

**МИНИСТЕРСТВО СЕЛЬСКОГО ХОЗЯЙСТВА РОССИЙСКОЙ ФЕДЕРАЦИИ**  
**ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ**  
**УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ**  
**«САРАТОВСКИЙ ГОСУДАРСТВЕННЫЙ АГРАРНЫЙ УНИВЕРСИТЕТ**  
**ИМЕНИ Н.И. ВАВИЛОВА»**

**ВАВИЛОВСКИЕ ЧТЕНИЯ – 2020**

Сборник статей Международной  
научно-практической конференции,  
посвященной 100-летию открытия закона гомологических рядов  
и 133-летию со дня рождения академика Н.И. Вавилова

Конференция поддержана Российским фондом фундаментальных исследований  
в конкурсе на лучшие проекты организации онлайн-конференций,  
проводимых во втором полугодии 2020 года  
(Договор № 20-016-22001\20)

24–25 ноября 2020 г.

Саратов  
2020

УДК 378:001.891  
ББК 4  
В12

В 12 Вавиловские чтения – 2020: Сборник статей Международной научно-практической конференции, посвященной 100-летию открытия закона гомологических рядов и 133-летию со дня рождения академика Н.И. Вавилова. – Саратов: Амирит, 2020. – 315 с.

ISBN 978-5-00140-684-6

Редакционная коллегия:

д-р техн. наук, профессор *Д.А. Соловьев*  
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УДК 378:001.891  
ББК 4

Материалы изданы в авторской редакции

ISBN 978-5-00140-684-6

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## **RED WOOD ANTS (FORMICA S. STR.) AS A METHOD OF BIOLOGICAL PROTECTION IN PHYTOCENOSSES OF THE MORDOVIA REPUBLIC**

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**Abstract.** This article explains the method of cartographical monitoring of red wood ants (subgenus *Formica* s. str.) as active forest protectors on the example of specific diversity in Mordovian phytocenoses.

**Key words:** republic of Mordovia, phytocenoses, red wood ants, digital mapping, geographic information systems.

The Republic of Mordovia is a relatively large region located on the East European Plain. It can be conditionally divided into three parts – the western part on the Oka-Don lowland, the central and eastern parts on the Volga lowland (therefore, in some sources Mordovia is mentioned as a part of the Middle Volga) [9].

Climatically, the republic is located in the temperate zone, mainly on sod-podzolic soils interspersed with gray forest soils. The predominant type of phytocenosis in Mordovia is mixed forest; there are also deciduous, coniferous forests (mainly pine ones) and meadows. Some plant communities are located on specially protected territories (Mordovia State Nature Reserve, Smolny National Park) [10]. Despite this, the phytocenoses of Mordovia are regularly affected by abiotic, anthropogenic and biotic factors including leaf-eating pests of woody plants. One of the solutions of this problem is the use of *Formica* s. str. ants' as forest protectors.

The use of red wood ants as active predators in biological forest protection dates back to the 1960s and continues up to current days. However, the ants themselves are influenced by negative, mainly anthropogenic factors (deforestation, soil pollution, mechanical destruction of anthills etc.). To minimize the consequences of this effect, the subgenus *Formica* s. str. was taken under protection – beginning from the operation «Ant» organized in 1970s [1;5] up to the currently active project «Monitoring *Formica*» initiated in 2010-2013, whose main research object is the complex of anthills – group of the same species' anthills with common feeding compartments. The essential function of this project is the inventory of anthills at three levels – registration level (entering general information about the complex in a single register), basic level (obtaining necessary information to analyze the state of the complex) and monitoring level (obtaining information for using the complex as a regular monitoring object) [2].

The project's activity is widespread on the territory of almost all Russian regions. The main result obtained while its research activity is the creation of interactive taxonomic databases which include information about specific diversity of Russian red wood ants. Particular attention is paid to specially protected territories including ones located in the Volga Federal District. However, «Monitoring *Formica*» had to deal with lack of cartographic material for a clearer picture of the ecological situation in the explored territories. Therefore, in 2016 there was decided to create a geodatabase and a digital map of the anthills' complexes in the Middle Volga and its environs including Mordovia.

