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RESEARCH ARTICLE

Populations of *Hippophae rhamnoides* as an indicator of tugai forest degradation in the Zarafshan River valley

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Abstract

Tugai forests of the Zarafshan River valley are highly vulnerable ecosystems experiencing increasing anthropogenic pressure and hydrological alterations. Assessing their degradation requires reliable biological indicators. This study aims to evaluate coenopopulations of *Hippophae rhamnoides* L. as an indicator of tugai ecosystem transformation. Field investigations were conducted in five coenopopulations within the Zarafshan National Nature Park. The study included analysis of ontogenetic structure, population density, morphological variability, and vitality indices based on standardized geobotanical and population-biological methods. All studied coenopopulations were classified as normal but incomplete. Under anthropogenic disturbance (grazing, fires, and fruit harvesting), left-skewed ontogenetic spectra dominated, characterized by a prevalence of young generative individuals and reduced regeneration. A fire-affected coenopopulation exhibited a right-skewed spectrum with accumulation of middle-aged generative and senile individuals and absence of pre-generative stages, indicating severe degradation. In less disturbed habitats. A centered ontogenetic spectrum was observed, reflecting relatively stable population conditions. Population maintenance was primarily supported by vegetative reproduction. while seed regeneration remained low. Morphological traits showed moderate variability (CV = 2.3–37.2%), indicating limited adaptive plasticity. Vitality analysis revealed both thriving

and depressed coenopopulations depending on habitat conditions. The results demonstrate high sensitivity of *Hippophae rhamnoides* to environmental changes and confirm its suitability as an indicator of tugai forest degradation. Reduced vitality and weak regeneration highlight the need for urgent conservation and restoration measures in the Zarafshan River valley.

Keywords
Riparian communities, demographic structure, regeneration patterns, vitality classes, human pressure, habitat disturbance, ecosystem transformation, conservation assessment

Introduction

Tugai ecosystems of Central Asia are unique floodplain complexes of the arid zone and are regarded as important centers of biodiversity and key structural elements of river valleys. In the contemporary literature, tugai forests are characterized as desert floodplain forests that play a significant role in maintaining ecological stability, conserving habitats, providing forage and other ecosystem services and restraining desertification processes. Their existence is closely associated with the condition of floodplains and the integrity of river ecosystems; therefore, any changes in the hydrological regime are rapidly reflected in the structure of vegetation cover (Schulz and Kleinschmit 2023).

Within the Zarafshan River valley, the remaining areas of tugai vegetation are of particular conservation value. The Zarafshan National Natural Park established on the basis of a former reserve, represents one of the few protected sites of floodplain vegetation in the region. According to published data. the flora of the park includes 416 species of vascular plants, while the protected territory itself extends as a narrow strip along the right bank of the Zarafshan River (Kabulova et al. 2025). At the same time, this area is located within a landscape subjected to pronounced anthropogenic transformation, where natural tugai habitats have been preserved only fragmentarily. For resource plant species occurring within the national park, signs of changes in population parameters under the influence of anthropogenic factors have already been reported (Ishmuratova et al. 2024).

One of the characteristic species of floodplain shrub communities is *Hippophae rhamnoides* L. This species is regarded as an ecologically plastic and economically valuable shrub with a broad habitat amplitude and is especially important for the reclamation and stabilization of disturbed lands. The literature emphasizes that sea buckthorn belongs to the group of actinorhizal plants and forms symbiotic nitrogen-fixing associations with bacteria of the genus *Frankia*, which increases its resistance to poor and disturbed substrates and contributes to the improvement of habitat conditions. Additional interest in this species is related to the fact that *H. rhamnoides* is dioecious and the responses of male and female individuals to stress factors may differ, which gives particular importance to the analysis of sex structure

and population organization in natural coenopopulations (Li et al. 2004; Diagne et al. 2013; Enescu 2014; Chen et al. 2023; Ma et al. 2023; Liu et al. 2024).

