Bioecological features and significance of the genus Bee-Eater- *Merops* in Uzbekistan

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**Abstract.** The article presents the results of the research conducted in Uzbekistan in 2020-2023 on the bioecological characteristics and importance of European Bee-eater - *Merops apiaster* and Blue-cheeked Bee-eater - *Merops persicus*. The purpose of this study is to determine and assess the distribution, number and dynamics of *M. apiaster* and *M. persicus* in Uzbekistan, factors controlling their reproduction, nutrition, importance in nature and in bee farms, to experiment with effective methods to prevent biodamage caused by bee-eaters to bee farms and to protect them. As a result, recommendations are being developed to protect these species and prevent their bio-damaging activity. Zoological, ecological, questionnaire, statistical and comparative analysis methods were used in the research. The scientific novelty of the research is as follows: distribution characteristics of *Merops* species in Uzbekistan, their number and dynamics in biotopes, and abiotic and biotic factors controlling them were determined; the reproductive cycle of woodpeckers, their nesting places, the structure of their nests, the passage of reproduction stages, the efficiency of reproduction and the environmental factors affecting it were determined; changes in the nutritional composition and trophic relations of the species were determined in accordance with the reproductive and post-reproductive cycles; it has been proven that bee-eaters increase in stomach mass and accumulation of fat in the stomach and internal organs are the results of hyperphagia and lipogenesis events that occur in preparation for autumn migration; the importance of *M. apiaster* and *M. persicus* in nature and in bee farms was evaluated and their participation in various biocenotic relationships was revealed; the bioacoustic repellent "*Merops* – distress signal" was developed and its effectiveness in controlling the behavior of bee-eaters was proven by testing; appropriate recommendations for reducing the participation of *Merops* in biodamage in bee farms and their protection were developed.

1 Introduction

In the world, research is being conducted to protect the world of animals, including birds, to limit their illegal hunting, to preserve their habitats and to determine their economic value. Special attention is being paid to the development of the scientific basis of managing their
behavior based on the study of the ecology of species harmful to human economy. Despite the efforts being made to protect the animal world at the international level, in recent years, negative attitudes towards certain types of animals, including birds, have been observed based on an incorrect assessment of their importance in the economy. This can be seen in the many deaths of birds belonging to the genus Bee-eaters-Merops, which damage bee farms. The development of scientific bases for solving these problems and optimizing conflict relations is of urgent importance today.

2 Materials and methods

We conducted a study to study bee-eaters during 2020-2022 in all regions of the Republic of Uzbekistan. The studies used zoological, ecological, questionnaire, and statistical methods, as well as methods of comparative analysis of the study.

During the study period, 134 specimens of *M. apiaster* and 213 *M. persicus* were collected, 115 stomachs, 1020 pellets and food waste from 48 nests were collected and processed. All processed specimens are taken from web nets, which are supplied by beekeepers on beekeeping farms. The materials were analyzed in the laboratory of the Department of Zoology of the National University of Uzbekistan. Food residues in the stomachs were fixed in 70% alcohol, and the remains of feed from sheep and nests were stored in separate coats. The leftover feed was resumed in warm water prior to study. Eschenbach mobilux led lupa and MBS-1 binocular microscope were used in laboratory detection of animal species containing food residues. In order to visually study the content of feed, observations were made in the main feeding sites of these species (beekeeping facilities, the vicinity of various reservoirs, agrotsenoses). When determining the number of birds per unit area, the corresponding methods were used [3]. The number of birds found in certain biotopes was calculated using the following formula:

\[
D = \frac{n}{2} \cdot Lw
\]

Where \(D\) is the density; \(n\) - the number of birds encountered in the counting places; \(L\) is the length of the route; \(W\) - width of the route. The census results are extrapolated to a comparable area of 10 ha. The egg shape index is determined by the formula proposed in:

\[
IF = 100 \times \frac{d}{D};
\]

Where \(IF\) is the egg shape index; \(d\) - egg width, mm; \(D\) is the length of the egg, mm.

The collection and determination of the species composition of insects found in the diet of birds was carried out according to the relevant recommendations and determinants.

To determine the effectiveness of the bioacoustic repellents KORSHUN-8 PRO and SAPSAN-3 produced in Ukraine, as well as the bioacoustic repellent "Merops - distress signal" developed by us, bee-eaters were tested in beekeeping farms and nocturnal colonies.

3 Results and Discussion

Based on the inventory of specimens of *M. apiaster* and *M. persicus* (\(n=196\)) in the ornithological collections of Uzbekistan, dating from the end of the 19th and the first quarter of the 20th century, it was found that their distribution and time of arrival do not
correspond to our data. It was determined that during the migration period both species spread sporadically, and in other periods *M. persicus* mainly spreads along the middle and lower reaches of the Zerafshan, and *M. apiaster* in the mountainous and foothill zone.