Materials for the mapping were taken from the results of field research done by employees of the Mordovian State Natural Reserve and scientists of the Nizhny Novgorod Lobachevski State University [3;4;6;8]. These materials contained samples from the anthills including not only to the subgenus *Formica* s. str. but also other representatives of the genus *Formica*. Total sample includes insects belonging to 11 species – *Formica fusca*, *F. rufa*, *F. sanguinea*, *F. pratensis*, *F. polycтена*, *F. pressilabris*, *F. exsecta*, *F. cunicularia*, *F. cinerea*, *F. aquilonia* and *F. glauca*. Only 4 species of them

belongs to the subgenus *Formica* s. str. – red wood ant *Formica rufa*, small wood ant *F. polycтена*, meadow ant *F. pratensis* and northern wood ant *F. aquilonia*.

Data about each point where anthills were discovered, indicating the species and type of phytocenosis, was formed into a \*csv table, which served as the basis for a digital map. The map was created using geographic information systems (GIS) on the ArcGIS Online platform. ArcGIS Online is a cartographic service which supports export of any data to the map in a format of a point, linear or polygonal (planar) feature layer [11;12]. This service also includes a set of tools for spatial analysis [13], which can permit, e.g., to filter the point feature layer by ant species or phytocenosis, or join points containing information about anthills into clusters and determine the dominative species in each cluster.

The essential result of the work is the map of the Mordovia republic containing a layer of 70 points with information about anthills discovered in each point. Geographically, the predominant part of them belongs to the Temnikovskiy district – on the territory of the Mordovian State Natural Reserve and its environs. Also there can be seen single anthills in the Krasnoslobodskiy district and on the northern border of the republic with the Nizhny Novgorod region (figure 1).

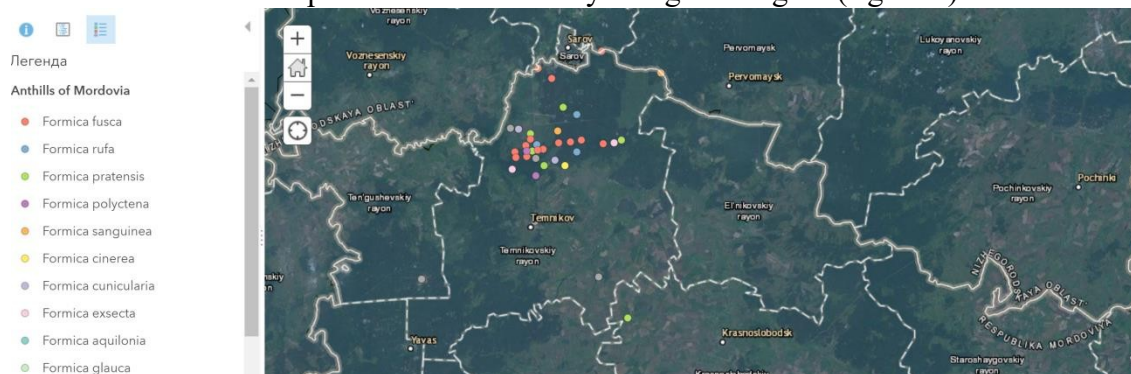


Figure 1. Specific diversity of *Formica* ants on the territory of Mordovia

During clustering, all points were joined into 6 clusters of different sizes. 3 of them belong to the Temnikovskiy district, 1 – to the Tengushevskiy district, 1 – on the border of Temnikovskiy and Krasnoslobodskiy districts, 1 – on the border with the Nizhny Novgorod region. The largest clusters (> 9 anthills) are located on the territory of the Temnikovskiy district and are mainly grouped in the Mordovian Natural Reserve. In 4 clusters the dominative species is the brown wood ant *Formica fusca* which doesn't belong to the subgenus *Formica* s. str. In 2 other clusters no evident dominant can be seen – the proportional division of the species inside them is approximately equal (figure 2).

