Ecological and biological adaptations of the hemiparasite Odontites luteus (L.) Clairv. (Orobanchaceae) on the territory of the conservation stow "Levadki" Oak Grove (Russia)

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Abstract. The abundance of Odontites luteus (L.) Clairv (Orobanchaceae) was studied on the territory of the conservation stow "Levadki" Oak Grove (Russia). The average species abundance was 11.75 ind./m² on the study area during the growing season. The phenological phases of the plant hemiparasite were studied, the indicators of seed productivity and the efficiency of its fruit formation were examined. O. luteus, being an annual plant, forms a significant number of flowers and fruits within a single specimen (the average number of seeds is 1,930). The specific affinity of the semi-parasite to the host plants has been studied.

The topography, climate, variety of vascular plants, and a large set of ecotopes of the Crimean Piedmont create favorable conditions for the development of both host and parasitic plants, closely interconnected by the trophic links. Parasites-spermatophytes do not play a leading role in the composition of plant communities; however, they are very important component of natural communities. Like any parasites, they participate in the regulation of the population abundance of their hosts, thereby affecting certainly the formation and stability of natural biocenoses [1-3].

Plants-parasites belonging to the family Orobanchaceae are extremely interesting objects of research, having an important practical significance. On the one hand, they are one of the most important objects of the national plant quarantine service, on the other hand, they are a model for developing basic theoretical generalizations in parasitology of the angiosperms.

Hemiparasite Odontites luteus (L.) Clairv. is one of the representatives of the family Orobanchaceae, occurring quite rarely in the Crimea and growing on the meadow, steppe and rocky slopes in almost all natural areas of the peninsula [4]. The study of this object is relevant since O. luteus may serve as a "plant" model to study the relationships between a hemiparasite and a host plant. The present study aims to search for the ecological and biological adaptations of the hemiparasite O. luteus in the environment of the Crimean Piedmont during the growing season of 2019 on the steppe slopes of the conservation stow "Levadki" Oak Grove [5]. Thirty 1-m² discount areas have been selected randomly at the total sampling area of 400 m². During the growing season, O. luteus specimens were counted monthly (30-day interval) at each discount area; the phenological phase of the plants was determined according to the generally accepted method [6]. The seed productivity of O. luteus was evaluated using the accepted method [7]. Photographic evidencing of
seeds was performed using stereoscopic microscope SZN71 (Soptop, China), species names of vascular plants are given in accordance to the online international database "The Plant List" [8].

The natural vegetation cover of the study area and its surroundings, presented by carbonate chernozems, combines the remains of meadow and petrophytic steppes, sparse shrub and forest communities with the participation of Quercus pubescens Willd., Pinus nigra subsp. pallasiana (Lamb.) Holmboe, Fraxinus excélsior L., etc.

Deforested areas between singly standing oak forests are occupied by meadow and petrophytic steppes; the xerophilic semi-shrubs and various grasses make the most of the plant communities, namely Festuca valesiaca Schleich. ex Gaudin, Bothriochloa ischaemum (L.) Keng, Teucrium chamaedrys L., Asphodeline taurica (Pall.) Endl., as well as species of the genera Thymus L., Achillea L., Euphorbia L., Paeonia L., Stipa L., etc.

The population dynamics of O. luteus in the study area in 2019 is presented in Table 1; in particular, the average abundance of hemiparasite plants on the discount areas was 12.96 ind./m² (August) and 10.53 ind./m² (September), respectively. Therefore, we can conclude that the abundance of O. luteus in August is slightly higher than that in September; in general, the average abundance of O. luteus was 11.75 ind./m² during the growing season. The findings of another species of the genus Odontites, Odontites vulgaris Moench, in 1.5—2.0-km distance from the study site attracts much attention. This species was absent in the study area; its abundance was extremely low at the site of finding. Therefore, we suggest it did not compete with O. luteus for the host plants due to a significant distance between the local habitat areas of these two species.

