A REPORT OF RSPB-SUPPORTED SCIENTIFIC RESEARCH AT KOYTENDAG STATE NATURE RESERVE, EAST TURKMENISTAN

COMPILED BY GEOFF WELCH

EDITED BY GEOFF WELCH, PAVEL STOEV

rspb giving nature a home

PENSOFT

A REPORT OF RSPB-SUPPORTED SCIENTIFIC RESEARCH AT KOYTENDAG STATE NATURE RESERVE, EAST TURKMENISTAN

Compiled by Geoff Welch

Edited by Geoff Welch, Pavel Stoev

A REPORT *of* RSPB-SUPPORTED SCIENTIFIC RESEARCH AT KOYTENDAG STATE NATURE RESERVE, EAST TURKMENISTAN

Compiled by Geoff Welch

Edited by Geoff Welch, Pavel Stoev

PENSOFT

2019

A report of RSPB-supported scientific research at Koytendag State Nature Reserve, East Turkmenistan

Edited by Geoff Welch, Pavel Stoev

Maps by Atamyrat Veyisov

Citation:
Welch G, Stoev P (Eds.) (2019) A report of RSPB-supported scientific research at Koytendag State Nature Reserve, East Turkmenistan. Pensoft Publishers, Sofia, 88 pp.

or

Georgiev K, Menliev S, Linnell J (2019) Mammals. In: A report of RSPB-supported scientific research at Koytendag State Nature Reserve, East Turkmenistan. Pensoft Publishers, Sofia, 77-82 pp.

First published 2019
ISBN 978-954-642-968-1 (paperback) (Pensoft Publishers)
ISBN 978-954-642-967-4 (e-book) (Pensoft Publishers)

PENSOFT Publishers
12, Prof. Georgi Zlatarski Str.
1111 Sofia, Bulgaria
e-mail: info@pensoft.net
www.pensoft.net

Printed in Bulgaria, July 2019

All of the work in Turkmenistan detailed in this report was carried out under the Memorandum of Understanding between the Ministry of Agriculture and Environment Protection of Turkmenistan and the Royal Society for Protection of Birds, within the Project on "Improvement of the status of birds and other biodiversity in Turkmenistan".

rspb giving nature a home

Figure 1. Camera trap training. Photo credit: Jeremy Holden (RSPB).

Figure 2. Bird survey training. Photo credit: Jeremy Holden (RSPB).

Figure 3. Survey team at sinkhole near Garlyk. Photo credit: Jeremy Holden (RSPB).

Table of Contents

Figure 4. Location of Koytendag. Map by Atamyrat Veyisov.

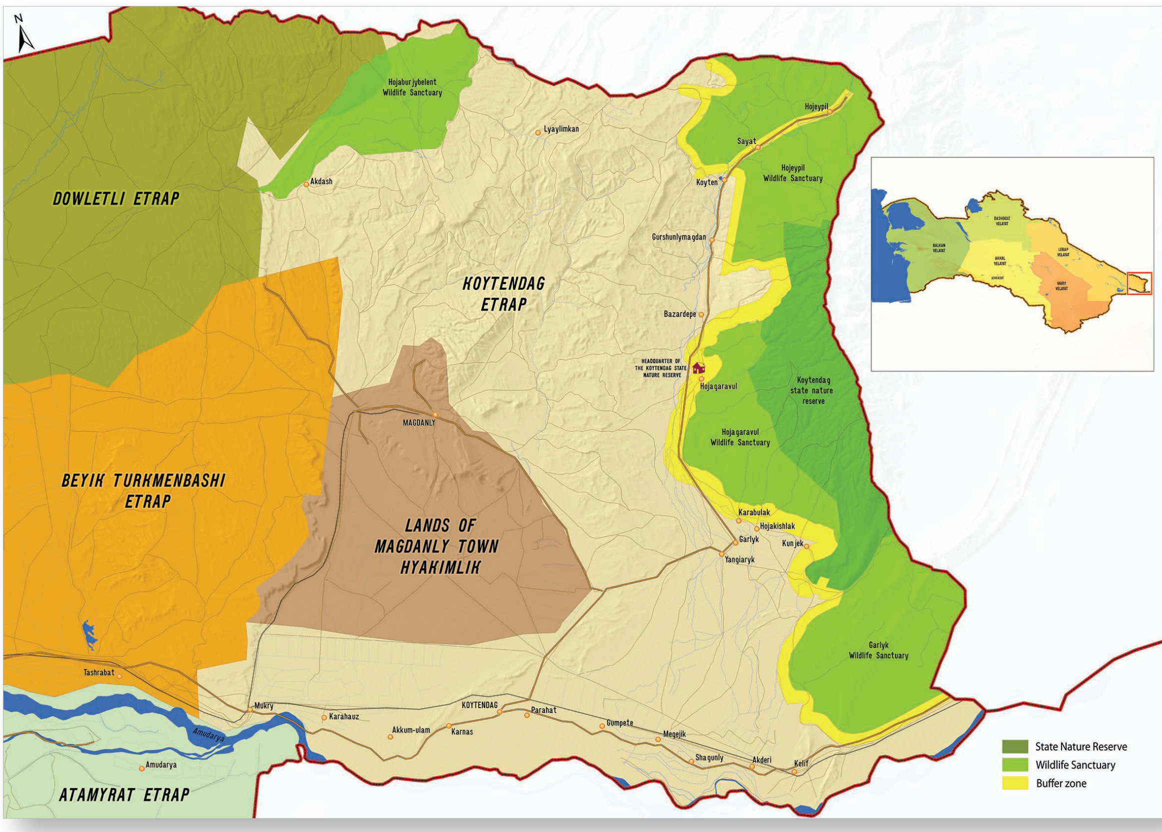


Figure 5. Boundaries of Koytendag. Map by Atamyrat Veyisov.

Introduction

Situated in the extreme south-east of Turkmenistan, on the international border with Uzbekistan and close to the border with Afghanistan, Koytendag presents one of the most distinctive landscapes in Central Asia – see figures 4 and 5. The state nature reserve and wildlife sanctuaries that form the site extend from the hot, dry semi-desert plains of the Amudarya valley to the snow-capped peaks of Airy-baba. Rising to 3,137 m, this is the highest mountain in Turkmenistan. The Koytendag ridge (former Kugitang or Kugitangtaw) is a continuation of the Gissar ridge, itself the south-western end of the Pamir-Alay mountain range – a mountain chain that extends for over 800 kms from the Pamirs to the Tien-Shan with more than thirty-five peaks over 5,000 m.

Based on Udvardy's biogeographic classification (Udvardy 1975) Koytendag is situated in the Palaearctic Realm, Pamir-Tian-Shan Highlands Province, in a transition area between mixed mountains and highland systems with complex zonation and cold-winter (continental) deserts and semi-deserts. The site lies close to the borders of three other Udvardy Provinces: the Turanian, the Hindu Kush Highlands and the Anatolian-Iranian Desert and contains elements of the flora and fauna of each of these Provinces. The site is also one of 50 Important Bird and Biodiversity Areas (IBAs) in Turkmenistan, with biome-restricted bird communities from three biomes, and lies within the Central Asian Mountain Forests and Steppes WWF Global 200 Ecoregion and the IUCN/WWF Mountains of Central Asia Centre of Plant Diversity.

The Koytendag region is characterized by high mountain ridges dissected by deep canyons, many over 100 m deep. Each canyon has a distinct flora and features resulting in the region having great aesthetic, scientific, recreational and touristic importance. In the lower parts of the western slopes of the Koytendag ridge, the landscape is dominated by steep escarpments and cliffs. In the central section, there is an extensive area of very steep-sided, winding valleys bordered by a dramatic karst landscape. Erosion of the Jurassic limestone has created a complex of more than 300 caves, shafts and sinkholes, considered to be among the most important cave systems in Eurasia. These caves contain an extremely diverse array of geological formations and support a unique cave fauna. Along the south-eastern slope of the Koytendag ridge are several alluvial fans, some still with running water but many are permanently dry.

The plains are dominated by low wormwood scrub and patches of tamarisk but as altitude increases these give way to grazed pastures, extensive areas of juniper woodland, with a rich carpet of tulips and primulas in spring, finally becoming a rocky, but equally striking, alpine zone with low cushions of prickly thrift. The numerous, seasonal springs and streams provide important patches of more diverse and lush vegetation – see figures 6 to 10.

Figure 6. Habitat at Koytendag. From Airy-baba looking south-west. Photo: Jeremy Holden (RSPB).

Figure 7. Habitat at Koytendag. Juniper woodland at Maydan. Photo: Jeremy Holden (RSPB).

Figure 8. Habitat at Koytendag. Daraydere river. Photo: Jeremy Holden (RSPB).

Figure 9. Habitat at Koytendag. *Artemesia* scrub in the Koyten valley. Photo: Jeremy Holden (RSPB).

Figure 10. Habitat at Koytendag. Dry landscape of the Koytendarya valley. Photo: Jeremy Holden (RSPB).

Table 1. Regular annual monitoring and research at Koytendag State Nature Reserve.

Factor		Periodicity	Location of records
Biological resources			
Plants	Phenology	1-2 times/month during spring and summer	The headquarters administration of Koytendag State Nature Reserve in Bazardepe village and Ministry of Agriculture and Environment Protection of Turkmenistan in Ashgabat
	Distribution – Red Data Book species only	1-2 times/month during spring and summer	
Birds (limited range of species at present)	Species, numbers and general distribution	1-2 times/month during spring, summer and winter	
Markhor and Urial	Number of males/ females/ young and general distribution	Spring and autumn (10-15 day survey periods)	
Fauna - general	Camera trapping in 2013 and 2014	Throughout the year	
Geological objects			
State of geological Nature Monuments	Visual assessment of condition	Throughout the year	The headquarters administration of Koytendag State Nature Reserve in Bazardepe village and Ministry of Agriculture and Environment Protection of Turkmenistan in Ashgabat
Caves (by specialists of the Koytendag Geology Research expedition)	Air temperature, humidity and radioactivity outside and inside cave entrances plus 3-4 sampling points deep within the caves	Monthly	
Environmental			
Meteorological data (from Etrap meteorological station in Koytendag town)	Air and soil temperature, precipitation, wind speed and direction, humidity	Daily	The headquarters administration of Koytendag State Nature Reserve in Bazardepe village and Ministry of Agriculture and Environment Protection of Turkmenistan in Ashgabat
Water resources - General	Dynamics of seasonal watercourses	Seasonal	
Kaynarbaba lake and Aksuw (by specialists of the Koytendag Geology Research expedition)	Air and water temperature, and levels of radioactivity (U and Ra) and hydrogen sulphide H_2S	Monthly	

Protection

Koytendag State Nature Reserve and three Wildlife Sanctuaries – Hojapil, Garlyk and Hojaburjybelent – were established between 1986 and 1990 to protect and preserve the mountain ecosystem of the Koytendag region and to maintain the ecological balance between the environment and increasing economic activities. Together these covered an area of 116,366 ha. Of particular importance was the protection of rare species such as markhor, important habitats such as pistachio and juniper forests, and the impressive dinosaur trackways at Hojapil. In 1990 the area under protection was increased to 122,377 ha with the establishment of a fourth Wildlife Sanctuary, Hojagarvul. In 2014, minor revisions were made to the boundaries of Hojapil, Garlyk and Hojagaravul Wildlife Sanctuaries and a 18,112 ha buffer zone was added so that currently a total of 129,047 ha is under protection and management.

Scientific research

The natural wonders of Koytendag have been studied for many years but much of the research has focussed on the paleontological and geological features of the site, with the result that many aspects of the site's biodiversity are still comparatively poorly known and documented. In 2012, at the instigation of the President of Turkmenistan, Gurbanguly Berdymukhamedov, the Turkmen Government decided to nominate Koytendag as the country's first UNESCO Natural World Heritage Site. The first stage in this process was the organisation of a major scientific expedition and conference in spring 2012. With the participation of experts from over 20 countries this provided an opportunity to highlight and review the international importance of the site. A major outcome of this expedition and conference was the signing of a Memorandum of Understanding (MoU) between the Ministry of Nature Protection of Turkmenistan (now the Ministry of Agriculture and Environment Protection of Turkmenistan) and the RSPB. Under this MoU the RSPB has provided, and continues to provide, technical support to Koytendag to assist with the preparation of the World Heritage nomination dossier, production of an up to date site management plan, and resources and training for key reserve staff. The MoU also covers Bathyz State Nature Reserve in south-east Turkmenistan which is another potential UNESCO Natural World Heritage Site.

Coordinated and funded by the RSPB, three teams of international biodiversity experts visited Koytendag between 2013 and 2015, plus separate technical visits to develop the management plan and run training courses, and the results of these visits are presented in this report.

In addition to these dedicated surveys, reserve staff implement an annual monitoring programme – see table 1 – which covers selected biological, geological and environmental factors and provides a basis on which the dedicated surveys can build.

Scientific research

1. Hydrogeology

2. Flora

3. Surface-dwelling invertebrates

4. Cave fauna

5. Fish

6. Amphibians

7. Reptiles

8. Birds

9. Mammals

Figure 11. Entrance to new underground lake (Photo credit: Mikhail Pereladov).

1. Hydrogeology

Aleksandr Degtyarev and *Mikhail Pereladov*

Whilst the majority of research has concentrated on the biodiversity of the site, limited work has also been carried out on the hydrogeology of the site because it has played, and continues to play, a key role in the development of the site; it supports a unique cave fauna; and it provides an essential resource for local communities.

1.1 Background

The characteristic features of the hydrological regime of the Koytendag ridge can be attributed to the high rate of precipitation filtration by the soil, the presence in the mountain ridge of several aquifers and the abundance of gypsum rock, which has formed large underground cavities with varying degrees of flooding – *see 1.4 Discussion regarding the karstic nature of the site for more details*. Together these have led to the formation of several hundred water sources of various types including springs, wells, sinkholes, cave lakes etc. As well as physical differences, water bodies vary in relation to chemical composition, temperature, inter/intra-annual fluctuations in volume etc. These variations have, in turn, influenced the development of different cave fauna complexes.

1.2 Methodology

A total of 13 water bodies were visited – see table 2 and figure 12 – with locations being representative of the valley of the Koytendarya throughout its length and in transverse section. At each location information was collected on water temperature, flow rate, chemical composition and presence of biota.

Due to time limitations, many water sources such as those on the western side of the valley remain unexplored. Similarly, it was not possible to collect information on hydrogeological dynamics such as intra-annual and long-term fluctuations. Field data was complemented with information from the literature. Recommendations for future work to address these limitations are given in section 1.5.

Table 2. Water bodies surveyed in May 2015.

Date	Site name	GPS coordinates
24/05	Kaptarhana	N 37° 49.686’ E 066° 24.627’
25/05	New cave near Hojapil	N 37° 56.750’ E 066° 39.245’
25/05	Spring near Koyten village	N 37° 55.172’ E 066° 29.242’
26/05	Suw Oyuk sinkhole	N 37° 35.806’ E 066° 24.322’
27/05	Suw Oyuk and neighbouring sinkholes	N 37° 35.806’ E 066° 24.322’
28/05	Gulshirin	N 37 ° 40.345’ E 066 ° 23.218’
29/05	Hashim-Oyik	N 37 ° 38.545’ E 066 ° 22.967’
30/05	Lead mine galleries	N 37 ° 38.553’ E 066 ° 22.958’
30/05	Soouk-Komar	N 37° 44.328’ E 066° 21.512’
31/05	Aksay	N 37° 44.938’ E 066° 23.558’
31/05	Big sinkhole with cold air	N 37° 41.368’ E 066° 19.284’
31/05	Cold air grotto	N 37° 41.155’ E 066° 19.159’
31/05	Entrance to large underground lake cave	N 37 ° 39.330’ E 066 ° 20.801’
01/06	Gap-Gotan	N 37 ° 38.497’ E 066 ° 24.428’

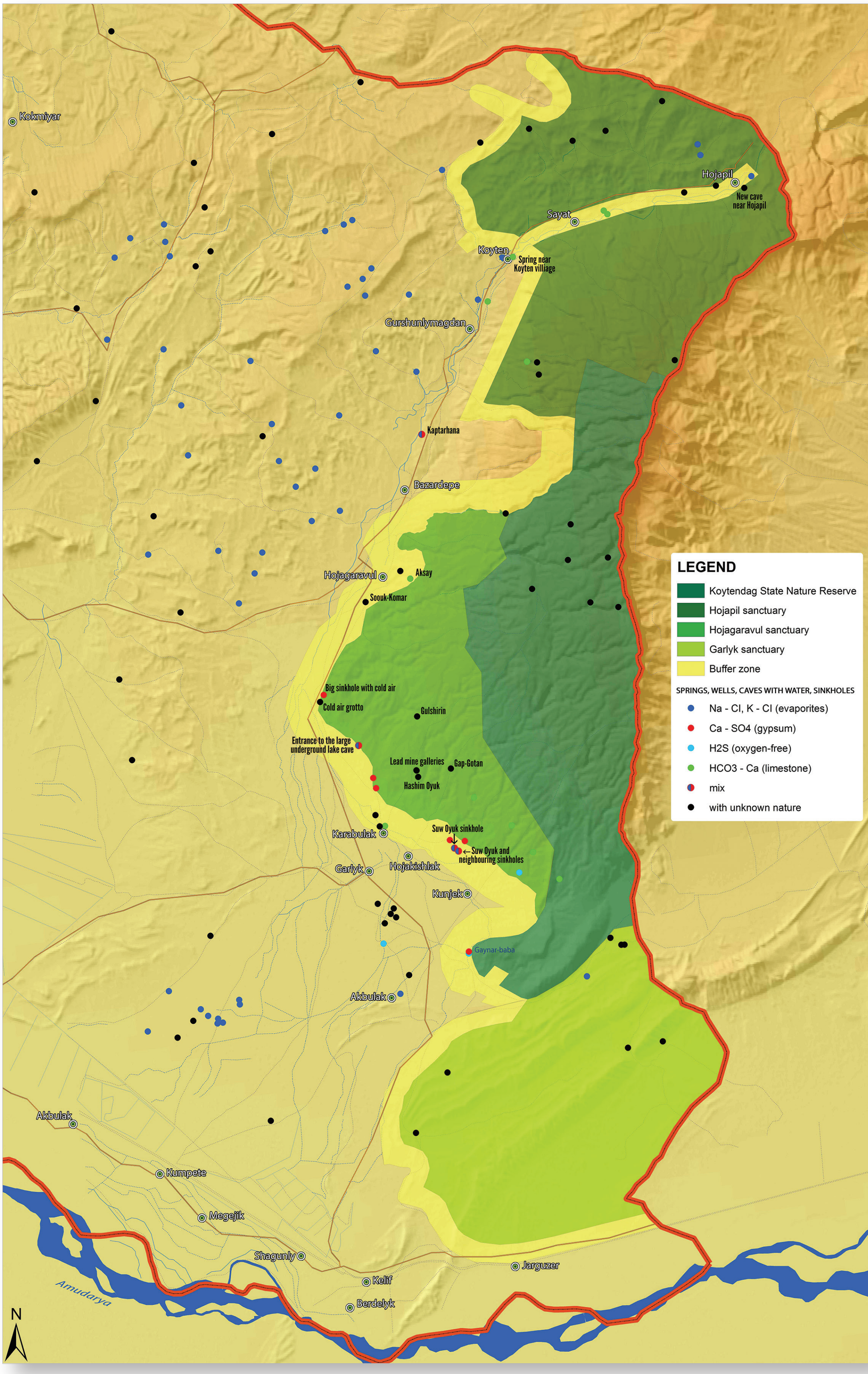
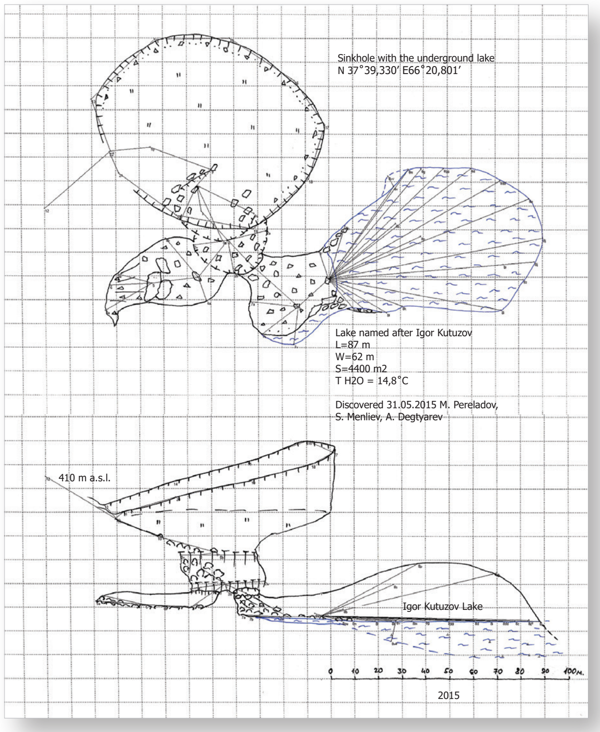


Figure 12. Caves and springs at Koytendag. Map by Atamyrat Veyisov.

Figure 13. Sketches of newly discovered cave with lake.



1.3 Results

1. New cavity with several dry sinkholes and running water near Hojapil village discovered. The estimated length of the underground cavity is approximately 100 m, with a depth of approximately 25 m.
2. New sinkhole with dry lake in the bottom discovered.
3. New cave with an underground lake – see figure 13 – discovered. The area of the lake is estimated to be 4,400 m^2 making it the largest underground lake not only in Turkmenistan but also in the whole territory of the former USSR. Although no biota have yet been found in the lake, studies should continue.

1.4 Discussion

Based on physical characteristics, five principle types of water body have been identified:

1. Highly mineralized water bodies in gypsum caves fed by water draining the mineral salt zone eg Kaptarhana. The fauna in these water bodies is represented by a complex of maritime relict species (Birstein and Lyovushkin 1967), as well as fish from the nearby river.
2. Small lakes and pools in the caves of the ridge, usually with a volume of only a few cubic metres. An exception is the lake in the Krasnoyarsk cave system at Gap-Gotan, which is approximately 10 m in length with an average depth of 40-50 cm. In contrast to the water bodies that have access to the surface, all of these water bodies are non-flowing, small in volume and are fed by water filtering through surface sediments. The fauna in these waters was not studied in 2015.
3. Water bodies occurring in gypsum, stable in volume with a weak inter-annual water exchange eg gypsum sinkholes in the foothills, including the sinkhole with the blind loach, sinkholes with lakes of variable water level and the lower horizons of the Karabulak sinkholes.
4. High mountain lakes in the limestone caves with standing fresh water – there is one known lake in this category in the upper An Dere canyon. The fauna in this lake was not studied in 2015.

5. On the basis of drilling data, there is a zone of artesian fresh water in the limestone under the valley at a depth of 200-300 m, but there is no information on these reservoirs.

Water bodies can also be classified according to their hydrochemical composition:

1. Calcium-hydrocarbonate HCO_3^- – Ca^{2+}. These waters form after contact with limestone. Salinity is usually up to 300 mg/l. Examples include two springs in the area of Hojapil, the spring near the remnant forest on the outskirts of Koyten village, the Aksay spring, and the Karabulak spring.
2. Gypsum – Ca^{2+} – SO_4^{2-}. These waters form after contact with gypsum or anhydrite. Mineralization may be high, up to 2.5 g/l. One example is the Upper-Kaynar spring (2.5 g/l).
3. Hydrogen sulfide water – H_2S. These waters are oxygen-free and form in the presence of organic matter. Salinity is low, up to 0.5 g/l. Examples include the lower Kaynar spring and Kunduzke spring, 6 km west of Kaynar and a spring 6 km to the east of Kaynar.
4. Salty and bitter-salty springs. Cl- – Na+ and Cl- – K+ water. These waters form after contact with evaporates such as halite (NaCl) and silvina (KCl). Mineralization may be up to several hundred g/l. Almost all of the springs on the western bank of the Koytendarya are of this type. None have been recorded on the eastern bank.
5. Waters of mixed chemistry eg salt water with gypsum or salt-gypsum-hydrocarbonate. Mineralization is >2.5 g/l and should be referred to as Cl- – Na+ and a Cl- – K+. Examples include Kaptarhana (11 g/l), sinkhole with the underground lake (3 g/l) and the Suw Oyuk sinkhole (5 g/l).

From the work carried out to date and the known geology of the area, it appears that there are three distinct and separate hydrochemically homogeneous systems at Koytendag:

1. The western bank of the Koytendarya. Almost all water sources are salty or bitter-salty. According to a geological map of Koytendag the surface of this area consists of lower and upper Cretaceous deposits. These red-coloured Cretaceous sediments cover salt-bearing (upper Cretaceous) strata, belonging to the late Jurassic J_3.
2. The Koytendag karst massif to the east of the Koytendarya. All springs surveyed were of calcium hydrocarbonate and the rocks are limestones of the Celloveian-Oxfordian age (J_3cl-ox).
3. The downstream section of the Koytendarya valley where it becomes a wide alluvial plain, adjacent to the channel of the Amudarya. Here there are up to 40 sinkholes, some dry others with water. All are based on gypsum with brackish water. The sinkholes were formed by the dissolution of the gypsum-anhydrite strata of kimmeric – Tithonian (J_3km-t) age with a subsequent collapse of the red-layer of the roof. This region also includes a large water-filled cavity with a diameter of 100+ m and a depth of 80+ m.

The Koytendarya is the boundary between gypsum and hydrocarbonate facies on the eastern side and salt facies on the western side. Its water is a product of their mixing. At its source (elevation 930 m) the water of the Koytendarya is hydrocarbonate-calcium and salty. In Koyten village on the eastern side of the valley an efflorescence with a characteristic taste of silvinite (KCl) was found. At altitudes of about 500 m the Koytendarya begins to dry out, branching and merging in a thick layer of alluvial deposits. The river then flows beneath the surface and streams are only observed during seasonal floods. At an altitude of about 260 m the water of the Koytendarya discharges into the Amudarya through submarine springs.

The findings of the 2015 survey and the literature raise several interesting questions regarding the hydrogeology of Koytendag.

1. Sinkholes in gypsum-bearing strata. These increase in number with decreasing altitude – singles (Kaptarhana and the 'Dead Lake' near Koyten) at c. 600 m; at the junction of the slope of the mountain and the river valley at c. 500 m there are scattered examples, then dozens are located in the bottom of the valley at 320–400 m. Although gypsum-bearing strata can be seen on the steep slopes of the Koytendag mountains, no sinkholes are known outside of the valley. The formation of sinkholes requires a combination of gypsum-bearing strata and a relatively constant supply of flowing water. At Koytendag this only occurs as groundwater associated with the river. The formation of sinkholes never occurs where there is only standing water. This explains the number of sinkholes found at the junction of the valley and the mountain slope and indicates that there is a movement of groundwater below the surface of the valley.

The morphology of sinkholes at Koytendag, with a predominance of vertical and even inwardly-sloping walls suggests that the process of dissolution of the gypsum strata is recent (on a geological time scale) and in one of the initial stages of development, i.e. they are of geomorphologically young origin. There is no reason to associate their formation with previous wet periods.

