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Factors providing adaptations of rose-ringed parakeet (*Psittacula krameri*) in the urban ecosystems of the city of Baku

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Rose-Ringed Parakeet is native to Southeast Asia and Africa. It is a new species in Azerbaijan's ornithofauna that are settled in the anthropogenic ecosystems of Baku. This article analyzes and interprets nesting, feeding behaviors and interspecific relationships that ensure the adaptation of this species to the urban ecosystems of Baku. Monitoring was conducted in the Baku Seaside National Park as a model area. Rose-Ringed Parakeet has been shown to exhibit high mobility and plasticity in both nesting and seasonal feeding strategies. That is, they select long-lived tall (20-40 m) trees with a trunk diameter of 0.6-1.3 m for successful nesting. They build their nests at a height of 4-6 m above the ground. The diameter of the entrance to the nests (8-10 cm) is suitable for the size of the bird's body. This protects the eggs and chicks from their natural enemies and increases the productivity of the nest (the number of chicks per pair). Another environmental factor that ensures the settlement of this species in Baku is the large number of feed facilities. Rose-Ringed Parakeet satisfies its need for food in all seasons by eating the fruits and seeds of 21 tree species. Both the above-mentioned and the lack of competition between species for nests, natural enemies, as well as human tolerance are the factors that created the conditions for the settlement of this species in the anthropogenic ecosystems of Baku.

Keywords: *Rose-Ringed Parakeet (RRP) tree, nest, feed, adapt*

INTRODUCTION

Currently, the study of urban birds is one of the topical areas of ornithological research (Allen and Holling, 2010). This is due to the fact that a number of species are taken out of the natural habitat and span out in different ways (escapes from the cage and the zoo, the owner releases the bird from the cage, etc.) in other areas (mainly in urban parks, in gardens, etc.) as a result of human activities (introduction, commercial, smuggling) (Blackburn et al., 2015; Simberloff, 2009; Richardson, 2010; Parau et al., 2016). Of the 342 species of birds brought to Europe, 74 species have spread in the domestic environment through the above-mentioned ways and have formed numerous populations as a result of adaptation. Of these, 53 species are parrot species (Katsanevakis et al., 2012).

One of the species of parrots that are taken to regions outside its natural range and adapted to new natural conditions is the Rose-Ringed Parakeet. It is (ordo: *Psittaciformes* Wagler, 1830 - *Psittacula krameri* Scopoli, 1769) a native of Asia (Pakistan, India, etc.) and is located in Central Africa (Parau et al., 2016; Chalishkan, 2021). Rose-Ringed Parakeet is currently distributed in 71 countries around the world (Belausov, 2017).

It has been found that the number of Rose-Ringed Paraketees (hereinafter referred to as RRPs) in Europe has increased rapidly since the 1960s at the expense of imported individuals (Strubbe and Matthysen, 2009). From 1981 to 2007, 231,048 RRPs were imported to 37 European countries (Jackson et al., 2015). In 2015, the number of RRPs in European countries was reported to be at least 85,120 individuals (Parau et al., 2016).

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RRP is a dendrophilic bird, nesting in trees and feeding on plant parts. Therefore, birds that escaped from cages and zoos and were released into the wild by their owners, settled in parks and gardens in cities with favorable climates and vegetation, forming large populations (> 500 individuals) (154 populations in 37 countries). (Parau et al., 2016). The role, number and adaptation features of RRP in urban ecosystems of Brussels (Strubbe et al., 2010: Weiserbs, 2010), London (Ballmer et al., 2013), Randstad (Claassen, 2014), Reyn-Heckar (Brown, 2009), Rome (Fraticelli, 2014), Istanbul, Ankara, Izmir (Parau et al., 2016; Caliskan, 2021), and in other cities have been studied to this day.

Baku is one of the cities inhabited by the RRP forming a natural population. In the years 2004 (Sultanov and Mammadova) and 2005 (Sultanov et al.), there were reports of registering this species in Baku. Another report states that RRP was illegally brought to Baku by a businessman in the 1990s (31 individuals) and released into the wild by the Customs (Belausov, 2017). It is noted that the number of RRPs in Baku increased from 21 to 32 individuals in 2003-2007 (Mammadova et al., 2008).

