Wild relatives of potato or less known representatives of the nightshade family (Solanaceae Juss.)

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Summary:

Nightshade family (Solanaceae Juss.) is represented in the domestic flora by both native species and of the foreign origin, including invasive. Characteristic feature of many taxa of the nightshade family is the presence of different kinds of active substances from the group of alkaloids (nicotine, atropine, scopolamine), responsible for their toxic properties. Not many people are aware that it embraces vegetables (e.g., potatoes, tomatoes, peppers and eggplant) as well as stimulants (e.g., tobacco) and poisonous plants. From the last group noteworthy polish species are: bittersweet nightshade, henbane and deadly nightshade. Solanaceae for centuries have been used in folk medicine in many regions of the world, and the substances contained in them were also used in many sectors of conventional medicine. They were also bound with many folk beliefs.

Key words: nightshade (Solanaceae), flora of Poland, poisonous plants, protected plants, alkaloids

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Introduction

The family Solanaceae (Solanaceae Juss.) comprises, depending on taxonomic approach, from 2,300 to 2,930 species, classified into over 90 genera (Eich, 2008). The greatest variety of species can be found in the tropical zone, but Solanaceae also occur in other regions of the world except the circumpolar areas. They include both herbaceous and ligneous plants with pentamerous, sympetalous and polysymmetric flowers, frequently of astonishing colors (e.g. the genus *Petunia* Juss.). Their fruits are of the capsule or berry type, gladly consumed by animals and humans (as e.g. tomato plant *Lycopersicon edculentum* Mill.) (Rutkowski, 2014). The characteristic of Solanaceae is their content of various active alkaloid substances (nicotine, atropine, scopolamine), which determine the properties of individual species. They affect mainly the central nervous system and depending on the dose consumed may produce hallucinations, loss of consciousness, convulsions, and may even cause death.

Solanaceae include cultivated vegetables (i.e. potato, tomato, bell pepper or eggplant also known as aubergine), stimulants as e.g. cultivated tobacco (*Nicotiana tabacum* L.), and highly poisonous plants. Mentioned among the latter representatives of domestic flora should be e.g. deadly nightshade (*Atropa belladonna* L.),

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bittersweet (*Solanum dulcamara* L.), or henbane (*Hyoscyamus niger* L.). One should bear it in mind that potato tubers (*Solanum tuberosum* L.) may be just as dangerous. Consumption of a sprouting potato tuber may cause a serious food poisoning. The so-called "spots" from which the sprouts grow should be removed due to their high content of harmful solanine. Just as harmful are greenish tubers, which – like leaves – contain more alkaloids: solanine and chaconine. The substance is only inactivated to some extent through heat treatment, which is why potatoes should not be consumed raw. Particularly dangerous is consumption of the fruits of *Solanum tuberosum* (small round berries) due to their highest solanine content (Sołtys, 2013).

The Latin name of the family Solanaceae refers to psychoactive properties and probably stems from the word *sol*, which means „sun", *solament* – „consolation, solace", or *solari* – „soothe, ease" (Rajewski 1996). On the other hand, the English name "*nightshade*" suggests negative associations with the discussed plants (Ciechomska, 2014). This relates probably to their use as ingredients of magical formulas and poisons in antiquity and the Middle Ages. Today, their potential – or the potential of the substance they contain, to be exact – is used mainly in medicine. The example is atropine, a compound found in the leaves and roots of belladonna. It is used in symptomatic treatment of the Parkinson's disease or as a mydriatic in vision screening (Ciechomska, 2014).

Selected representatives of Solanaceae in Polish flora

Native species

Deadly nightshade (*Atropa belladonna* L.), also known as belladonna, is among the most characteristic native plants children have been warned against for ages

