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ECOLOGICAL ANALYSIS OF PLANTS IN ALMATY REGION
(Enbekshikazakh and Talgar districts)

This article presents the results of a study obtained during an ecological analysis of the flora of the Almaty region (using the example of Talgar and Enbekshikazakh regions). Plants are a vulnerable component of biota, as they are the primary link in the food chain and play a major role in absorbing various pollutants due to their attachment to the soil substrate. Plants grow and develop under the influence of a variety of factors. Natural settlement of plants leads to the formation of plant communities, which can be used to judge about the state of biodiversity of a particular region. In this regard, the inventory and analysis of the flora of any region have been, is and will always be relevant. One of the global tasks of our time is to study the problems and preserve biological diversity. The aim of the work was to conduct an ecological analysis of the flora of Almaty region (on the example of Talgar and Enbekshikazakh districts), reflecting the characteristics of the environment and a variety of living conditions. Flora was studied using traditional methods of floristic and field geobotanical studies. The distribution of plant species of Almaty region by life forms showed that the predominant are perennials (1009 species or 65.5%), annuals (266 species or 17.3%) and shrubs (101 species or 6.5%). The smallest part of species belongs to biennial plants (80 species or 5.2%), trees (46 species or 3%), and suffrutices (8 species or 0.5%), lianas (4 species or 0.2%) and 1 species, which is 0.01% of the total number of trees. As a result of the ecological analysis of the flora of Almaty region, which is based on the classification of groups in relation to soil moisture, revealed that the majority are mesoxerophytes (770 species or 49.9%), xerophytes (309 species, which is 20.05%), mesophytes (278 species or 18.04% of the total number of species), xeromesophytes (154 species or 9.9 %). A smaller part of the flora of the region is composed of hygromesophytes (16 species of ill1, 0.3 %) and mesohygrophytes (14 species, which is 0.9%).

Key words: flora, Almaty region, ecological analysis, life forms, ecological groups.

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Алматы облысының өсімдіктерінің экологиялық талдау (Талгар және Еңбекшіказах аудандары бойынша)

Берілген мәліметтерде Алматы облысында (Талгар және Еңбекшіказах аудандары бойынша) жүргізілген өсімдіктерінің экологиялық анализінің зерттеу нәтижелері көрсетілген. Өсімдіктер – биотаның осал компоненті, ой тәрізді олар трофикалық тізбектің бастапқы бөлігі.
таблицы және субструктас әдістемелердің орындауы әртүрлі субстратқа үйрімді болуы мүмкін.

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Экологический анализ растений Алматинской области
(на примере Талгарского и Енбекшиказанского районов)

В данной статье представлены результаты исследования, полученные в ходе проведения экологического анализа флоры Алматинской области (на примере Талгарского и Енбекшиказанского районов). Растения – уязвимый компонент биоты, так как они являются первичным звеном в трофической цепи и выполняют основную роль в поглощении разнообразных загрязнителей вследствие их прикрепленности к субстрату. Растения растут и развиваются под воздействием комплекса различных факторов. Естественное заселение растений приводит к образованию растительных сообществ, по которым можно судить о состоянии биоразнообразия конкретного региона. В связи с этим инвентаризация и анализ флоры любого региона были, есть и будут всегда актуальными. Одной из глобальных задач современности является изучение проблем и сохранение биологического разнообразия. Целью работы было провести экологический анализ флоры Алматинской области (на примере Талгарского и Енбекшиказанского районов), отражающий характерные особенности среды и разнообразные условия существования. Флора изучалась с использованием традиционных методов фармакологических и полевых геоботанических исследований. Распределение видов растений Алматинской области (Талгарского и Енбекшиказанского района) по жизненным формам показало, что преобладающими являются многолетники (1009 видов, или 65,5%), однолетники (266 видов, или 17,3%) и кустарники (101 вид, или 6,5%). Наименьшая часть видов относится к двулетникам (80 видов, или 5,2%), деревьям (46 видов, или 3 %), и полукустарникам (17 видов, или 1,1%), незначительное количество составляют кустарнички (9 видов, или 0,6%), полукустарнички (8 видов, или 0,5%), лианы (4 вида, или 0,2%) и 1 вид, что составляет 0,01% от общего количества существующих видов. В результате экологического анализа флоры Алматинской области, в основу которого принята классификация групп по отношению к влажности почв, выявлено, что большую часть составляют мезоксерофиты (770 видов, или 49,9 %), ксерофиты (309 видов, что составляет 20,05 %), мезофи́ты (278 видов, или 18,04 % от общего количества видов), ксеромезофиты (154 вида, или 9,9 %). Наименьшую часть флоры региона составляют гламеосифо́фиты (16 видов, или 1,03 %) и мезогигрофиты (14 видов, что составляет 0,9%).