These authors provided only a small amount of information on the registration and number of RRPs. The role of environmental and anthropogenic factors, interspecific relationships, trophic ties, and limiting factors that ensure the adaptation of RRP to local urban ecosystems have not been analyzed or interpreted. Therefore, we aimed to study the role of floristic abandonment of phytocenoses, trophic conditions in the adaptation of RRP and the impact of biodiversity on the ecosystem.

MATERIALS AND METHODS

The study was carried out in the Seaside National Park in Baku (40°21′36″,49°50′13″). (Fig.1).

Fig. 1. General view and scheme of the Seaside National Park inhabited by RR.

Table 1. Number of trees and nests used by RRP for nesting

Type of tree	Height, m	Diameter, m	Tree lifespan, year	Number of slots	Height of the nest from the ground, m	Entrance to the nest, cm
Common ash, *F. excelsior*	30-40	0.7-0.9	200-250	5	4-6	8-10
Poplar pencil, *P.gracilis*	30-40	0.8-1	80-100	2	5-6	7-10
Black poplar, *P. nígra*	20-30	1-1.2	80-100	2	4-6	7-9
Oriental plane, *P.orientalis*	30-40	1-1.3	200-300	1	5	8
Horse-chestnut, *A.hippocastanum*	25-30	0.6-0.8	200-300	1	4	9

The research took place in the "Old Boulevard" area (3.5 km), which was established in 1909. The area of this park, selected as a model area, is larger than the area of the "Governor's Garden", "Philharmonic Garden", "Botanical Garden" and others, where the RRP was registered. In recent years, the territory of the park has been expanded and areas dubbed "New Boulevard", "White City", and "Flag Square" have been created. Over 100 species of long-lived trees and shrubs imported from Italy, Turkey, Mexico, Spain, France, Germany, the United States, Australia, Africa, Argentina, and other countries were planted and adapted to the local climate in both these areas and in the "Old Boulevard". Seaside National Park is one of the places of recreation and tourism. There are also many commercial, entertainment, recreation and sports facilities, as well as highways and tall residential buildings nearby.

Objects of research - birds, trees, shrubs, nests, and food eaten by birds. The type, height (roughly), diameter (with a measuring tape), and the number of trees nested by the RRP (Mammadova, 2010) in the park were defined. The number of nests in the trees, the height from the ground, the diameter and depth of the entrance (with a tape measure) were studied. In addition, the type of trees and shrubs they eat in all seasons (fruits, seeds, shoots, leaves, etc.), the shape of the fruit, the ripening period (Mammadova, 2010), the daily and seasonal feeding behavior of birds were studied as well. Observations and records were made in April, September, December of 2021 and January 2022. Route and stationary observation methods were utilized.

Intergenerational ties also influence the adaptation of RRP to phytocenoses. Therefore, nesting and diet competition behaviors between birds and animals living in the park and the RRP were studied. RRP's self-defense and aggressive behaviors were studied as well.

RESULTS AND DISCUSSION

Note that, only the registration and number of RRPs have been indicated in both the Seaside National Park and other gardens, while the characteristics of phytocenosis adaptation have not been studied (Sultanov and Mammadova, 2004; Sultanov et al., 2005; Mammadova et al., 2008). Eleven pairs (22 individuals) were found nesting in the park. 50-60 RRPs are recorded in the park area, along with young individuals and individuals coming from other areas to feed. Considering this, we have studied the role of factors providing the adaptation of RRP to the phytocenoses of the Seaside National Park. It was identified that the species composition of trees and shrubs has a significant impact on the settlement and number of dendrophilic RRP in phytocenosis. This is because RRP uses different types of trees and shrubs for nesting, feeding, spending the night, and relaxing. For these purposes, RRPs prefer different trees and shrubs belonging to domestic phytocenoses in different geographical areas (Mohammad et al., 2015; Chalishkan, 2021).

It was found that RRPs choose nesting sites by relying on the characteristics of the trees such as altitude, the diameter of the trees, age, size, and depth of the nest cavity. In the Seaside National Park, RRPs use the trees listed in the table for nesting (Table 1). All 11 nests we recorded are located in 5 species of trees. 45.45% of the 11 nests are located in the *Common Ash* tree. *Poplar*

pencil (18.18%), *Black poplar* (18.18%), *Oriental plane* (9.90%), and *Horse-chestnut* (9.90) trees are taken the next places on the list. Other parameters of trees and nests in the park are given in Table 1.