due to its poisonous properties. It can be found mainly in clearings but also in forests and scrubs. The sites of its occurrence are located in Southern Poland, mainly in the lower ranges of Sudety and Karpaty mountains (Piękoś-Mirkowa and Mirek, 2006). It is easily distinguishable due to its brown- and violet-colored corona and fruits in the shape of large and shiny black berries (Fig. 1). The perennial may grow up to 2 meters high (Rutkowski, 2014). The Latin name of belladonna is derived from *Atropos* – the Greek goddess of destiny (who cut the thread of life, which means that the plant's name reverts to its poisonous properties), while "belladonna" means „beautiful lady". Nightshade's unusual properties were already known in antiquity. In ancient Rome, belladonna berries were used to give the eyes a specific shine and to dilate the pupils (Szary, 2013). In the Middle Ages, nightshade was among the main ingredients of the „witch ointments" that produced hallucinations (Szary, 2013). The properties are caused by tropane alkaloids – atropine, belladonna, hyoscyamine, scopolamine – contained in nightshade. The substances are now used in medicine. The herbalist's raw materials – nightshade leaves and root-stock – are antispastic and analgesic agents utilized in many branches of medicine: for example, atropine is used to dilate the pupil for the purpose of eye screening in ophthalmology. It is also used to ease the attacks of bronchial asthma or renal colic, and also in the treatment of cholepathies (Volak and Stodola, 1987). The plants from which the extract is obtained for pharmaceutical purposes are cultivated as those naturally occurring are partly protected (Rutkowski, 2014; Regulation, 2014). One should bear it in mind that nightshade is really dangerous: just 3-4 berries consumed by a child may cause death (Hennenberg and Skrzydlewska, 1984).

Another wild relative of potato that occurs naturally in Poland is henbane bell (*Scopolia carniolica* Jacq.) (Fig. 2). The rare species grows in Eastern Carpathians and in Pieniny Mountains. It occurs most often in scrublands, highly shadowed forests (it prefers alder wetlands, beech forests, mountain sycamore forests), at the base of midforest rocks, on rocky slopes, and less frequently – in herb communities (Piękoś-Mirkowa and Mirek, 2006). In the Western Carpathians, it was planted in graveyards and around shrines (Szary, 2013). It is a protected plant (Regulation, 2014) – its sites of occurrence are endangered particularly in alder forests, which suffer from flood control operations (Piękoś-Mirkowa and Mirek, 2006). Like its relatives, henbane bell contains substances that are dangerous for human health: hyoscyamine and scopolamine, which may permeate the skin. Its roots and rhizomes are particularly poisonous. The symptoms of poisoning relate to the nervous system (flush, dilated pupils, agitation, hallucinations, frenzy), the cardiovascular system (tachycardia) or the respiratory system (dyspnea and paralysis leading to death) (Szary, 2013). Small doses are used in medicine to reduce the smooth muscle tone, and due to its impact on the nervous system, the plant is also used in surgery and psychiatry (Czikow and Łaptiew [Chikov and Laptyev?], 1987) In the past ages, the peoples of Eastern Carpathians used henbane bell as an anesthetic and effective cure for alcohol poisoning; the plant also had the opinion of an effective aphrodisiac (Szary, 2013).

Bittersweet (*Solanum dulcamara* L.) is a common species throughout the plain and in lower mountain areas (Szafer et al. 1986). It prefers moist habitats, as e.g. river banks. It often occurs in alder swamps and ash-alder meadows (Witkowska-Żuk, 2013). In Europe, the plant occurs naturally; however, it turned out to be invasive once it was introduced in the North American flora (Witkowska-Żuk, 2013). As opposed to the other discussed species of Solanaceae, it is not an herbaceous, but a subshrub with a lignified stem. It is easily identified due to its flowers with a violet corona and yellow stamina as well as the red egg-shaped berries (Rutkowski, 2014) (Fig. 3). Its name is derived from the bittersweet taste of its berries, which are better left untasted – the plant is highly poisonous. For many ages, it was used in folk medicine as an expectorant, laxative and diuretic. This is no longer the case today, as an overdose

Fig. 1. Deadly nightshade (*Atropa belladonna*)
Source: Wikimedia Commons (2016)

Fig. 2. Henbane bell (*Scopolia carniolica*)
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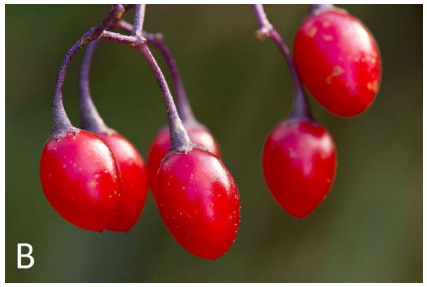

Fig. 3. Bittersweet (*Solanum dulcamara*)
Source: H. Zell (A), Christian Fischer (B), Wikimedia commons (2016)

Fig. 4. Black henbane (*Hyoscyamus niger*)
Source: Parik Ilme, Wikimedia commons (2016)

Fig. 5. Black nightshade (*Solanum nigrum*)
Source: Andre Engels, Wikimedia commons(2016).

may be dangerous: excessive consumption of saponines contained in bittersweet causes hemolysis (Krejca and Macku, 1986). Bittersweet also contains steroid alkaloids: soladulcidine, solasodine and tometidenol (Różański, 2008).