Despite the existence of individual publications devoted to the flora of the Zarafshan National Natural Park and to the current state of some resource plant species (Erdonov et al. 2023; Abduraimov et al. 2025; Saribaeva et al. 2025), the coenopopulation organization of *H. rhamnoides* in the tugai communities of the Zarafshan River remains insufficiently studied. Of particular relevance are questions concerning the role of the species in different types of plant communities, the features of the demographic and ontogenetic structure of its populations, the degree of morphological variability of individuals, and their vitality status under conditions of unequal anthropogenic pressure. A comprehensive study of these parameters is necessary for assessing the current population status of the species and for determining priorities for its conservation within floodplain ecosystems (Ishmuratova et al. 2024; Kabulova et al. 2025).

The aim of the present study was to assess the current state of the coenopopulations of *H. rhamnoides* in the tugai ecosystems of the Zarafshan River within the territory of the Zarafshan National Natural Park. To achieve this aim, plant communities involving the species were investigated, the demographic and ontogenetic structure of its coenopopulations was analyzed, the morphological variability of individuals was characterized, and the vitality status of populations under different degrees of anthropogenic impact was evaluated.

Materials and methods

Hippophae rhamnoides L. is a branched, thorny shrub of the family Elaeagnaceae. It is a small tree or shrub 2–5 m in height with numerous shortened thorn-bearing shoots. The species is distributed in river valleys, on rocks and cliffs, and also occurs in gardens (Flora Uzbekistana 1959). Sea buckthorn is known as a valuable useful plant and, in many countries of the world, is attracting increasing attention as a medicinal species because its fruits, leaves, and bark are rich in vitamins and other biologically active compounds (Demidova 2007). In addition, it is considered an important source of food ingredients (Mörsel et al. 2015). Owing to its pronounced nitrogen-fixing capacity, this species is widely used for land amelioration, reclamation of disturbed territories and stabilization of sandy sites and slopes (Ruan and Li 2002).

Geobotanical descriptions were carried out according to the generally accepted method on sample plots of 100 m² (Korchagin, 1964). The Latin names of plant species were given in accordance with the international taxonomic database Plants of the World Online (POWO). The ontogenetic structure of coenopopulations was studied using generally accepted approaches of plant population biology (Zhivotovsky 2001). Herbarium specimens collected during field investigations were used to determine the ontogenetic state of individuals. The ontogenetic spectrum of a

coenopopulation was defined as the proportion of individuals belonging to different ontogenetic states, expressed as a percentage of the total number of recorded plants. Population density was determined as the number of individuals per unit area (Coenopopulations of Plants 1977).

The vitality of individuals was assessed by averaging the normalized values of all analyzed morphological traits relative to the mean values for the entire sample. According to the results obtained, individuals were assigned to three vitality classes: a – high vitality; b – intermediate vitality, and c – low vitality. The vitality type of coenopopulations was determined using the Q criterion:

Q= 1/2 (a + b) > c – prospering coenopopulations;

Q = 1/2 (a + b) = c – equilibrium coenopopulations;

Q = 1/2 (a + b) < c – depressive coenopopulations.

For the quantitative assessment of the degree of prosperity or depression of a coenopopulation. the IQ index was used:

$$IQ = (a + b) / 2c$$

At IQ values > 1. the state of the coenopopulation was assessed as prospering; at IQ values < 1, as depressive; whereas the degree of deviation of the index from 1, corresponding to the equilibrium state, reflected the severity of prosperity or depression.

To evaluate the general vitality status of coenopopulations, the population index, namely the coenopopulation vitality index (IVC), proposed by A.R. Ishbirdin and M.M. Ishmuratova (2004), was used. This index was calculated on the basis of the size spectra of generative individuals composing the studied coenopopulations.