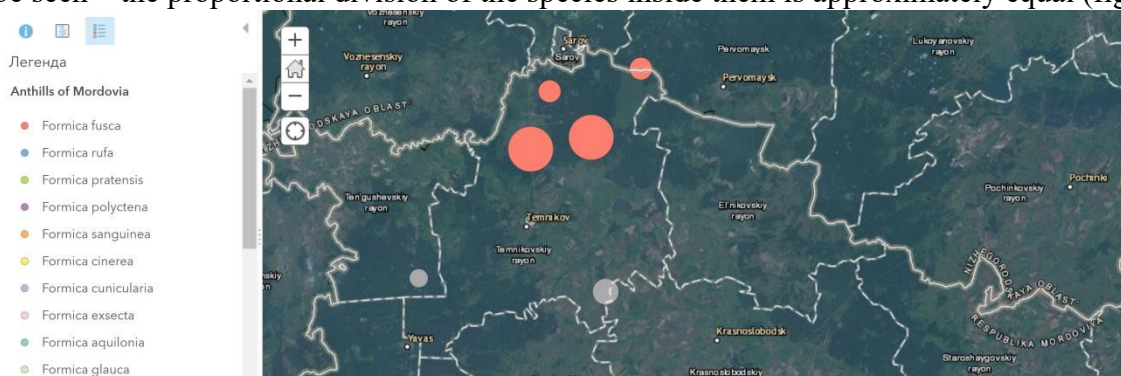


Figure 2. Clustering of *Formica* anthills in different Mordovian districts

During the statistical analysis of results it was found out that, although representatives of the subgenus *Formica* s. str. are not dominant ant species in the phytocenoses of the republic, this is relatively common for the explored territory – red wood ant *Formica rufa* was registered in 13 anthills and takes the second position after brown wood ant *F. fusca* which was discovered in 27 locations. Less common the meadow ant *F. pratensis* (in 8 anthills) and the small wood ant *F. polycтена* (7 anthills). The northern wood ant *F. aquilonia* was found only in 1 anthill in the

Temnikovsky district, what can be explained by its preference to the southern taiga zone, which is not typical for Mordovia [7].

While analyzing the percentage proportion of species discovered in Mordovian phytocenoses it was found that 42% of the general sample can be determined as *Formica* s. str. ants. Among them, the most widespread species is *Formica rufa* (19%), the rarest is *F. aquilonia* (1%) (figure 3).

### % of *Formica* s. str. ants in Mordovian phytocenoses

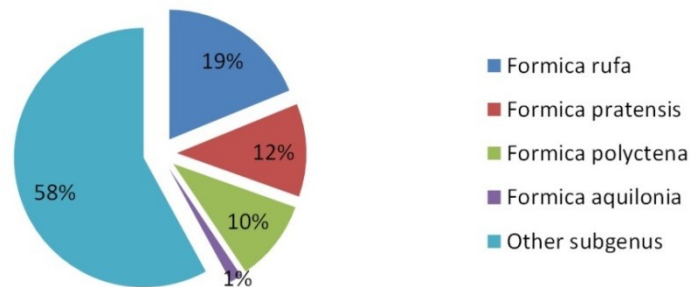


Figure 3. Percentage of *Formica* S. Str anthills in Mordovian phytocenoses

It is necessary to remark that red wood ants do not inhabit all phytocenoses of the Mordovia republic, preferring to form both complexes and single anthills directly in forests, leaving meadows and steppe slopes for other species. During the research the largest part of *Formica* s. str. ants was found in the zone of mixed forests (65% of the sample), 28% of anthills were found in areas related to deciduous forests, 7% - in forests with a clearly predominant coniferous cultures (figure 4).

### % of phytocenoses inhabited by *Formica* s. str. ants

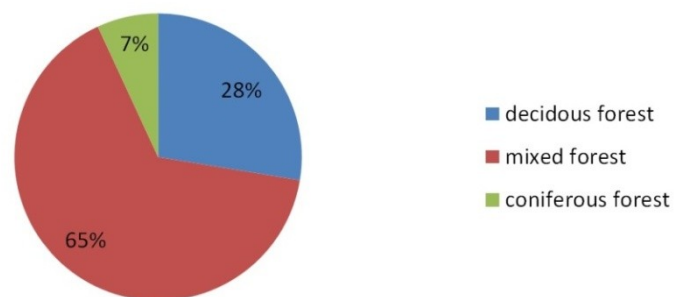


Figure 4. Percentage of Mordovian phytocenoses inhabited by red wood ants

Thus, it should be taken into account that, despite the clear prevalence of other ant species in the plant communities of the Mordovia republic, the proportion of the subgenus *Formica* s. str. is still relatively high. It is especially related to the Mordovian State Natural Reserve, where any economic activity is strictly limited, because of what ant populations, as well as the conditions of the forest-forming cultures themselves are under regular supervision. Based on these facts, on this territory red wood ants can control the number of such dangerous pests as pine sawfly *Diprion pini* L., large birch sawfly *Cimbex femoratus*, gypsy moth *Lymantria dispar* etc. It shows that their introduction to new phytocenoses can evidently solve the pest problem. However, despite the

undeniable role of ants in forest protection, the necessity of other protective methods including chemical ones, unfortunately, must not be forgotten.

The author expresses gratitude to her scientific advisor PhD Vladimir Alexandrovich Zryanin for the provided data and assistance in research process.

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