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# Phytocenotic, bioecological and invasive activity of the invasive species *Xanthium strumarium* L. in some districts of Azerbaijan

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***Abstract:*** The study of phytocenotic and bioecological features of phytoinvasions allows to better understand the nature of these plants and develop quarantine measures to limit their activity. The article provides phytocenotic and bioecological characteristics of *Xanthium strumarium* L. in Quba and Khachmaz regions. It has been established that *X. strumarium* occurs along roadsides, railways, on wastelands, and also forms communities on forest outskirts, along open water channels and along the coastlines of the Caspian. The communities with the dominance of *X. strumarium* described in natural habitats are characterized by us as groupings, associations, and formations. The species is invasive. The study of the underground part of the plant showed that its root system can change depending on the soil moisture regime. Plant with taproot of 10-20 cm grows on dry and periodically humidified due to moisture of atmospheric precipitation areas (wastelands, roadside strips, household plots, light forest coenoses). Reproduction is exclusively by seed. In areas with high or "swampy" type of moisture and salinity (riverine strip, coastal sands, ditches, water channels, etc.), the root system is located in the upper soil horizon (5-10 cm), numerous root shoots of 30-40 cm long extend from the main root. In this case, reproduction can occur both interchangeably and vegetatively. The invasive activity of the species is facilitated by the features of biology: the efficiency of seed distribution, the ability to vegetative reproduction, resistance to all forms of anthropogenic impact, and wide ecological amplitude. In spite of this, the invasive activity of *X. strumarium* is limited by vertical zoning and by more highly competitive invasive species – *Amaranthus retroflexus*, *Xanthium spinozum.*

***Key words:*** *biological features, coenopopulation, distribution, Greater Caucasus, invasive species, Xanthium strumarium*

## INTRODUCTION

Out of 10 species distributed on the whole Earth, three species are found in the Caucasus and Azerbaijan - *Xanthium strumarium* L., *X. spnosum* L. and *X. ocidentale* L. According to "Flora of Azerbaijan" [1961] and "Conspect of Flora of Azerbaijan" [Askerov, 2011] both plants are separate species. All representatives of the genus are known as American species, but they are generally distributed in America, Europe, West, Central Asia, the Mediterranean countries. However, it should be noted that D. Love and P. Dansereau [1959] conducted a revisionof the genus *Xanthium* in 1959 and established that *X. ocidentale* is synonymous with *X. strumarium*. The same identification is supported by "The plant List" and World Flora Online. It is believed that the natural area of *X. strumarium* was Central and South America, from where it first spread throughout America and then to the countries of the Old Continent. The species produce 500 to 2.300 fruits. Its fruits can be spread over long distances by sticking to animal or human. The fruits are transported through rivers and channels due to their high swimming ability. *X. strumarium* causes contact dermatitis in respiratory system in some people [Weaver, Lechowicz, 1983].

The research conducted in the territories of Quba and Khachmaz districts in the second half of the XX century, showed that *X. strumarium* was found as a component of vegetation [Agajanov, 1971; Kakhramanova, 2001; Shakhsuvarov et al., 1993]. However, at present our observations show that the rough cocklebur dominates in the natural coenoses, and even creates various plant units. Considering the high invasive activity of *X. strumarium*, the purpose of the study was to identify phytocenotic, biological features and invasive activity of the species in some districts of Azerbaijan along the Greater Caucasus.

## MATERIAL AND METHODS

The object of study is *X. strumarium* (cocklebur)

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and vegetation of Quba and Khachmaz districts of Azerbaijan that situates along the Greater Caucasus. The objectives of the study include the determination of the dependence of occurence on sea level, distribution areas and ecological conditions, density, projective cover, number of surface distribution, invasive activity, associations of plant compounds, phytocenotic role in the groups of plants where they grow.

