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## Sosnowsky's hogweed – current environmental problem

### Barszcz sosnowskiego – wciąż aktualny problem środowiskowy

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**Keywords:** Sosnowsky's hogweed, invasive plant, environmental threat, health threat

**Słowa kluczowe:** Barszcz Sosnowskiego, roślina inwazyjna, zagrożenie środowiskowe, zagrożenie zdrowotne

#### Abstract

Sosnowsky's hogweed was brought to Poland as a silage plant for cattle in the mid-20<sup>th</sup> century from the Caucasus. It was grown mainly in National Farms. However, the hogweed quickly spread across the natural environment. It is a highly invasive plant and possesses strong burning qualities. Every year many people suffer from its burns. The hogweed is also dangerous for animals. Being an invasive species, it displaces natural plant species of the native flora. It can threaten the flora and landscape of a particular area. The aim of the article is to present the problem including the frequency of occurrence of Sosnowsky's hogweed in Poland, to show the negative effects for human health and the methods to fight it in its habitat.

#### Streszczenie

Barszcz Sosnowskiego został sprowadzony do Polski jako roślina uprawna na paszę dla bydła w połowie XX wieku z Kaukazu. Głównie był hodowany w Państwowych Gospodarstwach Rolnych. Barszcz jednak w krótkim czasie przedostał się do środowiska naturalnego. Jest rośliną bardzo ekspansywną i posiada silne właściwości parzące. Każdego roku poparzonych zostaje wielu ludzi. Barszcz jest również groźny dla zwierząt. Jako gatunek inwazyjny wypiera naturalne gatunki roślinne rodzimej flory. Może zagrażać florze i krajobrazowi obiektów właściwych dla danego terenu. Praca ma na celu ukazanie problemu, w tym wykazanie skali występowania barszczu Sosnowskiego na terenie Polski, ukazanie negatywnych skutków zdrowotnych dla człowieka oraz metod jego zwalczania w środowisku bytowania.

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## 1. INTRODUCTION

Sosnowsky's hogweed (*Heracleum Sosnowskyi* Mandel L.) is a native Caucasus plant. It was named in honour of a researcher in the flora of the region professor D.I. Sosnowski by I.P. Modenowa in 1944 [Kostecka-Mędalska et al., 1963].

In Poland it was introduced into cultivation as a silage plant for cattle in the second half of 20<sup>th</sup> century in National Farms and by individual farmers. It was also treated as a honey plant [Gałczyńska and others 2016].

Since the first years of cultivation, Sosnowsky's hogweed has been a source of numerous problems [Lutyńska, 1980] despite a considerable amount of produced silage and its plenitude of nutrients (e.g., fats, carbohydrates, etc.). It appeared that the cattle were unwilling to eat the silage based on the species due to its bitter flavour and the smell and taste of the milk and meat produced from the cattle that was fed this silage changed, which considerably decreased their trading value [Wojtkowiak et al., 2008]. Later, research on the quality of the plant revealed its toxic qualities, causing burns both among animals and humans [Wrzesińska et al., 2000].

The problem of Sosnowsky's hogweed's invasion in Poland was noticed in 1990s, which made the farmers withdraw the cultivation. At that time, the press reported numerous incidents

of burning in summer, among people who came into contact with the plant especially while relaxing by the water [Wróbel, 2008].

The research conducted by Rzymiski et al. in the area of social awareness of dangerous qualities of the Caucasian hogweeds revealed relatively low level of knowledge of the problem. They stated that only 58% of the interviewees had heard of the dangerous qualities of the plant. The source of information most frequently indicated was the Internet (48%), TV programmes and school education (28%) and friends (19%) [Rzymiski et al., 2015].

Sosnowsky's hogweed's invasion in the natural environment and its negative health consequences to animals and humans are significant problems, both in the aspect of environmental protection as well as environmental health; and, as a result, it is required that extensive preventative measures should be undertaken in the field of health education. Educational actions should be accompanied by the elimination of the plant in its natural habitat.

The aim of the work is to show the frequency of occurrence of Sosnowsky's hogweed in Poland, including identifying methods to fight it in its habitat and negative health consequences for humans as they are exposed to its effects.