2. Subterranean water movement. Movement of water through the red-coloured and gypsum deposits of the alluvial layer on the plain has not been recorded but there is a theoretical possibility of water movement from the riverbed to the east through gypsum caverns or cavities. Salty water, characteristic of water in the Koytendarya, was noted in gypsum sinkholes that are level with the river (Kaptarhana [8.5g/l NaCl], Suw Oyuk [2.5g/l NaCl], in the sinkhole with the underground lake [0.5g/l NaCl], and the sinkhole with sazans). This indicates a flow of groundwater from the river to the sinkholes in a south-eastern or eastern direction. This, however, does not exclude the movement of hydrocarbonate-calcium waters of the karst massif from the north or north-east to the south or south-west i.e. from the mountains to the river, or from the north-west to south-east i.e. again from the mountains but along the course of the river. A mixture of chloride and hydrocarbonate waters occurs in the alluvial and gypsum-bearing rocks on the east bank between the river and edge of the alluvial valley.

3. Correspondence of water levels in sinkholes with the water level in the riverbed. This has been recorded for Kaptarhana, the sinkhole with the underground lake, Suw Oyuk and the sinkhole with sazans. There are currently no known sinkholes with suspended lakes, however, such lakes were observed in the 1980s – in the now dry Kooushner`s sinkhole (fluctuation exceeding 10 m), the now dry Smirnoff`s sinkhole (10+ m), the sinkhole with the underground lake (recent remains of aquatic plants at a height of 15+ m above the present level of the lake) and the dry sinkhole with cold air (10+ m). In the case of the last two mentioned, water levels were probably higher within the last few years. Such fluctuations are not linked to fluctuations of the groundwater level since the water level in the Suw Oyuk sinkhole, only 700 m from from Kooushner`s and Smirnoff`s sinkholes, would also fluctuate but its level does not change. Possible explanations are that there are canals, caverns or cavities in the substrate which periodically open and close or fluctuations are linked to major fluctuations in precipitation from year to year combined with difficulties in runoff.

4. Cave and water temperature. From the theory of karst massif formation, at least in areas with humid climates, they are supercooled in comparison with the average atmosphere. This is because the temperature in the atmosphere decreases by 6.5^0 C for each 1 km change in altitude. In addition, snow and rain water that has penetrated deep into the karst massif loses thermal contact with the atmosphere. The temperature inside the massif is determined by the heat generated by the movement of geothermal water – the potential energy of water is completely converted into kinetic energy and then fully into heat. This results in a warming of 2.34^0 C for each 1 km change in altitude. In other words, if, at a given altitude, the atmosphere and water entering the massif have the same initial temperature, at the outflow from the massif, i.e. a karst spring, the temperature will be $6.5^0 - 2.34^0 = 4.16^0$ C below the average temperature of the atmosphere for each kilometre change in altitude. This explains why very deep karstic springs contain abnormally cold water.

Measurements were made of several springs at the foot of the mountain – Two Springs close to Hojapil, the spring near the relict forest on the outskirts of Koyten village, Aksay spring, the highland spring near the Lead Mine and Karabulak spring – and these gave a paradoxical result, all temperatures were close to the atmospheric average. This is confirmed by the temperature of the caves at Gulshirin, Hashim-Oyuk and Gap-Gotan. In these caves air temperatures are close to the average annual atmospheric temperatures at the same altitude i.e. the entire massif does not show signs of negative anomalies in temperature. This means that none of the identified watercourses has passed through the massif, rather they all drained through the surface layers of soil and loose sediments which were in thermal contact with the atmosphere.

5. Karst features at Koytendag. The conclusion above regarding the movement of water through the Koytendag massif creates an interesting paradox – the karst massif in its present form is, apparently, not really karstical. Because of the large number of caves, this statement seems wrong. However, it should be noted that:

a) there is an almost complete absence of surface karstic formations on the surface of the mountain;

b) there are numerous deep canyons;

c) there is a general lack of water in the caves.

Typical karst topography is characterized by a large number of karstic craters and sinkholes and a complete lack of a surface river network. Koytendag exhibits the opposite i.e. a river network and an absence of craters. The lack of water in the caves can be explained by current aridity of the climate. Pluvial epochs, corresponding to the epochs of glaciation in Europe, could be accompanied by more humid conditions in the caves but the development of the canyons and the lack of surface karst forms are explained only by the absence of karstic capability of the rocks. It seems likely that Maltsev, who carried out detailed research of the karst systems of Koytendag, was correct in proposing that the karst systems are a relict, only activated in the recent geological past. However, the paradox remains because during the formation of the massif the rocks obviously exhibited karstical properties.

Karstical capability is determined not only by the solubility of the rocks but also by their fracture characteristic. The same rock may be karstical and non-karstical depending on the presence or absence of cracks. For example, cracks in limestone, especially small cracks, are easily sealed by material dissolved in flowing water. Where there is a vertical temperature gradient, water flowing down through the rocks increases in temperature and, as a result, the carbonate content of the water can easily become supersaturated leading to the sealing of the cracks. If orogenic (geological structural deformation) processes are reduced and do not generate new macroscopic fractures, the mountain will eventually lose its karstical capability. This seems to be the case at Koytendag and clearly there is much still to be studied and discovered at the site.

1.5 Recommendations for future work

As a general point, it is recommended that future research is carried out around the time of snowmelt (March) and/or furthest from the time of snowmelt (October, November) – this would complement the work carried out in May/June 2015.

1.5.1 To study the dynamics of the main characteristics of the waterbodies in all of the underground lakes.

1.5.2 Conduct a diving inspection of the underground lakes in order to assess their configuration, hydrological and hydrochemical characteristics and the presence of relict fauna, especially the newly discovered lake.

1.5.3 Search for ‘suspended’ underground lakes on the upper plateau of the ridge, study the conditions of their formation, their hydrological characteristics and the presence of fauna.

1.5.4 Collect data on the structure of the salt deposits in the area of the reserve and on the horizons of underground water exposed by mining activities associated with the Garlyk potash plant.

1.5.5 Collect data on the potential impact of the Garlyk mine on the water resources in the foothills of the Koytendag ridge.

1.5.6 Assess the potential impacts of the development of gypsum quarries in the border area of Garlyuk wildlife sanctuary on the distribution of seasonal water flows.

1.5.7 Map the profile of salinity in the Koytendarya along its entire length.

1.5.8 Compare this profile with NaCl–salinity of sinkholes in the valley in order to determine the sources of water for the sinkholes – net river recharge with the addition of gypsum components; karst water with addition of gypsum components; mixing of karst hydrocarbonate waters with the waters of the river recharge?

1.5.9 Carry out quarterly monitoring of water levels and temperatures in the sinkholes (and caves), especially in the spring. Particular attention to be paid to those sinkholes with a variable water level – Kooshner, Smirnoff, Sinkhole with Underground Lake and Cold Sinkhole, and the stable Upper – and Lower-Kaynar springs. Compare these results with (a) river levels, (b) aquifer recharge rates from the mountain, (c) snowmelt in the mountains and (d) annual precipitation patterns. Confirm or refute the hypothesis that the Upper-Kaynar spring is the main discharge along the fault throughout the southern and possibly the central part of the Koytendag karst massif.

1.5.10 During periods of exceptionally heavy rains, occurring approximately every 5-10 years, monitor the behaviour of water levels in the sinkholes and flow of the Kaynar spring.

1.5.11 Explore the major water sources that were not surveyed in 2015 – Chindjirski and Bulak-Darinskii.

1.5.12 In the Underground Lake, measure the temperature of the air over the lake and the lake's water to investigate whether in winter the cave and lake accumulates the winter cold and thus provide an explanation of the abnormally cold temperatures recorded.

1.5.13 Examine in winter the abnormally cold (+10.5 C) air in Soouk-Komar, Big Sinkhole (with cold air) and the cold cave close to it to ascertain whether 'winter' air flow is opposite to 'summer' air flow. Additionally, in autumn measure the temperature of the air in these caves to find out whether increases in air temperature are the result of a 'summer flux' between summer and autumn. These data will answer the question about the nature of the anomalous cold – is it because of the temperature of the air in contact with cold karst waters or is it the cold, stored in winter, by the upward movement of air within the mountain?

1.6 Bibliography

Anonymous (1983) Jurassic formations south of the USSR. Proc. Science, Moscow, 208 pp. In Russian.

Anonymous (1972) Soviet Geology, Vol. XXII, Moscow, 649 pp. In Russian.

Degtyarev AP, Menliev S, Pereladov MV (2015) The discovery of the underground lake in the Koogitung (Turkmenistan). In Speleology and Spelestology – to the 170th Anniversary of the Russian Geographical Society, Proceedings of the VI International Scientific Conference, Nabereznye Chelny: 63-66. In Russian.

Kamelin R (1979) The Kuhitansky mining district of Central Asia. Komarov Proc 31, Science. In Russian.

Kirsta BG (1976) Hydrological features of the western regions of Central Asia (Turkmenistan). Science, Ashgabat, 295 pp. In Russian.

Maltsev VA (1982) Carbonate Karst of the south-western slope of Kugitangtou. In Status, problems and methods of studying the deep karst USSR (Union of karst materials III and Speleology meeting). Moscow, VIEMS, 153 pp. In Russian.

Maltsev VA (1993) Minerals of karst caves Cap Kutan. World of Stones 2: 5-30. In Russian.

Maltsev VA (1994) Aerosol genesis of mineral aggregates of caves: a critical analysis of the available hypotheses. Issues of Physical Speleology Vol. 1. MIPT, Moscow: 89-99. In Russian.

Maltsev VA (1996) Sulfates filamentary crystals and their aggregates in caves. Proceedings of the University of the Bristol Speleological Society 20(3): 171-185.

Maltsev VA (1997) Stalactites, crystlactites, corlactites, tuflactites: four types of "stalactite-like" formations, generated from crystallization environments with different physical properties Transactions of 12th International Congress of Speology: 267-270.

Maltsev VA (1997) Minerals of Cupp-Coutunn cave. Cave minerals of the world, 2nd edition, NSS: 323-328.

Maltsev VA (1998) Stalactites with "internal" and "external" feeding. Proceedings of the University of the Bristol Speleological Society 21(2): 149-158.

Maltsev VA, Bartenev OS (1989) The results of mineralogical studies of caves at Cap Kutan in Turkmenistan. In Problems of a comprehensive study of karst mountainous countries (Proceedings of the International Symposium), Tbilisi: 209-211. In Russian.

Maltsev V, Belakowsky D (1992) The Cap Kutan cave system in the mountains of Eastern Turkmenistan Kugitang. Lapis Minerallien Magazin 17 (2): 13-18. In German.

Maltsev V, Korshunov V (1994) Geochemistry of fluorite and some other features in the Kugitangtou Ridge caves, Turkmenia. Breakthroughs in Karst Geomicrobiology and Redox Geochemistry, Karst Water Institute, 47 pp.

Maltsev VA, Malishevsky DI (1989) About the hydrothermal stage on the later part of the evolution of the Cupp-Coutunn cave system. Proceedings of the 10th International Congress of Speleology, Vol. III, Budapest: 815-816.

Maltsev VA, Self CA (1992) Cupp-Coutunn cave system, Turkmenistan, USSR. Proceedings of the Bristol University speleological society 19: 117-150.

Maltsev VA, Turchinov II (1989) Gypsum Cave Dzhurinskaya ephemera. In Geology and prediction of mineral deposits in Eastern Siberia, Irkutsk: 82-83. In Russian.

Figure 14. *Corydalis popovii*, endemic to Koytendag. Photo credit: Jeremy Holden, RSPB.

2. Flora

Mark Gurney, Owen Mountford, Galina Khamanov, and *Shaniyaz Menliev*

2.1 Background

Knowledge of the flora of Koytendag is based largely on the literature, principally Nikitin and Geldihanov (1988) and Komarov *et al.* (1933-1964), and opportunistic recording by visiting botanists and reserve staff.

2.2 Methodology

Systematic recording and limited collection were carried out in April/May 2014 and these field records were supplemented by a detailed desk study of the available literature.

2.3 Results

Fieldwork in April/May recorded 23 endemic or near endemic species, though the identification of a few specimens has still to be confirmed. Based on information in Nikitin and Geldykhanov (1988), of these, 11 species are reported as being endemic to Koytendag – see table 3.

As the result of being situated at the intersection of three biomes, the Koytendag region has an outstanding and important floristic diversity and richness, with 1,136 species recorded. There are 242 species with known medicinal properties and 124 species which are the wild ancestors of crop and domestic fruit varieties.

The flora of Koytendag itself includes a minimum of 982 species of higher plants of 430 genera from 86 families. At least 197 species (20%) are endemic to the Pamir-Alay biogeographical region, with 48 species endemic to the property itself – see table 4. The taxonomic status of an additional ten species reported as being endemic is currently unclear. Ten species are listed in the Red Data Book of Turkmenistan (2011) – see table 5. Three species – walnut *Juglans regia* (LC), pistachio *Pistacia vera* (NT) and a species of almond *Amygdalus bucharica* (VU) – are included in the IUCN Red List.

Table 3. Endemic species of Koytendag recorded in April/May 2014.

Species	Location/comments
Allium oschaninii	On rocks in the dry gorge at 37.727°N, 66.373°E
Anemone baissunensis	In higher grasslands and scree
Corydalis popovii	Occasional under scrub in the grasslands
Dianthus brevipetalus	Occasional on rocks in the lower parts of gorges
Ferula nevskyi	Occasional in higher grasslands
Fritillaria olgae	In scrub in the gorge at Tamcy at 37.765°N, 66.492°E, 1920 m asl
Impatiens nevskii	Frequent under trees along the bottom of the Daraydere gorge
Prangos bucharica	Frequent in grasslands and gorges
Pseudosedum longidentatum	On rocks in lower parts of gorges
Rhinopetalum bucharicum	Occasional in higher grasslands and scree, as at 37.785°N, 66.523°E, 2320 m asl
Scutellaria leptosiphon	Common on vertical rock faces in the lower parts of gorges

Table 4. Endemic plants reported as occurring at Koytendag.

Species	Species	Species
Juno vvedenskyi	*Haplophyllum bucharicum*	*Pentanema propinquum*
Silene nevskii	*Haplophyllum vvedenskyi*	*Xylanthemum rupestre*
Silene plurifolia	*Aulacospermum dichotomum*	*Lepidolopha fedtschenkoana*
Silene bobrovii	*Bunium kuhitangi*	*Artemisia scotina*
Rosa bellicose	*Ferula tuberifera*	*Artemisia albicauli*
Astragalus densus	*Spirostegia bucharicas*	*Echinops praetermissus*
Astragalus bobrovii	*Scutellaria leptosiphon*	*Echinops multicaulis*
Astragalus subspinescens	*Scutellaria colpodea*	Cousinia *bobrovii*
Astragalus willisii	*Scutellaria nevskii*	Cousinia *leptoclada*
Astragalus kahiricus	*Scutellaria heterotricha*	Cousinia *glabriseta*
Astragalus kuhitangi	*Scutellaria squarrosa*	Cousinia *triceps*
Astragalus aemulans	*Phlomis spinidens*	Cousinia *dimoana*
Astragalus subschachimardanus	*Lagochilus nevskii*	*Jurinea popovii*
Astragalus plumbeus	*Eremostachys gypsacea*	*Jurinea tapetodes*
Oxytropis pseudoleptophysa	*Helichrysum mussae*	*Lactuca spinidens*
Oxytropis megalorrhyncha	*Pentanema parietarioides*	*Taraxacum gnezdilloi*
Reported endemics but with uncertain taxonomic status		
Gagea kamelinii	*Salsola lipschitzii*	*Onobrychis nikitinii*
Stipa kuhitangi	*Strigosella malacotricha*	*Hymenocrater incisodentatus*
Stipa gnezdilloi	*Astragalus rubri-galli*	
Ranunculus vvedenskyi	*Hedysarum plumosum*	

Table 5. Red Data plants recorded at Koytendag.

Species	Turkmenistan Red Data Book status	IUCN Red List status	Koytendag endemic	Pamir-Alay endemic
Asplenium trichomanes	II (EN)			
Cheilanthes pteridioides	II (EN)			
Corydalis popovii	IV (Rare)			X
Salsola lipschitzii	II (EN)		Status unclear	
Juglans regia	III (VU)	LC		
Cleome gordjagini	IV (Rare)			X
Astragalus kelifi	IV (Rare)			X
Onobrychis nikitini	IV (Rare)		Status unclear	
Tulipa ingens	II (EN)			X
Ungernia victoris	II (EN)			X

2.4 Discussion

The Koytendag region is a distinct geo-botanical area in the western Gissar region of the mountainous Middle Asian province of the Iranian (Anatolian- Kurdistan-Mediterranean) group of mountain provinces (Afro-Asian arid zone, Dominion of the Ancient Mediterranean). Analysis of the flora of the region shows that Koytendag is transitional between the Kopetdag flora and the flora of the Pamir-Alay. There are many species in common with the flora of the western Pamir-Alay mountains, the Pamir-Alay-Tien Shan and the Upper Pandj Alps. There is also a notable number of Kopetdag-Khorasan and Turan mountain species.

A key feature of the vegetation communities of Koytendag is that they are usually formed by

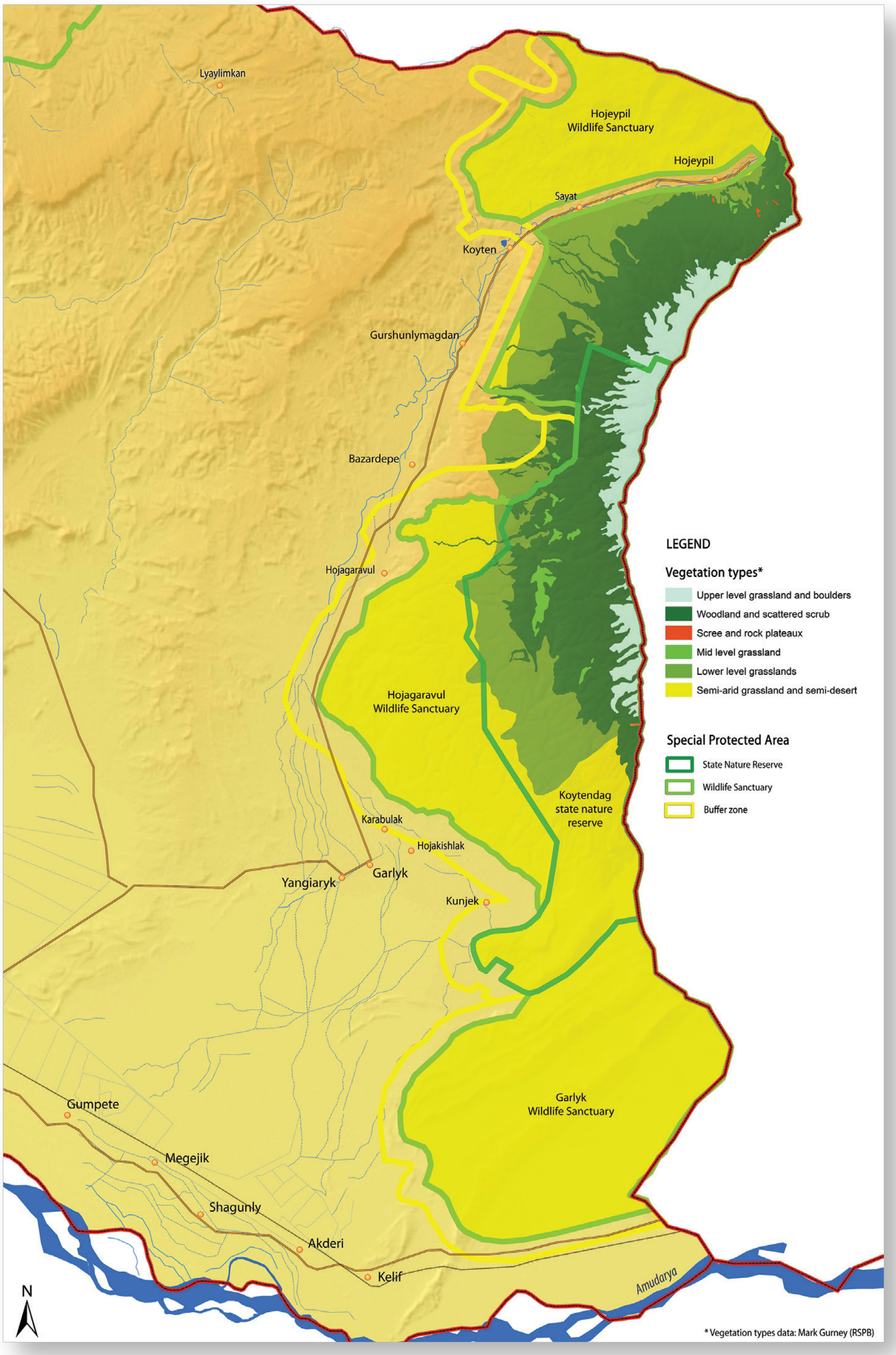


Figure 15. Broad vegetation classification of Koytendag. Map by Atamyrat Veyisov.

species associations where Pamir-Alay and Gissar rare and endemic species occur at the edges of their natural distributions and comprise more than 30% of the total number of species. The principal species are: *Juniperus seravschanica, Corydalis popovii, Salsola lipschitzii, Tulipa ingens, Allium oschaninii, Allochrusa gypsophiloides, Kuhitangia popovii, Cleome gordjaginii, Astragalus kelifi, Astragalus kuhitangi, Onobrychis nikitinii, Zizyphus jujuba, Pistacia vera* and *Ungernia victoris.*

Among the junipers and upland xerophytes there are many species whose origin is connected with the Koytendag region such as *Rubia komarovii, Xylanthemum rupestre, Glaucium squamigerum, Galatella coriaceae* and *Pseudolinosyris grimmii.* The subalpine belt (c. 2,900 m) is dominated by *Astragalus kuhitangi, Acanthalimon erythraeum* and *A. majewianum* and small bushes of *Rosa kuhitangi* and *R. ecae*. Above 3,000 m there are fragments of alpine meadows with species including *Juniperus seravschanica, Acer pubescens, Amygdalus bucharica, Atraphaxis pyrifolia, Kuhitangia popovii*, *Allochrusa gypsophiloides* and low tussocks of *Cleome gordjaginii.* Scattered copses are formed by *Platanus orientalis, Ziziphus jujuba* and *Pistacea vera.*

A broad classification of the vegetation types of Koytendag is shown on figure 15.

A review of the flora of Koytendag (Mountford 2015) shows that a significant proportion of the flora is representative of the Pamir-Alay mountains, including not only the endemic element but also many species with a somewhat greater range, extending to the adjacent ranges of southern Turkmenistan bordering Iran and Afghanistan and to the western Tien-Shan.

The strictly endemic element of the flora of Koytendag is found over a wide range of habitats within the site. Not surprisingly, endemic species are best represented in the higher altitudes of the mountains on stony or rocky slopes and in gorges, ravines and cliffs. Koytendag endemics are also frequent in the Central Asian juniper *Juniperus seravschanica* zone, though they are more associated with rock outcrops and open areas than the juniper scrub-forest *per se*. Certain endemic species have particular soil or bedrock requirements, being found only in either limestone, sandstone or gypsaceous strata. Endemism is least pronounced in the foothills and in anthropogenic habitats, though at least one apparently endemic species, *Lactuca spinidens*, is found in wheat fields.

The location of Koytendag along the border with Uzbekistan and relatively close to Afghanistan (and to a lesser extent Tajikistan) makes the definition of endemism more than usually difficult and artificial. However, using the biogeographical region of the Pamir-Alay as the context for assessing endemism stresses the real importance of Koytendag at an international level. Conversely species such as *Cheilanthes pteridioides*, which is designated as important in a Turkmenistan context, is well-distributed outside the country.

Very few of the species recorded from the site are included in the IUCN Red List and hence it is not possible to ascribe an international threat status to the majority. However, those plants restricted to Koytendag undoubtedly merit a higher IUCN threat category than 'Least Concern'. Nonetheless a handful of species from the property combine a wider international range with being near threatened or vulnerable and decreasing according to IUCN. The most prominent species in this category are fruit/nut trees – walnut, pistachio and one species of almond – all of which include the mountains of Turkmenistan in their native ranges. Walnut and pistachio are very widely cultivated and, in the case of walnut, naturalised in some countries, but within their very restricted native ranges they are decreasing and threatened by fruit collection, livestock grazing and cutting. The species of almond is endemic to Central Asia and has a small area of occupancy, with a severely fragmented distribution and continuing declines in habitat area and numbers of mature individuals.

Ideally the proportion of endemic species in the Koytendag area should be compared with other protected areas within the Central Asian mountains in order to assess the importance of Koytendag objectively. Throughout Central Asia there are several important centres of endemism and in no sense could one regard other centres as a substitute for Koytendag. The species accounts in *Flora SSSR* make it clear that Koytendag is one of the most important floristic areas when assessed either at the scale of the Pamir-Alay or more generally for the mountains of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, as well as adjacent areas of Iran and Afghanistan.

2.5 Recommendations for future work

2.5.1 Provide additional copies of Nikitin and Geldihanov (1988) and any additional general and easily understandable plant guides to assist reserve staff and visiting botanists learn the families of plants. Consideration should also be given to producing a simple photographic guide to the most important species of the site, with notes on distinguishing them from similar species for use by reserve staff.

2.5.2 Increase the field skills of reserve staff and local botanists through the provision of training in plant taxonomy, identification and recording.

2.5.3 To assist with the future research, conservation and management of the key species of the site, prepare 'ecological profiles' for all of the site-specific, regionally endemic and Turkmenistan Red Data Book species.

2.5.4 Whenever reserve staff come across important species, records of the location using GPS, population size (rough estimates eg 1-10, 11-50, 51-100, 101-500, >500), habitat and associated species should be taken. Additionally, as identification skills develop, reserve staff should record when they fail to record species in areas where the habitat appears to be suitable.

2.5.5 When collecting herbarium specimens, it is essential that details of location (GPS), date, habitat and population size are also noted. Specimens should be identified as soon as possible as some features can be lost as specimens dry.

2.5.6 Vegetation communities and habitats should be identified and mapped so that the distribution and extent of each can be documented. As far as is possible, each important species, both plants and animals, should then be assigned to each habitat or community.

2.5.7 Assess the state of the vegetation in the state nature reserve with respect to the impact of and recovery from past grazing.

2.5.8 Investigate past forest cover to assist in planning future reforestation activities if considered appropriate.

2.5.9 Use fixed point photographs to monitor vegetation changes and to illustrate 'good' and 'bad' habitat. This is particularly important in the grazed wildlife sanctuaries, the gorges that receive large numbers of visitors, the borders of the state nature reserve and throughout the high altitude zone.

2.5.10 Contract an experienced ecologist and land economist to investigate the sustainability of grazing in the wildlife sanctuaries especially in relation to their value for biodiversity.

2.6 Bibliography

Hasanov F (1987) Xerophytic trees and shrubs of Kugitangtau. Dissertation. Tashkent. In Russian

Kamelin R V, Hasanov F (1987) The vertical zonation of vegetation at Kugitang (Southwest Pamiroalay). Journal of Botany 72, 11. In Russian

Kamelin R (1973) Florogenetic analysis of the natural flora of mountainous Central Asia. Nauka, Leningrad. In Russian

Komarov VL (ed.) (1933-1964) Flora of the U.S.S.R. Vols. 1-30. Izdatel'stvo Akademii Nauk SSR. Leningrad.

Magnus L, Zetterlund H (1997) *Corydalis*: a gardener's guide and monograph of the tuberous species. Pershore: Alpine Garden Society.

Mountford O (2015) Assessment of the Vascular Flora of Koytendag (Kugitang). Report to RSPB.