Results

Characteristics of coenopopulations and plant communities

During the field investigations, five coenopopulations of *H. rhamnoides* L. growing in the tugai ecosystems of the Zarafshan River within the territory of the Zarafshan National Natural Park were studied. In all examined phytocenoses, *H. rhamnoides* was an important component of the vegetation cover, and in some communities it acted as a dominant species.

The first coenopopulation was studied in the Zarafshan National Natural Park (N 39.655064, E 67.108809) within a forb – *Tamarix* community. The dominant species of this community were *Anisantha tectorum*, *Tamarix ramosissima* and *Geranium pusillum*. The total projective cover of the herb layer was 70%, of which 45% was contributed by the dominant species. The projective cover of *H. rhamnoides* in this community did not exceed 10%. The second coenopopulation (CP 2) was de-

scribed in a forb–sea buckthorn community (N 39.650127, E 67.129881). The soil at the site was stony. The total projective cover was 80%, while the share of the dominant species. *H. rhamnoides* reached 60%. The floristic composition of this community included 22 species of flowering plants. The third coenopopulation (CP 3) was studied in a grass–sea buckthorn community (N 39.638499, E 67.153463). The soil at the site was stony meadow soil. The total projective cover of the herb layer was 70%. The vegetation cover was dominated by *Festuca ambigua*, *Poa bulbosa* and *H. rhamnoides*. The fourth coenopopulation (CP 4) occurred in the tugai of the Zarafshan River within the territory of the national park (N 39.635895, E 67.164416) in a forb–shrub community. The total projective cover of the herb layer reached 70%. The soil at the site was loamy, sandy-loamy, and meadow in character. The fifth coenopopulation (CP 5) was identified in a sea buckthorn–oleaster plant community (N 39.760091, E 66.844552). The soil at the site was stony. The total projective cover of the herb layer was 70%. The community was dominated by *H. rhamnoides* and *Elaeagnus angustifolia* (Fig. 1., Table 1).

Demographic and ontogenetic structure of coenopopulations

To characterize the population structure and demographic spectrum of the coenopopulations of *H. rhamnoides*, eight ontogenetic states were distinguished: p, j, im, v, g1, g2, g3 and s. The maintenance of populations of this species is carried out predominantly through vegetative reproduction; therefore, a partial shoot was used as the accounting unit. Taking into account the biological characteristics of the species and its modes of reproduction, the characteristic ontogenetic spectrum may be considered a centered spectrum with a maximum at mature plants and an increase in the proportion of virginal individuals, which reflects a slight rejuvenation of ramets. At the same time, seed regeneration is weakly expressed.

Table 1. Characteristics of plant communities involving *Hippophae rhamnoides*

№ CP	Geographic coordinates	Dominant species	Total projective cover, %	Projective cover of the studied species, %
1	N 39.655064 E 67.108809	*Anisantha tectorum*, *Tamarix ramosissima*, *Geranium pusillum*	70	10
2	N 39.650127 E 67.129881	*H. rhamnoides*, *Bromus scoparius*, *Poa bulbosa*, *Medicago minima*	80	60
3	N 39.638499 E 67.153463	*H. rhamnoides*, *Festuca ambigua*, *Poa bulbosa*	70	8
4	N 39.635895 E 67.164416	*Festuca ambigua*, *Hordeum murinum*	70	4
5	N 39.760091 E 66.844552	*H. rhamnoides*, *Elaeagnus angustifolia*	70	25