Ключевые слова: Алматинская область, экологический анализ, жизненные формы, экологические группы.
Introduction

In recent decades, all studies on flora and vegetation have focused on the conservation of biodiversity at different levels of its structural organization (species, population, cenotic, ecosystem, landscape) [1-4].

Kazakhstan, as a party to the Convention on the conservation of biological diversity, has its obligations to preserve biological diversity. In accordance with the UN Convention on biodiversity, the first stage for conservation is inventory [5].

In recent years, the study of biodiversity of terrestrial plants of Almaty region has been devoted to a number of scientific works and conducted numerous field studies [6-11].

The flora of Kazakhstan, including the flora of Almaty region (Talgar and Enbekshikazakh district), is characterized by a rich gene pool and unique reserves of useful plants, primarily wild species with medicinal properties, a significant part of which is promising for the study of chemical composition and biologically active substances, which are high-tech and competitive products, which are in increasing demand in the world market [12].

Plants are a vulnerable component of biota, as they are the primary link in the food chain and play a major role in the absorption of a variety of pollutants due to their attachment to the soil substrate. Plants grow and develop under the influence of a complex of different factors. Natural settlement of plants leads to the formation of plant communities, which can be judged on the state of biodiversity in a particular region [13-18].

In this regard, the inventory and analysis of the flora of any region, in particular the Almaty region (Talgar, Enbekshikazakh districts), were, and will always be relevant. The problem of the study and conservation of biological diversity is a global task of our time. This is especially important for the natural complex of Almaty region (Talgar, Enbekshikazakh districts), which is characterized by a rich Fund of biological diversity.

Materials and methods

A list of field expedition research routes for the study of the flora of Almaty region (on the example of Talgar and Enbekshikazakh districts) (figure 1) for the period of 2018 has been developed.

The material of the research was the herbarium material of the Department of biodiversity and bioresources of the al-Farabi Kazakh National University, as well as its own collections of species composition of plants carried out for the period of 2018.

Classical methods of floristic and geobotanical studies were used. Several expeditions were conducted to Almaty (Talgar and Enbekshikazakh regions) region, including spring, summer and autumn periods. As a result, more than 2000 herbarium sheets of higher vascular plants were collected. Treatment, determination and comparison of plants were carried out using morphological and geographical method.

In the field, the flora was studied using traditional methods of floristic research.

In determining the herbarium samples were used as sources of “Flora of Kazakhstan”, “Illustrated determinant of plants of Kazakhstan”, the definition of families and genera was carried out with the help of “Flora of Kazakhstan” M.S. Baitenov [19-21].

The location of species and supraspecific categories in the flora and floristic spectrum carried out according to the system of A. L. Takhtajan [22]. The spelling of Latin names, the nomenclatural changes of the taxa were verified in accordance with S. K. Cherepanov [23].

Results and discussions

As a result of the analysis of the species composition of plants, compiled on the basis of own and literary data, the flora of Almaty region (Talgar and Enbekshikazakh district) includes 554 genera and 1541 species from 114 families [7,21, 24].

Plants grow and develop under the influence of a complex set of factors simultaneously acting on them, causing adaptive reactions. The struggle for moisture was the main impetus for the evolution of the plant world, as evidenced by the history of the formation of modern flora of different regions of the globe (since the Cretaceous period) [25].

So, in relation to water, the following ecological groups are distinguished: hydrophytes, hygrophytes, mesophytes, mesoxerophytes, xeromesophytes and xerophytes [26].

Since the flora of the study area is constantly changing and depends on the water regime, we have identified 6 groups in the study area: mesohydrophytes, hygromesophytes, mesophytes, mesoxerophytes, xeromesophytes and xerophytes (table 1).
As a result of the ecological analysis of the flora of Talgar and Enbekshikazakh districts, which is based on the classification of groups in relation to soil moisture, revealed that most plants were of the mesoxerophytes (770 species or 49.9 %). These are the plants adapted to conditions slightly less than average on the amount of moisture in the soil. They are intermediate between xerophytes and xeromesophyte [27-28]. Mesoxerophytes typical for sand and clay mining areas, and of riparian forests. This is Ceratocephala testiculata (Crantz) Bess., Papaver pavoninum Schrenk and others.