Non-native species

As opposed to the species described above, black henbane (*Hyoscyamus niger* L.) is a plant of non-native origin. It is classified as an archeophyte, which means that it came to the territory of today's Poland before the Age of Discovery (16th century). Originating from the Iranian-Anatolian province, the plant reached Europe in the Neolithic Age, and the earliest archeological finds bearing the traces of its occurrence in the territory of today's Poland date from the Iron Age (Sudnik-Wójcikowska, 2011). Its most common habitats include fallows, roadsides, areas near human dwellings and rubbles (Kuźniewski and Augustyn-Puziewicz, 1986). Black henbane is easily identified in the field due to its cream-yellow corona petals with the characteristic dark violet reticulation and the large violet stamina (Fig. 4). Also its odor is characteristic, exceptionally strong and offensive (Stewart, 2011). Despite such clear diagnostic features, cases of black henbane poisoning do occur. Sometimes the plant is consumed on purpose to produce hallucinations, as it contains a mixture of alkaloids including hyoscyamine, scopolamine and atropine (Kossak, 1995). The plant was particularly popular during the Middle Ages as an ingredient of the famous ointments that supposedly helped witches fly (Szary, 2013). The legend is not completely without grounds as the sense of floating is an inseparable symptom of black henbane poisoning (Kossak, 1995). Consumption of any fragment of the plant (each of its parts being poisonous) may cause paralysis of the central nervous system. The herb's strength was known already in ancient Egypt, about 2500 B.C. – it served as the ingredient of a potion that could instantly kill even the strongest persons, but was also used in moderate doses as a pain killer (Kossak, 1995). In Polish folk medicine, black henbane was used as an analgesic, diastolic, anti-asthmatic and anti-inflammatory agent, especially in parodontopathies (Kuźniewski and Augustyn-Puziewicz, 1986).

Another relative of potatoes, which came to the territory of today's Poland before 1500 (i.e. also an archeophyte) is the European black nightshade (*Solanum nigrum* L.). It is known to have arrived in Europe already during the Neolithic Age but its origins have not been determined yet. It is supposed to originate from Atlantic coast or from the Mediterranean area (Sudnik-Wójcikowska, 2011). It is common in the plains and lower mountain areas (Szafer et al., 1986). The species includes several subspecies, forms and varieties that differ from one another as regards sprout pubescence, berry color and leaf crenation. The plant is usually small (growing up to 0.5 meter high) with lozenge- and egg-shaped leaves with sinuate indentations gathered in an corymbothyrsus, white flowers with yellow pistils and shiny black berries up to 1cm diameter (Rutkowski, 2014) (Fig. 5). The plant also features variable content of glycoalkaloids (especially solanine) – their concentration varies from organ to organ and from population to population. Most dangerous, however, are unripe fruits and leaves (Sudnik-Wójcikowska, 2011; Kaźmierczak, 2015). The symptoms of solanine poisoning include diarrhea, dyspnea and brown color of urine indicating renal damage (Kaźmierczak, 2015). Black nightshade is a synanthropic plant related to man-transformed or –created habitats. Its convenient ecological niches include waste land, areas near human dwellings, ground adjoining fences, the vicinity of sewers, root crops cul-

tivation areas (as weed), and especially in areas where the soil is heavy (Żuławy) or excessively manured with nitrogen (Sudnik-Wójcikowska, 2011).

