ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Diversity of Life Forms Hypericum Perforatum as an Essential Component of the Species Stability in Steppe Meadows of Forest-Steppe Zone.

Svetlana A Dubrovnaya*, and Landysh Z Husnetdinova.

Kazan (Volga region) Federal University, 420008, Kazan, Kremlevskaya, 18.

ABSTRACT

We investigated the coenopopulations of Hypericum perforatum on the meadows of steppe zones with different types of moistening. The sustainable existence the species coenopopulations was determined by the variation of vegetative propagation methods, performed by creeping-rooted or long rooted shoots. Almost all meadows were represented by plants, forming creeping-rooted or long rooted shoots and the plants, forming both types of shoots at the same time. The share of such plants was a little over 4.9 %%. In disturbed habitats and steppefied meadow was the proportion of plants that developed creeping-rooted shoots was high (over 70%). Within the flood meadow conditions the share of plants, forming creeping-rooted shoots reduced to 12%, with the dominance of long rooted plants. In the forest-steppe zone the disturbed habitats for hypericum is characterized by the combination of competition and ruderal strategy of behavior. It was manifested in rapid development of individuals at the early stages of ontogenesis (hospitality plants flowered and formed creeping-rooted shoots in the second year), in the ability to develop a large number of seeds, to form power species. Within the conditions of intact meadows the competition and competitive - tolerant behavior strategy of the species was implemented. The amount of plants with horizontal rooting shoots (long rooted life form) was increased. This provided both the preservation of regeneration kidneys, and the increase of the space occupied by the species. Ecological and coenotic conditions of a specific community was influenced on the implementation of the sexual and vegetative propagation feature of shoots that mainly developed the life forms and the species behavior strategy.

Keywords: Hypericum perforatum, life forms, behavior strategy

ISSN: 0975-8585

INTRODUCTION

The stability of plant communities as biological system depends on the ability of its elements to resist the fluctuations of external factors that contribute to the preservation of community structure and the maintenance of functional links between all elements of the system. This is largely determined by the presence of ecological valence among a wide range of types, which is a prerequisite for the adaptation to a changing environment. The adaptation of species populations is largely carried out by morphological plasticity of the species, where the spatial position of the shoots system, their growth and development is influenced by external conditions. Thus any expressions of morphological adaptation are related to the inclusions of multiple cellular and intracellular regulation systems that allow to consider a morphological adaptation as a "final product" of physiological adaptation [1].

One of the factors ensuring a steady state of the species in community is the plasticity of the species morphological structure. The analysis of the literature showed that H. perforatum in natural populations develop various forms of life [2]. If we consider the structure of the underground organs the life form of the species was determined as virgate root, creeping-rooted [3] or Geofit [4]. G.M. Zozulin noted the formation of plagiotropic roots for Hypericum (cit. by [3]). In the context of meadow communities a virgate rooted, an optional virgate rooted or an optional creeping-rooted forming life-forms was determined [5]. It was noted earlier [6, 7, 8] that the creeping-rooted life form was formed under the terms of cenosis subjected to severe degradation. The ability to create a variety of life forms provides a wide area of the species distribution, the development of a variety of habitats. The implementation of different kinds of life forms allows individuals to remain on the explored space at the breaking of plant communities and the cyclic change of vegetation types. The plants of different life forms within plant communities are characterized by different space retention and development strategies. During the study of H. perforatum coenopopulation structure it was noted [9] that the plants of long rooted and long-rooted - rod-shaped rooted life forms are confined to the glades, edges, upland meadows, forest and grassland areas. The plants with rod-like rooted form were encountered in the deposits.

Purpose of the study. To identify the mechanisms that determine the stable existence of Hypericum perforatum in various types of community in the forest-steppe zone of the Republic of Tatarstan.

MATERIALS AND METHODS

The objects of the study were artificial coenopopulation loci and the coenopopulations of hypericum in meadow communities of the forest-steppe zone. A brief description of the communities is represented in Table 1.

15-20 plants of middle-aged generative ontogenetic state were randomly dug for the research in each community. The number of above-ground shoots, the number of flowers was calculated on an innovation. To determine the ability of creeping-rooted shoots development the side, horizontally placed roots were dug. In the presence of weed forming, lodge, rooted shoots were determined. The life form of the species was determined at the presence of creeping-rooted, horizontal, established shoots. To study the individual development of the species at the early stages of ontogenesis in May 2012 a bed with the size of 100x0,3 m was planted with the seeds of H. perforatum, which grow on steppe meadows. The calculation of survived plants and the determination of their ontogenetic state was conducted in June of each year. At the end of the season 2014 all surviving plants were dug out.