If we compare the results of our and other authors, we can see differences and similarities. For comparison, in Germany, the majority (57.0%) of RRP nests are located in the Plantain leaf maple (*Acer pseudoplatanus*) tree with a trunk diameter of 0.8-1.50 m (Chaika et al., 2011). In India and Africa, the homeland of the RRPs, nests are located at 9-27 and 5-14 m above the ground. In Pakistan, the RRP trunks nests in 15 different species of trees with a diameter of 0.6-2.15 meters. The entrance to the nest is 5.5-20.3 cm and is located 4-6 m above the ground (Mohammad, 2015). Differences in the height of the nests from the ground, the density of tree trunk, and the diameter of the nest entrance are due to the fact that different species of trees in different areas do not grow at the same rate and they gradually age. This process is significantly influenced by the soil surface, climate, diseases, and parasites of the area where the trees are located.

It has been identified that RRPs prefer long-lived, old, and tall trees for nesting. Other studies also confirm it (Prajapati and Prajapati, 2012; Renton et al., 2015). Considering that the "Old Boulevard" area of the park was created in 1909, we can say that the trees, where the nests are located (they are trees of local nature) are over 100 years old. The location of the nest in a long-lived tree allows them to use it for a long time. As the tree ages, cracks and fissures form in its trunk. It is easier to build a nest there. Such cracks allow for 2-3 nests in a tree. There are 2-3 nests per tree in Pakistan (Mohammad, 2015) and 9 nests in Germany (Chaika et al., 2011).

We recorded only one nest in one tree in the Seaside National Park. The holes in the wood are made by the RRP itself. The diameter of the entrance is according to the body size. Stray cats in the park enter the nest and try to eat the egg and nestlings. However, the small entrance to the slot does not allow it. The absence of snakes in the park also contributes to safe nesting. The depth of the nests is 27-32 cm. At the bottom of the nest, the birds lay leaves and feathers. We recorded 1 hole in each slot. The hole is used for entry and exit (Fig. 2).

The scientific literature indicates that older and more experienced couples prefer trees with a diameter of 2 m for nesting (Mohammad, 2015). If we consider that RRP nested in the trees with a diameter of 0.6-1.3 m (Table 1) and 19 individuals were registered for the first time in the Seaside National Park in 2004 and 2 individuals in 2006 (Mamadova et al., 2008) we can say that the population is younger.

It was found that the adaptation of RRPs to the Seaside Park had a significant impact on the diet stocks of the phytocenosis, in addition to the factors mentioned above. This is because stocks in the phytocenosis affect the time of RRP nesting and nest productivity (number of nestlings per pair). Therefore, the presence of feed objects is important in the RRP's strategy of nesting site selection. According to the literature, parrots also follow the ripening stage (phenology) of the fruits of individual trees and use them in feeding strategies. Such a selection strategy increases the probability of success in reproduction (Renton et al., 2015).

More than 3,000 trees, shrubs, and grasses have been planted in Seaside Park. Here, we recorded that RRPs fed with soft parts of 22 species of trees and shrubs (i.e., shoots, flowers, fruit stems) and hard seeds (Table 2).

It is related to the blossoming of trees and shrubs in various months, ripening of their seeds and fruits, and remaining duration on the tree. In spring and summer, RRP feeds on vegetative (leaf) and generative (flower) shoots of 12 species of trees and shrubs (Table 2). RRP feeds on leaves and flower shoots both simultaneously (i.e. when germinating at the same time) and separately (for example, *Cotoneaster acuminatus; Aésculus hippocástanum; Quercus ilex*) (Table 2). The trees and shrubs in the park bloom in different months. Commencing from March (Laurus nobilis) until October (*Vítex ágnuscástus) Vítex ágnuscástus*) the development of vegetative and generative organs allows the RRP to feed on the soft parts of plants in the spring and summer. Birds eat different parts of the flower (pistil, perianth, stamen, petal). Starting from February (*Cupressus arisonica*) until January (*Pinus pinea)* the seeds and fruits ripen. As a result, the feed ration of the RRP becomes richer in the fall months. During this period, RRP feeds on 20 species of trees and shrubs and seeds (Table 2).

