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ORIGINAL ARTICLE

The ecological role of Accipitridae vultures in terrestrial landscapes of Azerbaijan

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Scavengers can provide ecosystem services to people by removal of dead animals that could become sources of disease. From such point of view, it seems appropriate to evaluate these benefits in Azerbaijan in quantitative terms. To this end, in 2013, an extensive monitoring was organized in the Turyanchay Reserve, which covers six regions and neighboring territories (the total population here is 640 thousand people). A high level of animal mortality in the Turyanchay Reserve is supported by the concentration of 24 species of wild mammals and 700 thousand domestic animals in the surrounding environment. The difficult terrain area is another factor leading to the death of animals. Animals grazing on hillsides often break down and die. The bodies of domestic and wild animals killed by wolves also often remain lying on this territory. In addition, vehicles traveling along the Agdash-Gabala highway cause the death of many domestic and wild animals. During the two months of the study (from June to July), 62 dead animals were found. Ten kinds of diseases were identified in 38 undecomposed bodies of these animals. Scavengers eat animal bodies in one-three days (without bones), preventing them from becoming a source of infection. The role of necrophages in minimizing of epizootic cases and improving sanitary conditions is important for ecosystems, because the blood of most animals is a carrier of diseases and most of the parasites present in it are common to both humans and animals. Scavengers can be used by veterinary organizations as indicators to simplify the identification of animal bodies and the subsequent disposal of their remains.

Keywords: ecosystems; scavenger birds; animal corpses; disease; indicators; Azerbaijan

Introduction

Scavengers provide three different ecosystem services (Beasley et al., 2015). First, they improve interconnection and therefore stability within food chains (Wilson and Wolkovich, 2011; Inger et al., 2016). Second, they can distribute nutrients both within and beyond ecosystems (Schlacher et al. 2015). The third factor is that the scavengers' sanitary functions associated with removing of animal bodies from the environment are most beneficial to people. The importance of scavenger birds as providers of ecosystem services can be illustrated by examples from around the world. For example, a significant anthropogenic decline in the number of vultures in India has led to an increase in the number of wild dogs and rats, which are both rabies and leptospirosis, and as a result, the amount of government spending on health is almost £ 10 billion per year (Markandya et al., 2008).
An outbreak of bovine spongiform encephalopathy in 2001 led to the introduction by the European Union of regulations that tightened the procedure for farmers to remove animal bodies of livestock. which were previously eaten by scavengers. The result was an increase in costs (Margalida and Colomer 2012), greater negative impact on the environment (Morales-Reyes et al., 2015) and detrimental effects on vulture populations (Margalida et al. 2010). Earlier, scavengers were widely used in many places around the world to remove food waste, carcasses and feces by eating vertebrates, but today these tasks are largely entrusted to modern sanitary methods, although scavengers are still used in some areas of Africa and India (Mundy et al., 1992).
Azerbaijan is one of the main habitats for these species. In the study area, many wild and domestic animals die for various reasons, including natural aging, drowning in rivers, falls from hills, falling into traps, traffic accidents, killings by predators, diseases and others. In addition, owners of dead animals leave them in landfills, throw them into ditches and rivers. Places where the majority of animal deaths occur belong to the areas where people live. As a result, "non-recycled" animal bodies become sources of infectious diseases for the population (Froloch, 2002; Reggenbusk et al., 2014; Beasley et al., 2015; Ingler et al., 2016). Based on the foregoing, we examined the "sanitary" role of scavengers in a particular area. To this end, we recorded dead animals in the area. We have identified the number of animal bodies representing sources of disease. In addition, we studied the time periods of eating these animal bodies by scavengers.

Material and methods

The study was conducted on the territory of the Turyanchay State National Reserve and in the surrounding areas (40°46'090"N 47°24'020" E; area 22,488 ha), covering a zone of 6 regions (Agdash, Gabala, Goychay, Yevlakh, Oguz and Sheki) of Azerbaijan (Figure 1). Field work was carried out from July to August 2013.