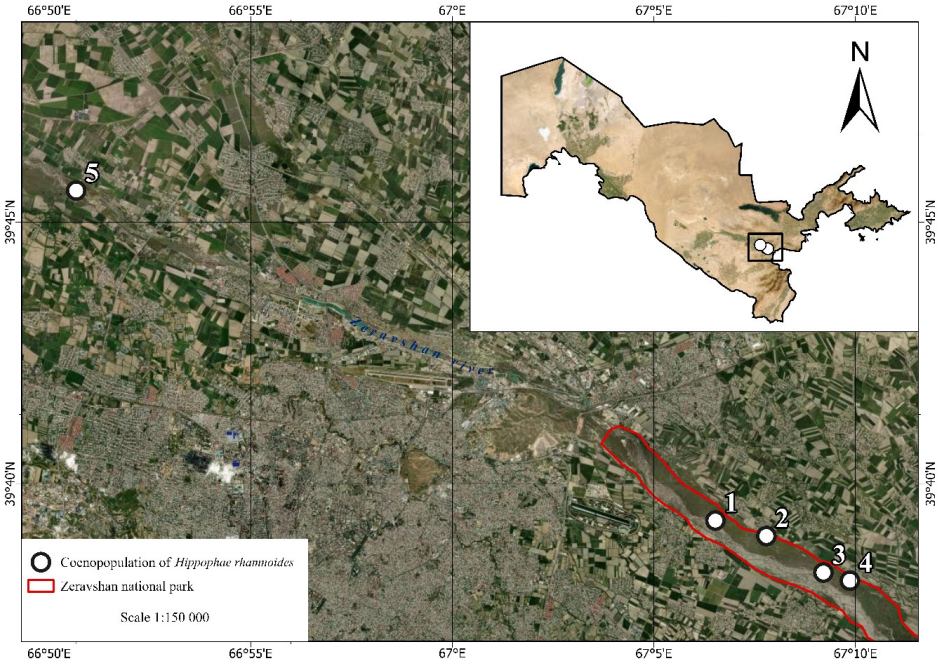

Figure 1. Coenopopulations of *H. rhamnoides*.

According to the classification of Uranov A.A and Smirnova O.V. (1969), all studied coenopopulations of *H. rhamnoides* belong to the normal but incomplete type. The total number of individuals in particular coenopopulations varies from 2 to 37. Of these, the number of female individuals ranges from 2 to 15, whereas the number of male individuals ranges from 15 to 23. Under anthropogenic impact, including fruit harvesting, cutting and breaking of fruit-bearing shoots, as well as livestock grazing, the sex ratio changes in the coenopopulations and a predominance of male individuals is observed (Table 2). It should be noted that earlier, in the coenopopulations of the Zarafshan National Natural Park, the predominance of female individuals over male ones had been recorded (Ishmuratova et al. 2024).

The ontogenetic structure of *H. rhamnoides* is represented by three types of spectra: left-sided (CP 1, 2, 3), right-sided (CP 4), and centered (CP 5).

The left-sided spectra are unimodal, with the maximum occurring in young generative individuals. Such a variant of the spectrum is formed under conditions of predominance of vegetative reproduction and may be regarded as a temporary variant of the centered spectrum. Its formation is probably associated with disturbance of the regularity of regeneration in the coenopopulations of *H. rhamnoides* under the influence of anthropogenic factors. The mean density of individuals in these coenopopulations is 0.46–0.74 individuals per 25 m^2. A right-sided ontogenetic spectrum is characteristic of CP 4, which occurs in a forb–shrub community. This coenopopulation was classified as strongly disturbed because the site had

been periodically exposed to fires, which negatively affected the development of *H. rhamnoides* individuals. As a result of fire impact, pregenerative and generative individuals died, actively growing axillary generative shoots were damaged, as well as the apical axillary vegetative buds. This, in turn, led to the activation of dormant buds and the formation of weakened individuals, predominantly in the middle-aged generative state. In this population, the accumulation of old generative and senile individuals was observed. The mean plant density in CP 4 is 0.04 individuals per 25 m². A centered type of spectrum with a multimodal distribution, a maximum in middle-aged generative individuals and a local peak in virginal plants was recorded in CP 5, confined to the sea buckthorn–oleaster community. The increase in the virginal fraction is associated with a mixed mode of self-maintenance of the coenopopulation. Within this community, *H. rhamnoides* forms dense thickets and the mean density of individuals is 0.7 individuals per 25 m². The high proportion of middle-aged generative plants in this phytocenosis indicates relatively favorable conditions for the existence of the population (Fig. 2).

