatives from three countries – Poland, Ukraine and Slovakia. As in previous years, the conference integrated scientists from various countries and fields of science. All the papers met with great interest from the conference participants. Most importantly, the conference showed how important scientific research is, but also how nature education is conducted by the Bieszczady National Park and surrounding Forest Districts. More information on the conference can be found on the Bieszczady National Park website and in next year's issue of the Bieszczady Yearbooks.

przyrodniczej „Wielka Rawka-Nova Sedlica" oraz rezerwat „Havesowa" w Parku Narodowym Połoniny.

Tegoroczna XXVIII Międzynarodowa Konferencja zgromadziła 77 przedstawicieli z trzech państw – Polski, Ukrainy i Słowacji. Tak jak w ubiegłych latach konferencja integrowała naukowców z różnych państw i dziedzin nauki. Wszystkie referaty spotkały się z dużym zainteresowaniem od strony uczestników konferencji. Co najważniejsze ukazała jak ważne są badania naukowe ale również edukacja przyrodnicza prowadzona przez Park jak i okoliczne Nadleśnictwa. Więcej informacji na temat konferencji można znaleźć na stronie Bieszczadzkiego Parku Narodowego oraz w przyszłorocznym wydaniu Roczników Bieszczadzkich.

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# 10th Central European Dipterological Conference in Slovakia, Kežmarské Žľaby, September, 23–25, 2019

# X Środkowoeuropejska Konferencja Dipterologiczna na Słowacji, Kežmarské Žľaby, 23–25 września 2019

After a four-year break, the Department of Biology and Ecology at the Faculty of Natural Sciences of the Matej Bel University in Banská Bystrica organised another, this time jubilee´ conference, 10th Central European Dipterological Conference. Of course, ten conferences in a row are not such an unusual event. However, it is unique that these Conferences already have a fairly dignified tradition lasting half a century. Their predecessors were seminars of Czech and Slovak dipterologists, which were initiated in 1969 by Assist. Prof. Juraj Čepelák – at the time the head of the Department of Zoology at the Agricultural University of Nitra. At this Department, the important research centre for dipterous insects in Europe was created by him. A fifty-year journey – from the first meeting of Czechoslovak dipterologists to today's international conference – has not always been easy. It is admirable that the continuity of these meetings maintained. Over time in these seminars that were organised every 2–3 years, alternately on the Czech and Slovak side, were participated colleagues from Poland and Hungary, and therefore these events were transformed into international conferences in 1993.

Po czteroletniej przerwie, Katedra Biologii i Ekologii Wydziału Nauk Przyrodniczych Uniwersytetu Macieja Bela w Bańskiej Bystrzycy zorganizowała kolejną, tym razem jubileuszową X Środkowoeuropejską Konferencję Dipterologiczną. Oczywiście dziesięć konferencji z rzędu nie jest aż tak niezwykłym wydarzeniem. Jednak wyjątkowe jest to, że Konferencje te mają już dość godną, trwającą pół wieku tradycję. Ich poprzednikami były seminaria dipterologów czeskich i słowackich, których założycielem w 1969 r. był Doc. Juraj Čepelák, ówczesny kierownik Wydziału Zoologii Uniwersytetu Rolniczego w Nitrze. W ośrodku tym stworzył On ważne w Europie centrum badań nad owadami dwuskrzydłowymi. Pięćdziesięcioletnia podróż – od pierwszego spotkania czechosłowackich dipterologów do dzisiejszej międzynarodowej konferencji, nie zawsze była prosta. Godne podziwu jest to, że utrzymała się ciągłość tych spotkań. Z biegiem czasu w seminariach, które były organizowane co 2–3 lata, na przemian po stronie czeskiej i słowackiej, uczestniczyli koledzy z Polski oraz Węgier, a zatem wydarzenia te od 1993