The second place is occupied by xerophytes (309 species, 20.05 %), plant species adapted to live in conditions with periodically insufficient moisture or with a constant lack of moisture. They are adapted to life in conditions of low water supply. Xerophytes are plants of dry habitats that can tolerate a significant lack of moisture – in soil and in atmospheric. To this group belong species mountain territories, of the dry steppes. They have various adaptations to the conditions of lack of moisture: a highly developed root system, developed a water supply system (i.e., the leaves have a dense arrangement of veins), strongly reduced leaf blades, have powerful cover tissues (thick-walled, multi-layered epidermis with outgrowths and hairs that form a thick “felt” pubescence) [29]. Xerophytes include Ephedra equisetina Bunge and other plants.

The third ecological type – are mesophytes (278 species or 18.04 %) – species adapted to life in conditions of average water supply (average soil and air humidity). Plants of this ecological group are typical for floodplains of rivers and tugay. This

| Ecological type         | Type of place of growth                  | Number of species | % of the total number of species |
|-------------------------|------------------------------------------|-------------------|----------------------------------|
| Mesoxerophytes          | From a periodic lack of moisture         | 770               | 49.9                             |
| Xerophytes              | With strong lack of moisture             | 309               | 20.05                            |
| Mesophytes              | With sufficient moisture                  | 278               | 18.04                            |
| Xeromesophytes          | With periodic dryness                    | 154               | 9.9                              |
| Hygrophytes             | Periodically over a highly supersaturated | 16                | 1.03                             |
| Mesohygrophytes         | Periodically a highly supersaturated     | 14                | 0.9                              |

Total: 1541 100

Table 1 – Distribution of flora species in Almaty region (Talgar and Enbekshikazakh districts) according to habitat types
species such as *Clematis songarica* Bunge, *C. glauca* Willd., *Thalictrum alpinum* L., *Th. simplex* L., and others. The same group includes ephemera and ephemeroids [30], which form the spring flora.

The fourth place are occupied xeromesophytes. This is an intermediate ecological type between mesophytes and mesoxerophytes in the flora of the Trans-Ili Alatau. They are in the flora of the study region 154 species or 9.9 %. These are plants adapted to conditions with moisture reserves in the soil slightly below average. Xeromesophytes live in conditions with periodically dry habitats. These are *Delphinium camptocarpum* Fish. Et C.A. Mey., *Hypecoum parviflorum* Kar. etKir., *H. Trilobum* Trautv. and other plants.

A smaller part of the flora of the region is composed of hygromesophytes (16 species or 1.03 %) and mesohygrophytes (14 species or 0.9%). Hygromesophytes are *Potentilla supine* L., *Veronica anagallis-aquatic*, *Cyperus glomeratus* L. and other plants.

Thus, the conducted ecological analysis of the flora of the region showed us all the variety of ecological types. The dominance of mesoxerophytes, xerophytes and mesophytes indicates the intracontinental position of the study region.

We have analyzed the life forms of flora of Almaty region (Talgar and Enbekshikazakh district). Under the life form means a set of adult individuals of this species in certain growing conditions, with a kind of common appearance (habitus), including above-ground and underground organs (underground shoots and root system). The analysis of life forms of species of Almaty region (Talgar and Enbekshikazakh district) is presented in the figure 2. Among the plants growing in this area there are perennial, biennial, annual, suffrutices, shrubs, drawf semishrubs, semifrutex, trees, saplings and lianas. The distribution of plant species of Almaty region (Talgar and Enbekshikazakh districts) by life forms showed that the predominant are perennial (1009 species or 65, 5%), annual (266 species or 17.3%) and shrubs (101 species or 6.5%). The smallest part of species belongs to biennial (80 species or 5.2%), trees (46 species or 3%), and suffrutices (17 species or 1.1%), a small number are semifrutex (9 species or 0.6%), drawf semishrubs (8 species or 0.5%), lianas (4 species or 0.2%) and 1 species – saplings, which is 0.01 % of the total number of studied plant species.

The analysis of life forms according to I. G. Serebryakov showed that the basis of the flora of Almaty region (Talgar and Enbekshikazakh districts) are herbaceous polycarpics of 1086 species, which is 70.5% of the total species, monocarpics are represented by 266 species or 17.3%, shrubs are represented by 101 species or 6.5%, trees –47 species, which is 3%, the share of suffrutices and drawf semishrubs accounts for 1.6 % (45 species), shrubs-9 species or 0.6%, the smallest number of plant species is represented by Saprophytic and parasitic herbaceous perennials-7 species or 0.4 %.