ISSN: 0975-8585

Table 1: Characteristic of plant communities in the forest-steppe area of Republic of Tatarstan

Natural and historical areas of the forest-steppe zone of the Republic of Tatarstan	Habitats
The area of west pre-Volga forest steppe. The area of leached chernozems on eluvials of Lower and Jurassic rocks (mainly clay). The rainfall amount makes 440-460 mm/year.	**Ruderal community (overgrown ploughed field).** An abandoned agricultural land. Soil: leached chernozem. The coenopopulation of Hypericum is presented by the plants of the generative and pregenerative periods. The species composition of the community is represented by ruderal meadow plants, where the absolute dominance is represented by the plants of Asteráceae family.
	Floodplain red-oat-campfire grassy meadow.
East (East Zakamskiy) area of deciduous forests - an area of weakly podzolic soils on the eluvium of Permian rocks. The rainfall makes 420-440 mm/year.	**Upland meadow.** Narrow leaved bluegrass meadow. Gray forest soils. It is located on the border with broad-leaved forest. The plants of Poáceae, Fabáceaefamily prevail. Grasses are widely represented where there are plants of upland meadows, disturbed habitats and the plants of deciduous forests.
The area of southeast Zakamsk forest steppe - an area with a strong development of low-power crushed stone soils on Perm plate. Rainfall makes 420-440 mm/year	**Steppefied meadow.** Steppe-fescue grassy meadow on calcareous soils. The soils are calcareous, black soils. Cereals prevail; Stípapennáta Póa angustifólia. Legumes; Astragalusaustriacus, A. dánicus. The herbs are abundantly represented by steppe species.

RESULTS

The study of the species biology promotes the revealing of mechanisms that determine the steady state of the species in the community, and the creation of conditions for the formation of high-yield, regenerating artificial populations [10]. At the same time to identify the whole spectrum of the species biological potential its study is advisable to perform in a variety of habitats. A special place in this aspect occupies the study of species biology in artificial plantings, with the modeling of natural community conditions, which allow to evaluate the impact of a specific factor on the plant growth and development.

The development of Hypericum plant in artificial plantings occurred quite rapidly, due to the reduction of pre-generative period. For the second year the plant were in bloom and transited into a young generative ontogenetic state. However, the maximum efficiency of Hypericum artificial populations were observed when the plants reached its middle-aged ontogenetic status (Table 2), which was observed on the third - the fourth year of life. The performed studies showed that within the conditions of artificial planting a rod rooted - creeping-rooted life-forms developed. Caudex had a simultaneous development of a large number of innovations. The number of above-ground shoots increased to 20, the average number made 6.6 (Table. 2).

Table 2: Morphometric parameters of Hypericum perforatum plants in different ontogenetic states (Me)

Indicators / Ontogenetic states	The number of flowers per shoot	Height of plants	Number of innovations	Total amount of aboveground shoots	Leaf area (cm^2)
Plants of young generative state	18 **	54*	1	2*	1,7
Plants of middle-aged generative ontogenetic state	112	63	2	6,6	3,1

*P<0,05; **P<0,01; ***P<0,001

The productivity of artificial populations is limited to two, three years, after which a decline was marked. This is due to the loss of most middle-aged generative plants at the end of flowering, and to a low productivity of old generative plants. During the third year the intensive completion of artificial coenopopulations was marked by young plants of creeping-rooted origin. The ability to form creeping-rooted shoots was observed among the second year plants. However, the frequency of such plants was very low - 1.3%. About 30% of three-year plants developed creeping-rooted shoots. Vegetative arising ramets were not flowered in the year of occurrence, which contributed to the increase of pregenerative period plants. By the

ISSN: 0975-8585

fall the ontogenetic spectrum of coenopopulation had the character of a two-top curve. The bimodal ontogenetic spectrum with the maximum on the middle-aged plants of generative ontogenetic condition and the plants of virginal ontogenetic state reflected the steady state of the artificial population (Fig. 1), capable of self-renewal by seed and vegetative propagation.