Table 2. Demographic characteristics of coenopopulations of *H. rhamnoides*

CP	Plant sex	Age states of a plant, %								Total number of individuals	Degree of anthropogenic impact
		p	j	im	v	g1	g2	g3	s		
1	♀	0	0	0	14.1	21.4	28.6	21.4	21.4	27	high
	♂	0	0	0	8.7	39.1	21.7	26.1	4.3		
2	♀	0	0	0	15.3	38.5	23.1	15.3	7.7	32	moderate
	♂	0	0	0	21.1	15.8	15.8	26.3	21.1		
3	♀	0	0	22.2	11.1	55.5	11.1	0	0	13	high
	♂	0	7.1	21.4	14.2	35.7	21.4	0	0		
4	♀	0	0	0	0	0	0	50.0	50.0	2	high
	♂	0	0	0	0	0	0	0	0		
5	♀	0	20	13.3	26.7	13.3	26.7	0	0	35	none
	♂	0	25	15	25	5	30	0	0		

Morphological variability of individuals

In addition to age differentiation, plants characterized by pronounced plasticity also exhibit size differentiation within age groups. The morphological analysis of *H. rhamnoides* individuals was carried out using six traits: plant height, crown diameter, length of annual vegetative shoots, branching order, leaf length and leaf width. To assess trait variability, the coefficient of variation (CV) was calculated.

It was established that the values of the coefficient of variation ranged from 2.3 to 37.2%. In general, most traits were characterized by intermediate and high levels of variability. The highest CV values were recorded for leaf length in CP

(37.2%) and crown diameter in CP 5 (24.7%). The analysis of virginal individuals of *H. rhamnoides* showed that the mean values of the coefficient of variation for most traits in the studied coenopopulations were close to each other, whereas plant height was characterized by a lower degree of variation. The average level of trait variability (CV_{mean}) in most cases exceeded the average values and ranged from 14.9 to 16.8% (Table 3).