During the Age of Discovery, new and unfamiliar plant species were brought to Europe on a large scale. Many taxons of foreign origin became naturalized also in Poland where they occur naturally today. Neophytes – the name of non-native species that arrived after 1500 – can also be found among "potato's wild relatives" (Kornaś and Medwecka-Kornaś, 2002). They include e.g. devil's snare (*Datura stramonium* L.), probably brought to Poland with wool or soya during the first half of the 17th century from south-eastern areas of North America or South-European areas of USSR and western Asia (Szafer et al., 1986, Sudnik-Wójcikowska, 2011, Tokarska-Guzik et al., 2014). It is a species that does not invade natural plant communities (epecophyte) and occurs mainly in anthropogenic habitats, i.e. in ruderal habitats as well as field and garden crops (Sudnik-Wójcikowska, 2011). Devil's snare is a large plant with a branched and slightly hairy stem, strong dark green leaves and flowers with a tubular calyx and a white funnel-shaped corona (Fig. 6). It bears pouch-shaped fruits with characteristic long and rigid spikes and gradually spilling kernels with a reticular pattern (Sudnik-Wójcikowska, 2011). The plant arouses interest mainly because of its psychoactive properties due to the presence of poisonous tropine alkaloids (mainly hyoscyamine and scopolamine), tannins and organic acids in all of its organs (Kuźniewski and Augustyn-Puziewicz, 1986). It was used already in antiquity as a pain killer, soporific and aphrodisiac (Greene and Patterson, 1996; Herbert and Jagiełło-Wójtowicz, 2009). In the Middle Ages, it was used to increase the strength of beer (Müller, 1998). It also served as an ingredient of poisons the preparation and use of which was severely punished, including the death penalty for poisoners (Klepacki, 2007). Devil's snare was also used by the followers of Buddha, Shiva or the bloody goddess Kali, who mixed it with food to produce visions (Sein Anand, 2009). The plant causes both somatic changes which consist in relaxation of the smooth muscles and inhibition of the secretion of fluids (including mucus, sweat, gastric juice) (Ożarowski and Jaroniewski, 1987), and psychic changes as it provokes hallucinations. Cases of sexual abuse are known where the victim lost consciousness having been treated to devil's snare seeds by the abuser (Müller, 1998). Despite its toxic properties, attempts were made for some time to use *Datura* extract and seeds to cure manias, epileptic fits (Steenkamp et al., 2004), as well as rheumatism and arthralgia (Angielczyk, 2011; Wdowiak, 2013). In many underdeveloped countries, the plant is still used today for healing purposes. In Nigeria, a mixture of devil's snare and palm oil serves as a compress to treat painful insect bites, while in Nepal it is used as a pain killer, and – mixed with milk – for deworming. In Pakistan, women apply it to their breasts to prevent flabbiness (Garie and Subedi, 2013). Due to absence of legal regulations governing the cultivation and use of devil's snare, the plant serves as an available and cheap drug. It is often used by young persons who are unaware of the consequences (Cunningham, 2008). It causes intense side effects preceded by highly realistic and unpleasant experiences that may lead to profound psychosis. The symptoms of devil's snare poisoning include e.g. convulsions, tachycardia, dysuria, dryness of the mouth and increased pulse rate. Intoxication may persist for as long as several days and often leads to coma (Markiewicz, 2012; Motyka and Marcinkowski, 2014).

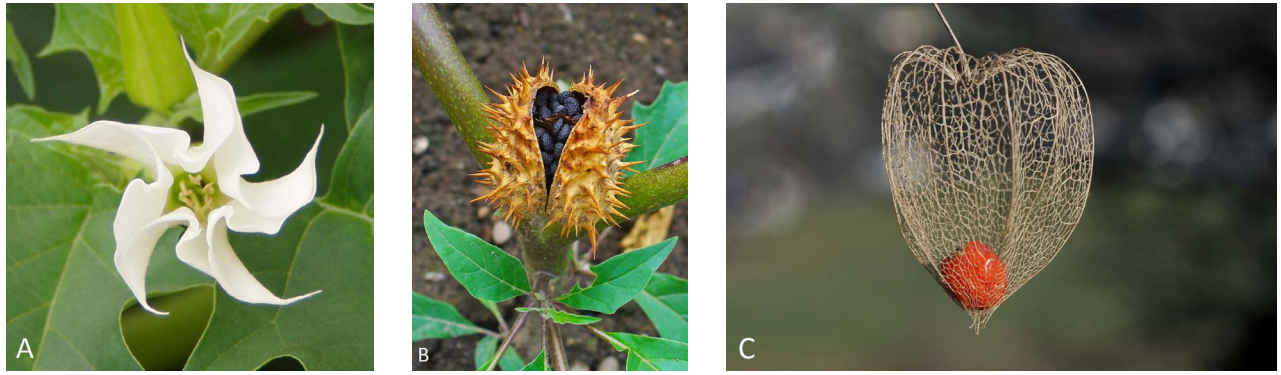

Fig. 6. Devil's snare (*Datura stramonium*)

Source: Júlio Reis (A), H. Zell (B), Wikimedia commons (2016).