Geobotanical descriptions were carried out according to B.M. Mirkin and L.G. Naumova [2001]. Model sample plots (10 m x 10 m) were set up in the selected areas in order to study the phytocenotic characteristics of the species. On the selected model areas, 5-10 small plots with the size of 1m$^2$ were laid (Fig. 1).

**Figure 1.** Growing of *Xanthium strumarium* on sandy substrates.

Here, the general projective cover and abundance [Braun-Blanket, 1964], density (1 m$^2$, 10 m$^2$), growing features (surface distribution), activity and effect on nearby plants of rough cocklebur were recorded. The frequency of occurrence of the species was defined according to P.D. Shennikov [1964] and activity to N.N. Panasenko [2019]. Horizontal projections of individuals on the plots were examined, recorded, and % ratio of cocklebur to plants growing with it were determined.

The biometric parameters was studied according to A.S. Kashin et al. [2015] and V.N. Golubev [1965]. Therefore, five model coenopopulations (CP1, CP2, CP3, CP4, CP5) of the species differing in the degree of anthropogenic disturbances and vegetation type were selected in the territories of Quba and Khachmaz districts. Environmental living conditions were also taken into account. Thus, CP1 was located along ditch, in high-moisture soils, semi-natural coenoses (Quba), CP2 in ruderal-segetal coenoses on soils moistened by rain around highways (Quba), CP3 on the border of woodlands with mountain-forest soils (Quba), CP4 along moderately humid garden plots in the settlements (Khachmaz), and CP5 in wet saline, dry sandy soils of the coastal strip (Khachmaz). Measurements were made on the basis of five individuals. Main five generative and vegetative parameters were selected. Thus, the height of the plant, number, length and width of leaves and fruits were measured. Estimation of the surface distribution property was calculated by the Morisita's overlap index [Morisita, 1959]. According to the Morisita's overlap index, the distribution is appeared to be random when equal to one (I = 1); a group distribution when more than one (I > 1); and stable distribution when less than 1(I < 1). Group distribution of the species characterizes its positive condition, stable distribution its relatively positive, and random distribution its negative condition in the area. Statistical analysis was performed in MS Excel 2003 supported by statistical software package Statistica 5.0 using standard indicators.

## RESULTS AND DISCUSSION

Electronic maps of distribution of the species *X. strumarium* in Quba and Khachmaz districts were developed (Fig. 2) and sea level distribution patterns were determined. The dependence of the species on vertical zoning was identified by the correlation coefficient (r) of occurrence on altitude above sea level (a.s.l.), which is 80% (Fig. 3). It was determined that in the range of -10 to 600-700 m a.s.l. the optimum conditions of the cocklebur is - 10 to 250 m a.s.l. and particularly at these heights the species growth will continue.

Plant communities with the participation of *X. strumarium* were divided into 3 types: a) natural i, b) synanthropic and c) agrocoenoses. The proportion of *X. strumarium* of plant groups in natural coenoses was analysed and higher percentage was recorded in the Khachmaz district (52%). In Quba district, on the