## 2. GENERAL CHARACTERISTICS OF THE SPECIES

Sosnowsky's hogweed is a species native to the Caucasian flora and belongs to the family *Apiaceae* [Kostecka-Mędalska 1962]. It is one of the four species of hogweed (*Heracleum*) growing in Poland.

Four hogweed species grow in Poland: giant hogweed (*Heracleum mantegazzianum*), Sosnowsky's hogweed (*Heracleum sosnowskyi*), common hogweed (*Heracleum sphondylium*, *Heracleum sphondylium* ssp. *sibiricum*) [Mirek, 2002]. Both Sosnowsky's hogweed and giant hogweed are ranked into big hogweeds of similar biology [Jahodová, 2007]. Due to their similarity, they are commonly referred to with the same name: Caucasian hogweeds [Gałczyńska, 2016].

Research proves genetic differences in the two species as some of their qualities differ morphologically [Tutin, 1968]; however, for practical reasons and due to the fact that in many studies Sosnowsky's hogweed and giant hogweed are treated as one, it has been decided that referring to the individual plants as belonging to *Heracleum sosnowskyi* or *Heracleum mantegazzianum* is of no importance. The crucial thing is differentiating them from one another, from similar species in the genus *Heracleum* or from the family *Apiaceae* [Muzykiewicz, 2017].

Due to similarity in the build of Sosnowsky's hogweed (*Heracleum sosnowskyi*) and giant hogweed (*Heracleum mantegazzianum*), the plants are difficult to identify. They both have similar morphological build. What separates them is the shape of leaves, the height of stems and the size of umbels [Rutkowski, 2014].

The characteristic feature of the Caucasian hogweeds is their size as well as solidity of their leaves, stems and umbels. They tend to reach the height of 3 metres, sometimes 4–5 metres and more [Jakubowska-Busse, 2013; Śliwiński, 2012]. They are considered one of the biggest herbal plants in the world. A leaf of Sosnowsky's hogweed can grow up to 2 metres in width [Wróbel, 2008], the stem can reach the diameter of 8–10 centimetres and the height of 2.5–5 metres [Śliwiński, 2012]. Scientific reports from 1970s indicate that coumarine derivatives were released from *Heracleum* resin substances [Fujita, 1956].

A variety of plant species occurring in the natural environment contain photosensitising substances that can cause phototoxic and photoallergic reactions. The plants include Sosnowsky's hogweed and giant hogweed [Weryszko-Chmielewska, 2014].

Plants that contain a high concentration of coumarine substances together with the impact of ultraviolet rays have phototoxic and carcinogenic qualities [Jaworek, 2017].

Essential oil of both Sosnowsky's hogweed and giant hogweed contains toxic substances, while isobergaptin, psoralen, bergaptin, pimpinellin and isopimpinellin were found in their ripe fruit [Wrzesińska et al., 2000; Jakubowska-Busse et al., 2013; Abyshev, 1973]. In both cases, these plants' sap contains furocoumarine compounds that primarily have photosensitising qualities [Wrzesińska, 2006].

Sosnowsky's hogweed is a monocarpic plant, which means that it flowers and fruits once in a lifetime; in other words, it dies after setting seeds. However, if it has been damaged before, it activates its regeneration potential and does not die but flowers

and sets seeds for many subsequent years. It has a firm root that is disproportionately long as compared to the aboveground part of the plant. It dies in winters, leaving only dry stems with inflorescences that can survive for several years. Its survivability is low with only a few strongest plants surviving from thousands of young plants. They are best adapted to continue the invasion. In the case of field crops, the production of seeds reaches 2.6 t from a hectare, while one plant produces from 10,000 to 40,000 seeds [Wojtkowiak et al., 2008; Śliwiński, 2012; Krzemkowski, 1995].

Scientific classification of Sosnowsky's hogweed is presented below [Wojtkowiak et al., 2008]:

- Domain: Eukaryota
- Kingdom: Plantae
- Subkingdom: Vascular
- Superphylum: Spermatophyta
- Phylum: Angiospermae
- Subphylum: Magnoliophyta
- Class: Rosopsida
- Subclass: Cornidae Frohne & U. Jensen ex Reveal
- Superorder: Araliaanae
- Order: Apiales
- Family: Apiaceae
- Genus: *Heracleum*
- Species: *H. Sosnowskyi*

## 3. THE OCCURRENCE AND THREAT TO THE BIODIVERSITY

Sosnowsky's hogweed is an invasive plant [Domaradzki, 2013]. It is included in the list of foreign species presented in the Regulation of the Minister of Environment issued on 9<sup>th</sup> September 2011, concerning the list of foreign plant and animal species that, if released into the natural environment, can pose a threat to native species or natural habitats. The invasibility of Sosnowsky's hogweed has been proved by research [Stupnicka-Rodzynekiewicz et al., 1996; Tokarska-Guzik et al. 2012].