Figure 1. A- Map of the territory where the study was conducted in the Republic of Azerbaijan; B-Turyanchay State Nature Reserve and surrounding areas where animal bodies were discovered.

These areas were selected for research for the following reasons. In the nature of Azerbaijan, these areas are considered the main habitat and feeding areas for scavengers such as the Griffon vulture (*Gyps fulvus* Hume, 1869), the Black vulture (*Aegypius monac*hus Linn. 1766), the Egyptian vulture (*Neophron percnopterus* Linn. 1758) and the Bearded vulture (*Gypaetus barbatus*) Habl. 1783). A high level of animal mortality in the Turyanchay Reserve is supported by the concentration of 24 species of wild mammals and hundreds of thousands of domestic animals in the surrounding environment. The difficult terrain area is another factor leading to the death of animals. The Turyanchay, Goychay, Garachay rivers, canyon mountains 400-650 m high above sea level, as well as deep ravines created difficult terrain areas in the natural environment of the reserve and in the neighboring territories. Local sown areas and pastures are located on this territory, and rare forests grow on the slopes of the mountains and river banks. In the surrounding areas there are many settlements, towns (population of 400 thousand people), tourist sites and transport routes (Karimov, 2011).

Hard terrain causes the death of animals as a result of a fall from the slopes of hills and from rocks, death in river floods and on migration routes in summer and autumn.

We preliminarily carried out organizational work together with veterinary and sanitary personnel in order to quickly detect animal bodies and analyze biomaterial before decomposition of bodies. In addition, we also identified routes. The purpose of the study was explained to the officials of the reserve, herders, villagers and hunters. They informed us about the whereabouts of the animal bodies using mobile phones. Several observations were made morning and evening from a car during a trip along the Agdash-Gabala road passing through the territory of the reserve. In the daytime, when the probability of animal death was very high, observations were made around the Turyanchay, Goychay and Garachay rivers, as well as on pastures. For two months we drove a total of 375 km by car, rode 42 km on horseback and walked 17 km.

In the process of monitoring, we used the following devices: Yukon 10x50 binoculars, Kova TSN-601 telescope, Sony DSC No. 10 digital camera, and also Alsten x2 portable voice recorder.

During the monitoring period, we found 62 bodies of domestic and wild animals. The bodies of 38 of them were in an undecomposed state. Anatomical and pathological examination of 38 bodies revealed the presence of echinococcosis and pasteurellosis in the internal organs of 17 animals.

Of the bodies of animals 21 were selected as presumably affected by infection, so samples of their biomaterials (skin, heart, liver, spleen, bone marrow) were selected for analysis. Due to hot weather, these materials were stored in a liquid solution of pure glycerin (30%) and sterile paraffin oil. Each individual material was supplied with a document containing information including the following data: name of the animal species, organ, clinical signs and changes in the anatomical pathology, diagnosis, as well as the date of shipment, and after that each material was sent to a veterinary laboratory in the city of Agdash (7 km from the Reserve). For laboratory analysis, generally accepted methods were used (Zharov, 2000; Karimov 2001; Borisov & Morozov 2003)