In recent years, due to global warming, these species have been expanding their distribution area in a northerly direction [1-2, 4, 10]. This feature is sometimes manifested in the mixing of their flocks and in violation of the principle of zonality of their distribution. It was found that in such biotopes as natural landscapes, agrocenoses, rural settlements and beekeeping farms, the average monthly and annual number of bee-eaters per unit area is variable. The lowest indicator for the average annual number of both species was recorded in natural landscapes, and the highest indicator in beekeeping farms. Seasonal changes in life cycles and trophic relations of bee-eaters are the main factors causing dynamic changes in their numbers in biotopes. The distribution of bee-eaters, their numbers and dynamics in different biotopes are inextricably linked with their life cycles and are variable (Figure 1).

![Fig. 1. Annual headcount dynamics of *M. apiaster* and *M. persicus* (April-October, 2021-2022 on 10 ha).](image)

The number of *M. apiaster* and *M. persicus* species in different biotopes (natural landscapes, agrocenoses, settlements and beekeeping farms) in April and October is relatively low, which is explained by the beginning and end of the stages of spring and autumn migrations. In July and August, high rates are observed, which occur as a result of replenishment of the population due to young individuals.

The reproductive cycle of bee-eaters, the change in their trophic relationships and the features of their defense, are both factors regulating their distribution and abundance. In particular, the frequency of meetings and the number of bee-eaters is higher in bee farms and in the directions where bees gather food [5-9]. The number of bee-eaters varies depending on the density of bees, and they are relatively larger within a radius of 500-1000 meters around bee farms (Figure 2). This trophic relationship confirms the importance of placing hives close to the places where bees forage.
In Uzbekistan, all found nests of *M. apiaster* (n=248) are located in different cliffs in the form of colonies, and nests of *M. persicus* (n=84) on cliffs and flat places, in the form of colonies and individually. The absolute height and depth of the nests is assessed as an adaptation to maintain the appropriate temperature and humidity in the nest, as well as to protect the nests from predators. Unlike most species, bee-eaters do not use old nests and build new ones every year. This is explained by the fact that various remains in the old nest create unfavorable conditions, the nest is occupied by other species, and the size of the nest changes as a result of erosion.

In the spring with arrival, bee-eaters choose a suitable nesting site, and some pairs have been observed attempting to build nests. This confirms that bee-eaters arrive in pairs and lack suitable nesting sites.

The average number of eggs in the nest in *M. apiaster* is 6.4, the height of the eggs is 25.15 mm, the width is 20.96 mm, the shape index is 84.29%, and in *M. persicus* these figures are 6.2, 24.61 mm, respectively, 21.59 mm, 88.46%. The success of reproduction in the observed nests in *M. apiaster* (n=14) was 63.5%, while the departure of eggs was 7.3%, the death of chicks was 29.2%, and in *M. persicus* (n=14), respectively, 45.0%, 20%, 35.0% (Table 1). It was revealed that the success of reproduction in both studied species mainly depends on the level of protection of the nests. The death of eggs and chicks occurs as a result of the destruction of nests by predators, shepherds, beekeepers, as well as when digging quarries. Mass departure of chicks from nests in both species begins in the second decade of July.

In nests of bee-eaters, uneven development of chicks and sometimes death of the latter are observed. Unlike other species, in the chicks of these species, a thick lining forms in the lower part of the heel joint, which is not found in adults.

Bee-eaters are a typical insectivorous species. We noted 77 species of insects in the food spectrum of *M. apiaster*, and 65 species of *M. persicus*. In the post-productive cycle, a relative increase in the proportion of *Apis mellifera* in the stomachs of the genus Merops was observed. The nutritional composition and nutritional activity of bee-eaters vary depending on the following factors: differences in natural conditions in the places where the reproductive and post-reproductive cycles occur; the difference in flight times for different insect species, the phenomena of hyperphagia and lipogenesis that occur in preparation for autumn migration.
Table 1. The average number, size and weight of bee-eaters eggs, as well as the success of reproduction.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>M. apiaster</th>
<th>M. persicus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg length (mm)</td>
<td>25.150±0.078</td>
<td>24.361±0.119</td>
</tr>
<tr>
<td>Egg width (mm)</td>
<td>21.207±0.080</td>
<td>21.621±0.121</td>
</tr>
<tr>
<td>Egg shape index (mm)</td>
<td>84.531±0.386</td>
<td>88.900±0.007</td>
</tr>
<tr>
<td>Egg weight (g)</td>
<td>6.894±0.042</td>
<td>7.048±0.056</td>
</tr>
<tr>
<td>Average number of eggs in a nest</td>
<td>6.4 ta (5-7 units)</td>
<td>6.2 ta (5-7 units)</td>
</tr>
<tr>
<td>Egg death percentage</td>
<td>7.3%</td>
<td>20.0%</td>
</tr>
<tr>
<td>The percentage of death of chicks</td>
<td>29.2 %</td>
<td>35.0%</td>
</tr>
<tr>
<td>Breeding success</td>
<td>63.5%</td>
<td>45.0%</td>
</tr>
</tbody>
</table>