**Fig. 1.** Participants of the 10th Central European Dipterological Conference (September 23–25, 2019) – Kežmarské Žľaby, High Tatras, Slovakia (Photo L. Hamerlík)
**Ryc. 1.** Uczestnicy X Środkowoeuropejskiej Konferencji Dipterologicznej (23–25 września 2019 r.) – Kežmarské Žľaby, Tatry Wysokie, Słowacja (Fot. L. Hamerlík)

The last, 10th jubilee Conference took place at the Crocus recreation center in Kežmarské Žľaby (Slovakia) under the patronage of the dean of the Faculty of Natural Sciences of the Matej Bel University – Assist. Prof. Jarmila Kmeťová and the mayor of the High Tatras – Ing. Ján Mokoš. This year's conference was attended by 52 dipterologists from 12 countries – so far the most in the history of these meetings. In addition to Slovakia and the Czech Republic, participants included experts from Hungary, Poland, Ukraine, Croatia, Serbia, Bulgaria, Lithuania, Great Britain, Germany and Russia (Fig. 1).

During the 3 days (September 23–25), a wide range of dipterological topics were presented and discussed, ranging from phylogeny and molecular taxonomy, to new results of studies on dipterous insects in different parts of the world, their ecology and even palaeontology and paleoecology (Fig. 2).

roku zostały przekształcone w konferencje międzynarodowe.

Ostatnia, X jubileuszowa Konferencja odbyła się w ośrodku rekreacyjnym Crocus w Kežmarské Žľaby (Słowacja), a patronowali jej dziekan Wydziału Nauk Przyrodniczych Uniwersytetu Macieja Bela Dr hab. Jarmila Kmeťová oraz burmistrz Tatr Wysokich Inż. Ján Mokoš. W tegorocznej Konferencji wzięło udział 52 dipterologów z 12 krajów – jak dotąd najwięcej w historii tych spotkań. Oprócz Słowacji i Czech, uczestnikami byli eksperci z Węgier, Polski, Ukrainy, Chorwacji, Serbii, Bułgarii, Litwy, Wielkiej Brytanii, Niemiec oraz Rosji (Ryc. 1).

W ciągu 3 dni (23–25 września) obrad omówiono i przedyskutowano szeroki zakres tematów dipterologicznych, począwszy od filogenezy i taksonomii molekularnej, po nowe wyniki badań nad dwuskrzydłymi w różnych częściach świata, ich ekologii, a nawet paleontologii i paleoekologii (Ryc. 2). Tradycyj-

**Fig. 2.** Prof. Tadeusz Zatwarnicki (Poland) during his presentation (Photo P. Bitušík)
**Ryc. 2.** Prof. Tadeusz Zatwarnicki (Polska) w trakcie swojego wykładu (Fot. P. Bitušík)

A traditional part of the Conference was a competition for the best student presentation. As usual, the international evaluation committee was strict but fair. Prizes funded in the competition by the mayor of the High Tatras and the company KVANT were awarded to Valentin Dorić (Croatia) and Andreas Laug (Germany).

Because science is a 'living man', there was also a gala dinner at the Ždiarsky House Museum. It was additionally enriched by the Ždiar wedding show, in which selected Conference participants took part in traditional costumes. Certainly, this event contributed to the friendly and informal atmosphere of this part of the Conference. At the end of the conference, for those interested, a trip to the Green Lake Valley (Dolina Zeleného plesa) was organised, which was successful, despite the fact that the weather was not perfect.

ną już częścią Konferencji był konkurs na najlepszą prezentację studencką. Jak zwykle międzynarodowa komisja oceniająca była surowa, ale sprawiedliwa. Nagrody ufundowane w konkursie przez burmistrza Tatr Wysokich i firmę KVANT zostały przyznane dla Valentina Dorić (Chorwacja) oraz Andreasa Laug (Niemcy).