Results

During June-July 2013, we found 62 bodies of animals in the Turyanchay National Reserve and neighboring areas. Of the 42 bodies, they were bodies of wild animals, and 20 were bodies of domestic animals. These bodies belonged to 7 species of wild and 6 species of domestic animals. Most of the bodies were found in more than 10 village pastures surrounding landfills, river valleys located near the areas of Turyanchay, Goychay and Garachay, as well as on the Gabala-Agdash highway. These were the bodies of animals that died for various reasons (they were killed by predator mammals, drowned in the river, were poisoned, fell into a trap, fell off rocks, died due to illnesses or were shot) (Figure 2). Among the 62 identified bodies, 38 (61.29%) had signs of various diseases. Consequently, among theese 38 animal bodies 22 (57.89%) belonged to seven wild species of animals. Animals that transmit the disease: Red fox (*Vulpus vulpes* L.), Golden jackal (*Canis aureus* L.), Wild boar (*Sus scrofa* L.), Grey wolf (*Canis lupus* L.) Brown hare (Lepus *europaeus* Pall.), European badger (*Meles melis* L.) and American raccoon (*Procyon lotor* L.). Among domestic animals, various diseases were detected in the bodies of a Cow (*Bos taurus domesticus)*, Domestic buffalo *(Bubalus b. bubalis*), Donkey (*Equus africanus asinus)*, Horse (*Equus ferus caballus)*, Domestic sheep (*Ovis aries*) and domestic dog (*Canus lupus famillaris)*. The table below describes the causes of death, the number of carriers of diseases and diseases found in bodies (Table 1). Among these 34.22% were infected with echinococcosis, 23.68% with rabies, 10.52% with tuberculosis, 10.52% with toxoplasmosis and 5.26 % with brucellosis. One of the two dead buffaloes was infected with anthrax, 1 out of 5 raccoons was a carrier of canine plague, and 1 was infected with pasteurellosis. Echinococcosis was found in 13 animals. The main carriers of this parasite were Red foxes (n = 5), Grey wolves (n = 3), stray Domestic dogs (n = 3) and Golden jackals (n = 2).

June-July is a period of increased need for food and intensive feeding of nestlings. At this time, we counted from 3 to 110 scavengers around one animal body, depending on its size. Griffins were 40% of these birds, Egyptian vultures - 30%, Black vultures - 26%, and Bearded vultures - 5%.

Table 1. Animal losses registered in the Turyanchay State Nature Reserve and neighboring areas within Jume-July of 2013.

Animal	Iindividuals	Death cause	Disease registered	Carrier of disease
Cow	1	disease	brucellosis	1
Buffalo	2	catch disease, drowned in river	anthrax	1
Donkey	1	killed by wolf	adenitis equorum	1
Horse	1	natural death, disease	adenitis equorum	1
Boar	1	disease	pasteurellosis	1
Sheep	7	infected by wolf, disease	tuberculosis rabies	4 1
Wolf	9	trapped, shooting dead	rabies, echinococcosis	1 3
Jackal	6	shooting dead, trapped	rabies, echinococcosis	2 2
Fox	14	knocked down by a car, shooting dead	rabies, echinococcosis	2 5
Domestic dog	7	disease, death by starvation	rabies, toxoplasmosis echinococcosis	3 1 3
Brown hare	2	knocked down by a car	brucellosis	1
Badger	6	knocked down by a car, disease	tularemia toxoplasmosis	1 3
Raccoon	5	shooting dead, trapped	canine distemper	1
Total	62		10	38

Scavengers found animal bodies in two ways: by collective search or by following wolves and crows (*Corvus cornix* L.). Scavengers have a number of features that increase the efficiency of their searches in order to detect animal bodies. Using in-flight "inspection" and sharp eyes, they can faster and more efficiently than mammals visually inspect a large area. They are able to use social information from conspecifics to locate the animal bodies (Inger et al. 2016). In other words, the landing of one of the flying and following each other griffins is a warning to the remaining birds about the availability of an animal body. Scavengers track wolves (about 100 individuals in the reserve and surrounding areas) who hunt in the afternoon and then eat the remains of animals killed by wolves. Noisy hooded crow clusters are also a signal of the presence of animal body.

Eating by the necrophagous birds the bodies of animals that are noticed by hooded crows and killed by wolves is of great importance since following eating a portion of an animal body, wolves usually leave or hide the other parts. As a result, the remaining parts become a source of disease.

Body weights of animal bodies affected the number of birds gathering around them. In other words, a maximum of 100-110 scavengers gathered around the animal bodies (n = 5) of cows, horses, donkeys and domestic buffalo weighing 100-250 kg. The soft parts of the animal bodies were eaten within 2-3 hours, and 5-10 birds ate the remaining parts the next day. During the monitoring, we noted that the soft parts (without the bones) of one large animal body were eaten by scavengers for a maximum of 2 days. A body of a relatively smaller size was eaten within 1-2 hours.

