Development of the dwarf shrub *Thymus mongolicus* (Lamiaceae) in the conditions of Southern Siberia

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Abstract. The features of the development of *Thymus mongolicus* in the conditions of Southern Siberia was studied. The similarity of the phases of morphogenesis of individuals in all habitats was established. The duration of individual ontogenetic states, the ontogenesis, the morphogenesis and the reproduction of *T. mongolicus* are depending on the topography, the substrate and the total projective grass cover. The identified features of development contribute to the adaptation of *T. mongolicus*, survival and distribution of the species in different conditions of Southern Siberia.

1 Introduction

Identification of the plant development features, the architecture, and the life forms depending on the habitat conditions are one of the promising areas of biodiversity research [1, 2]. Recently, this data has been used to create models of plant responses to climate change, to study the functional traits of populations and communities, and for biomimetic architecture [3, 4]. The objects of such studies are widespread plant species with high morphological variability. In this connection, *Thymus* L. is of interest. This work is devoted to the study of *Thymus mongolicus* (Ronn.) Ronn., which is widespread in the mountain steppes of Siberia [5]. The aim of the study is to identify the features of *T. mongolicus* morphogenesis in the conditions of Southern Siberia.

2 Materials and Methods

The material was collected nearby the village of Aktash (Mountain Altai), in the intermountain basin, in the petrophytic steppe, the total projective grass cover is 50 %, the projective cover of *T. mongolicus* is 3%. For comparative analysis we used data obtained earlier in the study of T. *mongolicus* in the Altai and Tuva [6], as well as data by N.M. Pyak [7]. In the study of ontogenesis, the concept of discrete description of ontogenesis was adopted [8]. The phases of morphogenesis are identified according to the works on the

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study of dwarf shrubs [9]. The type of *T. mongolicus* biomorph is established in accordance with the phytocenotic classification by O.V. Smirnova [10]. The age of the individuals was determined by the annual rings of skeletal axes using the Carl Zeiss SteREO Discovery stereomicroscope.V12 with AxioCam HRc camera (Germany).

3 Results

At the initial stages of ontogenesis (seedling (*p*), juvenile state (*j*)), individuals represent orthotropic **primary shoot**. During autumn germination, the shoot of the seedling is shorted to 0.5 cm long. The next year, in the juvenile state, an elongated annual shoot develops, the further development of the individual coincides with the development of *T. mongolicus*, described by N. M. Pyak [7], and *T. petraeus* Serg. [11]. During spring germination in the same year in juvenile individuals, the primary shoot is elongated to 1 cm. Buds are laid in the axils of all the leaves. In the second year, in immature individuals (*im*), the primary shoot consists of two elongated annual shoots and reaches 2 cm. From the buds in the leaf axils of the first annual shoot, orthotropic shorted (or elongated) vegetative shoots are developed. The **primary bush** is formed. In the third year, the apical part of the primary shoot dies off. Lateral shoots have monopodially growth, resting and proleptic buds begin to grow on the preserved part of the primary shoot (Table 1). The root system consists of a main root and adventitious roots.

In the fourth year in the virginal state (*v*), the lateral shoot, which is close in position to the place of death of the apical part of the primary shoot, becomes a replacement shoot and lies down. A plagiotropic acrosympodially main skeletal axis is formed. Similarly, the lateral shoots become from the 1st order. The type of biomorph is monocentric.

Table 1. Morphometric parameters of *Thymus mongolicus* individuals in different phases of morphogenesis

Phases of morphogenesis	**primary bush**		**clump**			**primary bush**
Ontogenetic state	*im*	*v*	*g1*	*g2*	*g3*	*ss*
Individual diameter, sm	2.9±1.8	9.4±2.3	15.8±3.4	35.5±2.5	13.1±1.8	5.3±2.1
Number of vegetative shoots, it.	4.0±1.2	13.0±5.7	21.6±4.1	72.0±6.7	35.6±7.8	6.3±2.2
Number of skeletal axes, it.	-	2.3±0.6	2.4±0.7	8.8±1.8	2.3±0.8	-
Number of generative shoots, it.	-	-	11.7±3.9	93.3±16.6	23.6±4.7	-
Number of partial bushes, it.	-	-	2.6±1.6	7.5±1.9	1.5±0.3	-