Nevsky SA (1937) Materials on the flora of the Kugitang foothills. Flora and taxonomy of higher plants, vol. 4. Moscow-Leningrad. In Russian

Nikitin VV, Geldihanov AM (1988) Plants of Turkmenistan guidebook/finder. Nauka, Leningrad.

Udvardy MDF (1975) A Classification of the Biogeographical Provinces of the World, IUCN Occasional Paper no. 18 IUCN, Morges, Switzerland.

Vlasenko GP (1995) Biological and ecological foundations of the culture of saponin plants in southern Turkmenistan. Dissertation. Ashgabat. In Russian

Figure 16. *Heser stoevi* – a new species of spider from Koytendag (Photo credit: Christo Deltshev, https://doi.org/10.3897/BDJ.4.e10095)

3. Surface-dwelling invertebrates

Pavel Stoev, Christo Deltshev, Yuri Marusik, Victor Fet, František Kovařík, Borislav Guéorguiev, Ivaylo Dedov, Toshko Ljubomirov, Dragan Chobanov, and *Shanyiaz Menliev*

Note. The cave fauna, which consists primarily of invertebrates, is treated separately.

3.1 Background

Knowledge of the surface-dwelling invertebrates of Koytendag is incomplete and based primarily on the literature and opportunistic recording. As can be seen from the bibliography, no specific studies of the site have been carried out and the most recent publications are almost 20 years old. During the 2015 expedition Pavel Stoev collected in Koytendag a number of invertebrate taxa, mostly under stones and on plants which were subsequently identified by various experts.

3.2 Methodology

Limited systematic collection, mostly in the proximity of cave entrances, was carried out in May 2015 – see table 6 and figure 17. Recording was a combination of visual surveys and hand collecting, mostly from grass tufts, shrubs or under stones; sieving of leaf litter with a leaf litter sieve; and using a light trap. In most cases, forceps were used to pick animals from the surface and put them into plastic tubes containing 95% alcohol. All specimens were labelled with temporary labels and later re-labelled under laboratory conditions with permanent labels. Active collecting of insects attracted by light was carried out at night at the state nature reserve headquarters using a mercury vapour light trap. Water beetles and other water bugs were collected opportunistically from springs or sinkholes with the aid of a hand net. Collecting sites are given in table 6.

Table 6. Invertebrate collecting sites at Koytendag, May 2015.

Reference number	Site name	Date	Habitat
1	Near Garlyk (1)	24 May	Dry grass
2	Kaptarhana (2)	24 May	Grassland and inside cave
3	State Nature Reserve headquarters, Bazardepe (3)	24 May	Grassland
4	Between Koyten and Kyrkgyz Dere, c7km from Koyten (4)	25 May	Under stones close to road
5	Between Koyten and Kyrkgyz Dere, c8-9 km from Koyten (5)	25 May	Under stones close to road
6	Kyrkgyz Dere (6)	25 May	Under stones
7	Kyrkgyz Grotto (7)	25 May	Humid habitats
8	Hojapil Dinosaur Plateau (8)	25 May	Under stones
9	Umbar Dere (9)	25 May	Under stones
10	Cave in Hojapil village (10)	25 May	Inside cave
11	Bashbulak spring (11)	25 May	In and around spring
12	Daraydere (12)	26 May	Under stones along track
13/14	Daraydere mine galleries (13 and 14)	26 May	In mine galleries

Reference number	Site name	Date	Habitat
15	Daraydere (15)	26 May	Vegetation above stream
3	State Nature Reserve headquarters, Bazardepe (3)	26 May	Light trapping
16	Gap-Gotan (16)	27 May	In mine gallery
3	State Nature Reserve headquarters, Bazardepe (3)	27 May	Light trapping
17	Gulshirin (17)	28 May	Shrubs, grass, under stones and inside cave
3	State Nature Reserve headquarters, Bazardepe (3)	28 May	Light trapping
18	Suw Oyuk sinkhole (18)	29 May	Around sinkhole and in water
19	Hashim Oyuk	29 May	Under stones and in cave entrance
3	State Nature Reserve headquartewrs, Bazardepe	29 May	Light trapping
20	Gurshun Magdanly (Kette-Kamov) mine gallery	30 May	Inside mine gallery
2	Kaptarhana	30 May	Inside cave
21	State Nature Reserve headquarters, Sowuk Kamar cave	30 May	Around cave

3.3 Results

More than 300 species of invertebrates have been recorded from Koytendag but the true total will be considerably higher. Some species of conservation importance recorded in each of the main orders, prior to the May 2015 survey are given in table 7.

Snails collected in 2015 have been identified by Dr. Ivaylo Dedov from the Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences. The specimens were assigned to six morphospecies belonging to 6 gen-

Table 7. Invertebrates recorded at Koytendag prior to May 2015

Order	No. of species	Comments
Mollusca	unknown	*Melanoides kainarensis* is included in the Red Data Book of Turkmenistan III (VU). This is the only species in this genus in Turkmenistan. It is believed that this species became separated from its nearest relatives in the Hindu Kush in the late Palaeogene, 66-23 million years ago
Ixodida (ticks)	unknown	Seven species new to science and endemic to Koytendag discovered in the last decade – *Imparipes kugitangensis*, *Imparipes placidus*, *Imparipes katalglyphi*, *Scutacarus sabinaesmilis*, *Scutacarus rotindulus*, *Premicrodispus paradoxus* and *Premicrodispus heterocaudatus* – Khaustov and Chydyrov (2004, 2010)
Orthoptera	38	Two species endemics to Koytendag – *Canophyma zimini* and *Canophyma bactrianum* – one species *Saga pedo* is listed as VU by IUCN and is included in the Red Data book of Turkmenistan category II (EN)
Coleoptera (beetles)	154	Two species included in the Red Data Book of Turkmenistan – *Carabus (Axinocarabus) fedtschenkoi* IV (Rare) and *Melanotus dolini* IV (Rare)
Lepidoptera (butterflies and moths)	59	Two species of note – *Parnassius mnemosyne* and *Papilio machaon*
Formicidae (ants)	30	One species endemic to Koytendag – *Monomorium kugitangi*

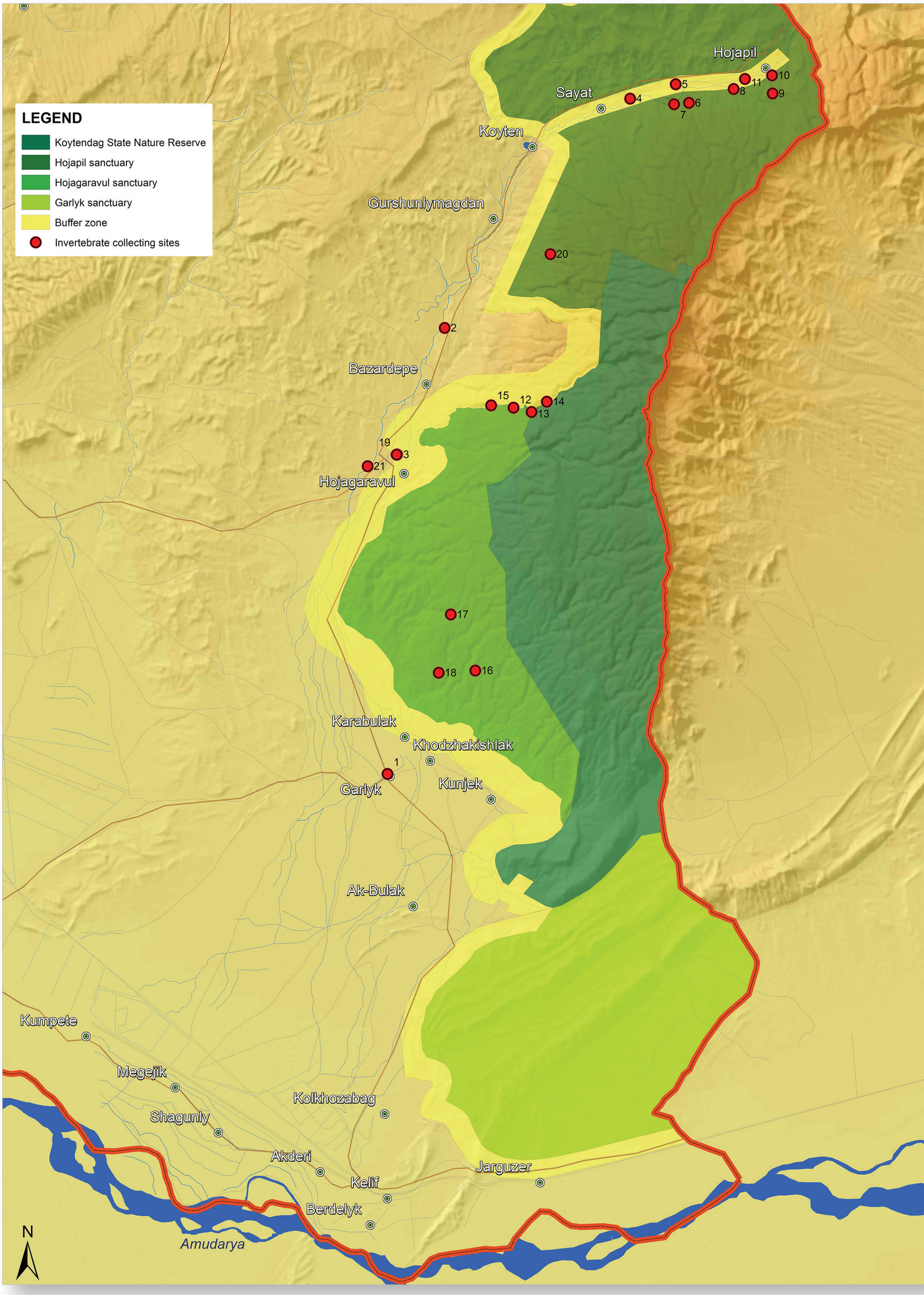


Figure 17. Invertebrate sampling sites at Koytendag. Map by Atamyrat Veyisov.

Figure 18. *Mesobuthus "gorelovi"* Fet et al., 2018 – a species of scorpion recently described from Central Asia (Photo credit: Pavel Stoev)

era: *Pseudonapaeus sogdianus* E.C. von Martens, 1874, *Oligolimax annularis* (S. Studer, 1820), *Gibbulinopsis signata* (Mousson, 1873), *Laevozebrinus* cf. *lenis* Schileyko, 1984, *Macrochlamus* sp. and *Radix* sp.

In May 2015, a scorpion potentially new to science – see figure 18 – was found which, based on examination of the collected specimens, Dr. Victor Fet and František Kovařík, world authorities in scorpion research, considers to be a member of the *Mesobuthus "garelovi"* complex (Scorpiones: Buthidae), which is today being split into several species. The species was formally described in 2018 as *Mesobuthus gorelovi* from Kazakhstan, Turkmenistan and Uzbekistan (Fet et al. 2018).

Figure 19. Habitus of *Chlaenius extensus*. Scale line = 1 mm. (Photo credit: Guéorguiev et al. 2018. Historia naturalis bulgarica. http://nmnhs.com/historia-naturalis-bulgarica/pdfs/hnb-2018-29.pdf)

A new species of spider, *Heser stoevi* Deltshev, 2016, was discovered in 2015 with specimens collected around the Dinosaur Plateau area at Hojapil and close to the Gulshirin cave at Garlyk. This genus is currently known to compromise 10 species distributed from India to the United States of America. It is considered that the new species at Koytendag is categorised as a localised endemic.

Further 10 species of spiders have been identified by Dr. Christo Deltshev and Dr. Yuri Marusik: *Uroctea limbata* (C.L. Koch, 1843) (Oecobiidae), *Hippasa partita* (O.P.-Cambridge, 1876) (Lycosidae), *Philaeus chrysops* (Poda, 1761) (Salticidae), *Megalepthyphantes nebulosoides* (Wunderlich, 1977) (Linyphiidae), *Trachyselotes pedestris* (C. L. Koch, 1837) (Gnaphosidae), *Enoplognatha thoracica* (Hahn, 1833) (Theridiidae), *Metleucauge dentipalpis* (Kroneberg, 1875) (Tetragnathidae), *Eusparassus walckenaeri* (Audouin, 1826) (Sparassidae), *Artema transcaspica* Spassky, 1934 (Pholcidae) and *Steatoda triangulosa* (Walckenaer, 1802) (Theridiidae).

Ants (family Formicidae) collected in 2015 have been identified by Dr Toshko Ljubomirov, a hymenopterist at the Institute of Biodiversity and Ecosystem Research – Bulgarian Academy of Sciences. All the four species belong to subfamily Formicinae (genera *Camponotus* and *Cataglyphis*) and subfamily Myrmicinae (genera *Pheidlole* and *Tetramorium*):

Camponotus turkestanus Er. André, 1882. Species distributed in the Palaearctic region, specifically from the Near East to Central Asia.

Cataglyphis aenescens (Nylander, 1849). Species widespread in the southern parts of Palaearctic region (except for westernmost areas of West Palaearctic and Palaearctic Africa).

Pheidole pallidula (Nylander, 1849). Species widespread in the southern parts of Holarctic region (in North America known from California and Colorado).

Tetramorium chefketi Forel, 1911. Species widespread in the southern parts of Central Palaearctic region with some range expansions on North Africa, Eastern Europe, and East Siberia.

The beetles collected in 2015 have been identified and published by Guéorguiev et al. (2018). The study is based on identification of 242 specimens belonging to 57 species from 15 families of the order Coleoptera. The following eight species are new for Turkmenistan: *Bembidion aeneum* Germar, 1823, *Chlaenius extensus* Mannerheim, 1825, *Gyrinus distinctus* Aubé, 1838, *Trichophya pilicornis* (Gyllenhal, 1810), *Thinodromus behnei* Gildenkov, 2000, *Gabrius hissaricus* Schillhammer, 2003, *Quedius novus* Eppelsheim, 1892, and *Galeruca jucunda* (Faldermann, 1836) – see figures 19 and 20.

Two species of cockroaches have been collected on Koytendag in 2015 – *Polyphaga saussurei* and *Shelfordella lateralis*. Mantises (order Mantodea) are represented by three morphospecies: *Bolivaria brachyptera* (?), *Empusa pennicornis* (?) and *Ameles* sp. (?) (det. D. Chobanov).

Figure 20. Habitus of *Galeruca jucunda*. Scale line = 1 mm. (Photo credit: Guéorguiev et al. 2018. Historia naturalis bulgarica).

3.4 Discussion

Based on the available information, the site supports one species *Sago pedo* which is globally threatened (VU) and classed as EN in the Red Data Book of Turkmenistan. Five additional species are included in the Red Data Book – *Saxetania cultricollis* (VU), *Anthia mannerheimi* (Rare), *Carabus* (*Axinocarabus*) *fedtschenkoi* (Rare), *Melanotus dolini* (Rare) and *Melanoides kainarensis* (VU).

Including the new species discovered in 2015, nineteen surface-living species are known to be endemic either to the site or to Turkmenistan – *Conophyma zimini*, *C. bactrianum*, *Microdera semenoviana*, *Dichillus dentipes*, *Prosodes kuhitangiana*, *Penthicus pinguis kughitangi*, *Turanana airibaba*, *T. kugitangi*, *Chazara staudingeri*, *Parornix kugitangi*, *P. asiatica*, *Imparipes kugitangensis*, *I. placidus*, *I. katalglyphi*, *Scutacarus sabinaesmilis*, *S. rotindulus*, *Premicrodispus paradoxus*, *P. heterocaudatus* and *Heser stoevi.* An additional six species – *Colposcelis lopatini*, *Prosodes subpilosa*, *P. monticola*, *Blaps medvedevi*, *Dissonomus latusculus* and *Hyponephele toharica* – may be endemic but their status is unclear due to presumed changes in taxonomy. A further six species – *Gnathosia kuhitangi*, *Dailognatha arnoldi*, *Blaps bogatshevi*, *Adesmia planidorsis* and *Melitaea didyma* – are reported to be endemic but actually occur outside Turkmenistan.

As little systematic work has been carried on the invertebrate fauna of Koytendag many more species that are endemic and/or of national conservation importance almost certainly await discovery.

3.5 Recommendations for future work

3.5.1 Continue investigation of surface-dwelling invertebrates, especially in the areas at and above 2,000 m, with particular emphasis on myriapods, insects, arachinds, snails.

3.5.2 Contact major museums to see whether they have records of invertebrates from Koytendag.

3.5.3 Organise a team of invertebrate experts to collect specimens for later identification. The team should include local and international experts who can place the species and site in context and provide training of local counterparts.

3.5.4 Extract all the records and information for Koytendag from the *Rare and insufficiently studies animals of Turkmenistan* and other legacy literature.

3.6 Bibliography

Atamuradov HI (1994) Peculiarities of composition and formation of coleopterofauna of South-Western Middle Asia (on example of Coleoptera, Elateridae, Tenebrionidae, Curcilionidae). PhD thesis, Kiev, 47 pp.

Deltshev C (2016) A new spider species, *Heser stoevi* sp. nov., from Turkmenistan (Araneae: Gnaphosidae). Biodiversity Data Journal 4: e10095. https://doi.org/10.3897/BDJ.4.e10095

Dlussky G, Soyunov O, Zabelin S (1989). Ants of Turkmenistan. Ylym. Ashkhabad, 1-273. In Russian

Fet V, Atamradov K (eds) (1994) Biogeography and Ecology of Turkmenistan Monographiae Biologicae vol. 7

Fet V, Kovařík F, Gantenbein B, Kaiser RC, Stewart AK, Graham MR (2018) Revision of the *Mesobuthus caucasicus* complex from Central Asia, with descriptions of six new species (Scorpiones: Buthidae). Euscorpius 255: 1-77.

Guéorguiev B, Merkl O, Schülke M, Fery H, Szénási V, Král D, Kejval Z, Németh T, Szalóki D (2018) Coleoptera (Insecta) from Ashgabat City and Köýtendag Nature Reserve, with nine first records for Turkmenistan. Historia naturalis bulgarica 29: 9-20.

Medvedev GS (1964) Zoogeographic characteristics of Tenebrionidae from Kugitang and a description of new forms. Zoological Zhurnal: 54-64

Tokgaev TB (1998) Biological diversity of insects of Turkmenistan. Ashgabat, In Russian.

Tsikolovets V (1998) The Butterflies of Turkmenistan. Kiev. 237 pp.

4. Cave fauna

Boris Sket, Pavel Stoev, Christo Deltshev, Yuri Marusik, and *Louis Deharveng*

4.1 Background

Knowledge of the cave fauna of Koytendag is limited (for the cave fauna of Central Asia see Decu et al. 2019). Published records comprise only 26 species of invertebrates: Protozoa (15); Gastropoda (2); Crustacea (Copepoda) (3); Crustacea (Malacostraca) (3); Coleoptera (2) and Psocoptera (1) plus the endemic blind loach – *see section 5*.

The systematic study of the fauna of the underground hydrological system of the Koytendag ridge began in the second half of the 20th century and initially consisted of collecting cave aquatic organisms which were found in large springs such as Kaynar and Chindzhir. Filtering the water flowing out of such springs revealed the presence of a localized blind isopod crustacean *Stenasellus asiaticus* whose physical appearance suggested they had a predominantly underground lifestyle. At the same time, work began on describing a relict fauna of marine origin in the Kaptarhana cave (Birstein and Ljovushkin 1967).

4.2 Methodology

In May 2015, 13 sites were investigated – see table 8 and figure 17 – including six caves (Gap-Gotan, Hashim Oyuk, Gulshirin, Kaptarhana, Kyrkgyz Grotto and a cave in Hojapil village), four abandoned mine galleries and one sinkhole. Kaptarhana and Gap-Gotan were visited twice as pitfall traps were set in both. Survey techniques were visual surveys of approximately 1 km of corridors close to the entrances of Gap-Gotan cave; filtering of water and sediment in limestone pools using

Figure 21. *Gammarus troglomorphus* Sidorov, Hou, Sket, 2018 (Amphipoda) from Garlyk, collected in Suuv Oyuk (Photo credit: Boris Sket)

Table 8. Cave fauna sampling locations.

Site name	Date	Habitat
Koytendag canal	24 May	Vegetated canal connected to the Amudarya
Kaptarhana	24 May	Sediment of lake in cave
Bashbulak	25 May	Gravel spring at the head of the Koyten river and large spring pool with rich submerged vegetation
Kyrkgyz	25 May	Spring
Below Dinosaur Plateau	25 May	Spring and narrow entrance to excavation
Daraydere	26 May	Strong spring at the artificial head of the stream and spring from a drilling hole in the wall of an unnamed tunnel
Gap-Gotan	27 May	Limestone pool in cave and limestone pool near entrance
Karabulak river	28 May	Small stream with rich submerged vegetation, spring and spring from gravel deposit
Gaynarbaba	28 May	Sulphurous spring, large karst spring and spring
Jarma-Tasbulak	28 May	Karst spring and spring
Hasim Oyuk cave	29 May	Dry cave
Suw Oyuk	29 May	Sinkhole lake, baited trap in sinkhole lake and environs of the sinkhole
Newly discovered lake in sinkhole	31 May	Sediment of lake in cave
Gap-Gotan	1 June	Baited pitfall trap in spacious dry part of cave

a hand-net with 0.5 mm mesh width (finer nets were tried but rapidly became rapidly blocked with silt); and ten pitfall traps[1] made from plastic cups baited with meat and/or cheese for several days in Gap-Gotan (4) and Kaptarhana (6). As there was a scarcity of water bodies in the caves, samples were also collected from springs which provide 'windows' into the ground water system. All specimens were processed in the laboratory using a binocular microscope. After sorting, specimens were provisionally identified and, where necessary, sent to specialists for confirmed identification. In addition to invertebrate sampling, Amphibia and Odonata were photographed and a separate detailed survey was made of the endemic blind loach – see section 5.

1 Pitfall traps are the standard sampling method used in the Dinaric karst caves, the Alpine region of the Balkan Peninsula, from Slovenia to N Albania and extending across W Coatia, and most of Bosnia and Herzegovna, and Montenegro, which has a particularly rich cave fauna.

4.3 Results

In addition to confirming the occurrence of the majority of previously recorded species and increasing the known distribution of many of these, the most significant result of the May 2015 survey was the discovery of two species of *Gammarus* new to science from Garlyk and Koyten, respectively – see figures 21, 22 (Siderov et al. 2018). Three previously unrecorded species of beetle were also found at Gap-Gotan Cave – *Bembidion (Ocyturanes) dyscheres* Netolitzky, 1943, *Eremosphodrus (Rugisphodrus) dvorshaki* Casale & Vereschagina, 1986 and *Cymindis (Paracymindis) asiabadense kryzhanovskii* Emetz, 1972 (Guéorguiev et al. 2018).

Among the most striking discoveries in the caves of Koytendag was a remarkable new genus and species of Campodeidae (Diplura), *Turkmenocampa mirabilis* Sendra & Stoev found in Kaptarhana cave (Sendra et al. 2017). This represents the first record of Diplura from Central Asia and also the first terrestrial troglobiont found in Turkmenistan. Although *T. mirabilis* was tenta-

Figure 22. *Gammarus parvioculatus* Sidorov, Hou, Sket, 2018 from Koyten, collected at Hojapil (Photo credit: Boris Sket)

tively placed by the authors in the subfamily Plusiocampinae, its true affinities remain uncertain. The new finding provides further support to the importance of Kaptarhana as a refuge for a number of endemic invertebrates.

The caves of Koytendag revealed to harbour also a few species of spiders (identified by Christo Deltshev and Yuri Marusik): *Pholcus parthicus* Senglet, 2008 (Kyrkgyz grotto, a cave in the village Hojeypil, cave Gulshirin); *Megalepthyphantes nebulosoides* (Wunderlich, 1977) (v. Garlyk, caves Gap Gotan and Hashim Oyuk); and *Tegenaria* sp. (cave Hashim Oyuk).

Although not necessarily strict cave-dwelling species, an additional several species potentially new to science were also recorded: springtails (Collembola): *Deuteraphorura* n. sp. (Kyrgiz grotto), Entomobryidae sp. (Cave Gap Gotan), *Coecobrya* n. sp. (cave Kaptarahana) (det. Louis Deharveng), and a Latridiidae beetle of genus *Corticaria* (Coleoptera) at Kaptarhana (identified by Wolfgang Rücker).

Based on differences in the species recorded it appears that there are at least three distinct and separate hydrological systems at Koytendag – Suw Oyuk, Kaptarhana and Koyten.

A large roost of *Rhinolophus bocharicus* bats was found in Kaptarhana. This cave is rich in guano and has a diverse invertebrate fauna. It also contains permanent water apparently fed by underground sources. Together these features make the cave of high conservation importance.

At Suw Oyuk, the only known location for the endemic blind loach, the following were recorded – *Bufotes oblongus* (Amphibia), *Ischnura elegans* and *Orthetrum coerulescens* (Odonata); *Gerris* sp. and *Notonecta* sp. (Hemiptera); plus unidentified Chironomidae, Cyclopoida, Ostracoda, Dytiscidae and Mollusca.

Although in no way to be considered a 'cave dwelling' species, porcupine *Hystrix indica* 'toilets' were found in several caves and these appear to provide an important food supply for the invertebrate fauna.

During the 2012 International Scientific Expedition, a beetle was collected from a limestone pool in Gap-Gotan cave on 25 May which appears to be a new species of *Xestodium*, however none were recorded during the 2015 survey.

Gammarus troglomorphus Sidorov, Hou, Sket, 2018 from Garlyk recorded from Suw Oyuk is a very aberrant species, one of the most troglomorphic within the genus. Eyes and pigmentation are totally absent and the appendages are very elongated. It is a troglobiont (Sidorov et al. 2018).

Gammarus parvioculatus Sidorov, Hou, Sket, 2018 from a spring-cave at Hojapil near Koyten shows no troglomorphy except the slight eye diminution (Sidorov et al. 2018). It was found in three springs, one of them in a half-cave, and individuals exhibit a variable degree of pigmentation; the eye is reduced to half the size of 'normal' gammarid populations. The species is considered to be an eutroglophile.

4.4 Discussion

As a rule, subterranean (cave) faunas are often significant constituents of national nature monuments as they are generally localised and therefore strictly or narrowly endemic. Each troglobiotic species is usually only present in one area and therefore vulnerable to extinction if the local population disappears. Troglobiotic and eutroglophile species are also scientifically very informative, illustrating the courses of adaptation and evolution in general. By contrast, subtroglophile and trogloxene species are usually much more widely distributed and not troglomorphic, however subtroglophiles may be very important as vectors of food between the surface and underground.

In addition to the newly discovered *Gammarus* species, other notable troglobionts are the isopod *Micrcharon halophilus* and the hydrobiid gastropod *Pseudocaspia ljovuschkini* Starobogatov. Additionally, there are a number of endemic relict species including *Stenasellus asiaticus* Birstein & Ljovuschkin and *Bogidiella ruffoi* Birstein & Ljovuschkin which were recorded from the Hodza-Kaynar spring.

Subterranean habitats, including caves, are characterised by the darkness, high air humidity, stable climatic conditions and a lack of food resources. The general morphological adaptation of troglobionts to these conditions is the reduction of non-functional structures, eg., reduction of pigmentation and eyes, and the elongation of appendages. These traits are called troglomorphy.