Table 1. Abundance dynamics of Odontites luteus (L.) Clairv. (Orobanchaceae) at the study site in 2019.

| Date | During the growing season |
|------|--------------------------|
| (August 6, 2019) | 12.96 ± 2.15 |
| (September 3, 2019) | 10.53 ± 1.75 |
| | 11.75 ± 2.04 |

The phenological spectrum of O. luteus evidences that the beginning of the growing season of this hemiparasite species starts in the third decade of May and lasts for the first two decades of June (Figure 1, Table 2). The budding phase and early flowering plants are observed from late June to mid-August; the phase of flowering en masse and beginning of fruit ripening is observed during the third decade of August and lasts until the end of September. The end of flowering and full maturation of the capsules are observed in October (Table 2). Therefore, by the flowering rhythm, O. luteus, being a summer annual plant, may be attributed to the late summer-mid-autumn species.

Table 2. The phenological spectrum of Odontites luteus (L.) Clairv. (Orobanchaceae) in 2019.

| Vegetation | Budding | Flowering | The end of flowering, fruit ripening |
|-----------|---------|-----------|-----------------------------------|
| III | I | II | III | I | II | III | I | II | III | I | II | III |
| May | June | July | August | September | October |
**Figure 1.** The early phase of the growing season (a), budding (b), and early flowering (c) of *Odontites luteus* (L.) Clairv. (Orobanchaceae); (a) — third decade of May and the first two decades of June, (b), (c) — from late June through mid-August.

The number of shoots per specimen are equal to the number of generative shoots, averaging 13.9 per specimen (Table 3). Seed productivity, which is commonly calculated as the number of seeds per specimen or generative shoot, depends on several external and internal factors. It is known that the most significant external factors are the weather conditions of a particular season associated with such phenophases as flowering and fruiting.

**Table 3.** Indicators of seed productivity and efficiency of fruit formation of the hemiparasite *Odontites luteus* (L.) Clairv.) in the Crimean Piedmont.

| No. | Signs                                      | Mean         |
|-----|--------------------------------------------|--------------|
| 1.  | Average number of shoots per 1 specimen, pcs. | 13.90 ± 2.07 |
| 2.  | Average number of generative shoots per 1 specimen, pcs. | 13.90 ± 2.07 |
| 3.  | Average weight of 1 inflorescence, mg      | 170.00 ± 4.96 |
| 4.  | Average number of flowers per 1 shoot, pcs. | 17.40 ± 1.89 |
| 5.  | Average number of flowers per 1 specimen, pcs. | 193.58 ± 9.54 |
| 6.  | Average number of fruits per 1 shoot, pcs. | 17.40 ± 1.89 |
| 7.  | Average number of fruits per 1 specimen, pcs. | 193.58 ± 9.54 |
| 8.  | Fruiting coefficient, %                    | 100 ± 0.21   |
| 9.  | Average number of seeds per 1 specimen, pcs. | 1930.00 ± 95.00 |
| 10. | Average seed size (length), mm             | 1.13 ± 0.09  |
| 11. | Average weight of 100 seeds, mg            | 142.33 ± 7.14 |

Both pollination of flowers and the formation of fruits and seeds depend on the factors mentioned above. For example, the number of flowers per shoot of *O. luteus* was on average 17.4 pcs., and the number of flowers and fruits per specimen, 193 flowers and fruits (capsules). The average number of seeds per specimen was 1,930 (Table 3). This fact indicates that *O. luteus*, being an annual plant, forms a significant number of flowers, fruits, and seeds within a single individual, thus showing signs of *r*-strategy.
Figure 2. The appearance of seeds of *Odontites luteus* (L.) Clairv. (Orobanchaceae).

In addition to high seed productivity, *O. luteus* is characterized by small seed size, which is 1.13 mm (length), and very low weight (1.42 mg/seed, on average) (Table 3, Figure 2), which allows this hemiparasite to form and effectively disseminate its generative diasporas.

Trophic hemiparasite *O. luteus* is not a highly specialized species in relation to the host plant species and thus can obtain water and minerals by gaustral modifications of root from a wide range of host plants belonging to different families and even classes of angiosperms. Meanwhile, it was possible to make a list of plant species preferred by *O. luteus* as the hosts, namely *Artemisia taurica* Willd., *A. absinthium* L., *Satureja taurica* Velen., *Reseda lutea* L., *Xeranthemum annuum* L., *Plantago lanceolata* L., and the species of the genus *Euphorbia* L., the most common host plants were *Teucrium chamaedrys* L., *T. polium* L., and *Festuca valesiaca* Schleich. ex Gaudin.

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