Being an invasive species, it displaces natural plants in their habitats. It behaves like a neophyte. Its attitude to other elements of an assemblage must be described as edification [Faliński, 1968]. The result of invasion is its constant colonization leading to vanishing of local species. The flora of assemblages infested by it is much poorer than the flora of the areas neighbouring the hogweed [Ciosek, 2010].

Research results reveal that Sosnowsky's hogweed poses a threat to the protected plants in National Parks: Ojcowski, Tatrzański, Biebrzański, Natura 2000 areas in the Stołowe Mountains, and also it may threaten some protected area objects – Jedlina Reserve, Landscape Parks of the River Bug Valley, Zelejowa Mountain Reserve [Wojtkowiak et al., 2008; Wróbel, 2008; Podgórska et al., 2011].

At the end of 20<sup>th</sup> century, it was reported that Sosnowsky's hogweed occurred locally on the whole area of Poland [Krzemkowski, 1995]. Although the cultivation of Sosnowsky's hogweed was stopped at the end of 1990s, the plant can still be spotted in Poland and its new habitats have been reported – even as far as several kilometres from the previous crop sites. It

usually occurs in places where it was cultivated before or where trials to remove it were improperly undertaken. Most typically, it grows along watercourses, on ditch banks, on the edges of fields and forests, on meadows and pastures, idle lands, along communication routes and in river valleys and in all kinds of wasteland [Wojtkowiak et al. 2008, Domaradzki et al. 2013].

An upsetting phenomenon can be the fact that Sosnowsky's hogweed occurs in urban agglomerations. Results of the research in the occurrence of *Heracleum sosnowskyi* and *Heracleum mantegazzianum* in Wrocław agglomeration conducted in 2008–2010 indicate finding 134 positions of both species located in Wrocław, Siechnice and 6 villages near Wrocław [Śliwiński et al., 2011]. Also, the research conducted in 2000–2006 in the location of *Heracleum sosnowskyi* in the area of Central Pomerania shows four cases of growing it as an ornamental plant. They were found: in a town square, flowerbed, private gardens and allotments in Słupsk, Chabrów, Mrzeżyno, Połczyn-Zdrój [Sobiasz, 2007].

Polish nationwide inventory of Sosnowsky's hogweed and giant hogweed conducted in 2012 revealed over 1700 sites of the Caucasian hogweeds. The analysis of the inventory shows that the plants of both species were identified on the whole area of Poland during the time of the research. The research findings indicate that locations of the Caucasian hogweeds were found at approximately every four borough [Sachajdakiewicz et al., 2015].

#### 4. EXPOSURE TO THE CONTACT AND MEDICAL HAZARD

In 1994–95, the press reported on the burns that people suffered because of the contact with Sosnowsky's hogweed in summer while relaxing by the water [Wróbel, 2008].

As it has already been stated Sosnowsky's hogweed has toxic and allergenic qualities. Its sap contains coumarine whose derivative is furocoumarine, which causes skin oversensitivity to solar radiation. It is the reason why the question of medical hazard resulting from an exposure to the contact of plant is an essential problem for a widely understood public health.

Surveys conducted in 2014 by medical doctor (dermatologist, general practitioners and occupational medicine specialists) revealed relatively low knowledge of negative health consequences after a contact with the Caucasian hogweeds. Nearly half of the interviewees had never heard of the Caucasian hogweeds and were unaware of the threats that they pose [Klimaszyk et al., 2014].