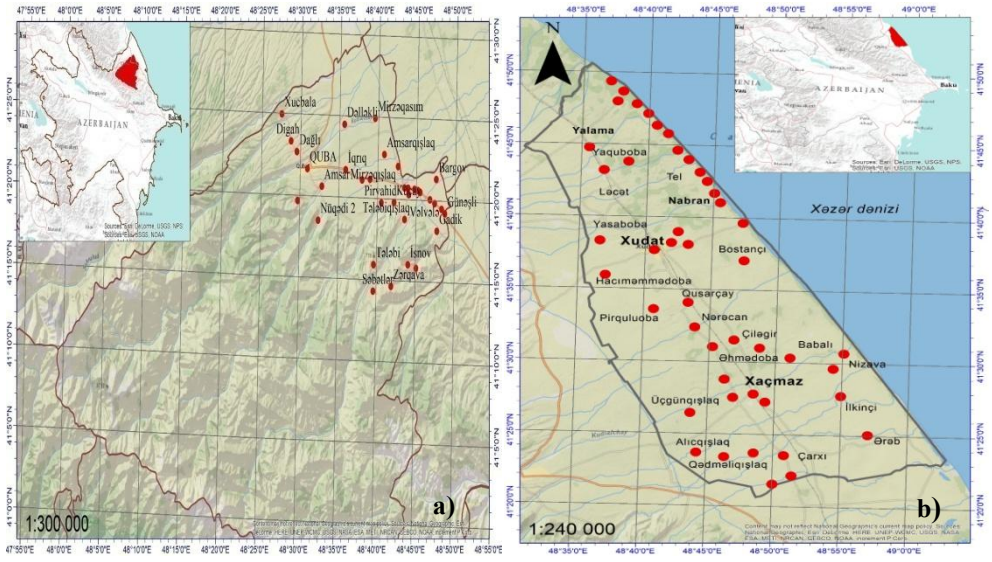



**Figure 2.** Map of distribtuion of *X. strumarium* in Khachmaz (a) and Quba (b) districts.

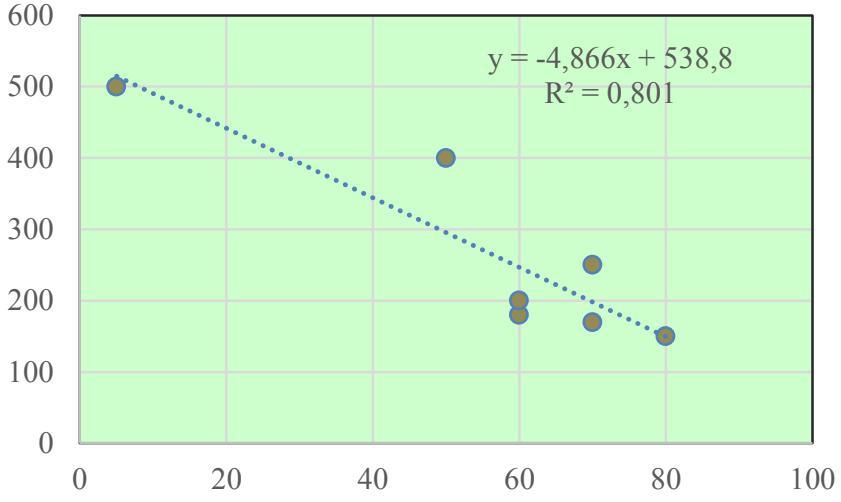
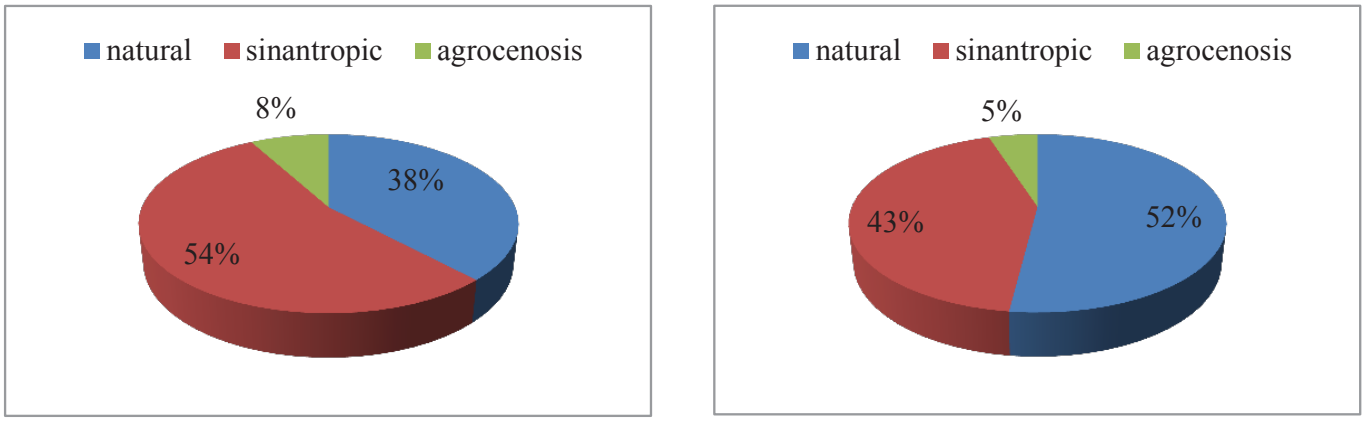