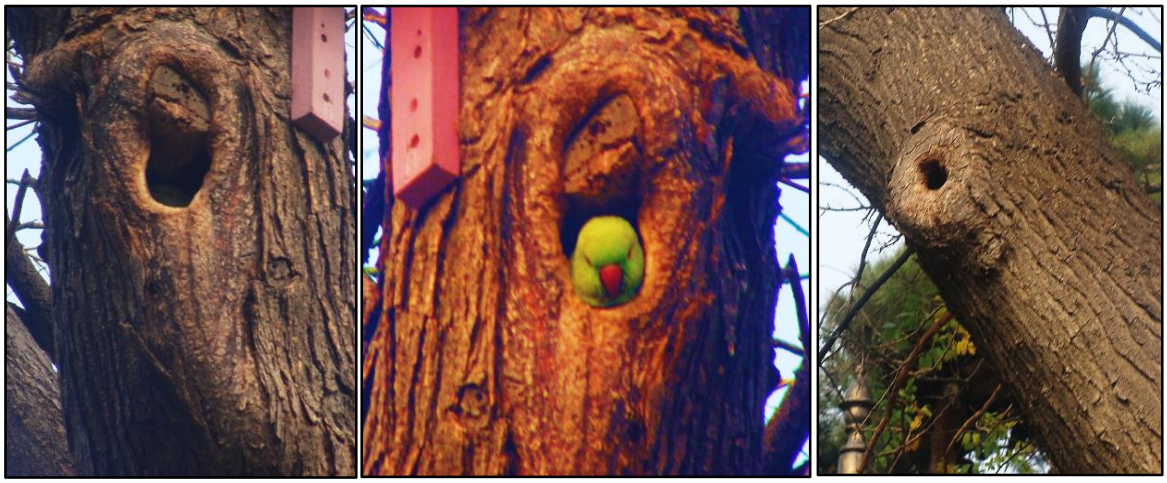

Fig. 2. Nests built and used by RRP on various trees.

Table 2. Trees and shrubs, containing diet sources of the RRPs in the Seaside National Park

Trees and shrubs	Number, pieces	Diet spectrum		
		flower and leaf shoots	seeds	fruit pulp
Styphnolobium japonicum, *Sofora Yaponica*	12	+ VII-VIII	+ IX-X*	
Laurel, *Laurus nobilis*	6	++ III-V		+ IX
Olive, *Olea europaea*	102	++ V-VI		+ IX-X*
Eastern thuja, *Biota orientalis*	46		+IX-XI	
Cilver crest, *Pinus pinea*	21		+ X-XII	
Chaste tree, *Vítex ágnuscástus*	30	++ VI-X	+X-XI	
Arizona cypress, *Cupressus arisonica*	22		+II-III	
European dwarf,*Cercis siliquastrum*	19	++ IV-V	+VIII-IX	
Finik, *Phoenix dactylifera*	20			+IX-XI
Yukon Belle, Pyracantha angustifolia	75		+ VIII	+ VIII
Cotoneaster, *Cotoneaster acuminatus*	10	+ IV-V	+ VIII	
Chestnut, *Aésculus hippocástanum*	31	+ V		+ VIII-IX
Holm qak, *Quercus ilex*	4	+ IV	+ X*	
Oriental plane, *Platanus orientalis*	7		+IV-VI	
Black poplar, *Pópulus nígra*	43	++ IV-V		
Poplar pencil, *Populus gracilis*	30	++ IV-V		
Common barberry, *Berberis vulgaris*	17	-		+IX-X
Common ash, *Fraxinus excelsior*	67	++ IV-V	+ VIII-IX*	
Pino, *Pinus eldarica*	80		+ X*	
Hornbeam, *Carpinus betulus*	32	++ IV-V		+ X
Notkins cypress, *Cupressus nootkatensis*	11		+ IX-X	

Fruits and seeds remain in the park for a long time on 163 trees and shrubs *(Sofora Yaponica; Quercus ilex; Fraxinus excelsior; Pinus eldarica; Olea europaea)*. These fruits and seeds form fodder facilities from October to March. In general, the share of seeds in the feed rations of RRP is higher. We identified that the RRP ate more of the Hornbeam (*Carpinus betulus)* fruit (nut) more and enthusiastically. The shells of the walnuts they eat are poured under the tree. Relying on these shells, it is possible to define the number of nuts they eat. They also fly to a nearby "botanical garden" to eat the fruit of this tree. Starting from February (*Cupressus arisonica*) until January (*Pinus pinea)* the seeds and fruits ripen. As a result, the feed ration of the RRP becomes richer in the fall months. During this period, RRP feeds on 20 species of trees and shrubs and seeds (Table 2). Fruits and seeds remain in the park for a long time on 163 trees and shrubs *(Sofora Yaponica; Quercus ilex;*