The Koytendag area is distinctly arid compared to most karst areas in the world. The average annual precipitation in Turkmenistan is 110-200 mm, compared to 900-1,600, extreme 4,600 mm, in the troglobiotically rich Dinaric karst area. This almost certainly explains the striking complete absence of cave crickets (Orthoptera: Rhaphidophoridae) which elsewhere are one of the most regularly present components of cave faunas. They are however mainly subtroglophiles, depending on feeding on the surface but regularly searching shelter in the entrance areas of caves. An additional characteristic of the Koytendag caves is the absence or extreme rarity of hygrophile troglobiotic beetles (Coleoptera); they are replaced by the explicitly xerophile groups Tenebrionidae and Ptinidae.

According to the literature (Brodsky 1928, 1929; Birstein and Ljovuschkin 1965; Chibisova 1967) there are relict Foraminifera in the lake at Kaptarhana. As foraminifera are principally marine animals, it is supposed that these are relicts of the past sea in the area but it is unclear whether any animals were found alive, they could possibly be sub-fossil specimens.

4.5 Recommendations for future work

4.5.1 Further studies of the caves in February / March, which are the most favourable for collecting months in the area. This is especially important for collecting living specimens of the tenebrionid beetles in Hashim Oyuk and the likely new callipodidan millipedes in Gulshirin.

4.5.2 Extending the biospeleological surveys to other caves and mine galleries in the area, especially in the higher parts of the mountain (above 1,000 m), where air temperatures in the caves are expected to be lower and the humidity higher.

4.5.3 Explore the fauna of the newly discovered cave that appears to have the largest underground lake in Turkmenistan and former SSSR.

4.5.4 Explore the cave near 'Svincovyi rudnik' mentioned by Ljovushkin (1969).

4.5.5 Carry out a pilot study of the totally unexplored Mesovoid Shallow Stratum (MSS) of the mountain which may reveal several new species.

4.5.6 Carry out regular monitoring of the invertebrate communities in the caves.

4.5.7 Search the flooded caves on the ridges of Karabil and Karadzhimulak where there may be refugia of relict fauna of the Tethys Ocean.

4.5.8 Collate data on the bioiversity of waterbodies in the adjoining Surkhandarya reserve in Uzbekistan. Ideally this would be a synchronous expedition on both sides of the Koytendag ridge.

4.6 Bibliography

Birstein YA (1985) The genesis of freshwater and deep cave faunas. Moscow. Science. 247 pp In Russian

Birstein YA, Ljovushkin SI (1965) Faune des eaux souterraines saumâtres de l'Asie centrale. International Journal of Speleology 1: 307-320.

Brodsky AL (1928) Foraminifera (Polythalamia) in Grundwasser der Wüste Kara-Kum. Acta Universita Asiae Mediae, Ser. 8, Zoologica, 5, 1-17. In Russian

Brodsky AL (1929) The fauna of the basins of the desert Kara-Kum. Acta Universita Asiae Mediae, Ser. 12, Geographica 5: 1-43. In Russian

Chibisova OI (1967) Testacea from some caves and karst reservoirs. Zoologicheskii Zhurnal 46: 181-186 (in Russian with English summary)

Decu V, Juberthie C, Lepure S, Gheorguiu V, Nazareanu G (2019) An overview on the subterranean fauna from Central Asia. Ecologica Montenegrina 20: 168-193.

Guéorguiev B, Merkl O, Schülke M, Fery H, Szénási V, Král D, Kejval Z, Németh T, Szalóki D (2018) Coleoptera (Insecta) from Ashgabat City and Köýtendag Nature Reserve, with nine first records for Turkmenistan. Historia naturalis bulgarica 29: 9-20.

Kniss V A (2001) Cave fauna of Russia and adjacent countries (history of study, composition and distribution). Bashkir University Publishing House, Ufa.

Lyovushkin SI (1969) About the subterranean fauna of Soviet Central Asia. 4th Int. Speleology Congress. Actes IV, Ljubljana. CIS 4-5: 145-149.

Sendra A, Sket B, Stoev P (2017) A striking new genus and species of troglobitic Campodeidae (Diplura) from Central Asia. Subterranean Biology 23: 47-68. https://doi.org/10.3897/subtbiol.23.14631

Sidorov D, How Z, Sket B (2018) Three new remarkable amphipod species (Crustacea: Gammaridae) from springs and subterranean waters of Central Asia. Zootaxa 4444 (4): 437-461. http://www.mapress.com/j/zt

5. Fish

Brian Zimmerman, Rachel Jones, and *Sarah Ball*

5.1 Background

The fish fauna of Koytendag is limited to ten species. The most important species is the endemic blind cavefish Starostin's loach *Troglocobitis starostini* (VU) (see figure 23) which appears to be restricted to the Suw Oyuk sinkhole. In addition to being endemic to Koytendag, the loach is the only blind cavefish species found in Northern Eurasia. Of the other species, these are mainly represented by Ponto-Caspian-Aral species (Turkestan barbel *Barbus capito* ssp. *conocephalus*, Turkestan gudgeon *Gobio gobio* ssp. *lepidolaemus* and striped bystranka *Alburnoides taeniatus*) and Iranian species such as *Capoeta capoeta* ssp. *capoeta*. Two species – common marinka *Schizothorax intermedius* and grey stone loach *Triplophysa dorsalis* – are restricted to the water basins of Koytendag within Turkmenistan. Two alien species have been introduced to the area – the numerous and widespread mosquitofish *Gambusia affinis* and *Cyprinus carpio* which in 2015 was only recorded from the swimming hole at Gaynarbaba and is presumably confined to this location. These species were introduced for a number of reasons including for food and biological control. In the case of *Gambusia affinis*, according to WHO this was introduced to Turkmenistan in the 1930s for the control of malaria mosquitoes.

5.2 Methodology

Fish fauna, environmental parameters and water quality were sampled at eight springs, rivers and cave systems within the site – see table 9 and figure 26. The sample sites comprised a range of representative locations of the key aquatic habitats in the reserve. A range of basic water quality parameters were tested using probes and colorimetric tests, both simple and rugged for field use. The tests explored the physical characteristics of the water at each site and the levels of common organic nutrients. Sites where open water can be sampled are abundant, however the majority are

Figure 23. Starostin's blind loach *Troglocobitis starostini*, collected in Suw Oyuk (Photo credit: Brian Zimmerman, ZSL)

irrigation channels that feed water from springs to villages and fields and most are used heavily for the watering, and in some cases washing, of livestock with inevitable inputs of organic pollutants. Though constant flow of new spring-fed water means nutrient levels are diluted and data show relatively low levels as a result – see table 10 – there was some evidence of local eutrophication such as abundant algae and cyanobacteria growth in pools. The sample sites were selected to allow comparisons to be made with the blind loach sinkhole site and to gain an understanding of their interconnectedness both hydrologically and biologically.

During the expedition the ZSL team, aided in interpretation by Michail Pereladov from VNIRO, conducted a training session with six staff members from the Koytendag State Nature Reserve team. The session covered the basics of water quality analysis using the Salifert test kits used during the fieldwork (calcium, alkalinity, pH, dissolved oxygen content, phosphate and nitrate). Some background was given for each parameter explaining what it was, the significance for aquatic animals and the implications of change in reflecting pollution events for example. A programme of regular monitoring was agreed with the reserve's Scientific Director, with samples to be taken monthly from three sites; the Suw Oyuk sinkhole, the Koytendarya and the newly explored cave lake and analysed for the parameters shown in table 10 plus temperature. The cave lake is a new site and it would be valuable to investigate if there is any connection between that and the Suw Oyuk sinkhole hydrosystem. The Koytendarya is the only sample site containing significant numbers of native fish fauna and which might be sensitive to environmental changes. In addition to the regular sampling programme, opportunistic samples will also be taken after notable events such as flooding that may affect the aquatic environment.

For fish, the principal sampling methods were by hand net and two hexagonal, multi-entry baited minnow traps of 1 m diameter. In total seven of the eight sites were thoroughly sampled. Site 7 was not sampled extensively however a specimen was obtained opportunistically. Additional opportunistic sampling was carried out at Ketdekol reservoir in Koyten village.

For the blind loach, collection of specimens was attempted via two methods; swimmers using hand held nets and baited minnow traps left overnight – see figure 24. The traps were set in the shaded part of the sinkhole at approximately 3m depth near the two entrances to the cave system. One was baited with cheese and the second with

Table 9. Ichthyological survey sample sites.

Site number	Site name	GPS coordinates	Altitude (m)	Species identified
1	Suw Oyuk sinkhole	N 37°35.824' E 066° 24.318'	373	*Troglocobitis starostini*
2	Karabulak	N 37°36.332' E 066°21.200'	327	*Gambusia affinis*
3	Jarme	N 37°36.633' E 066°21.348'	332	*Gambusia affinis*
4	Gaynarbaba	N 37°32.265' E 066°24.375'	324	*Cyprinus carpio, Gambusia affinis, Alburnoides sp.* (*taeniatus*)?
5	Koytendarya	N 37°43.444' E 066°19.523'	443	*Paracobitus longicauda, Capoeta* sp. (*capoeta capoeta*)
6	Bashbulak	N 37°56.421' E 066°33.298'	913	None
7	Kaptarhana	N 37°49.686' E 066°24.627'	610	*Capoeta* sp. (*capoeta capoeta*)
8	Gazlyk oba	N 37°35.604' E 066°20.839'	326	*Alburnoides* sp. (*taeniatus*)?, *Gambusia affinis*
9	Ketdekol reservoir			*Capoetobrama kuschakewitschi*

Table 10. Environmental data from sample sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Temp °C	21.8	21.1	22.6	23	27.3	19	n/a	21	n/a
pH	7.08	7.58	7.41	6.32	8.08	7.06	n/a	7.57	n/a
DO mg/l	5.74	4.42	8.66	0.68	7.12	8.15	n/a	5.44	n/a
Conductivity ms/cm)	13.46	9.67	9.43	11.83	8.83	2.10*	n/a	10.21	n/a
Calcium mg/l	690	200	165	225	140	100	n/a	253	n/a
Alkalinity meq/l	3.3	3.82	3.65	3.57	2.89	3.58	n/a	0	n/a
Phosphate mg/l	0	0	0	0	0.02	0	n/a	4.1	n/a
Ammonia mg/l	0.25	<0.25	<0.25	<0.25	<0.25	0	n/a	0	n/a
Nitrite mg/l	0	0	0	<0.1	0	0	n/a	0	n/a
Nitrate mg/l	7	10	5	5	1	5	n/a	10	n/a
Flow	None	Medium	None	Low	Medium	Medium	None	Low	n/a

sausage and secured with a cord to a rock at the surface for easy retrieval. The baited traps proved unsuccessful after two trapping sessions, one of 15 hours and the second of 48 hours. Collection using hand nets was successful once the fish moved into relatively shallow water to enable a free-diving swimmer to reach them.

In addition, two novel environmental monitoring techniques were tested. The first was the use of a remotely operated vehicle (ROV) for gathering

Figure 24. Setting a minnow trap (Photo credit: Brian Zimmerman, ZSL)

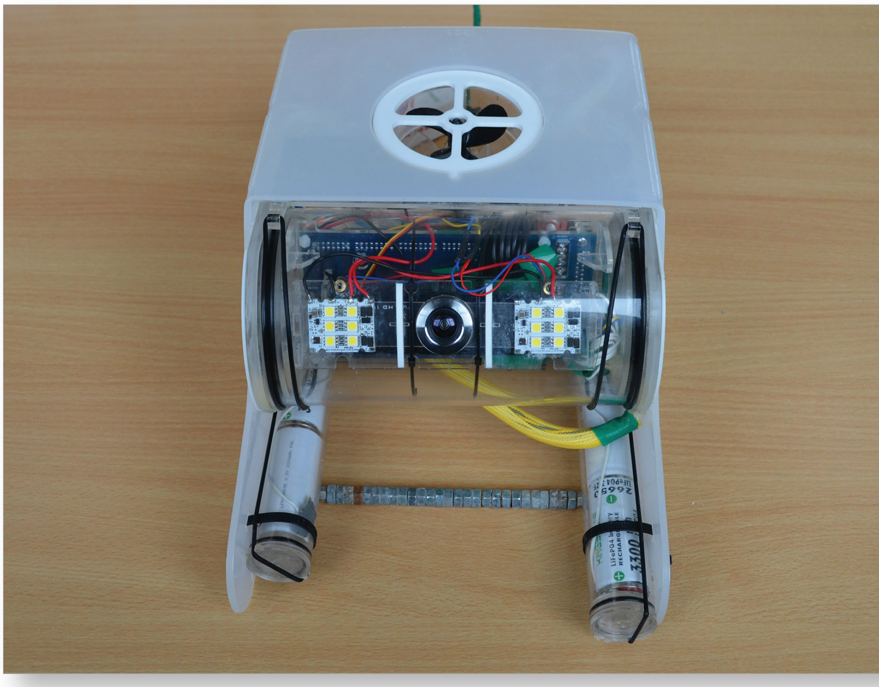


Figure 25. openROV v 2.7 (remotely operated vehicle) trialled for observing Starostin's blind loach *in situ* (Photo credit: Brian Zimmerman, ZSL)

video footage of the habitat and fish behaviour in-situ with minimal disturbance – see figure 25. The ROV used was the openROV v 2.7 from http://www.openrov.com/ assembled and tested at ZSL. The ROV was controlled from a laptop connected by an umbilical cable to the unit with a live video feed streaming directly to the laptop from the on-board camera. The use of the ROV was unsuccessful due to damage to the unit caused by water intrusion to the main chamber containing the electronics. The damage may have been sustained during shipping to the site and it was not possible to conduct repairs in the field. However, the limited time the unit spent in the water and the observations it gained from the site indicate that this approach could prove to be a useful tool for undisturbed monitoring and data collection of sensitive species in relatively inaccessible locations.

The second technique was to collect genetic material from the loach and any related species from the watershed to profile their DNA to test the potential for environmental DNA (eDNA) collection in the future as a means of measuring the full area of occupancy by the fish in the extensive cave system. The method of utilising environmental DNA is currently being used with amphibian population detection although its use for fish in cave systems is untried. The basic premise is developed from the DNA bar coding concept – http://www.barcodeoflife.org/content/about/what-dna-barcoding

The premise is that the cytochrome oxidase 1 gene (COI) located on the mitochondria of eukaryotic organisms encodes a relatively unique sequence for a species. The concept relies on taking a source of DNA and amplifying the COI gene from this source in order to identify what species are present in the source. This concept is applied to everything from probable single species sources (meat and skins in illegal wildlife trade, for example) up to sources with mixed species DNA, like water samples. By extension, this concept then becomes a means of identifying what eukaryotic species are present in environmental samples, like soil, snow and, in the cavefish scenario, water. By knowing how COI genes are unique to a certain species, PCR primers can then be designed that determine what region is amplified during PCR to target only the COI gene of the species of interest. To do this, other potential sources of DNA that would be most similar to the focal species present in the environment need to be sampled in order to exclude these as much as to target the focal species.

For the mitochondrial DNA analysis nine individual fish samples were included in the study, comprising four *Troglocobitis starostini*, two *Paraobitis longicauda*, one *Capoeta capoeta* and one *Alburnoides* sp. Samples (eight fin, one body) had been stored in ethanol. Samples were assigned a code TF1 – TF9 and studied blind to the identity of the individual to reduce subjective bias. DNA was extracted using a Qiagen blood and tissue kit

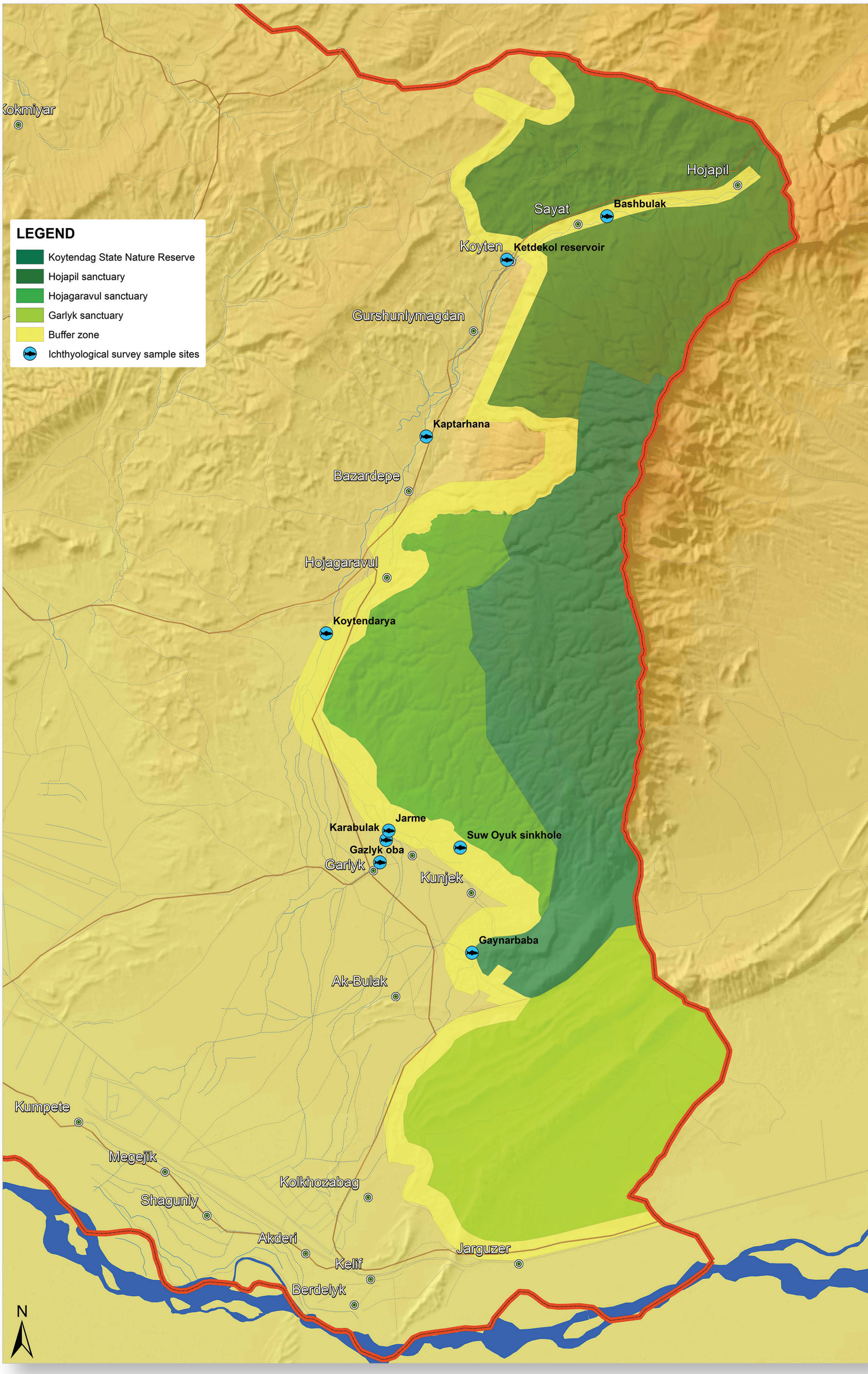


Figure 26. Ichthyological survey sample sites. Map by Atamyrat Veyisov.

and amplified PCR using universal primers for mitochondrial DNA (mtDNA) 12S and 16S RNA genes. PCR products were sequenced at GATC Biotech, using a Sanger method. Sequences were aligned using ClustalW in Bioedit. BLAST searches of Genbank and Mitofish nucleotide databases were used to identify closely homologous sequences.

5.3 Results

Seven of the ten species recorded for the area were identified during the sampling period – see table 7. For the blind loach, a total of eight individuals was observed. Seen *in-situ* the fish were all in contact with solid surfaces rather than free-swimming in the water column, presumably for purposes of orientation. Most were observed near the cave entrance in more than 3 m of water but one was observed within a metre of the water surface. Fish were seen in pairs on two occasions. Two whole fish were collected for further analysis, and fin clips were taken from a further three specimens. These specimens will provide more detailed anatomical information, as well as the first opportunity to carry out gut content analysis to understand the dietary preferences and to develop the genetic profile of this species for eDNA work.

The results of the mitochondrial typing analysis showed that groups of individuals showing identical haplotypes for 12S were also identical for 16S. Four 12S/16S haplotypes were identified. The 12S/16S haplotype groupings were consistent with the species of the test individuals:

a) TF1, TF2, TF4 and TF8 – all *Troglocobitis starostini*
b) TF6, TF7 – both *Paracobitis longicauda*
c) TF5 – *Capoeta capoeta*
d) TF9 – *Alburnoides* spp.

The phylogenetic tree of 12S mtDNA – see figure 27 – from the sampled individuals and closely homologous sequences in the nucleotide databases shows two strongly supported clades:

a) A 'loose' clade including the *T. starostini* and *P. longicauda* individuals in which there is generally low bootstrap support for sub-

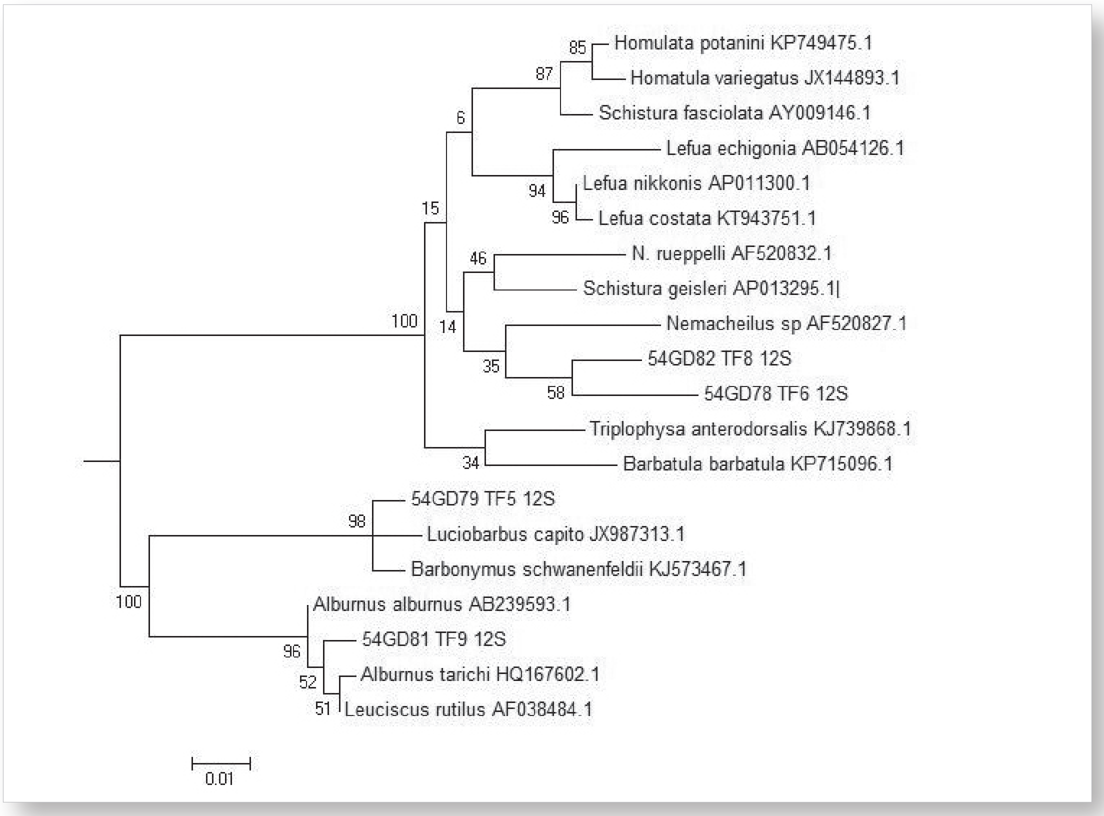


Figure 27. Blind loach mtDNA phylogenetic tree of the 12S haplotypes identified in the test individuals and closely homologous sequences from the Genbank nucleotide database.

Table 11. Suw Oyuk, Hojagaravul Wildlife Sanctuary (N 37°35.604' E 066° 20.839'; 326 m asl).

Date	Temp. outside cave (°C)	Temp. inside cave (°C)	Water temp. (°C)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
26.05.2015	-	-	26.8	11.30	11.30–13.36	0.08	0.38 (3.36%)	0.62 (690%)	6.74	0	7
29.06.2015	43	24.1	26.8	12.50	12.52–13.36	7.7	0.44 (3.08%)	1.46 (770%)	8	0	25
29.07.2015	39	38	22.4	11.55	12.10–12.57	7.5	0.57 (2.39%)	1.63 (690%)	10	0	75
28.08.2015	28.4	-	20.2	10.55	11.03–11.34	7.5	0.40 (3.30%)	2.78 (1110%)	8	0.03	30
29.09.2015	39.1	27.2	20.1	14.15	14.15–14.46	7.6	0.20 (4.45%)	1.37 (810%)	10	0.03	75
29.10.2015	30.0	21.2	20.1	13.10	13.30–13.53	7.6	0.28 (3.99%)	1.24 (880%)	6	0.03	75
30.11.2015	12.3	13.1	19.1	10.16	10.16–10.46	7.5	0.36 (3.53%)	1.22 (890%)	10	0.03	30
06.01.2016	19.3	16.3	19.1	09.38	09.41–10.15	7.5	0.22 (4.33%)	1.36 (820%)	10	0.03	50
06.02.2016	20	22.1	19.3	09.15	09.20–09.55	7.4	0.48 (2.85%)	-	6	0	25
06.04.2016	22	16.0	19.4	14.45	14.48–15.21	7.4	0.40 (3.30%)	0.42 (290%)	10	0	50
12.05.2016	29.3	24.1	20.1	10.20	10.24–10.59	7.4	0.40 (3.30%)	0.56 (220%)	8	0	50
06.06.2016	38.2	26.0	21.2	15.43	15.45–16.11	7.6	0.38 (3.42%)	0.60 (200%)	9	0	50
06.07.2016	39.4	26.0	21.4	12.36	12.40–13.08	7.8	0.42 (3.19%)	0.72 (140%)	10	0	50
12.08.2016	34.3	23.4	20.1	11.53	11.56–12.30	7.6	0.42 (3.19%)	0.54 (250%)	8	0	50
08.09.2016	31.3	26.0	20.2	14.10	14.13–14.40	7.4	0.40 (3.30%)	0.72 (140%)	8	0	50

Table 12. Gaynarbaba, Garlyk Wildlife Sanctuary (N 37o32.265' E 066o 24.375'; 324 m asl).