**Figure 3.** Correlation dependence of occurrence of *X. strumarium* (axis X) from the height above sea level (axis Y).

contrary, it is mostly inhabited (54%) in synanthropic coenoses (Fig. 4).

Plant communities were recorded in the study area. It has been established that, *X. strumarium* is the dominant of herb ruderal (*Xanthium strumarium* + *Xanthium spinozum* + *Amaranthus retroflexus*, *Xanthium strumarium* + *Chenopodium album* + *Erigeron bonariensis*, *Rubus anatolicus* + *Xanthium strumarium*), wetland (*Phragmites communis* - *Xanthium strumarium* + *Mentha aquatica*) groups, as well as a component of light forest coenoses (*Pyrus salicifolia* + *Quercus iberica* - *Xanthium strumarium*) in the Quba district. On the coast of the Khachmaz district, the plant occupies vast territories, as a plant formation and various variants of polydominant associations: *Xanthiums strumarium* + *Suaeda confusa* - *Suaeda altissima*, *Xanthium strumarium* + *Convolvulus persicus*, *Xanthium strumarium* + *Salsola tragos*, *Artemisia arenaria* - *Xanthium strumarium* + *Melilotus marittimus*.

The main habitats of *X. strumarium* in the Quba district are the edges of small water channels, which is called "arch" by the local population. Here it is a component of communities with the participation of species of the genera *Rumex* L., *Rubus* L., *Calamagrostis giganthea* Beauv., *Mentha aquatica* L. and etc. *X. strumarium* is




a) Quba district b) Khachmaz district

**Figure 4.** The ratio of the occurrence of *X. strumarium* in natural, synanthropic communities and agrocoenosis (%).

also found in the riverine, where it forms monodominant groupings with an area of 5-10 $m^2$. Other habitats are abandoned or littered areas of synanthropic coenoses. It forms poly- and mono-dominant groupings with an area of 2-5 $m^2$ together with local and alien weed species. In recent years, small groups of *X. strumarium* have been observed on the edges of forest communities (*Quercus iberica* + *Pyrus salicifolia* + *Crataegus kyrstotila*). The geobotanical description of the established profiles showed that *X. strumarium* is capable of penetrating into the depths of forest phytocoenoses only at a distance of 2-3 mm.

The ecological pattern of forest coenoses (shade, air and soil moisture) is not conducive to the normal growth of rough cocklebur, and it is likely that species expansion will not occur in forest coenoses. However, wood cutting, expected effects of fungal diseases and mass deforestation can lead to destruction of forest structures and desertification. In this case, there will be ecological changes in the forest ecotopes, which will result in the entry of shrubs and grasses, including cocklebur. Similar to Quba district, the main habitats of *X. strumarium* are "arch", abandoned areas, as well as the margins of coastal forest communities (*Quercus iberica* + *Carpinus betulus*) in Khachmaz district. It should be noted that the location of these forests near highways and villages creates conditions for the penetration of another aggressive invasive species of *Ailanthus altissima*. The penetration of *X. strumarium* into the coastal vegetation is also observed. In the coastal strip extending up to 30 km along the Caspian Sea, *X. strumarium* forms various plant communities with aborogen (Suaedetum, Argusetum) and other naturalized alien (*Conyza canadensis*) species. The description of the ecological profiles established in these areas shows that rough cocklebur is resistant to high chloride-type salinization in wet saline at a distance of 1 m from the seawater, and the growth of the plant is positive here. The studied species is frequently occured in synanthropized habitats. Therefore, it was decided to find out to what extent *X. strumarium* is a competitive species. It was revealed that rough cocklebur has been adversely affected by other widespread invasive species such as *Amaranthus retroflexus* L., *Xanthium spinozum* L. The calculation confirmed the high negative correlation between *X. spinosum* and *A. retroflexus* $R^2$ = -0.80 (80%); *X. spinozum* and *X. strumarium* $R^2$= -0.82 (82%). This indicates high viability of these species than that of rough cocklebur, and as they multiply, the presence of the rough cocklebur is likely to decrease. Another common invasive species *Conysa canadensis*, on the contrary, does not compete $R^2$ = 0.193 (19%). The relation of *X. strumarium* with local plants is $R^2$ = 0.913 (91%). This shows the strong influence of *X. strumarium* plant species on local plants.