![Figure 2 – Life forms of plants of Almaty region](image-url)
According to the classification of K. Raunkier [31], the distribution of plant species of Almaty (Talgar and Enbekshikazakh districts) region by life forms showed that the vast majority are hemicriptophytes (921 species, which is 59.77% of the total), followed by therophytes (246 species or 15.96%), cryptophytes (188 species or 12.20%), phanerophytes (152 species or 9.86%), chamaephytes (34 species or 2.21%) (Table 4).

### Conclusion

Thus, on the basis of research and analysis of the results of the data the following conclusions.

6 ecological groups of plants, among which the leading place is occupied by mesoxerophytes (770 species), which is typical for this territory is identified.

The analysis of life forms of Almaty region (on the example of Talgar and Enbekshikazakh districts) showed all the variety of life forms with the predominance of herbaceous polycarpics and monocarpic herbs, which is a typical feature of the studied flora.

According to the system of K. Raunkier, the overwhelming number of species belongs to the groups of hemicriptophytes (921 saw 59.77%) and therophytes (246 species or 15.96%).

Due to the fact that flora is a defining part of ecosystems and is subject to changes over time, it serves as an indicator of changes, and its current state is the result of phenomena that occurred earlier under the influence of natural and anthropogenic factors. Therefore, it is necessary development of monitoring and forecasting of the situation in order to improve it.

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**Table 2 – Distribution of species of flora of Almaty region (Talgar and Enbekshikazakh district) by I. G. Serebryakov**

| Life-form                                  | Number of species | % of the total number of species |
|--------------------------------------------|-------------------|---------------------------------|
| I. Trees (sapling)                         | 47                | 3.0                             |
| II. Shrub                                  | 101               | 6.5                             |
| III. Semifrutex                             | 9                 | 0.6                             |
| IV. Suffrutices and dwarf semishrub         | 25                | 1.6                             |
| V. Herblike polycarpous                    | 1086              | 70.5                            |
| VI. Saprophytic and parasitic herbaceous perennial | 7           | 0.4                             |
| VII. Herbaceous polycarpics                | 266               | 17.3                            |
| **Total**                                  | **1541**          | **100**                         |

**Table 3 – Distribution of flora species of Almaty region by “biological types” of K. Raunkier**

| «Biological types» of Raunkier | Number of species | % of the total number of species |
|-------------------------------|-------------------|---------------------------------|
| Phanerophytes                 | 152               | 9.86                            |
| Chamaephytes                  | 34                | 2.21                            |
| Hemicryptophytes              | 921               | 59.77                           |
| Cryptophytes                  | 188               | 12.20                           |
| Therophytes                   | 246               | 15.96                           |
| **Total**                     | **1541**          | **100**                         |
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References

Lebedeva N.V., Krivolutsky D.A., Puzachenko Yu.G. Geography and monitoring of biodiversity. – M.: Scientific and methodological center. – 2002. – P. 432–435.

Bracken MES, Friberg SE, Gonzalez-Dorantes CA, Williams SL. Functional consequences of realistic biodiversity changes in a marine ecosystem // Ecol. Lett. – 2008. – P. 924 – 928.

Isbell F et al. High plant diversity is needed to maintain ecosystem services // Nature. – 2011. – 477p.

Reich PB, Tilman D, Isbell F., Mueller K, Hobbie SE, Flynn DFB, Eisenhauer N. Impacts of biodiversity loss escalate through time as redundancy fades. Science. – 2012. – No 336. – P. 589– 592.

Convention on Biological Diversity: approved. UN June 9, 1992.

Ivashchenko A.A. Nature reserves and national parks of Kazakhstan. – Almaty: Almaty Kitap. – 2006. – P. 284.

Ivashchenko A.A. Materials for the flora of the Ile-Alatau National Park and adjacent territories // Tr. Ile-Alatau National Park. – Astana. – 2015. – No 1. – P. 29-71.

Ivashchenko A.A. Rare plants and plant communities of the Ile-Alatau National Park: distribution and state // Scientific. journals Terra. – 2012. – No 2. – P. 53-65.

Baytulin I.O., Ogar N.P, Nesterova S.G., Inelova Z.A. Flora Ileisk Alatau. – Almaty: Kazakh university. – 2017. – P. 196.