Date	Temp. outside cave (ºC)	Temp. inside cave (ºC)	Water temp. (ºC)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
29.08.2015	-	27.0	21.4	08.41	08.45-09.15	7.5	0.34 (3.65%)	0.30 (350%)	2	0	25
29.09.2015	-	39.2	21.4	12.02	12.02-12.38	7.5	0.32 (3.76%)	0.40 (300%)	6	0	25
29.10.2015	-	30.0	21.2	11.25	11.25-11.56	7.5	0.32 (3.76%)	0.14 (430%)	8	0	25
30.11.2015	-	9.2	21.0	07.01	07.01-07.35	7.5	0.35 (3.76%)	2.90 (1090%)	10	0.03	25
29.12.2015	-	22.0	21.0	11.55	11.55-12.25	7.5	0.34 (3.65%)	0.36 (320%)	10	0	25
06.01.2016	-	19.3	21.3	12.02	12.05-12.30	7.5	0.32 (3.76%)	0.54 (230%)	8	0	50
06.02.2016	-	18.1	21.2	11.28	11.30-11.56	7.4	0.32 (3.76%)	0.32 (340%)	8	0	25
11.03.2016	-	26.0	20.2	16.02	16.05-17.00	7.4	0.44 (3.08%)	0.56 (220%)	8	0	50
05.04.2016	-	26.0	20.01	12.59	13.02-13.36	7.4	0.32 (3.76%)	0.54 (230%)	8	0	25
06.05.2016	-	26.5	21.2	10.30	10.33-11.00	7.7	0.32 (3.76%)	0.54 (230%)	8	0	25
06.06.2016	-	30.3	22.0	10.48	10.50-11.25	7.7	0.32 (3.76%)	0.46 (270%)	8	0	10
06.07.2016	-	29.7	22.1	10.28	10.30-11.11	7.8	0.28 (3.99%)	0.48 (200%)	8	0	25
12.08.2016	-	23.0	21.3	09.27	09.30-10.08	7.8	0.50 (2.73%)	0.50 (250%)	12	0	25
08.09.2016	-	27.1	22.0	11.40	11.43-12.25	7.5	0.32 (3.76%)	0.54 (230%)	8	0	10

Table 13. Koytendarya, Bazardepe village on border with Hojagarawul Wildlife Sanctuary (N 37°43.444' E 066° 19.523'; 443 m asl)

Date	Temp. outside cave (⁰C)	Temp. inside cave (⁰C)	Water temp. (⁰C)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
28.05.2015	-	-	27.3	03.45	03.45-04.38	8.08	0.48 (2.89%)	0.72 (140%)	7.12	0.02	1
29.06.2015	-	41.0	28.4	17.45	18.01-18.37	8.0	0.54 (2.50%)	0.58 (210%)	8	0	10
29.07.2015	-	38.0	28.1	18.19	18.29-18.58	8.1	0.36 (3.53%)	0.18 (410%)	10	0.03	10
28.08.2015	-	33.0	25.1	16.55	17.00-17.35	8.1	0.18 (4.56%)	0.14 (430%)	10	0.03	10
29.09.2015	-	25.2	20.2	17.14	17.24-17.45	8.2	0.34 (3.65%)	0.39 (300%)	10	0.03	50
29.10.2015	-	22.3	15.1	16.05	16.13-16.39	8.1	0.28 (3.99%)	0.12 (440%)	10	0	15
30.11.2015	-	18.9	10.4	11.03	11.03-11.56	8.2	0.24 (4.22%)	0.41 (300%)	10	0	15
29.12.2015	-	16.1	9.3	16.06	16.35-17.00	8.2	0.26 (4.1%)	0.16 (470%)	12	0.03	25
06.02.2016	-	14	11.4	15.55	16.08-16.25	7.9	0.26 (4.10%)	0.14 (430%)	12	0	25
11.03.2016	-	20.0	14.2	11.14	11.18-11.50	7.7	0.82 (0.90%)	0.72 (140%)	12	0	10
06.04.2016	-	17.2	15.0	10.50	11.23-11.35	7.8	0.34 (3.65%)	0.60 (200%)	12	0.03	10
06.05.2016	-	19.4	15.6	15.10	15.14-15.45	7.8	0.36 (3.53%)	0.60 (200%)	12	0	10
06.06.2016	-	26.0	24.3	10.44	10.47-11.27	7.8	0.36 (3.53%)	0.58 (210%)	12	0	10
06.07.2016	-	31.0	33.1	15.36	15.40-16.09	8.1	0.64 (1.93%)	0.56 (220%)	12	0	10
12.08.2016	-	26.4	24.5	16.51	16.54-17.28	7.8	0.12 (4.90%)	0.58 (210%)	12	0	25
08.09.2016	-	26.0	16.2	16.00	16.03-17.40	8.2	0.64 (1.93%)	0.60 (200%)	12	0	10

Table 14. Kutuzov cave, Hojagaravul Wildlife Sanctuary (N 37°35.824' E 066° 24.318'; 373 m asl).

Date	Temp. outside cave (ºC)	Temp. inside cave (ºC)	Water temp. (ºC)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
29.06.2015	43.0	14.2	13.3	16.18	16.22-17.00	7.4	0.46 (2.96%)	1.64 (680%)	8	0.03	35
29.07.2015	22.8	19.1	13.2	16.52	17.10-17.46	7.6	0.48 (2.85%)	1.42 (700%)	8	0.03	50
28.08.2015	36.0	20.4	13.3	14.55	15.10-15.52	7.6	0.52 (2.62%)	1.24 (880%)	10	0	60
29.09.2015	-	19.5	13.0	15.50	15.55-16.38	7.7	0.38 (3.42%)	2.00 (1000%)	12	0.03	75
29.10.2015	-	-	-	-	-	-	-	-	-	-	-
30.11.2015	11.2	12.1	12.4	08.50	08.50-09.30	7.8	0.52 (2.62%)	1.35 (830%)	12	0	25
29.12.2015	14.3	12.0	12.1	14.40	14.57-15.27	7.6	0.46 (2.96%)	1.44 (780%)	15	0	75
06.02.2016	15.0	12.1	11.1	14.29	14.32-14.55	7.6	0.56 (2.39%)	1.56 (720%)	8	0.03	50
11.03.2016	20.0	16.0	11.4	10.27	10.30-11.11	7.4	0.62 (2.05%)	-	12	0	50
06.04.2016	23.0	15.1	12.2	17.14	17.18-17.52	7.7	0.46 (2.96%)	0.00 (500%)	12	0	50
06.05.2016	26.0	16.2	12.6	12.25	12.28-12.50	7.7	0.46 (2.96%)	0.40 (300%)	12	0	50
06.06.2016	34.2	13.4	14.0	17.41	17.44-18.10	7.5	0.46 (2.96%)	0.52 (240%)	10	0	50
06.07.2016	40.2	14.0	13.3	11.57	12.00-12.30	7.5	0.50 (2.73%)	0.66 (170%)	9	0	50
12.08.2016	34.2	13.0	11.2	14.44	14.47-15.23	7.8	0.56 (2.39%)	0.18 (410%)	15	0	50
08.09.2016	30.0	14.2	13.0	15.10	15.13-16.00	7.5	0.46 (2.96%)	0.32 (340%)	9	0	50

Table 15. Garabulak, Garlyk village border with Hojagaravul Wildlife Sanctuary (N 37o35.604', E 066o 20.839'; 326 m asl)

Date	Temp. outside cave (ºC)	Temp. inside cave (ºC)	Water temp. (ºC)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
28.05.2015	-	-	21.1	10.57	11.30-12.10	7.57	3.32 (3.82%)	0.60 (200%)	4.72	0	10
31.05.2015	-	-	21.0	09.00	09.00-09.50	7.57	0.26 (4.10%)	0.60 (200%)	2.25	0	10

Table 16. Jarme, Garlyk village border with Hojagarawul Wildlife Sanctuary (N 37o36.633', E 066o 21.348'; 326 m asl)

Date	Temp. outside cave (ºC)	Temp. inside cave (ºC)	Water temp. (ºC)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
28.05.2015	-	-	22.6-21.1	11.10	11.15-12.18	7.41	0.34 (3.65%)	0.68 (162%)	8.66 (104%) 4.87 (57%)	0	5

Table 17. Jarme, Gaynarbaba 'Ak suw' spring, Garlyk Wildlife Sanctuary (N 37o32.265' E 066o 24.375'; 324 m asl)

Date	Temp. outside cave (ºC)	Temp. inside cave (ºC)	Water temp. (ºC)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
28.05.2015	-	23	22.3	02.30	-	6.32	0.36 (3.57%)	0.60 (200%)	2.25	0	5
28.08.2015	-	26.0	21.4	09.20	09.25-09.50	7.5	0.26 (4.10%)	0.78 (110%)	2	0	5

Table 18. Bashbulak, Gyzylay village, Hojapil Wildlife Sanctuary (N 37o56.421' E 066o 33.298'; 913 m asl)

Date	Temp. outside cave (ºC)	Temp. inside cave (ºC)	Water temp. (ºC)	Sampling time	Time of analysis	Acidity (PH) mg/l	Alkalinity (KH) mg/l	Calcium (ca) mg/l	Oxygen (O_2) mg/l	Phosphate (PO_4) mg/l	Nitrate (NO_3) mg/l
29.05.2015	-	-	19.0	04.16	-	7.06	0.36 (3.58%)	100	8.15 (100%)	0	5

clades illustrating the limitation of resolution with the current representation of related taxa in the databases.

b) A second clade including two well supported subclades, the *Alburnoides* spp. individual (TF9) grouping with *Alburnus* spp. and *Capoeta capoeta* (TF5) with the sister subclade.

Results of follow-up monthly water quality monitoring by reserve staff at eight sites within the reserve are given in tables 11 to 14, with information from less regularly monitored sites in tables 15 to 18.

Analysis of data from the 16 month period – May 2015 to September 2016 – for the Suw Oyuk sinkhole allow some broad observations of selected parameters to be made but a continued data series into a second complete year is necessary in order to draw inter-annual comparisons – *see 5.4 Discussion*. The analysis carried out relates to:

1. Temperature

This appears to be a reliable and consistent set of data comparing temperatures at ground level above the sinkhole (Air), with those inside the sinkhole (Cave) and in the Water of the sinkhole lake (figure 28).

2. Oxygen levels

This parameter is difficult to measure accurately using the simple tests provided. Any agitation of the samples changes the oxygen saturation levels quickly as does any delay in conducting the test. The data are variable between 67% and 115%. The mg/l values in the raw data were converted to % saturation levels using altitude and temperature data (figure 29).

5.4 Discussion

In terms of the DNA analysis the haplotype grouping of the test samples is consistent with the species of the individuals. The extent of poly-

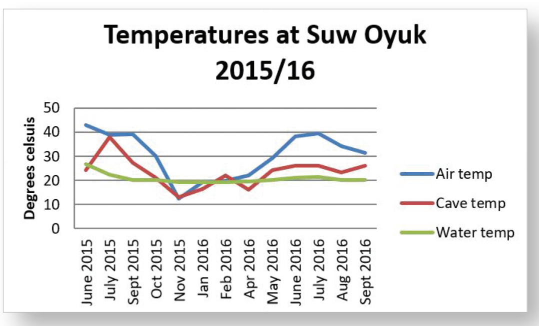


Figure 28. Temperatures at Suw Oyuk 2015/16.

3. Nutrient levels

These data record levels of phosphate (PO_4) and nitrate (NO_3) collectively tracking dissolved organic nutrient levels in the water (figure 30).

4. Calcium and carbonate levels (figure 31)

5. pH (figure 32)

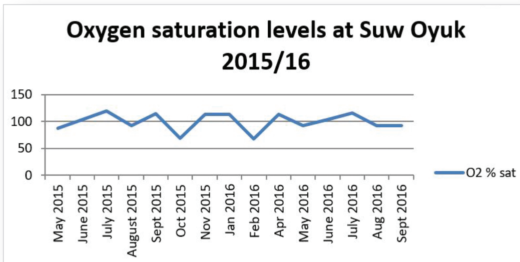


Figure 29. Oxygen saturation levels at Suw Oyuk 2015/16.

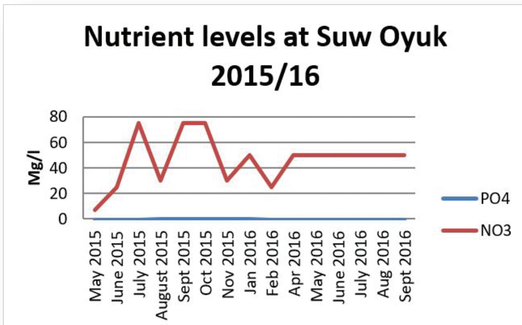


Figure 30. Nutrient levels at Suw Oyuk 2015/16.

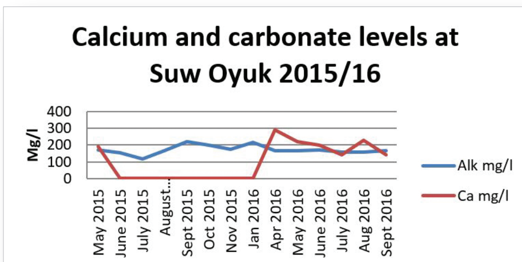


Figure 31. Calcium and carbonate levels at Suw Oyuk 2015/16.

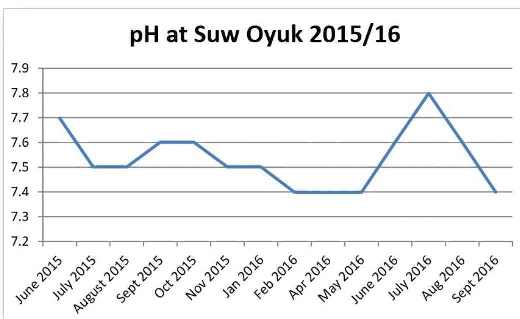


Figure 32. pH at Suw Oyuk 2015/16.

morphism within the 12S and 16S sequences was sufficient to allow resolution between the species included in this study. However, identification at the species level was not possible due to limited database representation of related taxa, a well-recognised limitation of mtDNA species 'barcoding'.

The primers used in this study would be unsuitable for the investigation of the distribution of the blind loaches using DNA from water samples as they amplify across a wide range of taxa. However, it should be possible to generate more specific blind loach primers from the polymorphic regions within the 12S and 16S regions amplified in the current study.

The evolutionary history was inferred using the maximum likelihood method based on the Kimura 2-parameter model. The tree with the highest log likelihood is shown. The percentage of trees in which the associated taxa clustered together (based on 500 bootstrap replications) is shown next to the branches. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. There were a total of 359 positions in the final dataset. The analysis involved 20 nucleotide sequences. Evolutionary analyses were conducted in MEGA6. Accession numbers are shown for homologous sequences downloaded from Genbank.

Based on current knowledge of the hydrogeology of Koytendag, it is generally agreed that the blind loaches were originally species living in the surface waters of the area which colonized Suw Oyuk probably from water courses which formerly linked Karabulak and Kaynar springs with the Amudarya, though the possibility that they reached the sinkhole during times of extensive flooding by the Koytendarya cannot be discounted. This hypothesis is based on the following geological conditions:

1. Analysis of the geological structure of the surface water bodies and the structure of deposits in the sinkholes shows that depressions in the valley are covered from above with a thick layer of alluvial deposits (pebbles, sand and gravel) which were brought either by flooding of the river in the historical past, or through the flow of debris from the canyon.

2. Analysis of the dry beds of the Koytendarya shows that even now during flash floods a large part of the valley can be covered by water.

3. In the recent past (a few hundred years ago) the Koytendarya was significantly larger and deeper and frequently overflowed into the Amudarya – there was even shipping up as far as Bazardepe village.

Therefore, during seasonal flooding, water from the Koytendarya could potentially have entered the sinkholes and brought with it fauna from the river. An estimate of the length of time that the river and cave fish fauna have been separated could be obtained by analysing the genetic distance between loach caught in the Koytendarya and blind loach in the sinkholes.

Maltsev also hypothesised that the loaches became isolated from other loach populations through the establishment of hydrogen sulphide 'barriers' – hydrogen sulphide is both toxic and creates anaerobic conditions – using the presence of three hydrogen sulphide springs in the area to support this theory. However, it is thought that the hydrogen sulphide springs are of recent geological origin and formed after the loaches had colonized Suw Oyuk.

Troglocobitis starostini was first recorded in 1979 by Vladimir Maltsev, first caught in 1981 by Nikolai Swerden and described in 1983 by Nikolai Parin. In 1986 the first scuba exploration of the sinkhole was conducted by Sergei Smirnoff who collected specimens and tried to keep them in an aquarium unsuccessfully. In 1987, which was a dry spring and the water level was lower, a further scuba survey descended into the cave system to a depth of 62 m – noting over 100 fish 10-15 m below the surface. In 1988, a wet spring, a survey noted the surface of the sinkhole was covered in debris and there had been a partial collapse of one of the side walls but the fish were seen feeding on the mud in the water. The latter was the last significant study of the site. In 1989 a smaller trip noted 20-30 fish near the surface of the water. In 1994 another small expedition collected fish in an attempt to breed them *ex-situ* (Salnikov) and the results of his work were published in 2004 and 2008 in Russian.

Distribution of the species is strongly associated with the distribution of bacterial films on the surface of cave bottom sediments. In the dry season plant debris (or other forms of organic matter) is blown into the sinkholes and becomes deposited on the bottom of the shallow lakes near the surface. At this time the majority of the fish population spreads into the upper (illuminated) part of the lake. After periods of heavy rain larger quantities of plant debris and animal matter can be found throughout all parts of the underwater caves and the fish disperse throughout the cave system. Additionally, it is thought that inter-annual fluctuations in water temperature in the sinkhole lake can be significant and can have a significant impact on the distribution of blind loaches and biological processes in their population.

In 1994, after an extensive flood when the sinkhole lake received a considerable amount of organic residues, local officials decided to close the channel that flowed directly into the lake and divert the water into the neighboring sinkhole which had no direct access to the main water body. As a result for the past 20+ years mudslides have never entered the Suw Oyuk sinkhole resulting in the formation of an entirely different seasonal succession. Instead of the periodic enrichment of the sinkhole lake by 'fresh' organic matter, the underground lake now receives water filtered through several hundred metres of gypsum rock that has dramatically changed the food source of the population of blind loaches. This raises the question as to whether it is necessary or preferable to leave the channel providing organic matter blocked or restore the old watercourse which periodically brings mud with organic residues to the sinkhole lake? As the flow of organic matter into the cave lake ecosystem existed since the formation of the sinkholes and the development of the blind loach populations, this can be considered as a normal process. However, there is a risk that should there be the deposition of another large amount of surface mud the connection between the lake and the main underground cavity could become completely blocked for further study. Such a blockage is unlikely to be an impenetrable barrier for the blind loach but it would prevent human access to the lower levels of the lake. In an extreme case, a major deposition of mud could cause complete blockage of the external lake and turn the sinkhole into a cavity filled with loose sediments – as has happened to a neighboring sinkhole that has absorbed debris flows from the Bulakdere canyon.

Fish species were recorded in three 'cave systems' – sazan near Jarme north of Garlyk, *Capoeta* sp. in Kaptarhana and blind loaches in Suw Oyuk – and there is speculation over how fish colonized each of these sites. In the case of the sazan, these are known to have been introduced. As Kaptarhana is located within 200 m of the Koytendarya where *Capoeta* sp. are known to occur, it is considered likely that there are existing or geologically recent connections between the two waterbodies. The presumed origin of the blind loach in Suw Oyuk is discussed in detail above.

Of the two introduced species recorded during the survey *Gambusia affinis* were virtually ubiquitous. The only sites where this species was noticeably absent were the sinkhole where the blind loach is found, the newly discovered cave lake and the main channel of the Koytendarya. In the case of the main channel of the Koytendarya the flow rate was higher than expected for typical *Gambusia affinis* habitat. The cave lake was completely devoid of any life or light and therefore considered unsuitable habitat for *Gambusia affinis*. However, the potential for introduction of *Gambusia affinis* to the sink hole should be considered; though unlikely the implications would be serious and should be considered a major risk.

Preliminary analysis of the water sampling at Suw Oyuk indicates the following:

1. Temperature

The data reveal the large range of seasonal temperatures from the surrounding environment (min: 12.3°C, max: 43°C, mean: 30.4°C, SD: 9.2, n=14) which is tracked by that inside the sinkhole despite generally less extreme values (min: 16°C, max: 38°C, mean: 23.4°C, SD: 6.24, n=13). In contrast the water in the sinkhole lake itself shows a remarkably constant temperature year-round with a range of only 7.7°C (min: 19.1°C, max: 26.8°C, mean: 21.09°C, SD 2.49, n=15). Given that the samples are assumed to have been taken at or very near the surface of the water where temperatures could be expected to be most variable, this might suggest even more constant temperatures at depths in the main subterranean water system.

2. Oxygen levels

As the water in the sinkhole lake is relatively still with no apparent currents or turbulence the results showing O_2 saturation levels >100% are most likely an artefact due to sampling error.

3. Nutrient levels

PO_4 levels are inconsequential whereas NO_3 levels, though variable ranging from 7 to 75mg/l, could generally be interpreted as high. The EU Nitrates Directive describes rivers and groundwater with nitrate concentration above 25 mg NO_3/l as reflecting a threshold of concern, and those above 50 mg NO_3/l as contaminated. This concern is reflected by the Environmental Protection Agency which has adopted a maximum contaminant level of 10 mg/l for nitrate-nitrogen in regulated public water systems, and the Secretary of State Standards of Zoo Practice states that levels above 20 mg/l in seawater should be avoided – the limit for freshwater is likely to be similar. The data from the sinkhole samples record values ≥50mg/l in 10 of the 15 months sampled (66%). The NO_3 in the water might reflect decomposition of debris blown into the upper layers of the lake from the surface and dead frogs and birds have been observed in the water which would also contribute nutrients as they break down. It may also represent contamination from agricultural practices on surrounding land, or from other water sources that may feed into the cave system elsewhere. There is no obvious seasonal pattern which might reflect agricultural use of fertilisers on crops, which is encouraging, but a longer data series is required to draw any firm conclusions.

The significant quantities of NO_3 in the upper waters of the lake would seem to confirm the sinkhole as a major source of nitrogen into the wider subterranean hydrological system and potentially a key driver of the productivity of this system that supports *Nemacheilus* and its associated sources of food. However, at higher levels of NO_3 problems of eutrophication leading to algae blooms are often a problem and this should be recorded if observed. It would be instructive to see what mixing of nutrients (if any) is happening by taking water samples from deeper in the cave system if possible. The NO_3 contamination may in fact be quite localised if mixing is limited or it may constitute a major source if input as noted above. Further analysis of this parameter using laboratory techniques might be useful.

4. Calcium and carbonate levels

The data for calcium is slightly confusing; assuming that the units it has been recorded in reflect the amount of reagent used for the test then after a conversion to mg/l several consecutive samples would record a reading of 0. The months that do record a positive result vary between 140 and 290 mg/l which would seem to be within a reasonable range for a cave system made from calcium sulphate. The months for which there is a reading of 0 may be due to testing error. The consistent alkalinity results (showing carbonate levels in mg/l) would also support the supposition that the calcium readings are errors and also support the observations of quite stable water quality in the cave system.

5. pH

pH varies between 7.4 and 7.8 and appears to show a high point in June/July for both years but a longer data series is required to draw conclusions about a seasonal pattern with any confidence.

In conclusion, nutrient levels in the sinkhole lake are of concern and warrant further investigation but overall the data are useful and create a good baseline to build on. A longer time series is required to allow inter-annual comparisons and a continued sampling and testing effort is recommended. Some re-training of reserve staff in the use of O_2 and Ca test kits may be required but it may also be the case that the tests are unsuitable for the field conditions at Koytendag. The value of building up a picture of how the water chemistry in the sinkhole varies seasonally and therefore a confident assessment of what is 'normal' should allow good recognition of the effects of any changes in the environment of the area in the future. It may be sensible to provide reserve staff with more accurate probe type water quality analysis equipment.

5.5 Recommendations for future work

5.5.1 Carry out a detailed survey of the cave system that the sinkholes form part of to understand the hydrological and biological importance and level of hydrological connectivity. This is particularly relevant for the newly discovered cave lake. This will require extensive equipment and specialist skills.

5.5.2 Quantify the size of the blind loach population in the underground system.

5.5.3 Compile a basic database of the physical and ecological characteristics of the sinkhole to allow a better understanding of the way the sinkhole functions and enable risks and threats to it to be better identified. The reserve staff are well placed to collect data on the seasonal and environmental changes happening in and around the sinkhole based on observations and simple water quality tests.

5.5.4 Carry out a programme of regular (monthly) monitoring of three sites – the sinkhole, the Koytendarya and the newly discovered cave lake – with analysis for the parameters listed in 4.4 plus temperature. This programme was agreed with the reserve's scientific director. The Koytendarya is the only sample site containing significant numbers of native fish fauna which might be sensitive to environmental changes. As well as regular sampling, opportunistic samples should also be taken after notable events such as flooding that may affect the aquatic environment. A simple data sheet was designed for this purpose. The sheet is designed to be printed out and taken into the field for observations by the rangers, then handed over to whoever is doing the water testing. The final data should be transferred to a spreadsheet for ease ofcomparison and to establish trends over time.

5.5.5 Consideration should be given to carrying out more detailed water quality analysis using techniques with a higher degree of accuracy. A range of potentially problematic substances such as pesticides, or evidence of hydrocarbon pollution can be established though this would require the coordination of international shipment of refrigerated samples to complete.

5.5.6 With specific reference to the blind loach – sequencing of the COI gene of the blind loach and other phylogenetically similar fish species in the area should be carried out and searches made for available genetic sequence databases for the COI gene sequence of phylogenetically similar fish species. Once all the sequences are compared, the primers specific to the blind loach can be designed. Searches of the genetic databases using the sequence that encapsulates the primer sequences and the intervening sequence should then be carried out to confirm that this amplicon is unique (by chance or through evolutionary convergences, species that are not closely related to the target species may share strong sequence similarity despite the lack of shared evolutionary history). If successful this will provide a set of primers that will only amplify the COI gene of the blind loach, allowing the extraction of DNA from water samples to show where the DNA of the blind loach occurs in the cave system. Because both water and fish move, this will not be a 100% representation of where the fish live but it should guide where more extensive ROV work should be carried out to confirm the eDNA results (Garner, pers. comm).

5.5.7 Investigate the current or geologically recent existence of hydrological connectivity between Suw Oyuk and Karabulak and Kaynar springs.

5.5.8 Net surveys of the Koytendarya and drainage channels to search for the relict Amudarya shovelnose sturgeon *Pseudoscaphirhynchus kaufmanni*.

5.6 Bibliography

Aliyev DS, Sukhanova A, Shakirova FM (1988) Fish of inland waters of Turkmenistan.

Science, Ashgabat, 156 pp. In Russian

Iwasaki W, Fukunaga T, Isagozawa R, Yamada K, Maeda Y, Satoh TP, Sado T, Mabuchi K, Takeshima H, Miya M, Nishida M (2013) Mitofish and MitoAnnotator: A mitochondrial genome database of fish with an accurate and automatic annotation pipeline. Molecular biology and evolution 30 (11): 2531-2540.

Kimura M (1980) A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. Journal of Molecular Evolution 16: 111-120.

Smirnov S (1983) A Blind Cave Loach from Southwestern Asia, *Noemacheilus starostini*. Tropical Fish Hobbyist 3: 54-58.

Parin NYa and Dolzhansky VY (1982) Kugitang blind loach – the first blind fish fauna of the USSR. Priroda [Nature] 8: 29-32. In Russian

Parin NV (1983) *Noemacheilus (Troglocobitis) starostini* sp.n. (Osteichthys, Gobitidae) A New Eyeless Fish from Underground Waters of Kugitangtau (Turkmenia). Zoologicheskii Zhurnal 62 (1): 83-89.

Pereladov MV (in preparation) A History of Investigations and Modern problems of Subterranean Aquatic Fauna Research and Protection at Kugitang-Tay Mountain Region, Turkmenistan. (Unpublished).

Prokofiev AM (2009) Problems of the Classification and Phylogeny of Nemacheiline Loaches of the Group Lacking the Preethoid I. (Cypriniformes: Balitoridae: Nemacheilinae). Journal of Ichthyology, 2010, 49, 10: 874-898.

Prokofiev AM (2010) Morphological Classification of Loaches (Nemacheilinae). Journal of Ichthyology 50, 10: 827-913.

Salnikov VB (2006) Ichthyofauna of the reservoirs of Kugitang. In: Problems of desert development. Ministry of Nature Protection of Turkmenistan and National Institute of Deserts, Flora and Fauna.