*Morphometric structure and bioecological features of Xanthium strumarium species.* The model selected for environmental condition showed that the dimensions of the morphometric parameters were different in various CPs. Thus, CP1, CP2 and CP3 shown higher values. CP4 values were slightly lower than CP1, CP2 and CP3 (Table). CP5 shown lower values due to the spread of CP5 in highly saline conditions. Observations have also shown that individuals in different coenopopulations differ in the weight of the surface mass. It was found that the CP1, 2, 3, 4 (250-300 $g/m^2$) have the highest phytomass of the aboveground part and CP5 (39.9 $g/m^2$) the lowest. Analysis of phenological spectra showed that the vegetation and fruiting periods for different years show sensitivity to the dynamics of

**Table.** Morphometric parameters and density of growth of *Xanthium strumarium* depending on the habitat.

| Morphometric values | Coenopopulations | | | | |
|---|---|---|---|---|---|
| | SP1 | SP2 | SP3 | SP4 | SP5 |
| Height (sm) | 30.7±6.16 | 43.0±9.77 | 41.7±23.4 | 35.66±11.5 | 12.33±7.4 |
| Number of leaves (piece) | 34.5±6.67 | 68. 3±9.18 | 69.0±9.61 | 45±13.13.2 | 6.3±2.0 |
| Length of leaf (cm) | 7.81±1.18 | 5.18±0.94 | 6.07±1.05 | 4.47±1.28 | 2.25±0.38 |
| Width of leaf (cm) | 6.5±1.2 | 5.04±0.9 | 5.92±1.07 | 4.016±1.19 | 2.02±0.17 |
| Length of fruit (cm) | 1.31±0.34 | 1.19±0.23 | 1.31±0.26 | 1.36±0.31 | 0.86±0.18 |
| Width of fruit (cm) | 0.98±0.35 | 0.88±0.32 | 1.19±1.21 | 0.97±0.27 | 0.5±0.16 |
| Number of fruits (piece) | 368.2±50.0 | 448.6±50.09 | 204.8±9.68 | 219.7±52.02 | 25.2±7.3 |
| Width of main generative body (mm) | 5.5±1.08 | 9.1±1.72 | 7.6±1.14 | 9.7±2.0 | 5.5±2.4 |
| 1 $m^2$ density | 3.0±1.24 | 2.7±0.82 | 1.0±0.69 | 3.2±0.91 | 4.0±1.63 |

air temperature. Growth weakens slightly at low air temperatures in the early stages of plant growth. This shows that global warming will not have a negative impact on the plant. The period of fruit formation and ripening is 30-40 days, and the general growth is 80-90 days. The morphological plasticity of the species is of great adaptive importance, changes in the form of the stem system contribute to the expansion of the range of *X. strumarium* species. It can be said that the plant has a high ecological plasticity, and in this view will further develop and expand the habitat.