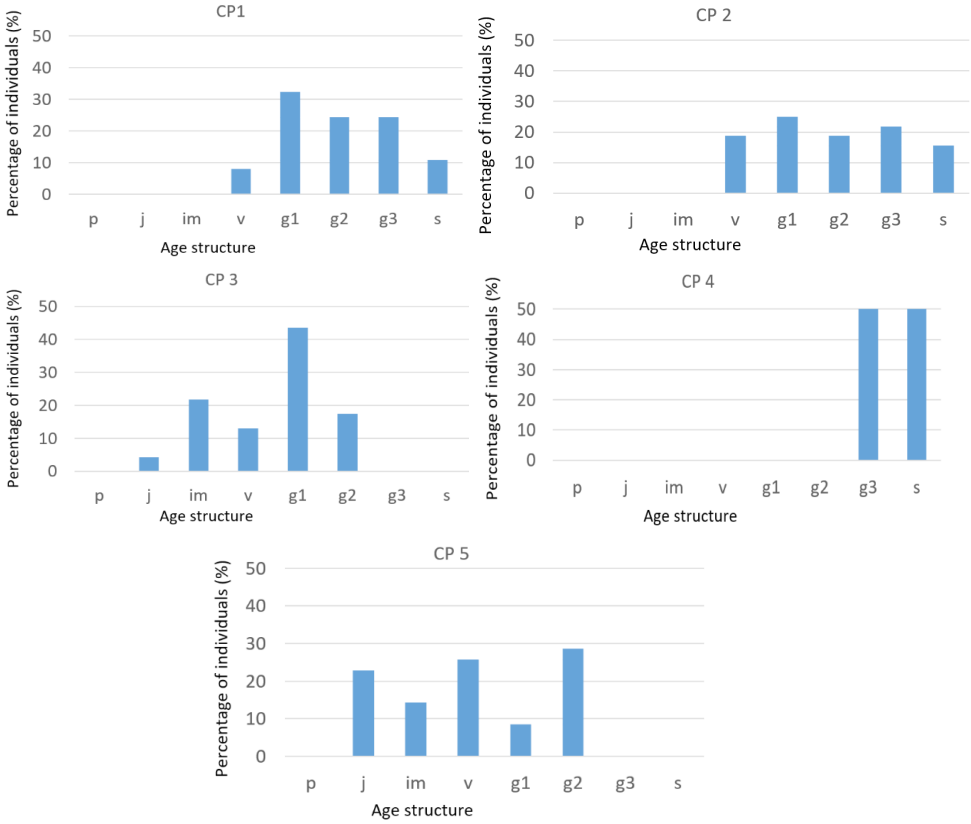

Figure 2. Ontogenetic structure of the coenopopulations of *H. rhamnoides*.

Vitality structure of coenopopulations

The vitality of the studied coenopopulations of *H. rhamnoides* varied from prospering to depressive states. Analysis of the vitality spectra showed that the highest proportion of individuals belonging to vitality class "a" was recorded in CP 5, which was also characterized by a high IVC value (1.0). An intermediate level of vitality was established in CP 2, where individuals of the intermediate vitality class "b" predominated and a high value of the IQ index (3) was recorded.

Table 3. Mean values and coefficients of variation of morphological traits of *H. rhamnoides*

Morphological traits	CP 1	CP 2	CP 3	CP 5	CV_{mean}, %
Plant height, cm	52.4±2.7 16.4	239.7±6.9 9.2	227.7±1.6 2.3	361.1±4.6 4.1	8.0
Crown diameter, cm	16.3±0.8 15.7	24.0±0.7 10.2	13.5±0.4 11.1	37.1±2.8 24.7	15.4
Branching order	3.0±0.2 21.1	3.3±0.2 19.4	4.1±0.2 17.1	4.7±0.1 9.8	16.8
Length of annual vegetative shoots, cm	5.5±0.3 21.8	20.2±0.6 8.8	6.4±0.3 16.3	25.8±1.1 12.8	14.9
Leaf width, cm	1.1±0.1 23.8	3.7±0.2 9.5	0.5±0.1 24.1	1.3±0.1 9.7	16.7
Leaf length, cm	0.6±0.1 15.8	0.8±0.1 37.2	2.8±0.1 8.4	3.9±0.1 4.2	16.4

Note: The upper value indicates the mean trait value and the lower value indicates the coefficient of variation. CV_{mean} = mean coefficient of variation.

The lowest vitality level was revealed in CP 1 and CP 3, which were characterized by a right-sided vitality spectrum with a high proportion of individuals of the lowest vitality class. In general, the highest vitality was recorded in CP 5, occurring in the sea buckthorn–oleaster plant community, whereas the least favorable conditions were characteristic of CP 3, described in the grass–sea buckthorn community. Thus, in the Zarafshan River valley, the coenopopulations of *H. rhamnoides* are represented by both prospering (CP 2, CP 5) and depressive (CP 1, CP 3) types of vitality state (Table 4).

Table 4. Mean values and coefficients of variation of morphological traits of *H. rhamnoides*

No	Vitality classes. %			IVC	IQ	Vitality type
	a	b	c			
CP 1	0	0.1	0.9	0.4	0.1	Regressive
CP 2	0.2	0.4	0.4	0.5	3	Prospering
CP 3	0.2	0.2	0.6	0.5	0.3	Regressive
CP 5	0.8	0.2	0	1.0	0	Prospering

Note: IVC = vitality index; IQ = coenopopulation quality index.

Discussion

The obtained results show that in the tugai ecosystems of the Zarafshan River, *H. rhamnoides* acts not only as a permanent component of the vegetation cover, but also as one of the structure-forming species of individual communities. Such a role of the species is in good agreement with its biological characteristics: sea buckthorn is a typical pioneer shrub of open habitats, capable of successfully occurring on poor, stony, and well-drained soils and of spreading both by seed and by means of root suckers. An additional ecological advantage of the species is provided by symbiotic nitrogen fixation, which allows it to maintain stability under conditions of low substrate fertility and to participate in the stabilization of disturbed habitats.