Shilin NI, Pereladov MV (2014) Koytendag (Kugitan) Blind Cave Loach – Rare and Vulnerable Representative of the Cave Fish Fauna. Caves, section Biospeleology 37: 150-157. In Russian

Starostin IV (1945) Materials on the fish fauna of the Karlyuk TSSR area. Proceedings of the Turkmen

branch of the USSR Academy of Sciences, 5-6: 131-136. In Russian
Starostin IV (1992) The fauna of inland waters of Turkmenistan. Ashgabat, 256 pp. In Russian
Swaim KM, Boeing WJ (2008) Relating Fish Abundance and Condition to
Environmental Factors in Desert Sinkholes. Department of Fish, Wildlife and
Conservation Ecology. New Mexico State University. Progress Report to U.S. Fish and Wildlife Service, Bitter Lakes NWR, 18 pp.
Tamura K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA6: Molecular Evolutionary Genetics Analysis version 6.9. Molecular Biology and Evolution 30: 2725-2729.
Yang Li, Zongqing Tan, Wang Daren, Xue Ling, Guan Mix-xin, Huang Taosheng and Ronghua Li (2014) Species identification through mitochondrial rRNA genetic analysis. Scientific reports 4, 4089. DOI: 10.1038/srep04089.

6. Amphibians

Geoff Welch

6.1 Background

There have been no recent systematic surveys of amphibians at Koytendag – *see Bibliography* – and only two species were known to occur at the site – *Rana ridibundus* and *Bufotes viridis / variabilis*.

6.2 Methodology

Opportunistic recording of amphibians was carried out in all wetlands visited.

6.3 Results

According to Litvinchuk et al. (2011), the species of green toad ocurring at Koytendag should be *Bufo turanensis*, however during recent survey work *Bufotes (Pseudepidalea) variabilis* was noted at Hojapil in 2014 and *Bufotes oblongus* in the Suw Oyuk sinkhole in 2015 making these records of significance.

6.4 Discussion

Without further study, given the paucity of species and observations, no meaningful comments can be made regarding the amphibian fauna of Koytendag.

Figure 33. *Bufotes* (*Pseudepidalea*) *variabilis*, Hojapil (Photo credit: Jeremy Holden, RSPB)

6.5 Recommendations for future work

6.5.1 As part of any future surveys of wetlands at Koytendag, principally in relation to the fish fauna, all observations of amphibians should also be recorded.

6.6 Bibliography

Litvinchuk SN, Mazepa GO, Pasynkova RA, Saidov A, Satorov T, Chikin YuA, Crottini DA, Borkin LYa, Rosanov YuM, Stock M (2011) Influence of environmental conditions on the distribution of Central Asia green toads with three ploidy levels. Journal of Zoological Systematics and Evolutionary Research 49(3): 233-239.

Shammakov SM, Marinina LS, Marochkina VV, Karryeva ShB (2004) The species composition of amphibians, reptiles and mammals of the reserves of Turkmenistan. Problems of Desert Development 4: 45-51. In Russian

Shukurov OSh (1975) On the ecology of the glass-lizard (*Ophisaurus apodus*) in eastern Turkmenistan. Proceedings of the 15th nauchno-teoreticheskoy konferencii prepodavatel'skogo sostava, Chardzhou: 17-19. In Russian

Shukurov OSh (1976) Herpetofauna of Kugitang and its foothills. Herpetology: 74-76. In Russian

7. Reptiles

Geoff Welch

7.1 Background

As with amphibians, there have been no recent systematic surveys of reptiles. Previous studies have recorded 34 species. Six species are regionally endemic – *Agama chernovi* and *Agama turkestanica* plus four species included in the Red Data Book of Turkmenistan (2011) – Levantine viper *Macrovipera lebitina* (VU), Tartar sand boa *Eryx tataricus* (Rare), Tajik racerunner *Eremias regeli* (VU) and black-spotted racerunner *Eremias nigrocellata* (VU).

7.2 Methodology

No specific recording of reptiles was made during recent visits to the site, though rapid racerunner *Eremias velox* (figure 34) was photographed near Garlyk and Turkestan rock agama *Paralaudakia lehmanni* close to the reserve's headquarters (figure 35) and Asian snake-eyed skink *Ablepharus pannonicus* at Tamcy in 2014.

7.3 Results

Because of the lack of observations, there are no results to report.

Figure 34. Rapid Racerunner *Eremias velox*, Garlyk (Photo credit: Jeremy Holden, RSPB)

Figure 35. Turkestan rock agama *Paralaudakia lehmanni* (Photo credit: Pavel Stoev)

7.4 Discussion

Without further study, given the paucity of observations no meaningful comments can be made regarding the reptile fauna of Koytendag.

7.5 Recommendations

7.5.1 As part of any future biodiversity surveys of Koytendag all observations of reptiles should also be recorded, particularly those that are regionally endemic or included in the Red Data Book of Turkmenistan.

7.6 Bibliography

Atayev Ch (1985) Reptiles of the mountains of Turkmenistan. Science, Ashgabat. 344 pp. In Russian

Bogdanov OP (1962) Reptiles of Turkmenistan. Turkmenian Academy of Sciences, Ashgabat 232 pp. In Russian

Habibullov MR (1990) Reptiles of Kugitang Tau (East Turkmenistan): fauna, ecology, conservation. Dissertation Candidate. Biol. Science. Leningrad. 18 pp. In Russian

Habibullov MR (1987) New discovery of Afghan (Defrashi) *snake Lytorhynehus ridgewayi* Boulenger, 1887 in Turkmenistan. Math. Turkmenian Academy of Sciences, Ser. biol. Science, 2: 69-70.

Rustamov AK, Habibullov MR (2009) Once again about the state of knowledge of the herpetofauna of Koitendag (Kugitang). Selevinia, Alamaty: 93-98. In Russian

Rustamov AK, Sopyev OS, Karaev M, Atayev ChA, Pinyasova RM (1988) Fauna and ecology of the birds and reptiles of the Kugitang Range – rare and little-studied animals in Turkmenistan. Ashgabat. In Russian

Shammakov SM, Marinina LS, Marochkina VV, Karryeva ShB (2004) The species composition of amphibians, reptiles and mammals of the reserves of Turkmenistan. Problems of Desert Development 4: 45-51. In Russian

Shammakov SM, Ataev ChA, Rustamov EA (1993) Herpetogeographical Map of Turkmenistan. Asiatic Herpetological Research 5: 127-136.

Shammakov SM, Atayev ChA (1972) About snakes in Turkmenistan. Science, Ashgabat, 29 pp. In Russian

Shammakov SM (1981) Reptiles of the plains of Turkmenistan. Science, Ashgabat, 312 pp. In Russian

Shukurov O Sh (1975) On the ecology of the glass-lizard (*Ophisaurus apodus*) in eastern Turkmenistan. Proceedings of the 15th nauchn.-teor.konf. prep. sostava, Chardzhou: 17-19. In Russian

Shukurov O Sh (1976) Herpetofauna of Kugitang and its foothills. Herpetology: 74-76. In Russian

8. Birds

Paul Donald, Petar Iankov, Eldar Rustamov, Shaniyaz Menliev, and *Geoff Welch*

8.1 Background

This is one of the best studied groups at Koytendag, and although past research has not been as intensive as at some other sites in Turkmenistan, the birds of Koytendag have been the subject of many studies from the 19th Century until the present day (Shestoperov 1936, Dementiev 1952, Rustamov 1958, Ataev et al. 1978, Sopyev 1979, 2012, Mischenko and Scherbak 1980, Red Data Book of Turkmen SSR 1985, Rustamov et al 1988, Saparmuradov and Eminov 1993, Bukreev 1997, Red Data Book of Turkmenistan 1999, 2011, Efimenko 2004, 2008, Rustamov 2013a, 2013b, 2018). Data is restricted and fragmentary and mainly about species composition, distribution and the phenology and biology of selected species, there are, however, a few quantitative studies (Rustamov et al., 1969, 1988).

The international importance of the site was recognised by its designation as one of 50 Important Bird Areas (IBAs) in Turkmenistan (Rustamov et al, 2009) qualifying under criteria A1 (Globally threatened species – saker falcon *Falco cherrug,* cinereous vulture *Aegypius monarchus,* Egyptian vulture *Neophron percnopterusl* Lammergeier *Aegypius barbatus*, steppe eagle *Aquila nipalensis* and eastern imperial eagle *Aquila heliaca*) and A3 (Biome-restricted species' assemblages – Eurasian high mountains (Alpine and Tibetan), Irano-Turanian mountains and Sino-Himalayan temperate forests) reflecting its unique position at the crossroads of several biogeographic zones. At the time of publication of the IBA inventory in 2009, the number of species recorded at Koytendag was 158 species. Ongoing research and taxonomic revisions have increased this figure to 229 species.

Figure 36. Egyptian vulture *Neophron percnopterus*, one of the globally endangered species at Koytendag (Photo credit: Jeremy Holden, RSPB)

8.2 Methodology

Systematic surveys and opportunistic recording of birds at Koytendag were carried out between May 2012 and March 2016, with most effort in spring 2014.

Between 21 April and 17 May 2014 an intensive survey was carried out using three methodologies:

a. random visits to different habitat types and elevations within the survey area to collect data about bird population composition and status;

a) targeted survey visits to areas known or considered likely to support species of high conservation importance (A1 Globally threatened / IUCN Red List species, A3 Biome-restricted species and species in the Red Data Book of Turkmenistan); and

b) transect and point counts to obtain information on the abundance or density of the birds in different habitats.

Observations were carried out between 07.00 and 18.00 hrs, including while travelling. Transect and point counts of all bird species were made in both mornings and evenings, and point counts of raptors between 09.00 and 17.00. GPS data were collected for all species of conservation interest, as well as at the start and end points of transects and for all counting points. All parts of the site were visited, though the majority of observations were made in the central section. The fewest observations were made in the south where access is restricted.

Seven point counts and nineteen transects (Bibby et al. 1998) of the breeding birds in different habitats were carried out. In addition, thirteen point counts were done especially for raptors (with larger distance belts than the 'conventional' point counts). Thus, in total 39 counts were made during the survey. The collected data regarding species composition and density of bird species in the main habitats of the mountain can be of help for assessment of the ornithological significance of the different parts of the site for the purposes of the management plan. In addition, a baseline for a future monitoring scheme of the birds in the Koytendag State Nature Reserve was set up.

Four of the six habitat types for bird complexes as defined by Rustamov et al (1988) and Rustamov and Rustamov (2007) were surveyed – see below and table 19. Due to historical differences in land use, each consists of a variety of habitats for birds. Urban and other anthropogenic areas (49 breeding species) were excluded and the High mountain belt (27 breeding species) was only observed for large and demonstrative birds distantly whenever observers were in the area.

Habitat 1. Mountain gorges and ravines with tree-shrub thickets (39 breeding species) located between 500 and 2,500m asl. Various types were covered by the study ranging from deep canyons with vertical cliffs and limited vegetation to relatively gentle slopes with rich vegetation. In general, the lowest parts have been modified by previous management, middle areas exhibit some anthropogenic influence and the highest areas, as a rule, are very natural due to their difficult accessibility.

Habitat 2. Mountain slopes covered by shrub-forb vegetation (57 breeding species) are covered with grassy and medium-sized bushy vegetation, generally up to 2m in height, but grassy areas predominate. These areas consist mainly of 'shiblyak' and semi-savanna vegetation (Efimenko 2006, http://iucnca.net/inforeserve572). Surveys were carried out between c. 1,200-1,850m asl. Grazing here is less intense and habitats in general are less degraded with predominately natural features.

Habitat 3. Juniper zone (53 breeding species) are dominated by bushes and juniper trees, although grass cover is also well developed. Surveys were carried out between 1,500-2,200m asl. This habitat overlaps with habitat 2 but the two differ in general appearance and dominance of bushes/trees and grasses respectively. The habitats in this zone are to a large extent natural, with a well preserved tree component, mainly *Juniperus seravschanica*, including many mature trees.

Habitat 4. Foothill areas and adjacent plains (30 breeding species) are very open with a simple plant composition of several species of low and shrubby grasses and consist principally of pastures and semi-desert areas lying between 300 and 600m asl. These are the most degraded areas and heavy grazing is ongoing.

Opportunistic recording, associated with other activities being carried out at the site were:

- 23 to 26 May 2012 – during the International Scientific Expedition, linked to the development of the UNESCO World Heritage nomination. Areas visited were Kyrkgyz, Hojapil, Umbardere, Daraydere, Gap-Gotan and around the guesthouse in Koyten village;
- April/May 2013 – during a Darwin Initiative Scoping visit – Kyrkgyz, Hojapil, Um-

Table 19. Point counts and transects.

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
Mountain gorges and ravines with tree-shrub thickets						
P_V_01	Point	0-50 m; 50-100 m; 100-150 m	37.768381 N 66.47305 E, 1,710 m	26.04.2014 (06:00-06:15) 11.05.2014 (06:00-06:15)	P. Iankov	Both sides of a ca. 120 m deep and narrow valley with shallow stony slopes in lower parts, steep in upper parts, with scattered but abundant bushes *Amygdalus spinosissima*, *Juniperus seravschanica*, *Acer pubescens*, tussocks of tall grasses and single trees *Juniperus seravschanica*, *Acer pubescens* etc. According to Efimenko (2006, http://iucnca.net/inforeserve572) *Scutellaria leptosiphon*, *S. nevskii*, *Andrachne fedtschenkoi*, *Parietaria judaica*, *Campanula fedtschenkoana* and others are common amongst the rocks of the Koytendag canyons
P_V_02	Point	0-50 m; 50-100 m; 100-150 m	37.76809 N 66.470322 E, 1,703 m	27.04.2014 (06:45-07:00)	P. Iankov	Edge of a deep rocky canyon with steep terrace-like stony slopes with grass patches, scattered *Amygdalus spinosissima* and single *Juniperus seravschanica*. In general, the vegetation of this altitudinal belt is of semi-savanna type (tussocks with *Artemisia scotina*, *A. albicaulis*, *A. tenuisecta)* and various semi-savanna communities with *Amygdalus spinosissima, Atraphaxis spinosa* and others (Efimenko 2006, http://iucnca.net/inforeserve572)
P_V_03	Point	0-50 m; 50-100 m; 100-150 m	37.78603 N 66.52692 E, 2,435 m	27.04.2014 (12:15-12:30)	P. Iankov	Edge of a deep rocky canyon at the tree-line with steep terrace-like stony slopes with large bare areas and scattered single low *Juniperus seravschanica,* and *Amygdalus spinosissima* and others. According to Efimenko (2006, http://iucnca.net/inforeserve572), at 2,300-2,800m a 'stlanik'(low) form of *Juniperus seravschanica* dominates, and it can be mixed with *Astragalus kuhitangi*, *A. bobrovii*, *Acantholimon erythreum*, *A. pungens*, *Silene plurifolia*, *Onobrychis echidna* and others, as well as prickly bushes such as *Cerasus amygdaliflora and Rhamnus minuta*
P_V_04	Point	0-50 m; 50-100 m; 100-150 m	37.67350 N 66.39577 E, 880 m	30.04.2014 (14:30-14:45)	P. Iankov	Relatively open rocky canyon with terrace-like slopes, cliffs, cave, scattered *Amygdalus spinosissima*, *A. bucharica*, *Atraphaxis spinosa*, with *Pistacia vera*, *Acer pubescens* and other tree species scattered on the slopes but also forming groups in the bottom of the dry valley. According to Efimenko (2006, http://iucnca.net/inforeserve572) in some canyons tree communities composed of *Crataegus turkestanica*, *Prunus cerasifera*, *Fraxinus sogdiana*, *Cerasus magaleb* occur.

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
P_V_05	Point	0-50 m; 50-100 m; 100-150 m	37.71344 N 66.45531 E, 1,660 m	01.05.2014 (11:00-11:15)	P. Iankov	Gentle slope on the edge of a narrow rocky valley with scattered *Atraphaxis spinosa* and *Amygdalus spinosissima*, with numerous single *Juniperus seravschanica, Acer pubescens* and *Prunus cerasifera* and others
P_V_06	Point	0-50 m; 50-100 m; 100-150 m	37.91544 N 66.49398 E, 841 m	05.05.2014 (07:10-07:25)	P. Iankov	Deep canyon with vertical cliffs and gentle slopes. Relatively abundant vegetation of *Amygdalus spinosissima*, *Atraphaxis spinosa* and others plus low *Acer pubescens, Fraxinus sogdiana,* and others. According to Efimenko (2006, http://iucnca.net/inforeserve572) in deep canyons tree species can be represented by *Crataegus turkestanica*, *Prunus cerasifera*, *Fraxinus sogdiana, Cerasus magaleb* together with *Scutellaria leptosiphon, S. nevskii, Andrachne fedtschenkoi, Parietaria judaica, Campanula fedtschenkoana* and others.
T_V_01	Transect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.91970 N 66.49015 E, 794 m End: 37.91608 N 66.49354 E, 863 m	05.05.2014 (06:15-06:50)	P. Iankov	Deep and gently rising canyon with vertical cliffs in places, steep and gentle slopes with vegetation in others. Vegetation generally abundant, consisting of *Amygdalus spinosissima*, *Atraphaxis spinosa* and others, plus low *Acer pubescens, Fraxinus sogdiana, Cerasus magaleb* and others. According to Efimenko (2006, http://iucnca.net/inforeserve572) in the deep canyons tree species can be represented by *Crataegus turkestanica*, *Prunus cerasifera*, *Fraxinus sogdiana, Cerasus magaleb* together with *Scutellaria leptosiphon, S. nevskii, Andrachne fedtschenkoi, Parietaria judaica, Campanula fedtschenkoana* and others
T_V_02	Transect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.92175 N 66.49444 E, 816 m End: 37.91966 N 66.49963 E, 849 m	06.05.2014 (06:55-07:30)	P. Iankov	Deep and dry rocky canyon with vertical cliffs along most of its length, with some tree and bush cover along the canyon bed - *Atraphaxis spinosa, Amygdalus spinosissima*, *Acer pubescens, Fraxinus sogdiana* and others. According to Efimenko (2006, http://iucnca.net/inforeserve572) in the deep canyons tree species can be represented by *Crataegus turkestanica*, *Prunus cerasifera*, *Fraxinus sogdiana, Cerasus magaleb* together with *Scutellaria leptosiphon, S. nevskii, Andrachne fedtschenkoi, Parietaria judaica, Campanula fedtschenkoana* and others

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
T_V_03	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.93877 N 66.65559 E, 1,302 m End: 37.93460 N 66.65868 E, 1,312 m	06.05.2014 (10:10-10:35)	P. Iankov	Deep narrow rocky canyon with vertical cliffs along its length, with single *Atraphaxis spinosa, Amygdalus spinosissima* and *Acer pubescens,* cold stream and waterfall. Busy touristic site with many visitors
T_V_04	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.73914 N 66.42019 E, 956 m End: 37.73977 N 66.41435 E, 918 m	07.05.2014 (18:05-18:30)	P. Iankov	Open, dry wide valley with gentle slopes and few vertical cliffs, with patches of *Amygdalus spinosissima, Atraphaxis spinosa, Acer pubescens, Pistacia vera* and others
T_V_05	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.782954 N 66.445391 E, 1,171 m End: 37.78452 N 66.43996 E, 1,001 m	08.05.2014 (17:25-17:55)	P. Iankov	Deep rocky gorge with vertical cliffs in places, steep and gentle vegetated slopes in others. Stream running along the valley, with abundant vegetation *Acer pubescens, Fraxinus sogdiana, Cerasus magaleb, Amygdalus spinosissima*, *Atraphaxis spinosa* and others, plus some grassy areas. According to Efimenko (2006, http://iucnca.net/inforeserve572) in the deep canyons tree species can be represented by *Crataegus turkestanica*, *Prunus cerasifera*, *Fraxinus sogdiana, Cerasus magaleb*, and amongst the rocks common are groups with species as *Scutellaria leptosiphon, S. nevskii, Andrachne fedtschenkoi, Parietaria judaica, Campanula fedtschenkoana* and others
T_V_06	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.785520 N 66.439017 E, 957 m End: 37.78381 N 66.43508 E, 923 m	08.05.2014 (18:10-18:35)	P. Iankov	As T_V_05, but stream only along about 100 m at the eastern end of the transect, the remaining 400 m being a dry valley
T_V_07	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.782659 N 66.432849 E, 841 m End: 37.78278 N 66.428370 E, 819 m	08.05.2014 (18:45-19:05)	P. Iankov	As T_V_05 and T_V_06, but valley completely dry and more open, with fewer cliffs and less steep slopes.

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
T_V_08	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.72245 N 66.49242 E, 1,854 m End: 37.723595 N 66.487814 E, 1,877 m	12.05.2014 (10:05-10:35)	P. Iankov	Dry stony valley with gentle grassy slopes, densely covered by tree and bushy vegetation, including *Juniperus seravschanica, Acer pubescens, Amygdalus spinosissima*, *Atraphaxis spinosa* and other. According to Efimenko (2006, http://iucnca.net/inforeserve572) the 'shyblyak' complex of xerophyle trees and bushes is well represented by *Zygophyllum atriplicoides* in association with *Pistacia vera*, *Acer pubescens, Amygdalus spinosissima, Sageteria brandtheriana*
T_V_09	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.72807 N 66.37642 E, 617 m End: 37.727003 N 66.371661 E, 564 m	14.05.2014 (18:25-18:55)	P. Iankov	Dry open valley with gentle grassy slopes close to the bottom of the valley, but upper parts with high cliffs (especially the southern slope). On the slopes and at the bottom of the valley scattered bushes and low trees occur, mainly *Amygdalus spinosissima*, *Atraphaxis spinosa, Acer pubescens, Salvia* sp. and others. According to Efimenko (2006, http://iucnca.net/inforeserve572) the 'shyblyak' complex of xerophyle trees and bushes is well represented by *Zygophyllum atriplicoides* in association with *Pistacia vera*, *Acer pubescens, Amygdalus spinosissima, Sageteria brandtheriana*
Mountain slopes covered by shrub-forb vegetation						
T_ GB_01	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.779358 N 66.483403 E, 1,797 m End: 37.776322 N 66.479217 E, 1,767 m	26.04.2014 (08:05-08:25)	P. Iankov	Open predominantly grassland area on a gentle slope with western exposure, covered with various communities of semi-savanna vegetation with single scattered *Amygdalus spinosissima* and low *Juniperus seravschanica* bushes. According to Efimenko (2006, http://iucnca.net/inforeserve572) the predominant species in plant communities on typical and dark grey soils include *Artemisia scotina*, *A. albicaulis*, *A. tenuisecta* and various semi-savanna low grasses, amongst which *Amygdalus spinosissima, Atraphaxis spinosa* occur, plus *Cousinia sprygini, C. rotundifolia, C. dimoana, Alhagi canescens, A. kirghisorum* and others, with some*Jurinea bipinnatifida*
T_ GB_02	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.775684 N 66.480558 E, 1,791 m End: 37.779295 N 66.484004 E, 1,811 m	26.04.2014 (08:30-08:45)	P. Iankov	Open grassland communities of semi-savanna type with patches of *Amygdalus spinosissima* and low/tall *Juniperus seravschanica* on both slopes of a small and shallow stony valley with patches of low bushes. The grassland communities according to Efimenko (2006, http://iucnca.net/inforeserve572) are composed of *Artemisia scotina*, *A. albicaulis*, *A. tenuisecta, Amygdalus spinosissima, Atraphaxis spinosa, Cousinia sprygini, C. rotundifolia, C. dimoana, Alhagi canescens, A. kirghisorum* and other species

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
T_ GB_03	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.93933 N 66.63258 E, 1,240 m End: 37.93914 N 66.62682 E, 1,243 m	04.05.2014 (06:25-06:50)	P. Iankov	Open grassland (pasture) on a gentle slope with northern exposure with tussocks of tall grasses, low *Amygdalus spinosissima* and groups of low *Acer pubescens* and other species, with two small and shallow (open) stony valleys. At the of the periphery of the low and medium belts of the mountain, at altitudes between 700 (800) and 2,000-2,300m, the 'shiblyak' and semi-savanna belt is represented by *Artemisia scotina*, *A. albicaulis*, *A. tenuisecta* and various low-grass semi-savanna communities with *Amygdalus spinosissima*, *Atraphaxis spinosa* (Efimenko 2006, http://iucnca.net/inforeserve572)
Juniper zone						
T_ BG_01	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.781013 N 66.517302 E, 2,172 m End: 37.776322 N 66.479217 E, 2195 m	27.04.2014 (08:45-09:15)	P. Iankov M. Gurney	Generally open stony area on a gentle slope with western exposure, close to the upper limit of *Juniperus seravschanica* associations. Bushes and single trees determine the general appearance, although there is significant grassland cover. Bushes represented by *Amygdalus spinosissima, A. bucharica* and others, mixed with low *Juniperus seravschanica* and *Acer pubescens*. Mature *Juniperus seravschanica* form the tallest plant stratum. According to Efimenko (2006, http://iucnca.net/inforeserve572) 'archovniks' (*Juniperus seravschanica* associations) are semi-savanna, semi-savanna-*Artemisia*-'shiblyak' and steppe associations. Amongst *Amygdalus spinosissima* there are single *Acer pubescens*, *Amygdalus bucharica*, *Pistacia vera*, *Cotoneaster suavis*, *Cerasus erythrocarpa*, *C. amygdaliflora*. Amongst 'archovniks' and 'tragakantniks' (1,700-2,800 m) steppe grasses occur, such as *Stipa kuhitangi*, *S. arabica*, *S. gnezdilloi* and others, as well as *Elytrigia setulifera*, *E. pulcherrima*, *E. intermedia*, *Festuca valesiaca* and *F. regeliana*
T_ BG_02	Tran-sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.71784 N 66.47283 E, 1,917 m End: 37.72037 N 66.46811 E, 1,885 m	01.05.2014 (18:00-18:20)	P. Iankov	Gentle hill slope with south-western exposure, with scattered mature *Juniperus seravschanica*, single scattered *Amygdalus spinosissima, A. bucharica* and others. Significant grassland cover, mainly *Artemisia* sp.. According to Efimenko (2006, http://iucnca.net/inforeserve572) together with *Juniperus seravschanica* there are *Acer pubescens*, *Amygdalus bucharica*, *Pistacia vera*, *Cotoneaster suavis*, *Cerasus erythrocarpa* and *C. amygdaliflora*, which give this altitudinal belt a characteristic "bushy" appearance