The invasive status of the species has been determined in the districts. Thus, *X. strumarium* behaves like an epicophyte in the Quba district, and its growth is not expected as much. In the Khachmaz district, it is an agrophyte, i.e. its development and spread in this district are expected in natural coenoses. The species mainly migrates through ditches which are widespread in both districts and wind. The distribution character of individuals of *X. strumarium* shows that its individuals is SP1<1 (positive development), SP2<1 (positive development), SP3>1 (relatively positive development), SP4<1 (positive development), SP5 <1 (positive development). Thus, *X. strumarium* has the lowest phytocenotic value in forest areas (SP3).

According to our observations, the shape and morphological parameters of the species' root system also depend on the growing conditions. The root system is more short-rooted monocentric in CP 2, 3, 4 generative individuals. In CP1 (the outskirts of the "arch") and CP5 (seaside) located in places of high humidity near the root system, one of the lateral roots lengthens and moves to the side, being located in the surface layer of the soil (Fig. 5). Generative individuals of SP1 are able to reproduce vegetatively.At the same time, in CP1, reproduction sometimes occurs vegetatively, from a laterally elongated root, while in CP5 this does not happen. It has been found that there are differences in width and length in the root systems of CP1 and CP5, which grow in soils with high moisture but differ in structure and salinity degree. In wet saline and sandy substrates, the root system of CP5 individuals is thin (the width of main shoot is up to 3 mm), long (length of main shoot is up to 5 cm), and more superficial (0-5 cm). Under these conditions, reproduction can occur interchangeably, and sometimes vegetatively. In CP1 the root system growing on moist, non-saline substrates, is more developed. The main root is 5-7 mm thick and up to 20-30 cm long. The main shoot is 5-7 mm thick, 20-30 cm long and 5-10 cm into the ground. Reproduction of individuals in these CPs is exclusively by seed.

The morphological plasticity of the species (CP1, CP5) is of great adaptive importance due to changes in the form of the stem system contribute to the expansion of the range of *X. strumarium* species. It can be said that the plant has a high ecological plasticity, and in this view will further develop and expand the habitat. The invasive status of the species has been determined in the districts.

It has also been established that the largest number of fruits is found in CPs growing in the vicinity of settlements, on wastelands and in light forests (CP1, 3, 4) and is 450-670 pcs./individual, and the smallest number in CPs growing on the coast and along the canals (2, 5) 50-120 pcs./individual. However, low fertility in these ecotopes is compensated by vegetative reproduction. The share of plant participation is the lowest in light forests (5%), because penetration into these coenoses is just beginning and higher in abondened areas, along ditches, channels (50-60%) and in the coastal zone (80-90%).


**Figure 5.** Structure of root system of *X. strumarium* species in moist substrates.

## CONCLUSION

As a result of the studies, main reasons for the intensification of the expansion of *X. strumarium* were revealed. This is the presence of a large number of disturbed natural ecotopes, the formation of large areas of abandoned and unkempt areas, unsuitable for plants of the local flora and ideal for reproduction of *X. strumarium*. It has been established that *X. strumarium* occurs along roadsides, railway tracks, on wastelands, and also forms communities on forest outskirts, along open water channels and along the coastlines of the Caspian. The communities with the dominance of *X. strumarium* described in natural habitats are characterized by us as groupings, associations, and formations. The study of the underground part of the plant showed that its root system can change depending on the soil moisture regime. *X. strumarium* manifests itself as an active invasive species in the studied areas of the Greater Caucasus. Invasive activity of the species is facilitated by the peculiarities of biology: the efficiency of seed distribution, the ability to vegetative reproduction, resistance to all forms of anthropogenic impact and a wide ecological amplitude. Despite this, the invasive activity of *X. strumarium* is limited by vertical zoning and more highly competitive invasive species are *A. retroflexus* and *X. spinozum.*

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## Azərbaycanın bəzi rayonlarında yayılmış *Xanthium strumarium* L. növünün fitosenotik, bioekoloji xüsusiyyətləri və invaziv aktivliyi