The predominance of vegetative self-maintenance revealed in the present study, together with weak seed regeneration, should be regarded as one of the key population features of *H. rhamnoides* under the conditions of the Zarafshan tugai ecosystems. The contemporary literature emphasizes that sea buckthorn is characterized by effective dispersal not only by seeds but also by root suckers, and that clonal spread often ensures the long-term persistence of dense thickets and the spatial stability of populations. At the same time, the success of seed regeneration in this species depends substantially on microsite conditions, light availability, soil status and the level of external disturbance. Therefore, the low proportion of pregenerative fractions in most of the studied coenopopulations probably reflects not merely the biological specificity of the species but rather a combination of limited seed renewal and the unfavorable influence of anthropogenic factors.

The diversity of ontogenetic spectra established in the studied coenopopulations indicates that the age structure of *H. rhamnoides* is highly dependent on the specific habitat conditions and the degree of community disturbance. The left-sided spectra in CP 1–3, in which the maximum falls on young generative individuals, may be interpreted as the result of a relative preservation of regenerative capacity under unstable replenishment of the younger age groups. In such cases, vegetative reproduction partially compensates for the insufficiency of seed-based recovery, but does not ensure full age balance of the population. In contrast, the centered spectrum of CP 5, with a local increase in the virginal fraction, reflects a more stable population state, in which the preservation of a mature generative core is combined with the recruitment of younger individuals. Apparently, this type of structure is the closest to optimal for the long-term existence of sea buckthorn coenopopulations in floodplain habitats. These conclusions are in good agreement with data indicating that stable thickets of *H. rhamnoides* are usually maintained through a combination of clonal spread and regular, although not always intensive, renewal.

Particular attention should be paid to the right-sided spectrum of CP 4, where the accumulation of old generative and senile individuals is observed under an almost complete absence of young fractions. Such a structure indicates a regressive direction of population processes and testifies to the disturbance of self-maintenance mechanisms. Taking into account the field observations, the most probable

reason for this is the regular impact of fires. In sea buckthorn, as in other shrubs characterized by a pronounced ability to resprout, damage to aboveground organs may trigger the processes of secondary shoot formation; however, the effectiveness of such recovery depends on the strength and nature of the disturbance, as well as on the resource reserves in underground organs. Experimental studies show that in *H. rhamnoides*, the formation of renewal shoots is indeed closely related to the pruning regime and the resource status of the plant; consequently, under repeated or severe damage, the regenerative potential may fail to compensate for the loss of young and fully functional generative individuals.

An important result of the present study is the revealed shift in sex ratio toward male individuals under conditions of anthropogenic pressure. For dioecious plants, such changes are of considerable demographic importance because they directly affect the reproductive potential of populations. Contemporary studies on *Hippophae* show that in natural communities of the genus, sexual imbalance is not uncommon, and its degree depends on habitat conditions and on differences in the resource strategies of male and female plants. In *H. rhamnoides*, female individuals usually bear higher costs associated with fruit and seed production and may therefore respond more strongly to stress factors. It has been experimentally demonstrated that under unfavorable impacts, including enhanced burial by substrate, female plants exhibit a more pronounced decrease in biomass, photosynthetic parameters and the number of root nodules in comparison with male plants. In this context, the predominance of male individuals recorded in disturbed coenopopulations may be regarded as the consequence of the selective elimination or weakening of female plants under the influence of fruit harvesting, breaking of fruit-bearing branches and livestock grazing.

The indices of morphological variability also confirm that the populations of *H. rhamnoides* within the studied territory exist under heterogeneous ecological conditions. The most variable traits were those associated with the spatial development of the individual and the assimilation apparatus, whereas plant height varied to a lesser degree. Such a pattern suggests that, in different coenopopulations, the species realizes different morphological strategies of adaptation to the combination of light conditions, cenosis density, soil characteristics and the level of disturbance. In general, this corresponds to the widely accepted view of the high ecological plasticity of sea buckthorn, which ensures its successful existence in a broad range of stressful habitats.