The first generative shoots appear in the middle part of the skeletal axes at year 7, the individual passes into a young generative state (*g1*). At the top of the generative shoot, a capitate thyrse is formed from opposite dichasias. Skeletal axes 2nd and 3rd orders develop in the bush. The plant is a **clump** consisting of a primary bush and 2–3 partial bushes. The monocentric type of biomorph changes to dense polycentric type. The clump lasts for the entire generative period (from young to old generative states), which is about 14 years. In the mature generative state (*g2*), vegetative reproduction begins. The separated ramets (partial bushes) are rejuvenated to a virginal or young generative state. Vegetative reproduction prevails over seed reproduction and ensures self-maintenance of *T. mongolicus* populations. By the age of 19, in the old generative state (*g3*), the clump breaks up into separate partial bushes that are in the same ontogenetic state. After that, the

individual passes into a subsenile state (*ss*) and is a dilapidated primary bush with several vegetative shoots in the basal part.

4 Discussion

The analysis of the obtained data, their comparison with the data obtained earlier [6, 7] showed the similarity of the morphogenesis of individuals growing in different habitats. However, depending on the shape of the topography, the substrate and the total projective grass cover, *T. mongolicus* shows a polyvariance of development. The longest duration of ontogenesis is observed in individuals in the petrophytic steppes on the mountain slopes (Table 2). Quickly, already at the 2nd year of development, the individual passes to branching and the primary bush is formed. Self-maintenance of populations occurs due to vegetative reproduction. In petrophytic steppes on the leveled areas of intermountain basins, the duration of ontogenesis of individuals is reduced, and self-maintenance of populations is carried out equally by seed and vegetative reproduction. The duration of ontogenesis of individuals also decreases along the banks of rivers on pebbles and on scree rocky slopes. The curtain is formed already in the virginal state, in the same or in the young generative state, vegetative reproduction occurs. Self-maintenance of populations occurs mainly in a vegetative way. The shortest duration of ontogenesis is observed in individuals in the sandy steppes on the interwoven sandy substrate. The primary bush is formed in the first year, when the primary shoot lies down and begins to branch. Skeletal axes and shoots are intensively rooted, and vegetative reproduction begins in the young generative state. The resulting ramets can be rejuvenated to an immature state.

Table 2. Characteristics of *Thymus mongolicus* development depending on the habitat conditions in Southern Siberia

Habitat, substrate	TPC / PC	A	B	C	D	E
Floodplain of the river, pebbles	12–25 / 1–15	до 15/4–5	3	*v*	vegetative	g_1
Scree slopes, rocks	25–35 / 1–2	до 17/5–6	3	*v*	vegetative	g_1 *(v)*
Sandy steppes, sand	10–15 / 7–12	до 10/2–3	1	*v*	vegetative	g_1
Petrophytic steppes of intermountain basins, soil and crushed rocks	30–40 / 3–5	до 16/5–6	2–3	g_1	vegetative and seed	g_2
Petrophytic steppes of slopes, soil among large stones	20–60 / 1–5	до 22/8–10	2	g_1	vegetative	g_2

Note. A — the duration of ontogenesis / mature generative state (yr.); B – the age of the individual at which the primary bush begins to form (yr.); C — the formation of clump (ontogenetic state); D – the main way of reproduction; E – the beginning of vegetative reproduction (ontogenetic state); TPC — total projected grass cover (%), PC — projected cover of *T. mongolicus* (%).

Thus, the features of *T. mongolicus* development (different duration of individual ontogenetic states, ontogenesis and morphogenesis phases, the way of self-maintenance of populations) contribute to plant adaptation, survival and distribution of the species in different habitat conditions of Southern Siberia.

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