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Fitoinvaziyaların fitosenotik və bioekoloji xüsusiyyətlərinin öyrənilməsi bu bitkilərin təbiətini daha yaxşı dərk etməyə və onların fəaliyyətini məhdudlaşdıran karantin tədbirlərinin hazırlanmasına imkan yaradır. Məqalədə Quba və Xaçmaz rayonlarında *Xanthium strumarium* L. növünün fitosenotik və bioekoloji xüsusiyyətləri verilir. *X. strumarium* yol kənarlarında, dəmir yolları, açıq su kanalları (arxlar) boyunca, eyni zamanda meşə kənarında və dominantlıq kimi iştirak etdiyi Xəzərin sahil zolaqları boyunca müxtəlif bitki birlikləri əmələ gətirir. *X. strumarium* aktiv invaziv növdür. Bitkinin yeraltı hissəsinin tədqiqi nəticəsində məlum olmuşdur ki, bitkinin kök sistemi torpağın rütubətlilik dərəcəsindən asılı olaraq dəyişə bilər. Quru və vaxtaşırı rütubətli atmosfer yağıntıları səbəbindən nəmlənən ərazilərdə (tullantılar, yol kənarında, təsərrüfat sahələri, yüngül meşə senozları) bitkinin kök sistemi 10-20 sm uzunluğunda çubuq tiplidir. Bitkinin çoxalması isə yalnız toxum vasitəsilə mümkündür. Yüksək və ya "bataqlıq" tipli nəmlik və duzluluq olan ərazilərdə (çay zolağı, sahil qumluqları, xəndəklər, su kanalları və s.) bitkinin kök sistemi yuxarı torpaq qatında (5-10 sm) yerləşir, əsas kökdən 30-40 sm uzunluqda çoxsaylı yan köklər uzanır. Bu zaman bitkinin çoxalması həm toxum, həm də vegetativ olaraq mümkündür.

***Açar sözlər:*** *bioloji xüsusiyyətlər, senopopulyasiya, yayılma, Böyük Qafqaz, invaziv növ, Xanthium strumarium*

## Фитоценотическая, биоэкологическая характеристика и инвазионная активность заносного вида *Xanthium strumarium* L. в некоторых районах Азербайджана

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Изучение фитоценотических и биоэкологических особенностей фитоинвазий дает возможность глубже понять природу этих растений и исходя из этого разработать карантинные меры по ограничению их активности. В статье приводится фитоценотическая и биоэкологическая характеристика *Xanthium strumarium* L. в Губинском и Хачмазском районах. Установлено, что *X. strumarium* встречается по обочинам дорог, у железнодорожных путей, на пустырях, а также формирует сообщества на лесных окраинах, вдоль водопроводных открытых каналов и береговых линий Каспия. Описанные в естественных местообитаниях сообщества с доминированием *X. strumarium* характеризуются нами как группировки, ассоциации и формации. *X. strumarium* – актив-

ный инвазивный вид. Изучение подземной части растения показало, что его корневая система может изменяться в зависимости от режима увлажнения почвы. На сухих и периодически увлажняемых за счет влаги атмосферных осадков участках (пустыри, придорожная полоса, приусадебные участки, редколесные ценозы) корневая система - стержневого типа, длинной 10-20 см. Размножение исключительно семенное. На участках с высоким или «болотистым» типом увлажнения и засоленностью (приречная полоса, прибрежные пески, канавы, водные каналы и т.д.) корневая система размещается в верхнем горизонте почвы (5-10 см), от главного корня отходят многочисленные длинные корневые отпрыски длинной 30-40 см. В этом случае размножение может происходить как сменным путем, так и вегетативно.

***Ключевые слова:*** *биологические особенности, ценопопуляция, распространение, Большой Кавказ, инвазивный вид, Xanthium strumarium*