Fraxinus excelsior; Pinus eldarica; Olea europaea). These fruits and seeds form fodder facilities from October to March. In general, the share of seeds in the feed rations of RRP is higher. We identified that the RRP ate the Hornbeam (*Carpinus betulus)* fruit (nut) more and enthusiastically. The shells of the walnuts they eat are poured under the tree. Relying on these shells, it is possible to define the number of nuts they eat. They also fly to a nearby "botanical garden" to eat the fruit of this tree.

We did not observe RRPs eating grass on the ground. The variety of diet objects (seeds, pine and oak cones, nuts, acacia beans, walnut, berries, and others) ripening at different times and remaining in trees and bushes for a long time (fruits are not harvested in the park) allows an RRP to find diet in all seasons. In the autumn and winter months, RRP's diet rations are richer (Table 2). In spring and summer, shoots, flowers, leaves, fruits, and seeds that remain on trees and shrubs for a long time form the diet of RRP.

Other ornithologists also report that RRPs change their feeding patterns from fruit or seeds to flowers at different times of the year. It is noted that the ration of the RRPs is formed from 7-26 plant species depending on the seasons. Ornithologists state that RRP demonstrates high mobility and flexible behavior in diet search and seasonal feeding strategies (Blanco et al., 2015). This is a universality that allows the RRPs to span out to the most diverse geographical areas.

It should also be noted that the presence of trees and shrubs of African and Asian origin (i.e., belonging to their historical homeland) in the Seaside Park (*Phoenix dactylifera*; *Olea europaea*, *Laurus nobilis*, *Vítex ágnus cástus*, *Pyracantha angustifoli*, *Quercus ilex*, *Taxus baccata* other) allows them to feed on traditional diet objects. One of the factors ensuring the settlement of RRPs in the park is the lack of competition between species and nests. One reason for this is the large number of tree species suitable for nesting. Another reason is that other species (Picidae, Sitidae, and others) that nest in tree crevices and holes do not breed in the park site. RRPs, which are better adapted to anthropogenic ecosystems than other bird species, are able to use nesting sites. In addition to RRPs, Rock dove (*Columba livia*) and Collared dove (*Streptopelia decaocto*) nest and feed in the park. These species are not considered RRP's diet competitors. Although the main feeding competitor was Hooded crow (*Corvus cornix*) we did not see any conflict over diet. Instead, we recorded that they feed on the same tree (Fig. 3).

Currently, the domestic population of this species has been formed in Baku. RRP is a new species in the Azerbaijani ornithofauna. Therefore, it is of great importance to predict the impact and role of RRP as an invasive species in the biodiversity of Azerbaijan. In order to clarify this issue, let's pay attention to the numerical dynamics and dispersion of the RRP population.

Fig. 3. There was no feed competition between RRPs and Hooded crow (*Corvus cornix*) on the same tree.

The number of this species in Baku ecosystems was 21 in 2003, 36 in 2004, 28 in 2005, 27 in 2006, and 32 in 2007 (144 individuals in total) (Mammadova et al., 2008). As can be seen, the number has increased in fluctuation type over 5 years. It is known that abiotic (weather conditions) and anthropogenic factors influence the processes in the population that regulate the dynamics of numbers (Neverova and Frisman, 2020). The following factors influenced the change in the number of RRPs in Baku under fluctuations. In some years, strong and cold winds, rainy, and frosty weather conditions have a negative impact on the number of pairs involved in reproduction and the beginning of reproducetion. The number of eggs laid in the nest is also decreasing. Currently, a maximum of a1 or 2 eggs is recorded in each nest. That is, nest productivity (the number of chicks given by a pair) is not higher. The anthropogenic factor is the illegal detention and sale of baby birds. This factor leads to a change in the sex ratio in the population and a decrease in the number of breeding pairs. At present, 200-250 individuals are registered in Baku. Due to the lower reproductive capacity of the population, the dispersion of RRP to other parts of the country is not observed. However, as an invasive species, RRP needs to be studied regularly and appropriate predictions made.