It should be noted that animal bodies of heavier weights attracted mainly Griffons and Black vultures. The skins and muscle parts of the bodies were consumed by Black vultures, the inward parts of the body by griffins, and the remains by Egyptian vultures. Vultures flew into the area during intensive feeding of the nestlings, although they do not nest in the reserve. Compared to vultures, Griffins and Black vultures, Egyptian vultures do not shy away from humans, so they mostly gather around of animals bodies of lesser weight that died from a collision with a vehicle and were buried in landfills. A similar conclusion was made on the basis of the fact that 12 of the 22 Egyptian vulture nests were located near the Agdash-Gabala highway (500-2000 m), the road on which there were always dead animals. We registered 21 bodies of Red fox, European badger and Brown hare, who died as a result of traffic accident on the Agdash-Gabala highway. One body was completely eaten by 3-5 vultures within 1-2 hours.

The number of the 62 bodies found in the reserve and its environs, 42 (67.7%) belonged to wild animals. This was due to an increase in the number of animals during June-July at the end of the breeding season. At this time, the facts of death were mainly found among inexperienced as well as weak and sick individuals with insufficient adaptive reaction. Another reason was the reduction of animal feed sources. A hungry animal was forced to seek food near settlements (landfills, yards and pastures). As a result, they were killed by people. When approaching areas of residence, sick animals can infect domestic animals. We found that wolves, foxes and jackals infect domestic dogs and sheep with rabies, as well as echinococcosis. In connection with the spread of rabies in Azerbaijan, about 250 thousand dogs were vaccinated in 2014. In the study region, 22.3% of dogs caught echinococcosis (Karimov, 2011).

In most areas, it is not possible to isolate settlements of wild animals that are carriers of diseases, vaccinate them, eliminating infections (mainly on pastures, migration roads) and cure sick domestic animals in a timely manner. (Grass 2007). The role of necrophagous birds in minimizing epizootic cases and improving sanitary-hygienic and conditions is important, since most wild animals carry about 50 diseases in their blood and most of these parasites are common for both humans and animals (Karimov 2011). The bodies that these birds feed on quickly decompose and are destroyed by microorganisms that release a number of harmful toxins. This makes decaying flesh a dangerous food source for most animals (Peisley ey al., 2017; Grelli et al., 2019).

Scavengers are resistant to bacterial toxins in decaying meat and occupy a key niche in the ecosystem in which they evolved (Roggenbuck 2014). Vultures are endowed in every sense with very strong stomachs. Being at least ten times higher than the acidity level of human stomach the stomach acidity level of vulture destroys a large number of potentially pathogenic bacteria.

Two types of anaerobic fecal bacteria - Clostridia and Fusobacteria. (Roggenbuck et al. 2014) predominate in the colonic microbial flora of the vulture. Both Clostridia and Fusobacteria are common soil bacteria. However, Clostridia have been documented as the cause of severe food poisoning in both humans and chickens, and are causing the periodic extinction of wild birds such as waterfalls and coastal birds. Meanwhile, the toxic effects of pathogenic bacteria on the metabolism of griffons are neutralized by clostridia and fusobacteria, as well as stomach juice (Van Immerseel et al., 2004; Grass et al., 2013). A deeper understanding of the importance of scavengers in ecosystems and their role in improving human well-being will probably lead to a better understanding of the species and eco-services that they provide.

Figure 2. Undecomposed animal bodies. 1 - a buffalo drowned in a river, 2 - a cow that fell from the rocks, 3 - bones of a horse killed by wolves; 4 - the remains of dead birds consumed by scavengers.

Conclusion

An analysis of the collected materials confirms that the Black vulture, Griffon vulture, Egyptian vulture, and Bearded vulture have a positive effect on sanitary conditions in natural and anthropogenic ecosystems, eating bodies of 38 bodies of animals that are carriers of echinococcosis and diseases in 6 regions. Scavengers can be used by veterinary organizations as indicators to simplify the identification of animal bodies and the subsequent disposal of their remains.

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