Scientific reports on the diagnosed negative health effects on the people exposed to the contact with Sosnowsky's hogweed prove that the human skin after a contact with the hogweed sap exposed to solar radiation (UVA) may undergo dermatoses of all three stages. Sores and ulcerations caused by the burns are difficult to heal and may persist even for several years and may cause the scars. In extreme cases, it may lead to extensive dermonecrosis. Just being in close proximity to a hogweed may lead to respiratory tract burns. Also, people who came into contact with the Caucasian hogweeds happened to suffer from general symptoms such as nausea, vomiting, headaches and so on. The plant's juice that gets into eyes may cause injuries

or, in extreme cases, vision loss. Some suppose that there is a possible connection between the compounds that the Caucasian hogweeds contain and skin cancers. On hot days, essential oils released by dense clusters of hogweeds may transpire from the plants' surfaces and float in the air even as far as several metres. So, there is a risk that injuries may be received even without a direct contact with the hogweeds [Guzik, 1994; Śliwiński, 2012; Wojtkowiak et al., 2008; Rzymyski et al., 2015].

In the situation of a direct exposure to the effects of Sosnowsky's hogweed, it is advisable to wash the skin with lukewarm water and soap as soon as possible after a direct contact with the plant so that the sap is removed from the skin surface. Next, it needs to be protected against the exposure to solar radiation for at least 48 hours. It is also recommended to apply cream with a high UV filter and hydrophobic lotions (containing linoleic acid, colloidal silicone dioxide) that inhibit phototoxic substances from penetrating through corneum and to keep avoiding exposure to the sunlight even if no symptoms occur during this time. If swelling and an inflammatory response occurs, it is advised to apply wet dressings or ice, take calcium pills or antihistamine tablets. It may prove effective to apply medications containing silver sulfadiazine. In case redness on the body occurs, it is recommended to locally apply glucocorticosteroids. In the case of extensive blisters and necrosis, glucocorticosteroids treatment should be considered. If the burn covers 30 percent of the skin's surface or more, it is advisable to administer an intensive anti-burn treatment including intravenous fluid substitution. It is important to remember that maintaining proper hygiene such as proper cleansing of the burn and a proper dressing (with, for example, silver sulfadiazine or silver ions, compresses with aluminium acetate, potassium permanganate or 3% boric acid) plays an important role in the local treatment especially to prevent a secondary infection [Nielsen et al. 2005; Khachemoune et al. 2006; Wierzejska et al. 2004; Sarhane et al. 2013; Mill 2008].

#### 5. CONTROLLING

Due to its toxicity and its invasiveness, Sosnowsky's hogweed needs to be controlled. In Poland, there are no legal regulations imposing statutory controlling and removing Sosnowsky's hogweed. The costs connected with definite removal of the species pose a serious problem for boroughs and owners of the properties where its habitats have been identified [Śliwiński, 2012; Gałczyńska et al., 2016]. It is the reason why they do not undertake firm actions aimed at effective elimination of the species from its habitat and they decide on preservative actions only. That is why, it is essential to choose a proper and, most importantly, effective method to control the plant.

Studies on the problem prove that removing hogweeds by means of cutting or ploughing is ineffective, while controlling it by digging out is dangerous to health, time-consuming and expensive. Irregular and incompetently implemented measures to remove Sosnowsky's hogweed have not eliminated the plants from their habitats but, quite the contrary, caused their further expansion [Śliwiński, 2009].

Results of the experiments that applied chemical methods against the Caucasian hogweeds were described by Żurek, Stupnicka-

Rodzinkiewicz, Klima and Badowski, who provided information about herbicide dosages, chemical sprays schedules, frequency of the actions performed and so on [Żurek, 2002; Stupnicka-Rodzinkiewicz et al., 2009].

Cutting and applying herbicides are the most common methods employed in Poland in order to reduce and eliminate the species. However, cutting does not eliminate Sosnowsky's hogweed from the environment but only prevents it from forming seeds and, as a result, feeding the soil-seed bank and spreading the plants. But it should be done repeatedly throughout a vegetative season. It must be kept in mind that neglecting the regular cutting within a vegetative season may defeat the purposefulness of the actions previously performed and, in consequence, contribute to increase in strength of the species in the examined area [Żurek, 2002; Podgórska et al., 2011].

Another method to control the species is cutting off its inflorescences. It should be remembered that the timing of application of the method is important. It should be applied at the early stage of blossoming of the last inflorescences. Performing the action too early may lead to a strong recovery of the plant and creating new inflorescences that will produce seeds fit to sprout. Applying the method too late will cause the seeds produced by the plant to ripen on the cut-off parts of the plants and then spread, if they are not utilized [Lutyńska, 1980; Gałczyńska et al., 2016; Śliwiński, 2012].