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
T_ BG_03	Tran- sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.71407 N 66.47088 E, 1,958m End: 37.70996 N 66.46854 E, 1,900 m	02.05.2014 (06:35- 07:00)	P. Iankov M. Gurney	Open gentle hill slope with north-western exposure, with closely spaced mature *Juniperus seravschanica*, single *Acer pubescens* and scattered *Amygdalus spinosissima, A. bucharica* and others. Grassland with a significant proportion of *Artemisia* sp. According to Efimenko (2006, http://iucnca.net/inforeserve572) together with *Juniperus seravschanica* there are *Acer pubescens*, *Amygdalus bucharica*, *Pistacia vera*, *Cotoneaster suavis*, *Cerasus erythrocarpa*, *C. amygdaliflora*, which give this altitudinal belt a characteristic "bushy" appearance
T_ BG_04	Tran- sect	0-50 m; 50-100 m; 100-150 m 500m	Start: (37.92834 N 66.65504 E, 1,581m End: 37.92403 N 66.65683 E, 1,703 m	05.05.2014 (14:20- 14:50)	P. Iankov	Steep stony slope with dense tree and bushy vegetation of scattered *Juniperus seravschanica* and more dense patches of *Acer pubescens, Crataegus turkestanica*, *Prunus cerasifera, Fraxinus sogdiana* with *Amygdalus spinosissima*, *Atraphaxis spinosa* and others. Grass cover relatively restricted, composed of *Artemisia sp.* and others. According to Efimenko (2006, http://iucnca.net/inforeserve572) on variable soils the main species are *Zygophyllum atriplicoides* together with with *Pistacia vera, Acer pubescens, Amygdalus spinosissima, Sageteria brandtheriana* and others
T_ BG_05	Tran- sect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.76637 N 66.46761 E, 1,667m End: 37.77087 N 66.46747 E, 1,665 m	10.05.2014 (08:40- 09:00)	P. Iankov	Gentle stony slope with western exposure and abundant scattered bushes and low trees *Amygdalus spinosissima*, *Atraphaxis spinosa, Juniperus seravschanica, Acer pubescens, Prunus cerasifera, Fraxinus sogdiana* and others. Grass cover well represented, composed of *Artemisia scotina, A. albicaulis* and others. On the typical dark grey soils dominant species are *Artemisia* sp. and variable low grasses with obligatory presence of *Amygdalus spinosissima*, *Atraphaxis spinosa* and others. Xerophyle trees and bushes at the 'shiblyaks' include good numbers of *Zygophyllum atriplicoides* in association with *Pistacia vera*, *Acer pubescens*, *Amygdalus spinosissima*, Sageteria brandtheriana and others (Efimenko, 2006, http://iucnca.net/inforeserve572)

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
P_ BG_01	Point	0-50 m; 50-100 m; 100-150 m	37.92931 N 66.65578 E, 1,546 m	05.05.2014 (11:35-11:50)	P. Iankov	Open hollow with steep slopes with predominantly *Amygdalus spinosissima*, *Atraphaxis spinosa, Acer pubescens, Crataegus turkestanica*, *Prunus cerasifera, Fraxinus sogdiana* and others. On the rocky areas scattered *Juniperus seravschanica* occur. Amongst grasses *Artemisia scotina, A. albicaulis, A. tenuisecta, Inula macrophylla* and others predominate. According to Efimenko (2006, http://iucnca.net/inforeserve572) on variable soils main species are *Zygophyllum atriplicoides* together with *Pistacia vera, Acer pubescens, Amygdalus spinosissima, Sageteria brandtheriana* and others
Foothill areas and adjacent plains						
T_ DP_01	Transect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.75624 N 66.37161 E, 522 m End: 37.75259 N 66.36826 E, 561 m	29.04.2014 (06:50-07:10)	P. Iankov	Highly degraded pasture on an open semi-desert area with low and very poor grass composition on a flat and a gentle loess hill slope with north-eastern exposure. According to Efimenko (2006, http://iucnca.net/inforeserve572) at these altitudes there is a belt of mountain semi-desert (desertified low-grass semi-savanna and vegetation) gypsum-containing soils
T_ DP_02	Transect	0-50 m; 50-100 m; 100-150 m 500m	Start: 37.44172 N 66.36163 E, 335 m End: 37.44269 N 66.36716 E, 348 m	29.04.2014 (17:40-18:10)	P. Iankov M. Gurney	Semi-desert area on a gentle southern slope with low and very poor vegetation, composed mainly by scattered low grasses and *Ferula* sp., mixed with scattered single low bushes
Raptor point counts						
P_R_01	Point	0-500 m; 500-1,000 m; > 1000 m	37.778804 N 66.478197 E, 1,744 m	26.04.2014 (09:00-09:15)	P. Iankov	
P_R_02	Point	0-500 m; 500-1,000 m; > 1000 m	37.76349 N 66.46676 E, 1,633 m	26.04.2014 (17:55-18:10)	P. Iankov S. Menliev	
P_R_03	Point	0-500 m; 500-1,000 m; > 1000 m	37.78644 N 66.52727 E, 2,457 m	27.04.2014 (12:45-13:00)	P. Iankov	

Ref	Count type	Distance belts used/ Transect length	GPS reference and altitude	Date and time of count(s)	Observer	Brief description
P_R_04	Point	0-500 m; 500-1,000 m; > 1000 m	37.44100 N 66.35857 E, 336 m	29.04.2014 (15:25-15:40)	P. Iankov	
P_R_05	Point	0-500 m; 500-1,000 m; > 1000 m	37.64896 N 66.32936 E, 378 m	30.04.2014 (09:55-10:10)	P. Iankov	
P_R_06	Point	0-500 m; 500-1,000 m; > 1000 m	37.67337 N 66.39592 E, 885 m	30.04.2014 (13:45-14:00)	P. Iankov	
P_R_07	Point	0-500 m; 500-1,000 m; > 1000 m	37.71432 N 66.47154 E, 1,964 m	01.05.2014 (16:00-16:15)	P. Iankov	
P_R_08	Point	0-500 m; 500-1,000 m; > 1000 m	37.67875 N 66.47661 E, 1,746 m	02.05.2014 (11:05-11:20)	P. Iankov	
P_R_09	Point	0-500 m; 500-1,000 m; > 1000 m	37.71613 N 66.44721 E, 1,543 m	02.05.2014 (17:50-18:05)	P. Iankov	
P_R_10	Point	0-500 m; 500-1,000 m; > 1000 m	37.90791 N 66.48064 E, 796 m	04.05.2014 (16:40-16:55)	P. Iankov	
P_R_11	Point	0-500 m; 500-1,000 m; > 1000 m	37.92789 N 66.65598 E, 1,583 m	05.05.2014 (16:35-16:50)	P. Iankov	
P_R_12	Point	0-500 m; 500-1,000 m; > 1000 m	37.84821 N 66.43139 E, 661 m	08.05.2014 (09:55-10:10)	P. Iankov	
P_R_13	Point	0-500 m; 500-1,000 m; > 1000 m	37.77473 N 66.38938 E, 591 m	09.05.2014 (10:00-10:15)	P. Iankov	

bardere, Daraydere, Gap-Gotan and around the reserve headquarters at Bazardepe;

- 21 to 26 August 2014 – during a management planning workshop. Areas visited were the juniper forest in the core zone and the vicinity of the reserve headquarters at Bazardepe;
- 6 to 9 October 2015 – during the IUCN Evaluation visit linked to the UNESCO World Heritage nomination. Areas visited were Kyrkgyz, Hojapil, Umbardere, Daraydere, Gap-Gotan and around the reserve headquarters at Bazardepe; and
- 25 to 30 March 2016 – during a raptor identification and monitoring training course. Areas visited were Kyrkgyz, Umbardere, Hojapil, Daraydere, Kojachilgazbaba and several gorges near the reserve headquarters at Bazardepe.

8.3 Results

Of the 229 species reported as occurring at Koytendag, recent research has recorded 154 (67%) of these, including two species new to Turkmenistan – Himalayan griffon *Gyps himalayensis* and common koel *Eudynamys scolopaceus* (Rustamov et al. 2016). Following several observations of vultures showing characteristics of Himalayan griffon, an adult bird was photographed on 27 April 2014 in the vicinity of Airy-baba Peak (3,139 m asl). Single birds were then observed several times in different parts of the reserve. The species was also observed in October 2015. Himalayan griffon is also a new biome-restricted species for the site, characteristic of the Eurasian high mountains (Alpine and Tibetan) biome. The common koel was a female observed in the Koytendarya valley near Khodjagaraul in the foothills of the western escarpment of the Koytendag mountain range on 8 May 2013. This bird was found dead in the same area on 14 May (Rustamov et al. 2016).

Five of the eight globally threatened species known from the site were recorded – saker falcon *Falco cherrug*, Egyptian vulture *Neophron percnopterus* and steppe eagle *Aquila nipalensis* (all EN) and lammergeier *Gypaetus barbatus* and cinereous vulture *Aegypius monachus* (both NT). The three species not recorded recently are greater spotted eagle *Aquila clanga* and eastern imperial eagle *Aquila heliaca* (both VU) and pallid harrier *Circus macrourus* (NT), all of which are scarce passage migrants or winter visitors.

Similarly, ten of the eleven biome-restricted species were recorded – see-see partridge, *Ammoperdix griseogularis*, yellow-breasted tit *Parus flavipectus*, dark-grey tit *Parus rufonuchalis*, sulphur-bellied warbler *Phylloscopus griseolus*, eastern rock-nuthatch *Sitta tephronota*, white-throated robin *Irania gutturalis*, Finsch's wheatear *Oenanthe finschii*, variable wheatear *Oenanthe picata*, white-winged grosbeak *Mycerobas carnipes* and chestnut-breasted bunting *Emberiza stewarti*. The only omission is bar-tailed treecreeper *Certhia himalayana*.

Data was also collected on 13 of the 17 species included in the Red Data Book of Turkmenistan (2011) – black stork *Ciconia nigra*, lesser kestrel *Falco naumanni*, saker falcon, peregrine falcon *Falco peregrinus*, barbary falcon *Falco pelegrinoides*, lammergeier, Egyptian vulture, cinereous vulture, short-toed snake-eagle *Circaetus gallicus*, steppe eagle, golden eagle *Aquila chrysaetos*, Bonelli's eagle *Aquila fasciatus* and Asian paradise-flycatcher *Terpsiphone paradisi*.

The distribution of all globally threatened, biome-restricted and Turkmenistan Red Data Book species recorded is summarised on figure 37.

As point count and transect data was collected using pre-defined distance bands, it will be possible to calculate estimates of bird density using the computer programme *Distance*. However, this analysis has not yet been carried out.

Due to the limited duration of the main 2014 survey, as well as a lack of systematically collected standard data for the area, it was very difficult to assess trends in population or distribution of key species. Some species eg eastern rock nuthatch appeared to be much more numerous than mentioned in the literature (Efimenko 2006) but it is impossible to say whether this is due to an increase in the population or underestimation in the past.

8.4 Discussion

The site clearly supports a rich and diverse avifauna. Of particular note is the large number and variety of birds of prey, including five species of vulture all of which are known or could potentially breed. Such a diversity of 'top predators' and scavengers is an indication of the overall high quality of the habitats and, at present, limited disturbance and persecution. However, there is the future risk of increased disturbance through activities such as rock climbing, paragliding and off-road driving and such activities need to be closely monitored and controlled.

The discovery of two bird species new to Turkmenistan is an indication of the value of future surveys as additional species are likely to be found, particularly given the site's proximity to Uzbekistan and Afghanistan. In Central Asia the Himalayan griffon is principally resident in the high mountain areas of eastern Afghanistan, Uzbekistan, Tajikistan, Kyrgyzstan and Kazakhstan, with limited westward dispersal in winter. However, observations of at least one individual at Koytendag in October 2015 suggests that the species may be resident at the site and could represent a significant westward expansion in the species' range. The common koel was an even more significant discovery as the species has not been recorded in Kazakhstan (Sklyarenko et al. 2008, Wassink 2015) or Uzbekistan (Kashkarov et al. 2008) and Ayé et al (2012) only include it in Appendix 1 (old vagrants, undocumented records and doubtfully recorded species) for Afghanistan. Mike Blair *in litt* considers that the species is uncommon, local, but regular in Afghanistan south of the Khyber range perhaps due to the large increase in small dams and local irrigation schemes there. The species might be found in extreme southern Uzbekistan and southwestern Tajikistan in the future.

8.5 Recommendations

8.5.1 Development of a systematic, objective monitoring programme, plus associated training of staff, to assist planning of future site management.

8.5.2 Appointment of an ornithologist to the state nature reserve staff.

8.5.3 Assessment of existing and potential future visitor impacts to key species, especially breeding raptors, in the main tourist areas of the site and development of a visitor management programme.

8.5.4 Development of a grazing strategy for the wildlife sanctuaries to reduce/reverse the effects of over-grazing and related habitat degradation.

8.6 Bibliography

Ataev K, Vasiliev VI, Gorelova RI, Karavaev AA, Kekilova AF, Sopyev O, Eminov A (1978) Data on the rare and threatened by extinction birds of Turkmenistan. Bulletin Academy of Science of Turkmenian Soviet Republic, Series of Biology Science 4: 70-80. In Russian

Ayé R, Schweizer M, Roth T (2012) Birds of Central Asia. Bloomsbury, London, 336 pp.

Bibby C, Jones M, Marsden S (1998) Bird Surveys, Expedition Field Techniques. Royal Geographical Society, Expedition Advisory Centre, London, 134 pp. In Russian and English

Bukreev SA (1997) Ornitho-geography and preservation of Turkmenistan. Center for Wildlife Conservation, Moscow, 160 pp. In Russian

Dementiev GP (1952) Birds of Turkmenistan. Turkmen SSR Science Academies, Ashgabat. In Russian

Efimenko NN (2004) Birds of the western part of Koytendag mountains. Problems of desert development 2: 56-58. In Russian

Efimenko NN (2008) Cadastre of Populations of the rare and poorly studied animals of Koytendag. Problems of desert development, 4: 48-51. In Russian

Kashkarov RD, Welch GR, Brombacher M (eds) (2008) Important Bird Areas in Uzbekistan. Uzbekistan Society for the Protection of Birds, Tashkent.

Lunina GA (1990) New data on the fauna and abundance of shorebirds in eastern Turkmenistan. In: Environmental issues. MY. 1. Inventory of natural resources Chardjou area. Chardjou: 103-108. In Russian

Mischenko YV, Scherbak NN (1980) New Records of new and poorly studied birds of Turkmenia. In: Journal of Zoology 1, Kiev: 13-17. In Russian

Red Data Book of Turkmen SSR (1985) Rare and Threatened Plants and Animals. Ashgabat, 413 pp.

Red Data Book of Turkmenistan (2011) Volume 2: Invertebrates and Vertebrates Animals Ed. 3rd, Revised and updated. Ashgabat, Ylym, 384 pp.

Red Data Book of Turkmenistan (1999) Invertebrate and Vertebrate Animals V. 1, Second Edition, Ashgabat, 371 pp.

Rustamov AK, Sopyev OS, Karaev M, Atayev ChA, Pinyasova RM (1988) Fauna and ecology of the birds and reptiles of the Kugitang Range. In: Flint VE

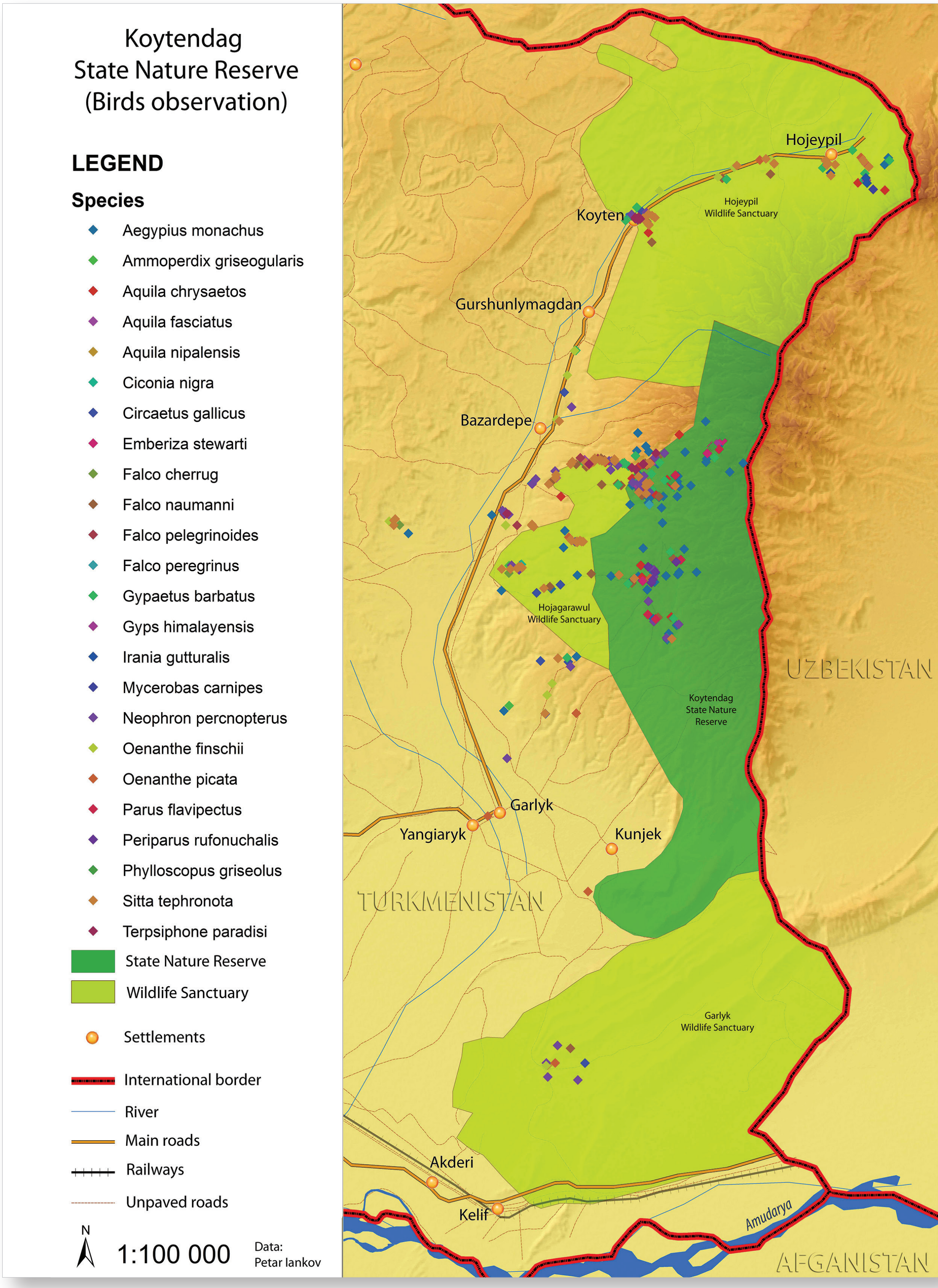


Figure 37. Observation locations of birds of conservation importance at Koytendag, April/May 2014. Map by Atamyrat Veyisov.

(Ed.). Rare and poorly studied animals of Turkmenistan. Ashgabat, Ylym: 82-117. In Russian

Rustamov AK, Sopyev OS, Karaev M (1969) Numbers of breeding birds of the Kugitang Ridge. In: Ornithology of the USSR. 1969. Proceedings of the 5th Soviet Union Ornithological Conference, Book 2, Ashgabat, Ylym: 82-117. In Russian

Rustamov AK (1958) Birds of Turkmenistan Vol. 2. Academy of Science of Turkmen Soviet Republic, Ashgabat, 252 pp. In Russian

Rustamov EA (2013a) Conspectus of the Contemporary Bird Fauna of Turkmenistan. In: Sopuyev OS, Herremov ShR (eds) Studies on the Biological Diversity of Turkmenistan (Vertebrata). Menzbir Ornithological Society, Central Asia Branch, Moscow-Ashgabat: 125-169. *In Russian*

Rustamov EA (2013b) Birds of Turkmenistan: Illustrated Field Guide. Ylym, Ashgabat.

Shestoperov EL (1936) Materials on the Fauna of Karlyuk Region of TSSR. Bulletin of the Turkmenistan Zoological Station, No 1, Ashgabat: 157-172.

Rustamov EA, Menliev S, Agryzkov E (2016) Common Koel *Eudynamys scolopaceus* new for Turkmenistan. Sandgrouse 38 (2): 197-198.

Rustamov EA, Welch GR, Brombacher M (eds) (2009) Important Bird Areas in Turkmenistan: priority sites for conservation. Ministry for Nature Protection of Turkmenistan. Ashgabat, 197 pp. (English, Russian and Turkmen editions).

Rustamov EA (2015) An annotated checklist of the birds of Turkmenistan. Sandgrouse 37 (1): 28-56.

Rustamov EA (2018) Modern checklist of the birds of Turkmenistan, version 2018. Herpetological and ornithological research: current aspects. Dedicated to the 100th Anniversary of A.K. Rustamov (1917–2005). Moscow: KMK Scientifi c Press. In Russian

Saparmuradov J, Eminov A (1993) Data about the numbers of some rare and threatened with extinction bird species in Southern Turkmenistan. In: Study of the Animal World of Turkmenistan. Ashgabat, Ylym: 109-119.

Sopyev OS (1979) Data on the birds of Order Galliformes of Kugitang. In: Protection of Turkmenistan Nature 5, Ashgabat, Ylym. In Russian

Sopyev OS (2012) Birds of Koytendag require special protection. In: Turkmen Nature, Undiscovered Miracles of Koytendag, Abstracts of reports of the International Scientific Conference, May 23-39, 2012, Ashgabat, Ylym: 365-366. In Russian and English

Sklyarenko SL, Welch GR, Brombacher M (eds) (2008) Important Bird Areas in Kazakhstan Association for the Conservation of Biodiversity of Kazakhstan, Almaty.

Stepanian LS (1990) Synopsis of the ornithological fauna of the USSR. M. Science. In Russian

Wassink A (2015) The New Birds of Kazakhstan. Wassink, De Cocksdorp, Texel, Netherlands.

Welch G, Donald P, Thorpe R, Iankov P, Rustamov E (2018) Interesting observations from Tallymerjen IBA, Turkmenistan, 2015 and 2016. Sandgrouse 40: 94-97.

9. Mammals

Kiril Georgiev, Shaniyaz Menliev, and *John Linnell*

9.1 Background

Several studies have been made of the mammal fauna of Koytendag – *see Bibliography* – and selected species, notably markhor *Capra falconeri* and urial *Ovis orientalis*, have been monitored annually since 1995. A total of 43 species of mammals has been recorded though four species – Libyan jird *Meriones libycus,* brown bear *Ursus arctos,* leopard *Panthera pardus* and goitered gazelle *Gazella subgutturosa* – have not been observed in the last 10+ years and are assumed to be locally extinct, and two species – small five-toed jerboa *Allactaga* (*Microallactaga*) *elater* and northern mole vole *Ellobius talpinus tancrei* – though known from the area are restricted to the lowlands bordering the protected area. Five species are listed in the 2011 Red Data Book of Turkmenistan – Geoffroy's bat *Myotis emarginatus* (Rare), European free-tailed bat *Tadarida teniotis* (Rare), Eurasian lynx *Lynx lynx* (Critically Endangered), markhor (Critically Endangered) and urial (Endangered) – with markhor and urial also listed as globally threatened by IUCN – Near Threatened and Vulnerable respectively.

9.2 Methodology

Annual monitoring by reserve staff is by direct counts at locations and/or times of year when animals are naturally concentrated – at the start of the autumn breeding season in the case of markhor and around watering points in winter in the case of urial.

RSPB-supported research has focussed on the deployment of 30 camera traps (Bushnell Trophy Cam HD Max – Black LED) for 71 camera trap station sessions during 2013, 2014 and 2015 – see figure 39. The data gathered are result of vocational training for the reserve staff in the use of camera traps and GPS (2013 and 2014) and the subsequent independent use of the camera traps by the reserve staff in order to record the species present at the site and obtain a general impres-

Figure 38. Camera trap image of male Markhor *Capra falconeri* (Photo: Koytendag State Nature Reserve)

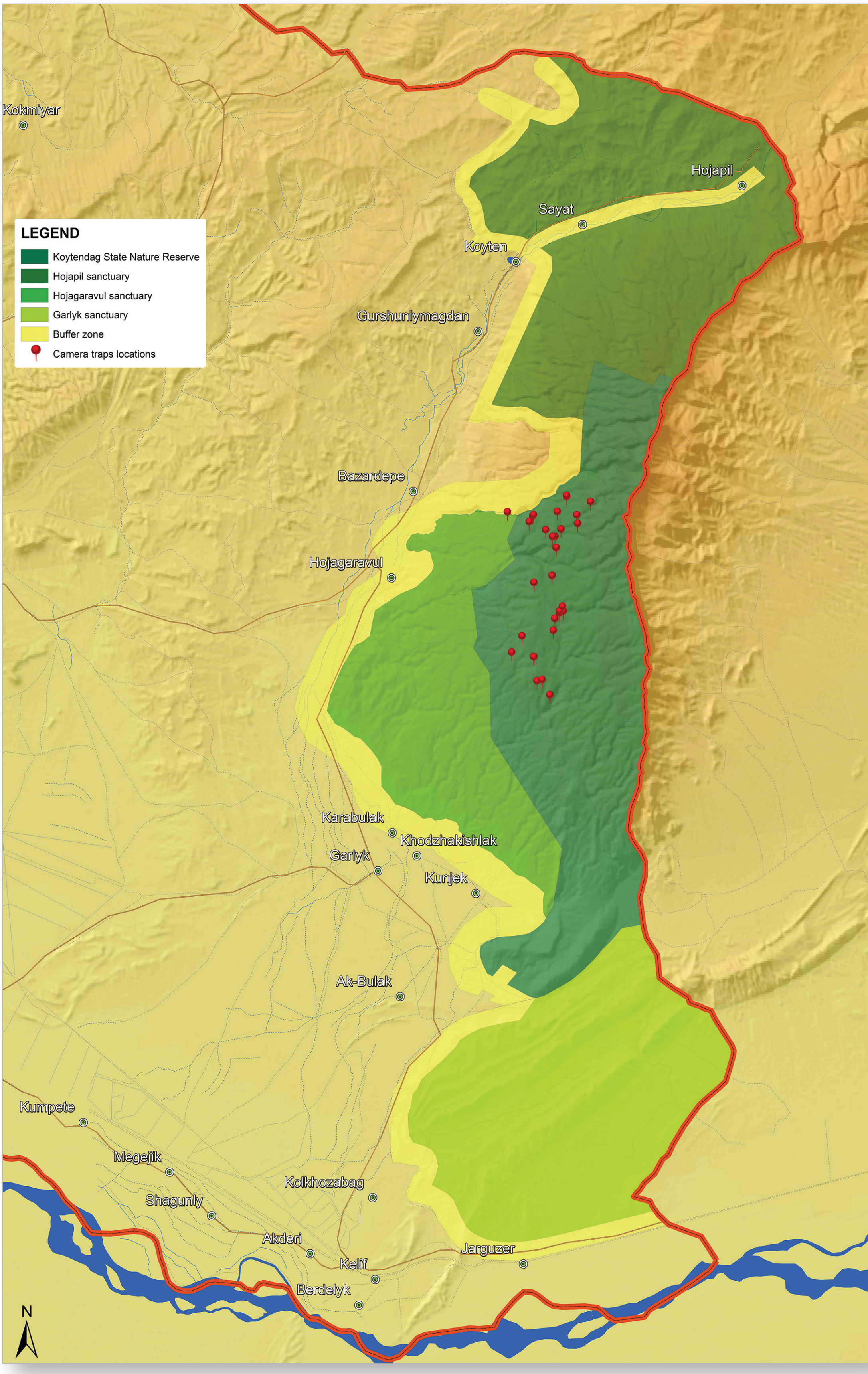


Figure 39. Camera trap locations at Koytendag. Map by Atamyrat Veyisov.

sion of numbers. More systematic use of camera traps is planned for the future and will build on the experience of reserve staff in using this methodology.

9.3 Results

Annual monitoring of markhor shows an increase in numbers from 69 in 1995 to 882 in 2013 – see figure 40. This is partly an actual increase in numbers but principally due to improved counting techniques over the years. Monitoring of urial shows a similar, those less marked, increase in numbers from 164 in 1995 to 250 in 2013 but numbers reached a maximum of 320 in 2010 – see figure 41. The changes from year to year are considered to be natural fluctuations.