CONCLUSION

The RRP population in the Seaside National Park (over 100 years old) is young in terms of the time period. The optimal ecological conditions of the ecosystem and the ethological characteristics of these birds had a significant impact on the settlement of the species that are native to Southeast Asia and Africa in the park. Environmental factors include the richness of the floristic composition of the ecosystem, the abundance of tree species for nesting, overnight protection, nesting, lack of enemies in diet grounds and interspecific competition, favorable trophic conditions, and wild climate. Ecological flexibility of RRP (i.e., acceptance to changes in environmental conditions), tolerance, fearless closeness with humans, colonial nesting, feeding, and protection are also ethological factors that ensure the adaptation of this species to urban ecosystems.

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Bakı şəhərində məskunlaşan yaxalıqlı tutuquşunun *(Psıttacula krameri)* eko-etoloji xüsusiyyətlərinin öyrənilməsi

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Yaxalıqlı tutuquşunun vətəni Cənubi-Şərqi Asiya və Afrikadır. Azərbaycan ornitofaunasında yeni növdür. Bakı şəhərinin antropogen ekosistemlərində məskunlaşmışdır. Məqalədə bu növün Bakı şəhərinin urboekosistemlərinə adaptasiyasını təmin edən yuvalama, yemlənmə davranışları və növlərarası münasibətləri analiz və şərh edilmişdir. Monitorinq model ərazi kimi Bakı Dənizkənarı Milli Parkda aparılmışdır. Müəyyən edildiki, Yaxalıqlı tutuquşu həm yuvalama yeri seçmə, həmdə mövsümi yemlənmə strategiyalarında yüksək mobillik və plastik davranış nümayiş etdirirlər. Yəni yuvaqurmanın uğurlu olması üçün uzunömürlü hündür (20-40 m), gövdəsinin diametri 0.6-1.3 m olan ağacları seçirlər. Yuvalarını yerdən 4-6 m hündürlükdə qururlar. Yuvaların girişinin diametri (8-10 sm) quşun bədən ölçüsünə uyğun olur. Bunlar yumurtanı, balanı təbii düşmənlərindən qoruyur yuva məhsuldarlığını (1 cütün

verdiyi bala sayı) artırır. Bu növün Bakıda məskunlaşmasını təmin edən digər bir ekoloji amil yem obyektlərinin çox olmasıdır. Yaxalıqlı tutuquşu bütün fəsillərdə yemə olan tələbatını 21 növ ağacın meyvısini, toxumunu yeməklə ödəyir. Həm qeyd etdiklərimiz, həmdə növlərarası yuva, və yem rəqabətinin, təbii düşmənlərinin olmaması, həmçinin insana tolerantlığı, bu növün Bakının antropogen ekosistemlərində məskunlaşmasına şərait yaratmış amillərdir.

Açar sözlər: *Yaxalıqlı tutuquşu, ağac, yuva, yem, adaptasiya*

Факторы, обеспечивающие адаптацию ожерелового попугая (*Psittacula krameri*) к урбоэкосистеме на примере города Баку

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В статье анализируются и интерпретируются гнездовое и пищевое поведение, ~~и~~ также межвидовые отношения, обеспечивающие адаптацию ожерелового попугая (*Psittacula krameri*) к Баку, как к самой крупной урбоэкосистеме Азербайджана. Мониторинг проводился в Бакинском приморском национальном парке, использукмом в качестве модельной территории. Было обнаружено, что попугай проявляет высокую подвижность и пластичность как в стратегиях гнездования, так и в стратегиях сезонного кормления. Показано, что для успешного гнездования ожереловые попугаи выбирают долгоживущие высокие (20-40 м) деревья с диаметром ствола 0,6-1,3 м. Свои гнезда строят на высоте 4-6 м над землей. Диаметр входа в гнезда (8-10 см) соответствует размеру тела птицы. Гнезда защищают яйца и птенцов от их естественных врагов и повышают продуктивность гнезда (количество птенцов, приходящееся на 1 пару). Еще одним экологическим фактором, обеспечивающим расселение этого вида в Баку, является большое количество кормовых объектов. Попугай удовлетворяет свои потребности в пище в любое время года, поедая плоды и семена 21 видов деревьев. Все вышеперечисленное, а также отсутствие межвидовой, гнездовой и кормовой конкуренции, естественных врагов и толерантность человека являются факторами, создавшими условия для расселения этого вида в антропогенных экосистемах города Баку.

***Ключевые слова*:** *Ожереловый попугай, дерево, гнездо, корма, адаптация*