Another method of controlling Sosnowsky's hogweed is deep ploughing. It's considered to be one of the effective ways of reducing the species' population; however, it does not eliminate the plant from its habitat thoroughly [Wrzesińska, 2006].

So far, no simple, effective and safe method of removing the plant has been developed. Herbicide spraying and cutting do not give the desired results.

Observations and the research in spreading and removing Sosnowsky's hogweed from its habitats reveal that mixed methods are most effective.

## REFERENCES

- ABYSHEV A. Z., DENISENKO P.P. 1973: The coumarin composition of *Heracleum sosnowskyi*. Chemistry of Natural Compounds; 4 (9): 515-516.
- CIOSEK M. T., SIKORSKI R., TRĘBICKA A. 2010: Wpływ Barszczu Sosnowskiego (*Heracleum Sosnowskyi* Manden) na strukturę i skład florystyczny fitocenozy. FRAGM. AGRON. 27(2): 39–46.
- DOMARADZKI K., DOBRZAŃSKI A., JEZIERSKA-DOMARADZKA A. 2013: Rośliny inwazyjne występowanie, znaczenie i zagrożenie dla bioróżnorodności. Progress in Plant Protection/ Postępy w Ochronie Roślin; 53 (3): 616-617.
- FALIŃSKI J.B. 1968: Synantropizacja szaty roślinnej. I. Neofityzm i apofityzm w szacie roślinnej Polski. Mat. Zakł. Fitosocj. Stos. UW, Warszawa – Białołęka: 229.
- FUJITA M., FURUYA T. 1956: J. Pharm. Soc. Japan: 76: 535
- GAŁCZYŃSKA M., GAMRAT R., ŁYSKO A. 2016: Wpływ gatunków inwazyjnych z rodzaju *Heracleum* SPP. (Apiaceae) na środowisko i zdrowie człowieka, Kosmos Problemy Nauk Biologicznych; 65 (4): 591-599.
- GUZIK J. 1994: Ocena stopnia zagrożenia rodzimej flory Polski oraz niebezpieczeństwa jakie może stwarzać dla człowieka barszcz Sosnowskiego (*Heracleum sosnowskyi* Manden.) - na podstawie wyników badań w południowej części kraju, Polska Akademia Nauk, Instytut Botaniki im. W. Szafera, Kraków.
- JAKUBOWSKA-BUSSE A., ŚLIWIŃSKI M., KOBYŁKA M. 2013: Identification of bioactive components of essential oils in *Heracleum sosnowskyi* and *Heracleum mantegazzianum* (Apiaceae). Archives of Biological Sciences; 65 (3): 877-883.
- JAHODOVÁ Š., FRÖMBERG L., PYŠEK P., GELTMAN D., TRYBUSH S., KARP A. 2007: Taxonomy, identification, genetic relationship and distribution of large *Heracleum* species in Europe (Chapter 1). [in:] Pyšek P., Cock M. J. W., Nentwig W., Ravn H. P. (eds). Ecology and management of Giant Hogweed (*Heracleum mantegazzianum*), CAB Internat. Wallingford.: 1–19.
- JAWOREK A. K., MICHAŁEK K., WOJAS-PELCA A. 2017: Reakcja fitofototoksyczna ze współistniejącymi zmianami odpowiadającymi *erythema multiforme* związana z ekspozycją

## 6. CONCLUSION

Introducing Sosnowsky's hogweed for cultivation in Poland as a fodder plant has not brought the desired results. The cases of negative effects on living organisms have proved it to be a dangerous plant, not only for the natural environment but also for people and animals living in it.

At present, Sosnowsky's hogweed's locations can be seen virtually on the whole area of Poland including cities, park complexes, private allotments and gardens. The data gathered in the nationwide census in 2012 reveals that there are over 1700 locations of the plant in Poland.

Despite the serious threats to living organisms resulting from the contact with the plant, the interest and knowledge of the problem are still inadequate. Research findings concerning the general knowledge of its undesirable impact on the natural environment, look and harmfulness based on the surveys conducted among the Polish society, including doctors and local government workers responsible for the environmental protection, have proved it to be at a low level.

