Ontogenetic structure of *Thymus* L. (*Lamiaceae*) coenopopulations in Yakutia

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Abstract. Ontogenetic structure of coenopopulations of four model species *Thymus extremus*, *T. indigirkensis*, *T. brevipetiolatus* and *T. pavlovii* widely distributed in Yakutia was studied. It was established that species coenopopulations were normal, most of them incomplete. Dependence of the type of the ontogenetic spectrum of coenopopulations on growth conditions and ontogenesis pattern was revealed in thymes of different biomorphs. The bimodal type of the ontogenetic spectrum (monocentric dwarf subshrub *T. extremus*) is conditioned by irregular seed regeneration and lack of ripe and old generative stages. Formation of the left-side type of the ontogenetic spectrum is governed by the emergence of vegetative propagation of individuals (unobvious polycentric dwarf subshrub T. *brevipetiolatus* and dwarf semishrub *T. indigirkensis*) and substrate features (distinct polycentric dwarf semishrub *T. pavlovii*).

1 Introduction

Currently searching for ways of rational nature management has become increasingly important [1, 2]. A number of issues along this line are devoted to study of natural reserves of medicinal plant material. *Thymus* L. species are widely used in both official and common medicine. Mass collection of thymes by local population leads to sharp deterioration of natural population status and, as a consequence, to decrease in natural resources. One of the criteria of assessment of the current status of coenopopulations of medicinal plant species is their ontogenetic structure [3]. Medicinal properties of *Thymus* species are known since ancient times. They possess disinfecting, analgesic and antiseptic activities. *T. extremus* Klok., *T. indigirkensis* Karav., *T. brevipetiolatus* Čáp and *T. pavlovii* Serg. are widespread in the territory of Yakutia. The main habitats of the species are steppe plant communities on the southern and south-western cobble slopes of river banks and tops of the hills [4]. In literature there are data on the biology of *Thymus* sibiricus (Serg.) Klokov et Shost. growing in Central Yakutia [5], whereas data on the ontogenetic structure of coenopopulations of this and other species are absent. In this regard, the aim of the work was study of the ontogenetic structure of coenopopulations of model species *T. extremus*, *T. indigirkensis*, *T. brevipetiolatus*, and *T. pavlovii* in Yakutia.

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2 Materials and Methods

Coenopopulations (CP) of four model species *T. extremus*, *T. indigirkensis*, *T. brevipetiolatus*, and *T. pavlovii* growing in different ecological-coenotic conditions of Yakutia were studied (Table 1). When studying the ontogenetic structure of CP, standard methods were used [6–8]. The transects 1 m wide and 5–10 m long were divided into test plots at $1m^2$, a continuous account of individuals at each of the ontogenetic stage was carried out. As a unit of account, a primary shoot, a primary bush and a clump in individuals of seed origin, a partial bush and a system of partial bushes in individuals of vegetative origin were taken into consideration. An ontogenetic spectrum of CP was defined as a ratio of plants at various ontogenetic stages expressed in a percentage of the total individual number [6]. To characterize CP were used demographic indices of age and effectiveness. The type of a coenopopulation was established by L.A. Zhivotovskiy's "delta-omega" classification [7]. The ecological density of CP was defined when calculating individual abundance per unit of habitable space [8].

Table 1. Characteristic of habitats of *Thymus* coenopopulations in Yakutia

CP	Locality of CP	Community / dominating species	TPCD/PCD %
1 (*T. extremus*)	Vicinities of Yakutsk, gentle slope of the Lena River bank, south-eastern exposure, steepness 10^0, meadow-chernozem sandy-loam soil	Herb-sheep's fescue steppe (*Festuca lenensis* Drobow, *Artemisia pubescens* Ledeb., *Veronica incana* L., *Carex duriuscula* C.A. Mey., *Pulsatilla flavescens* (Zucc.) Juz.)	80/3
2 (*T. brevipetiolatus*)	Kobyansk region, vicinities of s. Smorodichny, slope of southern exposure, steepness 5^0, loam with cobble.	Spreading anemone-sheep's fescue-wildrye steppe (*Festuca lenensis, Elymus turuchanensis* (Reverd.) Czerep., *Pulsatilla patens* (L.) Mill., *Koeleria cristata* (L.) Pers., *Veronica incana*)	80/1
3 (*T. indigirkensis*)	Kobyansk region, vicinities of s. Sangar, slope of southern exposure of the Lena River bank, steepness 5^0, fine grain soil covered with cobble	Bush encroached by *Spiraea dahurica* (Rupr.) Maxim. and *Rosa acicularis* Lindl. herb bunchgrass steppe (*Agropyron villosum* (L.) Link, *Festuca lenensis, Carex pediformis* C.A. Mey., *Dracocephalum palmatum* Steph. ex Willd., *T. indigirkensis*)	60/5
4 (*T. pavlovii*)	Tompo region, southern exposure of	Grouping of vegetation (*Bromopsis pumpelliana*	35/5

	the slope of the Sete-Dabash Ridge, right борт of the Tyi-Synoga stream valley, steepness 30^0, rocky-subsiding outcrops, moss in crevices	(Scribn.) Holub, *Elymus confusus* (Roshev.) Tzvelev, *T. pavlovii, Dracocephalum stellerianum* F. Hiltebr., *Rhytidium rugosum* (Hedw.) Kindb.)	

Note: TPCD – total projective cover degree of the herb layer, PCD – projective cover degree of the species.