Inelova Z., Nesterova S., Kokoreva I. Plant biodiversity in Aksay gorge of Trans-Ili Alatau. First European Symposium // Research, conservation and management of biodiversity in the European seashores (RCMBES), Primarsko. – 2017. – P. 49.

Nesterova S., Kokoreva I., Inelova Z., Yerubayeva G. «Effect of recreational activities on the main plant communities of the Trans-Ili Alatau» // 17-th International multidisciplinary scientific geoconference (SGEM), Ecology and Environmental Protection, Albena, Bulgaria. – 2017. – No 52. – P. 289-296.

Gudziniskaya L.M., Gnedzhieva N.G. List of officinalplants of Kazakhstan. – Almaty: Kazakh university. – 2012. – P. 139.

Cunningham S.D., Ow D.W. Promises and Prospects of Phytoremediation // Plant Physiol. – 1996. – Vol. 110. – P. 715-719.

BarkleyT. Floristic studies in contemporary botany. Madroño. – 2000. – No 47. – P. 253-258.

Hudaberdi M., Nurbay A. The Features of the Vegetation and the Eco-Geography of the Taklamakan Desert in Xinjiang // China, Landschaftsentwicklung und Umweltforschung. – 2000. – Vol. 121 – P. 52-61.

Handa IT et al. Consequences of biodiversity loss for litter decomposition across biomes // Nature. – 2014. – Vol. 509. – P. 218 – 221.

Hillebrand H, Matthiessen B. Biodiversity in a complex world: consolidation and progress in functional biodiversity research // Ecol. Lett. – 2009. – Vol. 12. – P. 1405–1419.

Yasuvara M., Doi H, Wei C-L, Danvaro R, Myhre SE. Biodiversity– ecosystem functioning relationships in long-term time series and palaeoecological records: deep sea as a test bed // Phil. Trans. R. Soc.– 2016. – P. 371p.

Pavlov N.V. Flora of Kazakhstan. – Alma-Ata: Science, 1956-1967. – Vol. 1-9.

Goloskokov V.P. Illustrated determinant of plants of Kazakhstan. – Alma-Ata: Science, 1969-1972. – Vol. 1-2.

Baitenov M.S. Flora of Kazakhstan. – Alma-Ata: Science, 2001. – Vol. 1-2.

Tahaajan A.L. Magnoliophytes system. – L: Science, 1987. – P. 439.

Cherepanov S.K. Vascular plants of the USSR. – L:Science, 1981. – P. 509.

Baitenov MS, Kudabayeva G.M., Myrzakulov P.M., Toguzakov B.ZH. Flora of the Alma-Ata Reserve. – Alma-Ata: Gylym, 1991. – P. 154.

Chunbo H., ZhixiangZh.,Changhui P. How is biodiversity changing in response to ecological restoration in terrestrial ecosystems // Science of the Total Environment. – 2018. – P. 89.

Lotova L.I. Botany. Morphology and anatomy of higher plants. – M.: Kom Kniga, 2007. – P. 295-306.

Serebryakov I.G. Ecological morphology of plants. – M.: High School, 1962. – P. 377.

Archibold O. Ecology of World Vegetation. – London: Chapman and Hall. – 1995. – P. 510.

Michael H. «Xeromorphic» // The Cambridge Illustrated Glossary of Botanical Terms, Clive King, Cambridge University Press, 2001. – P. 156.

Serebryakov I.G. Ecological groups and life forms of plants. – Oxford: Clarendon Press. – 1934. – P. 632.

References

Archibold O. (1995) Ecology of World Vegetation. London: Chapman and Hall, P.510.

Baitenov MS, Kudabayeva G.M., Myrzakulov P.M., Toguzakov B.ZH. (1991) Flora Alma-Atinskogo zapovednika [Flora of the Alma-Ata Reserve]. Alma-Ata: Gylym, 154 p.

Baitenov M.S. (2001) Flora Kazakhstan [Flora of Kazakhstan]. Alma-Ata: Science, vol.1, pp.245-251.

Barkley T. (2000) Floristic studies in contemporary botany. Madroño, vol.47, pp.253-258.

Baytulin I.O., Ogar N.P, Nesterova S.G., Inelova Z.A. (2017) Flora Ileyskogo Alatau [Flora of the Trans Ili Alatau]. Almaty: Kazakh university, 196 p.

Bracken MES, Friberg SE, Gonzalez-Dorantes CA, Williams SL. (2008) Functional consequences of realistic biodiversity changes in a marine ecosystem. Ecol. Lett., vol.47, pp.924 – 928.