Ponieważ nauka jest 'żywym człowiekiem', odbyła się również uroczysta kolacja w Muzeum Ždiarskiego Domu. Wzbogacona została ona dodatkowo pokazem ždarskiego ślubu, w którym brali udział w tradycyjnych strojach wybrani uczestnicy konferencji. Z pewnością wydarzenie to przyczyniło się do przyjaznej i nieformalnej atmosfery tej części Konferencji. Na zakończenie tegorocznej edycji Konferencji, dla zainteresowanych, zorganizowano wycieczkę do Doliny Zielonego Jeziora (Dolina Zeleného plesa), która

At the end of this valley, mostly hidden in clouds, the extremely peculiar and photogenic spectacle was observed.

It is not appropriate to boast, but according to the opinions of participants, it seems that this year's Conference has ended positively, both in terms of organisation and science, thus met the expectations. After a two-year break, it was again an opportunity for European dipterologists to share their knowledge and experience, renew old and make new contacts and spend pleasant moments together. We look forward to the next such scientific meetings.

zakończyła się sukcesem, mimo że pogoda nie była idealna, a wyjątkowo osobliwy i fotogeniczny spektakl znajdujący się na końcu doliny, był w większości ukryty w chmurach.

Nie wypada się chwalić, ale zgodnie z opiniami uczestników wydaje się, że tegoroczna Konferencja zakończyła się pozytywnie, zarówno pod względem organizacyjnym, jak i naukowym, spełniając tym samym stawiane oczekiwania. Po dwóch latach przerwy, była to ponowna okazja dla europejskich dipterologów, aby podzielić się swoją wiedzą i doświadczeniem, odnowić stare i nawiązać nowe kontakty oraz spędzić razem miłe chwile. Z niecierpliwością oczekujemy kolejnych tego rodzaju spotkań naukowych.

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# Contents

Introduction ..... 3

## Botany & Algology, Mycology

*Adriana Brišová*

Inspirations by plant in the decorative motifs of St. Mary's Basilica in Kraków (Poland) ... 7

*Krystyna Towpasz*

Vascular plants of Pilzno surroundings (South-Eastern Poland) ..... 31

## Zoology

*Héctor M.J. López-Castilla, Ángel J. Ríos-Oviedo, William Cetzal-Ix, Saikat Kumar Basu*

Construction of the nest of *Amazilia rutila* De Lattre (Trochillidae) and its anti- predatory defensive strategy in a medium deciduous forest in Campeche, Mexico ..... 67

## Experimental Biology

*Angelika Kliszcz, Joanna Puła*

Assessment of earthworms activity based on eaten biomass from selected catch crops ..... 81

*Roland Kopaliani, Temur Gvinianidze, Rezo Jabnidze*

The bio-flavanoid concentrate of *Vitis vinifera* L. 'Red Aladasturi' ..... 91

*Aleksandra Mazur*

The role of seed coat in the germination and early stages of growth of bean (*Phaseolus vulgaris* L.) in the presence of chickweed (*Stellaria media* (L.) Vill.) ..... 103

*Peiman Zandi, Katarzyna Możdżeń, Beata Barabasz-Krasny, Yaosheng Wang*

The role of magnesium salts in germination and growth of *Cucumis sativus* L. ..... 119

## Ecology & Enviromental Protection

*Jiří Kupka, Hana Švehláková, Rostislav Poláček*

Selected environmental issues of the landscape of shale (Nízký Jeseník Mt., Czechia) – preliminary results ..... 135

## Various

*Andrzej Danel, Joanna Puła*

Plants as a treasury of fragrant substances for food industry and perfumery ..... 149

*Anna Kocoń, Sylwia Janiczek, Natalia Malejky-Kłusek*

Methods of protection against ticks (Acari: Ixodida) ..... 161

*Mohamad Hesam Shahrajabian, Wenli Sun, Qi Cheng*

Measures to achieve a stable farming system in sustainable agriculture – a short review ..... 170

*Sylwia Śliwińska-Wilczewska*
Cyanobacteria and cyanometabolites used in the pharmaceutical and medical industry ..... 180

Reports ..... 191

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