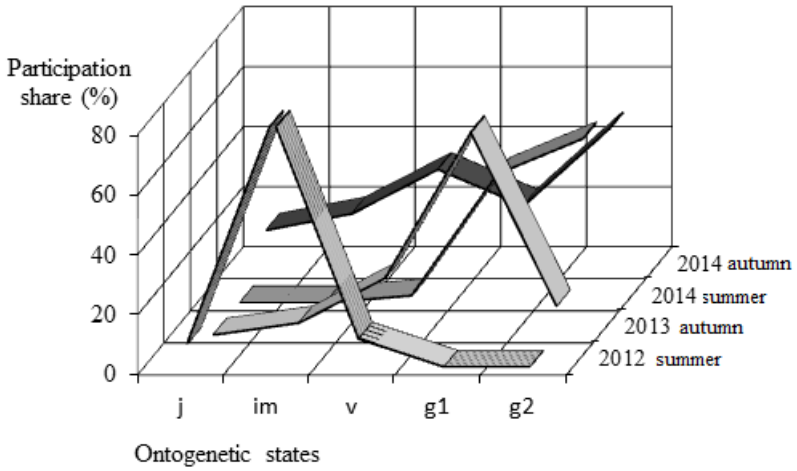

Figure 1: Ontogenetic structure variability of artificial coenopopulation in the season 2012-2014.

The rapid development of the plant at the early stages of ontogenesis, the ability to start a sexual and a vegetative reproduction in a short term allows St. John's wort to take disturbed habitats, acting as a kind of weed [11]. The analysis of the anatomical structure showed that in conditions of disturbed habitats the well-developed middle-aged plants of an ontogenetic state were aged from three to four years. The destructive open communities, characterized by a lack of root competition were the optimal growing conditions for St. John's wort. They developed the maximum biomass and maximum generative sphere expression. When you compare "The number of flowers per stem" the significant difference was found between plants growing on an overgrown arable land and in a floodplain meadows, with other communities. The plants in these habitats were not different. The difference between the plants growing in a steppe meadows and upland meadows was not revealed. According to the attribute "the number of seeds in a box" the difference between the plants of all communities was statistically significant (Table 3). The indicator "number of seeds in a box" for Hypericum plant on an overgrown arable land was several times higher than in pristine grassy meadows with a holistic grass tier.

When you compare the indicator "number of shoots in the bush" the difference between the plants of different habitats was not identified.

Table 3: The morphometric parameters of H. perforatum overground shoots in 2014

Attributes / Habitat	Number aboveground shoots in the bush Median	Number of flowers per stem		Number of seeds in a box	
		Median	Significance level	Median	Significance level
Overgrown arable land (1)	7	103	1-3*** 1-4***	120,5	1-2*** 1-3*** 1-4***
Floodplain meadow (2)	5	81	2-3*** 2-4***	39,5	2-3* 2-4**
Steppefied meadow (3)	6	37		66,6	3-4**
Upland meadow (4)	5	31		15	

1-3 pair comparison. Significance levels *P<0,05; **P<0,01; ***P<0,001.

On the basis of such characteristics as the ability to create powerful species, the ability to rapid development at the early stages of ontogenesis, a pronounced ability to reproduction, it is possible to talk about St. John's wort development in disturbed areas of competitive-ruderal behavior strategy, as was noted earlier [9]. When you restore a plant community the decrease of ability to sexual reproduction was marked, while maintaining the ability to the development of powerful species. The strategy changed into competitive and competitive tolerant one. The manifestation of different types of strategies [12] reflects the ability of species to respond quickly to a changing complex of ecological and cenotic factors by altering the vegetative and reproductive system.

The study of life forms diversity within an open source community showed that within the conditions of disturbed habitats in the populations the plants of rod rooted, creeping-rooted life-forms prevail, which contributed to the intense vegetative growing and reproduction. The development of St. John's wort life form based on semi wooden shoot, which may take an orthotropic, or anisotropic or plagiotropic position. For a number of Hypericum species the anatomical structure of aboveground shoots characteristic for the life form of bushes was marked [13]. All the variety of St. John's wort life forms in a meadow communities was determined by the ability of plants with a rod rooted life form to develop creeping-rooted or long rooted shoots at simultaneous formation of these types of shoots. On different types of grasslands the proportion of plants forming creeping-rooted shoots varied from 66% to 12%. But in disturbed area the proportion of plants forming creeping-rooted shoots, increased to 71%. However, even under the conditions favouring the development of creeping-rooted shoots the plants were met in the coenopopulations, forming long rooted shoots. On the overgrown arable land the share of such plants made 9%. The ability to the implementation of various life forms, provides a variety of methods for a vegetative propagation and sprawl, and along with sexual reproduction it ensures the stability of the species state in the community, as well as the possible survival of the species at the change of vegetation types. We identified the following forms of St. John's wort lives: rod-rooted, rod-rooted - creeping-rooted, rod-rooted - creeping-rooted - long rooted, rod-rooted - long rooted one. On different types of meadows the ratio of life forms varies significantly (Table 4).