Cherepanov S.K. (1981) Sosudistyie rasteniya SSSR. [Vascular plants of the USSR]. – L:Science, 509 p.
Chunbo H., Zhixiang Zh., Changhui P. (2018) How is biodiversity changing in response to ecological restoration in terrestrial ecosystems? Science of the Total Environment, 9p.

Cunningham S.D., Ow D.W. (1996) Promises and Prospects of Phytoremediation. Plant Physiol., vol. 110, pp. 715-719.

Inelova Z., Nesterova S., Kokoreva I. (2017) Plant biodiversity in Aksay gorge of Trans-Ili Alatau. First European Symposium .Research, conservation and management of biodiversity in the European seashores (RCMBES), Primarsko, vol 52, P.49.

Goloskokov V.P. (1969-1972) Illyustrirovanniy opredelitel rasteniy Kazahstana [Illustrated determinant of plants of Kazakhstan]. Alma-Ata: Science, no 1-2.

Grudzinskaya L.M, Gemedzhieva NG (2012) Spisok lekarstvennyih rasteniy Kazahstana [List of medicinal plants in Kazakhstan]. Alma, P.139.

Hudaiberdi M., Nurbay A. (2000) The Features of the Vegetation and the Eco-Geography of the Taklamakan Desert in Xinjiang, China, Landschaftsentwicklung und Umweltforschung. Ecol. Lett vol. 121, pp.52-61.

Isbell F et al. (2011) High plant diversity is needed to maintain ecosystem services. Nature, 477p.

Ivashchenko A.A. (2006) Zapovedniki i nationalnyie parki Kazahstana [Nature reserves and national parks of Kazakhstan]. Almaty: Almaty Kitap, 284 p.

Ivashchenko A.A. (2015) Materialyi k flore Ile-Alatauskogo natsionalnogo parka i prilegayuschih territoriy. [Materials on the flora of the Ile-Alatau National Park and adjacent territories]. Astana, no 1, pp. 29-71.

Ivashchenko A.A. (2012) Redkie rasteniya i rastitelnyie soobshchestva Ile-Alatauskogo natsionalnogo parka: rasprostranenie i sostoyanie [Rare plants and plant communities of the Ile-Alatau National Park: distribution and state]. Scientific. journals Terra, vol 2, pp 53-65.

Konventsiya o biologicheskom raznoobrazii [Convention on Biological Diversity] UN 9 June 1992.

Lebedeva N.V., Krivolutsky D.A., Puzachenko Yu.G. (2002) Geografiya i monitoring bioraznoobraziya [Geography and monitoring of biodiversity]. M:Scientific and scientific-methodical center, 432 p

Lotova L.I (2007) Botanika. Morfologiya i anatomiya vyisshih rasteniy [Botany. Morphology and anatomy of higher plants]. Moscow: Com Book, pp. 295-306.

Michael H. (2001) Xeromorphic. The Cambridge Illustrated Glossary of Botanical Terms, Clive King, Cambridge University Press, 156 p.

Nesterova S., Kokoreva I., Inelova Z., Yerubayeva G. (2017): «Effect of recreational activities on the main plant communities of the Trans-Ili Alatau» 17-th International multidisciplinary scientific geoconference (SGEM), Ecology and Environmental Protection, Albena, Bulgaria, vol. 52, pp. 289-296.

Pavlov N.V. (1956-1967) Flora Kazahstana [Flora of Kazakhstan] Alma – Ata: Science, no 1-9.

Raunkier C. (1934) The life forms of plants and statistical plant geography. Oxford, Clarendon Press, P. 632.

Reich PB, Tilman D, Isbell F, Mueller K, Hobbie S.E, Flynn DFB, Eisenhauer N. (2012) Impacts of biodiversity loss escalate through time as redundancy fades. Science, vol.336, pp.589– 592.

Serebryakov IG (1962) Ekologicheskaya morfologiya rasteni [Ecological morphology of plants]. Moscow: High School, P.377.

Tahtajyan A.L. (1987) Sistema magnoliolitov [Magnoliophyte system]. L.: Science, 439 p.

Serebryakov IG (1978) Ekologicheskie gruppy i zhiznennyie formyi rasteni [Ecological groups and life forms of plants]. Moscow, pp. 431-461.

Yasuhara M, Doi H, Wei C-L, Danovaro R, Myhre SE. (2016) Biodiversity–ecosystem functioning relationships in long-term time series and paleoecological records: deep sea as a test bed. Phil. Trans. R. Soc., 371p.