3 Results and Discussions

Study of *T. extremus*, *T. indigirkensis*, *T. brevipetiolatus* and *T. pavlovii* showed that in Yakutia peculiar morphological mechanisms of adaptation manifesting themselves in the diversity of life forms and biomorph types were formed in the species. In CP 1 *T. extremus* is a monocentric dwarf semishrub. The phase of a primary bush is prolonged in the individual ontomorphogenesis. Self-maintenance of CP occurs only by seeds. In CP 2 *T. brevipetiolatus* and in CP 3 *T. indigirkensis* are implicitly polycentric dwarf semishrub and dwarf semishrub, respectively. The most prolonged phase in the individual ontomorphogenesis is that of a clump. Self-maintenance of CP occurs by seeds and vegetatively. IN CP 4 *T. pavlovii* is explicitly dwarf semishrub. An adult individual also represents a clump. Self-maintenance of CP occurs vegetatively. Studied CPs of model species are normal, mostly incomplete (subsenile individuals are absent) (Table 2).

Table 2. Distribution of *Thymus* species individuals throughout the ontogenetic groups

CP	Ontogenetic groups, %								$D_{ecol.}$	ω	Δ	CP type
	j	im	V	g1	g2	g3	ss	s				
1	12.2	17.1	7.3	17.7	15.2	9.8	20.1	0.6	23.4	0.55	0.42	transitional
2	0.4	6.3	15.7	33.2	16.2	19.7	8.5	0	40.0	0.70	0.41	transitional
3	3.8	5.0	20.0	38.1	13.2	15.0	4.9	0	74.3	0.67	0.35	transitional
4	13.2	36.8	17.6	19.1	5.9	1.5	5.9	0	8.5	0.39	0.19	Young

Note. Ontogenetic groups: j – juvenile; im – immature; v – virginal; g1 – young generative; g2 – ripe generative; g3 – old generative; ss –subsenile; s – senile; D_{ecol} – ecological density (individual/m^2); ω –effectiveness index; Δ - age index; type of coenopopulations according to L.A. Zhivotovskiy's classification (2001).

The ontogentic spectrum of CP 1 *T. extremus* is bimodal. An absolute maximum is in the right-side part of the spectrum on subsenile individuals. Two local maxima are distinguished on immature and young generative individuals in the left-side part of the spectrum. Multiple top of the spectrum is conditioned by different factors. On the one hand, irregular seed regeneration encourages accumulation of different groups of regrowth. On the other hand, accumulation of subsenile individuals is linked with features of *T. extremus* development in forb-sheep's fescue steppe community with a lack of water supply and high sodding. So young individuals pass to the subsenile stage omitting ripe and old generative ones. In this regard, the group of ripe generative individuals in CP 1 does not prevail. According to "delta-omega" classification the CP is transitional.

The ontogenetic spectra of CP 2–4 are left-side, with the maximum on young generative (CPs 2 and 3) and immature individuals (CP 4). Formation of the left-side ontogenetic spectrum in CPs 2 and 3 in *T. brevipetiolatus* and *T. indigirkensis* is similar. Both CPs occur in the steppe communities on hill slopes. Vegetative spreading and

propagation are typical of species individuals in these conditions. Vegetative propagation occurs at the ripe generative stage. Ramets rejuvenated up to the young generative stage and sometimes in *T. indigirkensis* up to the virginal one annually separate from the maternal individual. This, as well as seed regeneration promote increase in young generative individual group and formation of the peak in the left part of the spectrum. Ecological density of CP of implicitly polycentric thyme species is high and reaches in *T. indigirkensis* 74,3 individual/m^2. CP self-maintenance is equally by seed and vegetative ways. Genet-ramet ratio is practically the same: in *T. brevipetiolatus* CP it amounts to 1:1,4, in *T. indigirkensis* CP – 1:1,2. According to "delta-omega" classification CPs 2 and 3 are transitional to ripe ones.

In *T. pavlovii* a rise in the left part of the spectrum falls on the group of immature individuals. The species habitat is characterized by specific features of the substrate. Individuals develop on the moss cover in the crevices of rocky outcrops. Favourable conditions for seed germination are formed here. However, only a small quantity of individuals passes to virginal stage in the future. This is linked with an adverse effect of moss in individual life at the later ontogenetic stages (conservative of permafrost, assists in preservation of soil low temperatures, leads to swamping). The same thing is also noted by J. L. Gornal et al. [9]. Duration of the ontogenesis of *T. pavlovii* genets does not exceed 8 years. At the ripe generative stage primary individual structures decay, and a plant breaks up completely into even-aged partial formations. CP self-maintenance is mainly due to vegetative regeneration of ripe generative individuals. Genet-ramet ratio in CP is 1:3,5. According to "delta-omega" classification CP 4 is young.

Thus, the study of the coenopopulations of model *Thymus* species in various ecological-coenotic conditions of Yakutia shows that all of them are normal, most of them are incomplete (individuals at the senile ontogenetic stages are absent). Dependence of the ontogenetic spectrum type on growth conditions and ontogenesis pattern was revealed in species of various biomorphs. Similar dependence was also revealed by some researchers when studying plant population structure in certain regions [3, 10 and others.]. A bimodal type of the ontogenetic spectrum in the monocentric dwarf semishrub *T. extremus* is governed by irregular seed regeneration and omitting ripe and old generative stages. Formation of the left-side ontogenetic spectrum of CP in implicitly polycentric semishrub *T. brevipetiolatus* and dwarf semishrub *T. indigirkensis* is conditioned by emergence of individual vegetative propagation, ramet rejuvenation (up to the young generative stage), combined way of CP self-maintenance. Accumulation of regrowth and formation of the left-side spectrum in explicitly polycentric dwarf semishrub *T. pavlovii* are to a greater extent due to peculiarities of moss substrate.

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