Table 4: The ratio of plants of different life forms in natural communities (%)

Habitat / Life forms	Arable land	Floodplain meadow	Upland meadow	Steppe formation meadow
Rod rooted	32	15	33,3	31,2
Rod rooted - creeping-rooted	59	8	33,3	56,2
Rod rooted - long rooted	0	55	0	3,1
Long rooted	0	18	33,3	0
Rod rooted - long rooted - creeping-rooted	9	4	0	9,4

A similar character of plants distribution with different life forms was in a steppe meadow and in the conditions of arable overgrown land. At a high participation of rod-rooted and creeping-rooted plants (50%), more than 9% of the plants are also formed creeping-rooted and long rooted shoots.

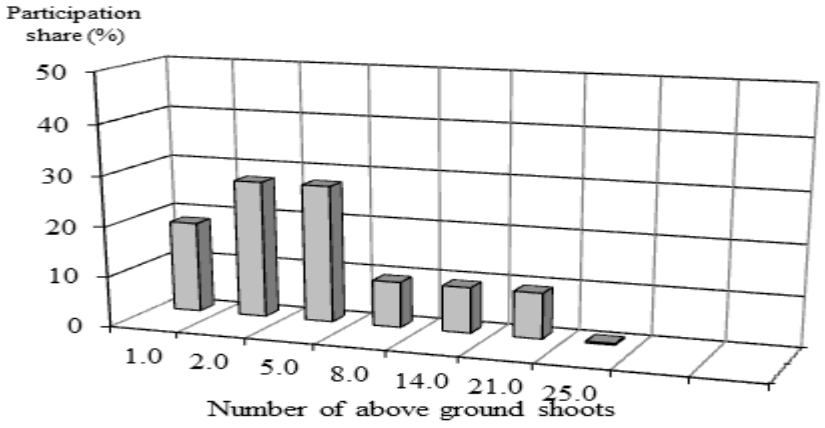

Figure 2: Distribution by classes of shoot number features among H. perforatum multi-shoot plants within a steppe meadow

ISSN: 0975-8585

An important feature of Hypericum plant in meadow communities was the ability of multi shoot plants formation. The steppified meadow with the individual plants of middle-aged generative ontogenetic state could implement more than 25 shoots at the same time. However, the plants producing up to 7 shoots prevailed (Fig. 2). The plants of middle-aged generative ontogenetic state had the increase in the number of realized shoots with the calendar age increase (rs = 0,442; P = 0.05). The maximum number of shoots was observed among the species, the absolute age of which made three or four years. Multi shoot H. perforatum species are characterized by a greater vitality; A large vegetative mass was developed, a greater number of generative shoots for one innovation. These plants were significantly superior by main indicators the long rooted plants and the typical plants with small shoots, which had at least three innovations (tab. 5).

Table 5: Morphometric parameters of H. perforatum plants of a middle-aged generative condition of different life forms on a steppified meadow (2011)

Indicators / Life forms		Median (Me)	Lower and upper limits of 95% confidence interval	Min - Max
Plant height				
Long-rooted		50 ***	45,5-52	44-61
Rod-rooted	Few shoots	51 ***	49-55	48-64
	A lot of shoots	61	56-69,5	53-74
Number of generative shoots (flowers) on innovation				
Long-rooted		61,5 **	39-98,5	24-126
Rod-rooted	Few shoots	69 **	57-95	44-156
	A lot of shoots	108	74,5-135,5	56-232
Number of shoots				
Long-rooted		2 *, ***	2-3	1-7
Rod-rooted	Few shoots	4,5 ***	3-9	1-16
	A lot of shoots	15	12,5-17,5	8-20
Total number of metamers				
Long-rooted		21	17,50-23,50	16-26
Rod-rooted	Few shoots	24,5	20,1-26,0	18-27
	A lot of shoots	22,5	21,5-25,5	17-30
Leaf blade area				
Long-rooted		1,1 **	1,02-1,69	0,96-3,24
Rod-rooted	Few shoots	1,4 **	0,91-2,31	0,48-2,31
	A lot of shoots	2,7	1,87-3,15	1,39-3,38

*P<0,05; ** P<0,01; *** P<0,001

The adaptive significance of multi shoot plants in meadow communities is not limited to the formation of highly productive species forming a large number of seeds. Due to the upright stems of dead shoots an outer "frame" is developed within which there is an accumulation of dust, sand, silt, leaves residues that lead to the formation of bedding, where regeneration buds are located. Thus, the formation of multi shoot species promotes the formation of an important biological quality - it increases the likelihood of buds preservation during the unfavorable period.

