Influence of Deformation of Circadian Rhythms on Changes in Ontogenesis of *Heracleum sosnowskyi* Manden Plants

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**Abstract.** The urgency of the problem of biodiversity conservation has grown significantly at present. In addition to the increasing anthropogenic impact on natural ecosystems, there is also a threat of changes in biocenoses due to the spread of invasive plant and animal species. The human factor also plays a significant role in this process. For example, the species *Heracleum sosnowskyi* Manden was used as an agricultural crop in the last century. Unfortunately, the specific properties of the plant made people refuse to use it as such. All varieties obtained by breeders were excluded from the State Register. However, the plasticity and biological aggressiveness of the species allowed it to successfully occupy an ecological niche in various biogeocenoses. Since the plant poses a real danger to human health, an intensive search is underway for ways to combat this poisonous invasive weed. The authors have developed a unique method of controlling plants *Heracleum sosnowskyi* M., effective and safe for humans and the environment.

**1. Introduction**

The emergence of an invasive species (plant, animal, or microorganism) in a long-term stable biogeocenosis is always a threat to the ecosystem, clear or potential. In many cases, the invasion of a plant species introduces changes in the structure and composition of the flora. In addition, there are also changes in the diversity of fungal and bacterial communities [1].

Entering the historically established biogeocenosis, invasive species deform almost all of its components: flora, fauna, and microbiota. This is especially dangerous for specific ecosystems containing rare species [2]. Under various conditions of the natural community, the effect of the negative impact of the Sosnowsky hogweed (*Heracleum sosnowskyi*) on the local fauna is modulated. For example, terrestrial animals, as well as birds, reacted differently to the introduction of an invasive species. This depended, first of all, on the characteristics of the reaction rate of the species, which had previously steadily occupied its ecological niche. Studies that were carried out on various landscapes (open spaces and territories occupied with woody and shrubby plants) showed the formation of a distribution gradient for various species depending on the habitat. In general, the negative influence of the invasive species on the total number of individuals, as well as (in some cases) on their structure, was noted [3].
Invasive plants change the biota in different directions, with a tendency to an increase in the rate of mineralization and an increase in the activity of enzymes. These changes indicate a significant stimulation of the circulation of substances. The authors conclude that these processes are aimed at preparing conditions for the successful development of new territories by invasive species [4].

In connection with the real threats to the preservation of species diversity in natural biogeocenoses, which arise due to the invasion of alien species, numerous attempts are being made to prevent or reduce the consequences of this phenomenon. Methods for predicting the probability of the spread of invasive species in some ecosystems have been developed on the basis of geostatistical tools. Digital models make it possible, with a sufficiently high accuracy (the selected threshold of 10%), to determine the likelihood of a negative development of the situation in specific ecosystems [5].

Despite the extremely high aggressiveness in comparison with many invasive plant species, Sosnovsky's hogweed is also considered as a source of biopolymers for obtaining valuable materials with high added value. Moreover, in this direction, they also see a way that will limit the distribution of the *Heracleum sosnowskyi* Manden species in Russia [6].

In this regard, it should be noted that often the collection and use of wild species in various industries is more costly than growing plants in culture. In addition, the range of *Heracleum sosnowskyi* Manden is currently also distributed in territories that are inconvenient or completely unsuitable for the use of mechanization (complex macro- and mesorelief, accumulations of stones, embankments, steep slopes, etc.).

The invasive species *Heracleum sosnowskyi* Manden is much easier to penetrate into abandoned agrocenoses and synanthropic territories than into natural biogeocenoses [7]. This is primarily due to the fact that for seed germination, easy accessibility to the substrate, the upper layers of the soil is required. In natural phytocenoses, a “damper cushion” of plant residues is formed, which prevents the *Heracleum sosnowskyi* Manden seeds from contacting with soil minerals. However, in the case of the formation of monospecific thickets due to strong shading, the sod is destroyed, which creates favorable conditions for seed germination and a rapid increase in the local area. Several factors contribute to the successful dispersal and increase in the range of *Heracleum sosnowskyi* Manden. First of all, a large number of seeds that one plant can form on the main and lateral generative shoots. One of the most important factors of successful penetration into the natural community is the erosion of the vegetation cover - destruction of sod, exposure of the upper soil layer [8].