The analysis of vitality structure showed that the studied coenopopulations differ substantially in their degree of well-being. The most favorable state was recorded in CP 5 and to a lesser extent, in CP 2, where vitality indicators were high and a pronounced generative core was preserved. In contrast, CP 1 and CP 3 were characterized by a depressive state, reflecting an unfavorable combination of age structure, morphological heterogeneity and anthropogenic load. Such a ratio of prospering and depressive coenopopulations allows *H. rhamnoides* in the Zarafshan River valley to be regarded as a species with a still preserved, but locally weakened, popula-

tion potential. Similar conclusions have been presented in other studies, in which the reduction of natural regeneration and the deterioration of population condition are associated primarily with anthropogenic disturbances, whereas a higher proportion of young individuals and dense clonal thickets are considered signs of increased ecological stability.

The results of the study indicate that the current state of the coenopopulations of *H. rhamnoides* in the tugai ecosystems of the Zarafshan River is determined by the interaction of two oppositely directed processes. On the one hand, the species maintains high stability due to clonal spread, the ability to recover after damage, and ecological plasticity. On the other hand, weak seed regeneration, disturbance of sex structure, and degradation of some coenopopulations under the influence of fires, grazing, and economic use indicate a decline in the long-term stability of individual local populations. In this connection, the conservation of *H. rhamnoides* in the Zarafshan floodplain should be focused not only on the protection of already existing thickets, but also on the limitation of anthropogenic disturbances in the sites where the loss of young and female individuals is observed.

Conclusion

In the tugai ecosystems of the Zarafshan River, *H. rhamnoides* is an important component of the vegetation cover and, in a number of communities, acts as a dominant species, forming coenopopulations that differ in floristic composition and structure. All studied coenopopulations of *H. rhamnoides* belong to the normal but incomplete type, which indicates the preservation of the general population core with incomplete representation of individual ontogenetic groups. Population maintenance is carried out predominantly through vegetative reproduction, whereas seed regeneration is weakly expressed. The ontogenetic structure of the coenopopulations is characterized by considerable heterogeneity and is represented by left-sided, right-sided, and centered spectrum types. The most stable state was recorded in coenopopulations with a centered spectrum and the presence of virginal individuals, whereas the right-sided spectrum reflects regressive processes associated with the disturbance of regeneration and the accumulation of old generative and senile plants. Anthropogenic factors, including fruit harvesting, breaking of fruit-bearing shoots, livestock grazing, and fires, exert a substantial influence on the state of *H. rhamnoides* coenopopulations. Under their impact, the participation of young age groups decreases, natural regeneration is disturbed, and the sex ratio shifts toward the predominance of male individuals. The morphological traits of *H. rhamnoides* individuals are characterized by intermediate and high levels of variability, which reflects the response of the species to the heterogeneity of habitat conditions. The most variable traits are the parameters of the assimilation apparatus and the spatial organization of the shrub, which indicates a sufficiently high morphological plasticity of the species. The vitality structure of the coenopopulations varies from

prospering to depressive states. The most favorable conditions for the existence of *H. rhamnoides* were recorded in sea buckthorn–oleaster communities, whereas in grass–sea buckthorn and disturbed habitats the vitality of plants decreases. This indicates a close dependence of population condition on ecological conditions and the degree of anthropogenic pressure. In general, *H. rhamnoides* in the Zarafshan River valley retains the capacity for self-maintenance due to vegetative reproduction and ecological plasticity; however, the long-term stability of some coenopopulations is declining as a result of weakened seed regeneration and increasing anthropogenic impact. This determines the necessity of protecting the habitats of the species and limiting economic pressure within tugai ecosystems.

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