The feeding activity of bee-eaters is observed before the autumn migration. During this period, the mass of their stomachs and fat reserves in various parts of the internal organs (stomach, intestines, in the coccyx area) increase (Table 2). The analyzes confirm that the bee-eaters' fat reserves are accumulated by the phenomena of hyperphagia and lipogenesis occurring in the period before autumn migrations. These phenomena are important in the life of migratory species and the success of autumn migrations is directly related to these phenomena.

As can be seen from the table, the net weight of the stomach in M. apiaster increases on average from 1.39 g (May) to 2.15 g (October) and the growth rate was 54%. In M. persicus, these figures were 1.45 g (May), 2.37 g (October), and 63%, respectively.

It was revealed that bee-eaters are actively involved in biocenotic relationships as relationships such as commensalism and predation. As a result of lodging-type relationships, several species use bee-eaters' nests as hiding places and nesting sites. In a parasitic relationship, bee-eaters' food waste serves as a food source for some species. Predation is clearly manifested in bee-eaters, in predator-prey trophic relationships. The noted biocenotic connections play an important role in ensuring the stability of the biocenosis. The significance of species of the genus Merops in nature is also expressed in their participation in soil formation, physical and chemical properties of the soil.

The economic importance of bee-eaters has been studied and evaluated on the example of beekeeping farms. To date, the role of bee-eaters in beekeeping has not been sufficiently studied and measures have not been developed to prevent the damage they cause. For this reason beekeepers consider these species to be harmful and destroy them in prohibited and ineffective ways. Bee-eaters in their area of distribution cause damage to bee farms and such activity continues for two months (August-September). During this period, in beekeeping farms, their average number reaches a maximum of 14 pcs. per 10 ha, and the frequency of encounters of bees increases relatively in the composition of food. The harm caused by bee-eaters in beekeeping is local and short-lived, and this cannot be the basis for their destruction. Given the above, as well as the importance of bee-eaters in the fight against agricultural pests, these species are useful in the conditions of Uzbekistan.

Currently, in practice, the measures used to control the behavior of bee-eaters are mainly based on the direct destruction of them by shooting them and destroying their contents in the nest. The following problems have been identified in managing the behavior and protection of bee-eaters: different approaches to assessing the value of bee-eaters, the lack of appropriate recommendations for managing their numbers and protecting them, and the low effectiveness of repellents used in practice.
Table 2. Changes in bee-eater stomach mass as a result of hyperphagia and lipogenesis (n = 115, in grams).

<table>
<thead>
<tr>
<th>Months</th>
<th>Average total stomach weight (with food)</th>
<th>Average weight of food in the stomach</th>
<th>Average dead weight of the stomach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M. apiaster (n=47)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>3.73 (3.01-4.58)±0.078</td>
<td>2.34 (1.69-3.06)±0.060</td>
<td>1.39 (1.29-1.52)±0.011</td>
</tr>
<tr>
<td>June</td>
<td>3.70 (3.00-4.42)±0.065</td>
<td>2.06 (1.18-2.83)±0.062</td>
<td>1.64 (1.14-2.24)±0.048</td>
</tr>
<tr>
<td>July</td>
<td>3.86 (2.26-5.30)±0.117</td>
<td>2.06 (0.40-3.21)±0.089</td>
<td>1.80 (1.36-2.26)±0.039</td>
</tr>
<tr>
<td>August</td>
<td>3.87 (2.46-5.20)±0.102</td>
<td>1.95 (0.69-3.47)±0.102</td>
<td>1.92 (1.39-2.61)±0.045</td>
</tr>
<tr>
<td>September</td>
<td>4.21 (2.93-5.95)±104</td>
<td>2.19 (0.85-3.90)±0.102</td>
<td>2.02 (1.44-2.54)±0.047</td>
</tr>
<tr>
<td>October</td>
<td>4.31 (2.69-5.39)±103</td>
<td>2.16 (1.04-3.70)±0.100</td>
<td>2.15 (1.65-2.56)±0.029</td>
</tr>
<tr>
<td></td>
<td>M. persicus (n=68)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>2.72 (2.36-3.16)±0.08</td>
<td>1.27 (0.48-2.04)±0.088</td>
<td>1.45 (1.10-2.03)±0.045</td>
</tr>
<tr>
<td>June</td>
<td>3.06 (1.69-4.36)±0.106</td>
<td>1.47 (0.30-3.20)±0.092</td>
<td>1.59 (1.15-2.36)±0.062</td>
</tr>
<tr>
<td>July</td>
<td>4.69 (2.47-7.08)±0.156</td>
<td>2.79 (0.52-4.88)±0.128</td>
<td>1.89 (1.15-2.53)±0.027</td>
</tr>
<tr>
<td>August</td>
<td>3.68 (2.02-6.29)±0.110</td>
<td>1.63 (0.32-3.80)±0.100</td>
<td>2.04 (1.46-2.70)±0.030</td>
</tr>
<tr>
<td>September</td>
<td>4.05 (2.88-6.27)±0.143</td>
<td>1.87 (0.55-3.55)±0.096</td>
<td>2.17 (1.45-2.72)±0.018</td>
</tr>
<tr>
<td>October</td>
<td>4.51 (3.36-5.82)±0.085</td>
<td>2.14 (1.52-3.11)±0.08</td>
<td>2.37 (1.82-2.77)±0.010</td>
</tr>
</tbody>
</table>