After the introduction of the invasive plant *Heracleum sosnowskyi* into natural ecosystems, changes occur in the number and composition of nematodes. The selective nature of the changes was noted - some parameters of the nematode community retained their original values. Others were deformed to a greater or lesser extent [9].

The species *Heracleum sosnowskyi* Manden is considered in many scientific works as aggressive with a high biological potential and universal in relation to environmental factors. The danger of the spread of plants is aggravated, in addition, with a strong allergenic effect on the human body. This is due to the negative effect on the skin, which, in addition to phototoxicity, can lead to chemical burns. As a result, a long-term dermatitis is formed, which in especially severe cases can lead to skin necrosis. It is no coincidence that workers who may be in the zone of influence of the plant are classified as a potentially high risk group [10].

2. Results and discussion

Plants of *Heracleum sosnowskyi* M. have a number of biological features that give them advantages over native species. High potential for the formation of a large number of mericarps (up to 100 thousand and more) are accompanied with reliable methods of their distribution. Our observations showed that the offsprings during the winter-spring period are almost completely separated from the mother plant (figure 1). On the central and lateral umbrellas of plants in the spring, they were found on average only in the amount of 5.7.

The fight against the invasive plant *Heracleum sosnowskyi* M. on the territory of settlements is also hampered with its dislocation in places that are difficult to reach for mechanized cultivation. So, for
example, plants can be found in household yards littered with waste woodworking enterprises, spontaneous dumps of settlements, rocky areas, ravines, ditches (figure 2).

![Image 1](image1.jpg) ![Image 2](image2.jpg)

**Figure 1.** Central and lateral umbrellas of *Heracleum sosnowskyi* M. plants after separation of mericarps.

**Figure 2.** The area where the fight *Heracleum sosnowskyi* M. presents technical difficulties.

After mowing (figure 3), replacement shoots are formed on the sections of the stems remaining above the soil surface for several days (figure 4, indicated with the arrow).

![Image 3](image3.jpg) ![Image 4](image4.jpg)

**Figure 3.** Stem sections remaining above the soil surface after mowing.

**Figure 4.** The emergence of a new shoot (indicated with an arrow) after mowing.

Using the supply of nutrients from the underground part of the plant, the new shoot grows intensively (figure 5) and quickly forms a leaf surface (figure 6).
We have developed a method for combating an invasive plant due to deformation of the parameters of circadian rhythms that are usual for this type. A vegetative plant (figure 7) is mulched with freshly cut grass (figure 8) or other bulk material (for example, straw).

In this case, the apical part of one leaf is left above the surface of the mulch layer (figure 9, highlighted by a circle). As a result, the parameters of circadian rhythms change. Both during the day and at night, the plant is isolated from sunlight. In addition, the temperature regime also changes, since under the mulch layer the amplitude of its oscillations is significantly smoothed out.

The study of the process of organogenesis of the leaf *Heracleum sosnowskyi* M. (figure 10) showed that both the apical and basal parts are involved in the axial growth.
Due to this, a large internal tension of the petiole is created under the layer of mulch, it bends and in some cases it breaks (figure 11). Only young shoots are able to break through the mulch layer (figure 12).

As a result, the leaves under the mulch layer gradually lose their green color, turn brown and die off. The circadian rhythm of photosynthesis is also severely deformed. Synthesis of plastic substances occurs only on a few fractions of a percent of the total leaf area of the plant. Their quantity and the energy obtained through photosynthesis of the leaf apex is absolutely insufficient to ensure respiration of tissues of old leaves, the root system, as well as growth processes that occur both in old leaves and during the formation of a new shoot. For this, the plant intensively consumes the supply of nutrients accumulated in the underground part.
Repeated mulching leads to the death of not only the formed young shoot, but also the underground part of the plant. As a result of regular mowing, the plant is able to vegetate up to 12 years. And at any time, under favorable conditions, it is ready for fruiting.

For the developed technique, a patent was obtained (figure 13) for the invention “Method for the non-contact removal of the Sosnovskyi hogweed plant (Heracleum sosnowskyi) from the controlled area” (Patent of the Russian Federation for invention No. 2704428 dated 28.10.2019).

Figure 13. Title page of the patent.

3. Conclusion
Solving the problem of the spread of the invasive species is a significant mission. If one, even a small area, remains, then there is always a risk of its expansion. In this regard, the task of finding opportunities for effective control over the processes of penetration of an invasive species into natural and anthropogenic ecosystems remains urgent.

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