The situation calls for the necessity to take actions aimed at increasing the level of social awareness of Sosnowsky's hogweed's harmful impact and the course of action that should be taken when coming into contact with the plant. The educational actions can be effective if they are professional, solid and widespread. So, it is essential to launch campaigns based on scientific evidence.

Another, parallel element of controlling Sosnowsky's hogweed is to fight it in its natural habitat. It can be realized with an active participation of local authorities and funds that will enable effective and safe actions to remove the plant from green areas.

It appears well-based and purposeful to continue the research to develop more effective methods of controlling Sosnowsky's hogweed in its habitat including the conditions for its growth.

- na barszcz Sosnowskiego. *Przegląd Dermatologiczny*; 104: 17.
- KHACHEMOUNE A., KHECHMOUNE K., BLANC D. 2006: Assessing phytophotodermatitis: boy with erythema and blisters on both hands. *Dermatol Nurs*: 18: 153-154.
- KLIMASZYK P., KLIMASZYK D., PIOTROWIAK M., POPIOŁEK A. 2014: Unusual complications after occupational exposure to giant hogweed (*Heracleum mantegazzianum*): case report; *International Journal of Occupational Medicine and Environmental Health*; 27(1): 141-144.
- KOSTECKA-MĘDALSKA O., CZABAŃSKI B. 1963: Zawartość olejku eterycznego w *Heracleum Sosnowskyi* Manden. z uprawy krajowej. *Acta Agrobotanica*; XIV: 25.
- KOSTECKA-MĘDALSKA O. 1962: *Heracleum sosnowskyi* Manden. W Ogrodzie Roślin Leczniczych A. M. we Wrocławiu. *Wiadomości Botaniczne*; 6 (2): 175-177.
- KRZEMKOWSKI J. 1995: Barszcz Sosnowskiego. *Przyroda Polska, Zarząd Główny Ligii Ochrony Przyrody, Warszawa*.
- KRZEMKOWSKI J. 1995: Barszcz Sosnowskiego (*Heracleum sosnowskyi* Manden.). *Parki Narodowe*; 3:20-21.
- LUTYŃSKAR. 1980: Badania nad aklimatyzacją i wykorzystaniem barszczu Sosnowskiego jako rośliny pastewnej, *Biuletyn Instytutu Hodowli i Aklimatyzacji Roślin*, 139:1-37.
- MILL J., WALLIS B., CUTTLE L., MOTT J., OAKLEY A., KIMBLE R. 2008: Phytophotodermatitis: case reports of children presenting with blistering after preparing lime juice. *Burns*; 34: 731-733.
- MIREK Z., PIĘKOŚ-MIRKOWA H., ZAJĄC A. I WSP. 2002: Flowering plants and pteridophytes of Poland – a checklist (w:) Z. Mirek (red.). *Biodiversity of Poland W. Szafer Institute of Botany, Polish Academy of Sciences. Kraków*; 1: 442.
- MUZYKIEWICZ A., NOWAK A., KLIMOWICZ A. i wsp. 2017: Fotoalergeny i związki fototoksyczne pochodzenia roślinnego. Zagrożenia i korzyści terapeutyczne. *Kosmos Problemy Nauk Biologicznych*; 66 (2): 211.
- NIELSEN C., RAVN H.P., NENTWIG W., WADE M. (ed.) 2005: *The Giant Hogweed Best Practice Manual. Guidelines for the management and control of an invasive weed in Europe. Forest & Landscape Denmark, Hoersholm*: 44.
- PODGÓRSKA M., WÓJCİK P. 2011: Barszcz Sosnowskiego (*Heracleum sosnowskyi* Manden., Apiaceae) u podnóża Góry Zelejowej w gminie Chęciny (Wyżyna Małopolska). *Rocznik Świętokrzyski. Ser. B – Nauki Przyrodnicze*; 32: 67-78.