CONCLUSION

Based on these studies we may conclude that in the conditions of forest-steppe zone on the meadows of different moistening regimes and disturbed areas the formation of different types of life forms and strategies is peculiar for St. John's wort. The disturbed habitats in the forest-steppe zone are the optimum conditions for the existence of the species. The plants with a well-defined generative sphere prevailed in coenopopulation. The plants were characterized by the rapid development at the early stages of ontogeny, that allows to talk about the implementation of the competitive ruderal behavior strategy of the species.

St. John's wort is manifested by a competitive and tolerant-competitive behavior strategy on restored meadows. Plants developed a strong biomass. The long-term retention of developed territory was performed by forming horizontal and rooting shoots - the formation of a long rooted life form. The of generative sphere implementation reduced. The ability to implement various types of shoots: creeping-rooted, long-rooted allows a species to remain on an occupied area in the process of succession, to explore different ecological niches.

On the destructive area and the meadows of different types of humidification there were the plants, generating creeping-rooted and long-rooted shoots. One may state only the change in the ratio of life forms in different communities. Ecological and coenotic specific community conditions influence the implementation of the sexual and vegetative propagation, the shoot formation feature, which largely develops a life form and a species behavior strategy..

ACKNOWLEDGEMENT

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

Conflict Of Interest

The author confirms that the presented data do not contain any conflict of interest.

REFERENCES

[1] Polevoy V.V. Plant Physiology. M.: Higher School. - 1989. - 464 p.
[2] Dubrovnaya S.A., L.U. Mavlyudova. The variety of Hypericumperforatum L. life forms on the territory of the Republic of Tatarstan // Scientific notes of Kazan univ. Natural science series. - 2012. - V. 153. - book 2 - pp. 170 - 182.
[3] V.N. Golubev. Basics biomorphology of herbaceous plants in the Central forest steppe // Proceedings of the Central Black Earth state reserve named after prof. V.V. Alekhin. Issue 7. Voronezh Univ. publishing house. - 1962. - 511 p.
[4] Raunkiaer C. The life forms of plants and statistical plant geography. Oxford: Clarendon Press. – 1934.– 632 p.
[5] Gontar E. M. Kurochkina N.Yu. The age structure of Hypericumperforatum (CLUSIACEAE), Polemoniumcaeruleum (POLEMONIACEAE) and Primulamacrocalyx (PRIMULACEAE) in Khakassia, Altai and in East Kazakhstan // Plant resources. - 2005. - V. 41. - №. 2. - pp. 17- 28.
[6] Tisdale E.W., Hironaka M., Pringle W. L. 1959. Observations on the autecology of *Hypercumperforatum* // Ecology. – 1959. – Vol. 40. – No. 1. – P. 54 –62.
[7] Clark N. The biology of *Hypericumperforatum* L. var. *angustifolium* DC. (St. John's wort) in Ovens Valley, Victoria, with particular references to entomological control // Aust. J. Bot. – 1953. – V. 1. – P. 95–120.
[8] E.M. Gontar, Godin V.N. The ontogeny of Hypericum perforatum // Ontogenetic atlas of medicinal plants. V. 3. Yoshkar-Ola: Mar. SU - 2002. - pp. 201-213.
[9] Parkhomenko V.M. Biological features and structure of Hypericum perforatum coenopopulations in conditions of Saratov region: Abstract of Dis. Cand. of biol. sciences. - Saratov. - 2012. – 20 p.
[10] A. Raal, Pihlik U. Paaver U. et al. Effect of Hypericumperforatum L. planting density, on its development and content of active substances // Plant resources. - 2004. - V. 40. - №. 3. - pp. 36-41.
[11] Weed Risk Assessment / editors: R. H. Groves, F. D. Panetta,J. G. Virtue. Collingwood: CSIRO PUBLISHING. – 2001. – 245 p.
[12] Grime J.P. Plant Strategies and Vegetation Processes. Chichester: J. Wiley Publ. - 1979.-222 p.
[13] Lotocka B., Osinsra E. Shoot anatomy and secretory structures in Hypericum species (Hypericaceae) // Botanical Journal of the Linnean Society. –2010. – V. 163. – P. 70–86.