Another neophyte from the family Solanaceae, which occurs naturally in Poland, is bladder cherry (*Physalis alkekengi* L.). It is a perennial herbaceous plant with small green-whitish flowers. It has a large, much inflated, minium-red calyx hiding a shiny orange berry-type fruit (Fig. 7) (Rutkowski, 2014). It came to Poland from southern areas of Central Europe, south-eastern Europe and south-western Asia during the latter half of the 19th century (Sudnik-Wójcikowska, 2011). Due to the intense color of its calyx, it is used nowadays for decorative and culinary purposes. It is edible and may be consumed both raw and processed, e.g. as marmalade.

Fig. 7. Bladder cherry (*Physalis alkekengi*)

Source: Bff (A), Friedrich Böhringer (B), H. Zell (C); Wikimedia commons (2016).

Fig. 8. Chinese wolfberry (*Lycium barbatum*)

Source: Danny S (A), AnRo0002 (B), Wikimedia Commons (2016)

Water extracts from bladder cherry fruits have detoxifying properties and increase urination and thus also elimination of harmful metabolites. They also reduce inflammation and edema, and regulate metabolism due to their content of flavonoids and saponines (Różański, 2007). It can be found in man-transformed habitats, such as gardens, allotments, shrubs or waste land within residential areas (Sudnik-Wójcikowska, 2011).

Chinese wolfberry (*Lycium barbatum* L.) (Fig. 8) is a neophyte like the previous two species; it is treated as a spreading threat to the native flora that is hard to eliminate (Tokarska-Guzik, 2012). It came to Poland from China in mid-18th century. Owing to its resistance to drought and high temperatures and tolerance of high nitrogen concentrations in the soil, it is planted all over Poland on river bank protections, buttresses, slopes and various heaps for their protection against erosion (Sudnik-Wójcikowska, 2011). Like most species of the family Solanaceae. Chinese berry is classified as poisonous (Szafer et al., 1986; Rutkowski, 2014). Cases are known of poisoning with its fruits of both humans and animals (Henneberg and Skrzydlewska, 1984). Surprisingly, despite their toxic properties, the fruits of Chinese berry and its close relative *Lycium chinense* Mill. are valued delicacies in Asia, where they are boiled and added to soups, rice, chicken or pork dishes. They are also used to prepare herb teas, juices, wines and fruit cordials, and also powdered and added to dietary supplements and tablets (Bogacz, 2009). The fruits are popular under their commercial name of *„goji"*. They were used for ages in traditional Chinese medicine to treat diseases of the lungs and heart as well as rheumatism over 2.5 thousand years ago. Today, they are a regular ingredient of many persons' diet, which is due to discovery in their composition of a water-soluble bioactive polysaccharide complex (LBP – *Lycium Barbarum* Polysaccharides) whose properties enhance immunity, delay aging and contribute to cancer prevention (Gan et al., 2004; Amagase et al., 2009; Kulczyński and Gramza-Michałowska, 2014). Besides, they are an excellent source of vitamins, minerals (e.g. phosphorus, copper, zinc, selenium, calcium and iron), carotenoids and polyphenol compounds as well asx proteins, carbohydrates, fats and unsaturated fatty acids of the omega-6 group, enhancing the efficiency of operation of the nervous system, brain, vision, liver and heart (Quian et al., 2004; Luo et al., 2004; Amagase et al., 2009; Bogacz, 2009; Cieślik and Gębusia, 2012). One should bear in mind, though, that the goji fruits should not be consumed unprocessed as they may disturb the functioning of the nervous and alimentary systems.

Recapitulation

The family Solanaceae comprises not only the popular cultivated plants (potato, tomato or bell pepper) but also a variety of naturally occurring species. Found in Poland are both native and non-native species, including invasive taxons that threaten the native flora. Some plants (henbane bell) are protected, but most are common synanthropic plants, often growing in the vicinity of human dwellings. Many have poisonous or medicinal properties that have been utilized for ages. One should bear it in mind that Solanaceae consumed as hallucinogens are extremely dangerous and may cause permanent changes of the central nervous system, serious disturbances of the alimentary and cardiovascular systems, and even death.

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