- RRZYMSKI P., KLIMASZYK P., PONIEDZIAŁEK B. 2015: Invasive giant hogweeds in Poland: risk of burns among forestry workers and plant distribution. *Burns*; 41, 8: 1816-1822.
- RUTKOWSKI L. 2004: *Przewodnik do oznaczania roślin Polski niżowej. Państwowe Wydawnictwo Naukowe. Warszawa*: 345.
- SACHAJDAKIEWICZ I., MĘDRZYCKI P. 2015: Problem inwazji kaukaskich barszczy w Polsce na podstawie Raportu końcowego zOgólnopolskiego Spisu Powszechnego Barszczu Sosnowskiego i Barszczu Olbrzymiego (w:) Lecha Krzysztofiak L., Krzysztofiak A. (ed): *Inwazyjne gatunki obcego pochodzenia zagrożeniem dla rodzimej przyrody. Krzywe*: 185.
- SARHANE K.A., IBRAHIM A., FAGAN S.P., GOVERMAN J. 2013: *Phytophotodermatitis. Eplasty*, 13:57.
- SOBISZ Z. 2007: *Phytocenoses with Heracleum sosnowskyi Manden. in Central Pomerania. Roczn. AR w Poznaniu, Botanica Steciana*, 386 (11): 53-56.
- STUPNICKA-RODZYNKIEWICZ E., KLIMA K. 1996: *Ekspansja Heracleum sosnowskyi Manden na terenie stacji doświadczalnej i okolicznych polach w Czyrnej k. Krynicy, Zeszyty Naukowe Akademii Techniczno-Rolniczej w Bydgoszczy, Rolnictwo*;196 (38): 165-172.
- ŚLIWIŃSKI M. 2012: *Inwazja barszczu Sosnowskiego na obszarze Natura 2000 w Górach Stołowych. Zielona Planeta*; 2 (101): 8-10.
- ŚLIWIŃSKI M., ANIOŁ-KWIATKOWSKA J. 2011: *Rozprzestrzenianie się Heracleum sosnowskyi Manden. i Heracleum Mantegazzianum Sommier & Levier (Apiaceae) w aglomeracji wrocławskiej. Bad. Fizjograf. II, Ser. Bot.*; 60: 151-163.
- ŚLIWIŃSKI M. 2009: *Konsekwencje wprowadzenia do uprawy Heracleum sosnowskyi Manden. na Dolnym Śląsku. Pam. Puł.*, 150: 287–292.
- TOKARSKA-GUZIŁ B., DAJDOK Z., ZAJĄC M., ZAJĄC A., URBISZ A., DANIELEWICZ W., HOŁDYŃSKI C. 2012: *Rośliny obcego pochodzenia w Polsce ze szczególnym uwzględnieniem gatunków inwazyjnych. Generalna Dyrekcja Ochrony Środowiska, Warszawa*.
- TUTIN T. G., HEYWOOD V. H., BURGESS N. A., MOORE D. M., VALENTINE D. H., WALTERS S. M., WEBB D. A. (eds) 1968: *Flora Europaea, Univ. Press. Cambridge*, 2: 366.
- WERYSZKO-CHMIELEWSKA E., CHWIL M., WESOŁOWSKI M. i wsp. 2014: *Rośliny wywołujące fotodermatozy. Alergoprofil*; 10 (4): 22-26.
- WIERZEJSKA K., ADAMSKI Z. 2004: *Światłne zapalenie skóry wywołane uczuleniem na rośliny. Phytophotodermatitis. Przegl Dermatol*; 91: 329-334.
- WOJTKOWIAK R., KAWALEC H., DUBOWSKI A. P. 2008: *Heracleum sosnowskyi Manden L. Journal of Research and Applications in Agricultural Engineering*, 53(4): 137-142.
- WRZESIŃSKA D., BŁĄŻEJEWSKA A. 2000: *Entomofauna of Heracleum sosnowskyi Manden. Journal of Plant Protection Research*; 40: 231-236.
- WRZESIŃSKA D. 2006: *Barszcz Sosnowskiego (Heracleum sosnowskyi Manden), inwazyjny chwast i metody jego zwalczania. Postępy Nauk Rolniczych*; 3.
- WRÓBEL I. 2008: *Barszcz Sosnowskiego (Heracleum sosnowskyi Manden.) w Pieninach. Pieniny – Przyroda i Człowiek*; 10: 37-43.
- ŻUREK H. 2002: *Metoda i technika zwalczania barszczu Sosnowskiego. Wydawnictwo IMUZ, Falenty*.