Ten identifiable mammal species were recorded with the camera traps, a total of 844 events of mammals passing cameras – see table 20. Separate events were recorded if at least 10 minutes passed between the camera being activated. As some cameras were placed at waterpoints some of events involved photographing 10-20 individuals during almost continual sessions. However, it should be noted that the image quality from the video sequences that the camera traps were set to record on was not very high, making some species identification difficult, therefore certain assumptions have been made based on known species' distributions.

Table 20. Camera trap recording frequency summary.

Species		No. of recording events	% frequency	Comments
1	Tolai hare *Lepus tolai*	301	35.7	
2	Markhor *Capra falconeri*	254	30.1	Photographs revealed a well-balanced population structure, with very large males, females and young.
3	Eurasian lynx *Lynx lynx*	68	8.1	Pictures indicated the presence of both reproductive females (followed by young) and single animals. Video quality was too poor to allow individual recognition.
4	Indian crested porcupine *Hystrix indica*	62	7.3	
5	Grey wolf *Canus lupus*	37	4.4	Pictures indicated the presence of reproduction (pictures of pups) and packs of up to 4 individuals.
6	Urial *Ovis orientalis*	36	4.3	Photographs revealed a well-balanced population structure, with very large males, females and young.
7	Red fox *Vulpes vulpes*	35	4.1	
8	European badger *Meles (meles) cansecens*	24	2.8	Koytendag represents one of the few areas where the European badger *Meles meles* overlaps with the recently separated Asian badger *Meles leucurus*. Taxonomy is still uncertain, and morphological criteria are not unambiguous, however, it appears that most of the 24 images represent European badgers.
9	Marten sp. *Martes foina*??	15	1.8	Image quality did not allow a definite identification but it is likely that they represent the beech marten.
10	Asian wild cat *Felis lybica*	12	1.4	Wild cat taxonomy is under constant revision but the 12 images obtained are considered most likely to belong to this recently recognised species.
Total		**844**	**100**	

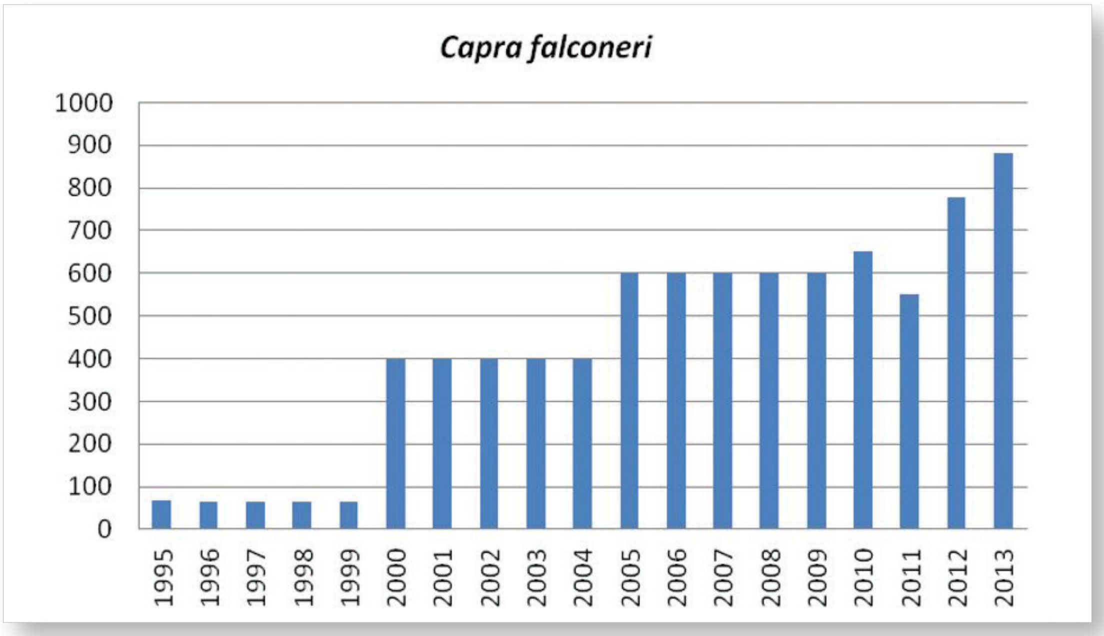


Figure 40. Population trends of *Capra falconeri* at Koytendag State Nature Reserve 1995 to 2013

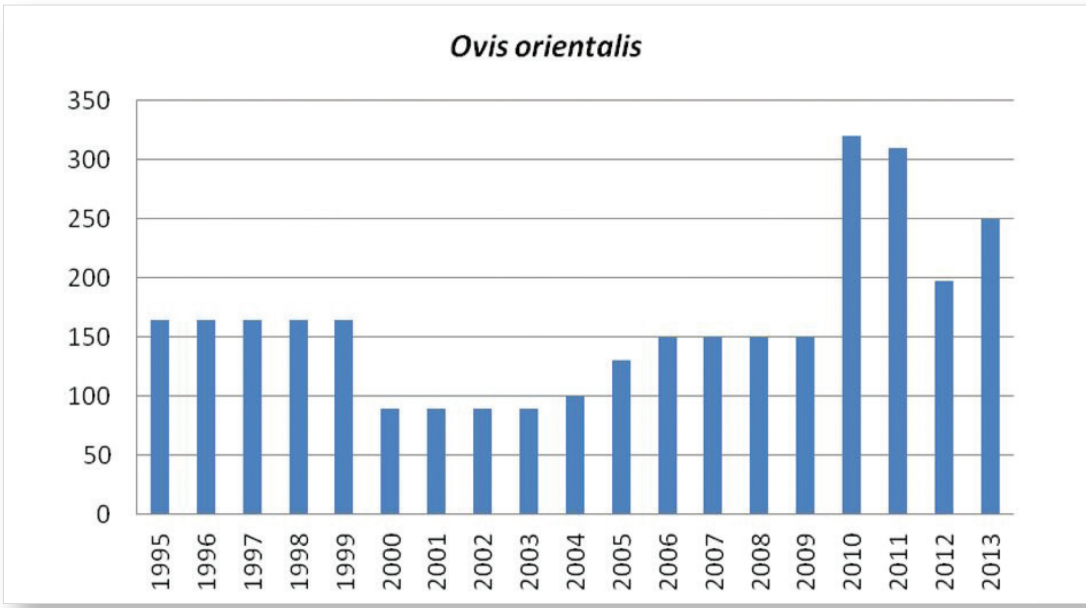


Figure 41. Population trends of *Ovis orientalis* at Koytendag State Nature Reserve 1995 to 2013

9.4 Discussion

Although the mammal species found at Koytendag are not highly endangered globally – most are LC, with one VU and one NT – there is still significant conservation value in the area. Firstly, the presence of a healthy markhor population is a major contribution to the conservation of a species that has a very limited global distribution – Koytendag supports the most western and isolated population of this species.

Secondly, the presence of Eurasian lynx and urial in the site represents the western edge of the Tian Shan populations. Although widespread, both species have very uncertain status and distribution in the region, such that the documentation of their presence in Koytendag is significant. The high number of Eurasian lynx pictures is especially positive. Although their ecology in the region has never been studied, it is likely that the high density of hares provides their major food source.

Thirdly, and most significantly, is the presence of a relatively intact mammalian community with large predators (wolves, lynx), medium sized predators (foxes, martens, badgers) and prey (markhor, urial, hares). The only species not detected was leopard *Panthera pardus* though the species is known to have occurred previously. Given the camera trapping density and the frequency with which other predators such as wolves and lynx were detected, it is highly unlikely that leopards escaped detection if they had been present.

9.5 Recommendations for future work

9.5.1 Establishment a National Park (II category IUCN) covering the state nature reserve and four wildlife sanctuaries – 129,047 ha. This would be in line with recommendations in the UNDP Project 3961 *Strengthening the management effectiveness of the protected area system of Turkmenistan* and several strategic planning documents of Turkmenistan eg *State of the Environment report for Turkmenistan* (SOE, 1998), the *National Environmental Action Plan* (NEAP, 2002) and the *National Biodiversity Strategy and Action Plan* (NBSAP, 2002). Recommendations in these documents include (i) developing a 'functional network' of protected areas; (ii) expanding and rationalising the Strict Nature Reserves; (iii) reviewing the conservation status of the current Protected Areas; (iv) establishing new national parks and (v) establishing new Protected Areas in under-represented habitats. In response to these strategic priorities, the Ministry of Nature Protection, now the State Committee of Turkmenistan on Environmental Protection and Land Resources, drafted a package of project proposals to direct the rationalization and expansion of the Protected Areas Draft Main Trends of Development of Protected Area System up to 2030 (2009) which includes the establishment of six National Parks (Central Karakum, Magtymguli, Balkan, Koytendag, Serhetabad, Archabil) within the next 20 years.

9.5.2 Training and motivation of staff, including overseas training visits. This should be organised both for staff of the state nature reserve and key officials from the State Committee for Environmental Protection and Land Resources. Training should include Management of protected areas; Study and monitoring of biodiversity; Fundraising; Stakeholder involvement; use of GIS and other high-technology methodologies; Public relations and information; Education, etc. Overseas training should involve not only western countries, but also former socialist countries eg Bulgaria and Romania which are similar in experience and cultural background.

9.5.3 Provision of equipment, based on a preliminary needs assessment and directly linked to implementation of the management plan, together with training of staff in its use. Particular emphasis should be given to the development and implementation of objective Scientific and Monitoring Programmes.

9.5.4 The feasibility of establishing close working relationships with conservation administrations in Uzbekistan, especially the Surkhan State Nature Reserve which adjoins Koytendag should be investigated. A trans-boundary site would provide opportunities for future collaboration, such as establishment of Peace Park, common scientific and monitoring programmes, experience exchange etc.

Notes and recommendations on the camera trapping

The staff at Koytendag have done a good job with the cameras available. There were some mistakes – placing cameras too far from the trail, or not taking care to remove vegetation in front of the camera – but such mistakes have been rectified with practice. The main limitation is in the quality of video images made by the cameras and the trigger time. Using still images would be an improvement over video, and the equipment is suitable for monitoring the distribution of the larger species across the landscape and monitoring water hole use, for example. However, for individual recognition of lynx to facilitate a population estimate, and for producing less ambiguous identification of the smaller carnivores (foxes, badgers, martens) it would be desirable to upgrade to cameras with faster trigger times (so they can be placed closer to trails) and with better image quality. White flash produces better images but causes more disturbance, and the better quality infra-red units should be sufficient for most purposes. However, it would have been useful to deploy at least a few units with white flash (NOT at water points) to accumulate some better images of several species.

It would have been useful to deploy cameras in a more structured manner, that span the whole study area in both space and time, including the lower regions that were not very well assessed in this survey.

Data management could also be improved. Although it is helpful to extract the images showing animals from those that do not, it is crucial that all images are stored to allow an assessment of camera function and facilitate analysis. Record keeping could also be improved as it was not always clear if the end of a session was due to a camera being taken down, running out of batteries, or another malfunction.

9.6 Bibliography

Lukarevsky VS (2000) Fauna and current status of populations of some species of large mammals in the Kugitang Range. Problems of desert development 4: 12-16. In Russian

Lukarevsky VS (2001) Leopard, striped hyena and the wolf in Turkmenistan. M. SIGNAR, 128 pp.

Marochkina VV (1993) Materials on bats (Chiroptera) of Eastern Turkmenistan. Math. Academy of Sciences of Turkmenistan, ser. Biol. nauk, No 3: 51-57.

Marochkina VV (1995) Materials on carnivorous mammals of Eastern Turkmenistan. Lutreola 5: 20-23.

Marochkina VV (1996a) The role of the reserves in eastern Turkmenistan – biodiversity of mammals. In: The problems of nature conservation. Conference proceedings. Ekaterinburg: 170-172. In Russian

Marochkina VV (1996b) Notes on the distribution of the mole vole (Rodentia, *Ellobius*) in East Turkmenistan. Zoologicheskyi zhurnal 75, 11: 1722-1728. In Russian

Marochkina VV (1996c) The mole vole (Rodentia, *Ellobius*) in East Turkmenistan. Notes AN Turkmenistan 5: 42-49. In Russian

Marochkina VV (2004) The results of monitoring the population dynamics of small mammals of East Turkmenistan. Arid ecosystems 10, 21: 62-69. In Russian

Marochkina VV, Agryzkov EN (1998) On the problems of biodiversity of East Turkmenistan. In Current issues of environmental protection and sustainable development in Turkmenistan. Ashgabat, 115 pp. In Russian

Marochkina VV, Marinina LS (2003) Inventory of the rodents of Turkmenistan. In Teriofauna of Russia and adjacent territories (VII Congress Theriological society). Proceedings of an international meeting on February 6-7, 2003, Moscow. Moscow, 214 pp. In Russian

Shammakov SM, Marinina LS, Marochkina VV, Karryeva ShB (2004) The species composition of amphibians, reptiles and mammals of the reserves of Turkmenistan. Problems of Desert Development 4: 45-51. In Russian

Strelkov PP, Sosnovtseva V, Babaev H 1979. Bats of Turkmenia. Trudy Zoologicheskogo instituta AN SSSR [Trans. Zool. Inst. Acad. Sci. USSR] 79: 3-71. In Russian.

Taryannikov VI, Persianova LA (1991) On the ecology of the Indian porcupine. Ecology, acclimatization and mammals in Uzbekistan. Fan. Tashkent: 12-16. In Russian

Weinberg PI, Valdez R, Fedosenko AK (1997) Status of the Heptner's markhor *(Capra falconeri* Heptner) in Turkmenistan. Journal of Mammology 78 (3): 826-829.

Summary

Major international expeditions to Koytendag were organised by the RSPB in 2014 and 2015, following a scoping mission in 2013. Opportunistic recording, principally of birds, was made during separate technical visits between May 2012 and March 2016.

The most significant findings from the research carried out are:

1 Hydrogeology

a) discovery of a new cavity with several dry sinkholes and running water near Hojapil village. The estimated diameter of the underground cavity is approximately 100 m, with a depth of approximately 25 m.
b) discovery of a new sinkhole with a dry lake in the bottom.
c) discovery of a new cave with an underground lake with an estimated area of 4,400 m^2 making it the largest underground lake not only in Turkmenistan but also in the whole territory of the North Eurasia.
d) confirmation that there are three discrete hydrological systems within the site.

2 Flora

A thorough review of the botanical literature, supplemented by limited fieldwork confirmed that:

a) a minimum of 982 species of higher plant occur at the site, with 48 species endemic to the site itself.
b) ten species listed in the Red Data Book of Turkmenistan (2011) and three species – walnut *Juglans regia* (NT), pistachio *Pistacia vera* (NT) and a species of almond *Amygdalus bucharica* (VU) included in the IUCN Red List – are known from the site.

3 Surface dwelling Invertebrates

A survey in 2015 resulted in the discovery of several species new to science or to Turkmenistan:

a) a new species of scorpion, *Mesobuthus "garelovi"* Fet et al., 2018 – a species of scorpion recently described from Central Asia
b) a new species of spider, *Heser stoevi* Deltshev, 2016 with specimens collected around the Dinosaur Plateau area at Hojapil and close to the Gulshirin cave at Garlyk. Further 10 species of spiders have been identified by Dr. Christo Deltshev and Dr. Yuri Marusik.
c) Eight species of beetles new for Turkmenistan: *Bembidion aeneum* Germar, 1823, *Chlaenius extensus* Mannerheim, 1825, *Gyrinus distinctus* Aubé, 1838, *Trichophya pilicornis* (Gyllenhal, 1810), *Thinodromus behnei* Gildenkov, 2000, *Gabrius hissaricus* Schillhammer, 2003, *Quedius novus* Eppelsheim, 1892, and *Galeruca jucunda* (Faldermann, 1836).

A review of the literature showed that:

d) nineteen species of surface-living invertebrates are endemic either to the site or to Turkmenistan.
e) one globally threatened species *Sago pedo* (VU) occurs (classed as EN in the Red Data Book of Turkmenistan)
f) five additional species are included in the Red Data Book of Turkmenistan (2011) – *Saxetania cultricollis* (VU), *Anthia mannerheimi* (Rare), *Carabus (Axinocarabus) fedtschenkoi* (Rare), *Melanotus dolini* (Rare) and *Melanoides kainarensis* (VU).

4. Cave fauna

A survey in 2015 resulted in the discovery of seven cave-dwelling species new to science:

a) two species of amphipods – *Gammarus troglomorphus* and *Gammarus parvioculatus*; a dipluran *Turkmenocampa mirabilis* Sendra & Stoev, found in Kaptarhana cave, three species of springtails (Collembola) from three caves, a Latridiidae beetle (Coleoptera) at Kaptarhana.

b) three previously unrecorded species of beetles were also found at Gap-Gotan – *Bembidion (Ocyturanes) dyscheres*, *Eremosphodrus (Rugisphodrus) dvorsh*aki and *Cymindis (Paracymindis) asiabadense kryzhanovskii*.

c) three previously unrecorded species of spiders were also found – *Pholcus parthicus* Senglet, 2008, *Megalepthyphantes nebulosoides* (Wunderlich, 1977) and *Tegenaria* sp.

d) ongoing analysis of samples may result in the identification of new troglobiotic cyclopoid copepods from Gap-Gotan.

e) in May 2012, a beetle was collected from a rimestone pool in Gap-Gotan cave which appears to be a new species of *Xestodium*, though none were recorded in 2015.

5. Fish

a) seven of the ten species recorded for the area were identified in 2015.

b) eight individuals of the endemic Starostin's blind loach *Troglocobitis starostini* (VU) were observed.

c) two novel survey techniques for the blind loach were trialled – use of a remotely operated vehicle to observe fish *in situ* and the collection of DNA samples in order to develop a means of detecting the presence of blind loach in water samples for surveying locations inaccessible to divers or remotely operated vehicles. More work is required to refine the DNA sampling methodology.

6. Amphibians

Two species were recorded that were new to the site:

a) *Bufotes (Pseudepidalea) variabilis* at Hojapil in 2014.

b) *Bufotes oblongus* in the Suw Oyuk sinkhole in 2015.

7. Reptiles

No dedicated survey work carried out.

8. Birds

a) of the 229 species of birds reported as occurring at Koytendag, 154 species were recorded between May 2012 and March 2016.

b) two species new to Turkmenistand were observed – Himalayan griffon *Gyps himalayensis* and common koel *Eudynamys scolopaceus*.

c) five of the eight globally threatened species known from the site were recorded – saker falcon *Falco cherrug*, Egyptian vulture *Neophron percnopterus* and steppe eagle *Aquila nipalensis* (all EN) and lammergeier *Gypaetus barbatus* and cinereous vulture *Aegypius monachus* (both NT).

d) ten of the eleven biome-restricted species were recorded – see-see partridge, *Ammoperdix griseogularis*, yellow-breasted tit *Parus flavipectus*, dark-grey tit *Parus rufonuchalis*, sulphur-bellied warbler *Phylloscopus griseolus*, eastern rock-nuthatch *Sitta tephronota*, white-throated robin *Irania gutturalis*, Finsch's wheatear *Oenanthe finschii*, variable wheatear *Oenanthe picata*, white-winged grosbeak *Mycerobas carnipes* and chestnut-breasted bunting *Emberiza stewarti*.

e) data was collected on 13 of the 17 species included in the Red Data Book of Turkmenistan (2011) – black stork *Ciconia nigra*, lesser kestrel *Falco naumanni*, saker falcon, peregrine falcon *Falco peregrinus*, barbary falcon *Falco pelegrinoides*, lammergeier, Egyptian vulture, cinereous vulture, short-toed snake-eagle *Circaetus gallicus*, steppe eagle, golden eagle *Aquila chrysaetos*, Bonelli's eagle *Aquila fasciatus* and Asian paradise-flycatcher *Terpsiphone paradisi*.

9. Mammals

a) annual monitoring by reserve staff since 1995 has shown an increase in the number of markhor *Capra falconeri* from 69 to 882 in 2013 and of urial *Ovis orientalis* from 164 to 250, with a peak of 320 in 2010. The markhor at Koytendag are the most western and isolated population of the species in the world.

A preliminary analysis of camera trap images has revealed the following:

b) confirmed breeding of Eurasian lynx *Lynx lynx*. Very little is known about the species' distribution in Central Asia.

c) numerous records of grey wolf *Canus lupus*.
d) numerous records of smaller predators such as wild cat *Felix silvestris*, red fox *Vulpes vulpes* and badger *Meles (meles) canescens* plus an unidentified mustelid, possibly *Martes foina*.
e) numerous records of tolai hare *Lepus tolai* and Indian crested porcupine *Hystrix indica,* with tolai hare being exceptionally common.
f) the presence of Eurasian lynx and grey wolf, both relatively numerous, and good numbers of prey such as urial is an indication that there is an intact predator-prey community at the site.

For all areas of research, recommendations for future work are presented.

Acknowledgements

The support and/or participation in fieldwork and reporting provided by the following individuals is gratefully acknowledged:
Dr. Guvandyk Poladov, Shirin Karryeva, Dr. Jumamurad Saparmuradov, Atamyrat Veyisov, Nurmuhamet Imamov, Nurjow Artykov, Sayfiddin Shaymuradov, Dr. Galina Kamahina, Dr. Ogulnabat Rahmanova, Maral Sahatova, Aman Kurbanov, Stephanie Ward and Jeremy Holden.

List of Contributors

Ball, Sarah – Institute of Zoology, Zoological Society of London, Outer Circle, Regent's Park, London, NW1 4RY, UK, (genetic sequencing of Starostin's blind loach)

Chobanov, Dragan – Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria, E-mail: dchobanov@gmail.com (identification of cockroaches and mantises)

Dedov, Ivaylo – Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria, E-mail: idedov@gmail.com (identification of snails)

Degtyarev, Aleksandr – Speleoclub 13 mm, Moscow, Russia, E-mail: degtyarev_a@mail.ru (member of the field research team, expert hydrogeology, karst, caves)

Deharveng, Louis – Institut de Systematique, Evolution, Biodiversite, ISYEB–UMR 7205–CNRS, MNHN, UPMC, EPHE, Sorbonne Universite´s, Museum national d'Histoire naturelle, Paris, France, E-mail: deharven@mnhn.fr (identification of springtails)

Deltshev, Christo – National Museum of Natural History, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria, E-mail: deltshev@gmail.com (identification of spiders)

Donald, Paul – BirdLife International, Pembroke Street, Cambridge CB2 3QZ, UK, E-mail: paul.donald@birdlife.org (member of the field research team, expert birds)

Fet, Victor – Department of Biological Sciences, Marshall University, Huntington, West Virginia 25755-2510, USA, E-mail: fet@marshall.edu (identification of scorpiones)

Georgiev, Kiril – BioSphere Ltd. Nature Conservation and Project Management, Sofia 1612, Lagera, bl. 60, app. 70, E-mail: kiril_boriana@blizoomail.bg (member of the field research team, expert mammals)

Guéorguiev, Borislav – National Museum of Natural History, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria, E-mail: gueorguiev@nmnhs.com (identification of beetles)

Gurney, Mark – Royal Society for the Protection of Birds, The Lodge, Sandy, Beds SG19 2DL, UK, E-mail: mark.gurney@rspb.org.uk (member of the field research team, expert naturalist)

Holden, Jeremy – Independent Nature Photographer, E-mail: jeremyxholden@gmail.com (Photos)

Iankov, Petar – Bulgarian Society for Protection of Birds / Birdlife Bulgaria, Nature Conservation Center Poda, Burgas 8000, Bulgaria, E-mail: petar.iankov@bspb.org (member of the field research team, expert birds)

Jones, Rachel – Zoological Society of London (ZSL), London, United Kingdom, E-mail: rachel.jones@zsl.org (member of the field research team, expert fish)

Kamakhina, Galina –Botanist, independent consultant, Ashgabat, Turkmenistan, Email: (gkamahina06@mail.ru), (checking botanical data and information)

Karryeva, Shirin – Biologist, Ministry of Agriculture and Environment Protection of Turkmenistan and RSPB National Project Manager, Ashgabad, Turkmenistan, E-mail: shirinkarryeva.sk@gmail.com (member of the field research team, lobbying, translation, logistics)

Kovařík, František – Department of Zoology, Charles University, Viničná 7, CZ-128 44 Praha 2, Czech Republic, E-mail: kovarik.scorpio@gmail.com (identification of scorpions)

Linnell, John –Norwegian Institute for Nature Research (NINA), P.O. Box 5685, Torgard, NO-7485 Trondheim, Norway, E-mail: john.linnell@nina.no (member of the field research team, mammal expert)

Ljubomirov, Toshko – Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria, E-mail: toshkoljubomirov@gmail.com (identification of ants)

Marusik, Yuri – Institute of Biological Problems of the North, RAS, Portovaya Str. 18 68500 Magadan, Russia, E-mail: yurmar@mail.ru (identification of spiders)

Menliev, Shanyiaz – Head of Scientific Department, Koytentag State Nature Reserve, Turkmenistan, email: shaniyazkoytendag@mail.ru (member of the field research team, expert on hydrogeology, flora, fauna)

Mountford, Owen-Independent consultant, UK, E-mail: om@ceh.ac.uk (expert botanist)

Pereladov, Mikhail – Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Laboratory of Coastal Research, Moscow, Russia, E-mail: pereladov@vniro.ru (member of the field research team, expert hydrogeology, karst, caves, fish, photos)

Rustamov, Eldar – Ministry of Agriculture and Environment Protection of Turkmenistan and RSPB National Project Coordinator, Ashgabad, Turkmenistan, E-mail: elldaru@mail.ru (member of the field research team, expert birds)

Sket, Boris – Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani, p.p. 2995, 1001 Ljubljana, Slovenia, E-mail: Boris.Sket@bf.uni-lj.si (member of the field research team, cave fauna, photos)

Stoev, Pavel – National Museum of Natural History, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd, 1000 Sofia, Bulgaria and Pensoft Publishers, E-mail: pavel.e.stoev@gmail.com (member of the reserach trip, compiling and editing of the research report, photos)

Veyisov, Atamyrat – Ministry of Agriculture and Environment Protection of Turkmenistan, and RSPB National Project GIS-expert, Ashgabad, Turkmenistan, E-mail: atamuratveyis@mail.ru (member of the field research team, expert on maps)

Ward, Stephanie -Royal Society for the Protection of Birds, The Lodge, Sandy, Beds, SG19 2DL, UK, E-mail: stephanie.ward@rspb.org.uk (RSPB Central Asia programme coordinator)

Welch, Geoff – Royal Society for the Protection of Birds, The Lodge, Sandy, Beds SG19 2DL, UK, E-mail: Geoff.Welch@rspb.org.uk (compiling and editing of the research report)

Zimmerman, Brian – Zoological Society of London (ZSL), London, United Kingdom, E-mail: brian.zimmerman@zsl.org (member of the field research team, expert fish, photos)

The book summarizes the results of the multidisciplinary research expeditions carried out in Koytendag Mountains, SE Turkmenistan from 2013 until 2015. Situated in the extreme south-east of Turkmenistan, on the international border with Uzbekistan and close to the border with Afghanistan, Koytendag presents one of the most distinctive landscapes in Central Asia. The field studies led to discovery of the largest underground lake in North Eurasia (Igor Kutuzov Lake), a number of new invertebrate species (*Turkmenocampa mirabilis*, *Hesser stoevi*, *Gammarus troglomorphus*, *G. parvioculatus*, etc.), and contributed to clarifying the status of several conservationally important fish, bird and mammal species.

9 789546 429674