We have tested and evaluated the effectiveness of bioacoustic repellents SAPSAN-3 and "KORSHUN-8 PRO" of Ukrainian production in beekeeping farms, as well as in bee-eaters overnight stays. When using these repellents in bee-eaters overnight, good results were obtained, and in beekeeping farms, on the contrary, since in farms the negative reactions of bee-eaters to these repellents appeared very slowly. This is explained by the low quality of the recorded sound intended for broadcast and the uniqueness in each region of the voices of individuals in the population.

We have proposed recommendations for eliminating existing problems in the field of bee-eaters behavior management and developed a bioacoustic repellent "Merops-distress signal". This bioacoustic repellent uses the voices of local populations of predatory species (Accipiter nisus, Falco tinnunculus) as well as bee-eaters distress calls as a deterrent sound. During the experiment of the bioacoustic repellent "Merops-distress signal" in the nocturnal colonies of bee-eaters, 100% results were recorded during the first session. When this repellent was broadcast in beekeeping farms in variants of 2.10, 16 and 25 minutes, it was found that their effectiveness is only 10-50%.

Practical recommendations:
- By recultivating old quarries around bee farms, creating inconveniences for the nesting of bees, not placing beehives near places where bee-eaters nest colonies (cliffs, steep rocks, collectors and ditches).
- Taking into account the fact that bee-eaters are strongly dependent on nesting sites during the reproductive cycle and live relatively stationary, and in the post-reproductive cycle they feed by migrating in large swarms, to establish the feeding of bees by migration until August.
- When placing beehives, choose places where there are no wires, pipes, dead trees installed on cypresses and other communication poles around them, and as thick as possible, thick trees.
- To identify the colonies of bee-eaters located in a radius of at least 3-5 km from the location of the bee farms by April and to close the opening of the nests and create opportunities for them to choose other nesting stations;
- To introduce the use of effective bioacoustic repellents in order to prevent the gathering of bee-eaters in bee farms.
• To shoot turkeys with various hunting weapons, catch them with nets and destroy their nests, absolutely limit the killing of eggs and chicks and consider these cases as illegal hunting.

4 Conclusion

In Uzbekistan, M. apiaster is widely distributed mainly in the mountainous and pre-mountainous areas, and M. persicus in the plain zone. In recent years, due to global warming, the lack of suitable nesting sites and the complication of trophic relations, interzation has been observed in the distribution of these species. The seasonal and diurnal dynamics of the number of bee-eaters depend on environmental factors, as well as the variability in the quantity and quality of food resources. The location of nesting stations and the structure of bee-eaters nests depend on the terrain, soil structure, and the degree of protection of the nest from the adverse effects of abiotic and biotic factors. The variability of the food composition and food activity of bee-eaters depends on their life cycle and insect ecology (migratory, reproductive and post-reproductive cycles, periods of flight and dormancy of insects). The increase in mass and accumulation of fat in the stomachs and internal organs of bee-eaters is the result of hyperphagia and lipogenesis occurring in preparation for autumn migration. Bee-eaters, participating in biocenotic relationships, play an important role in nature, and their harmful activity in beekeeping farms can be controlled. The developed bioacoustic repellent "Merops-distress signal" is intended to reduce the damage caused by bee-eaters to beekeeping farms. This repellent is effective in controlling the behavior of bee-eaters. M. apiaster and M. persicus are listed in the Red Books of some countries (Russia, Belarus), the damage they cause to beekeeping is local in nature and therefore the direct destruction of these species is inappropriate. To do this, it is necessary to ensure the participation of the general public, along with responsible organizations, in the development and implementation of measures to manage the behavior of bee-eaters and protect them.

References

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