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Migratory connections of Coraciiformes of Kazakhstan based on bird ringing

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Abstract. *Tashimova AR, Gavrilov E, Akentyeva YEV, Chalikova YS, Syrymgul ZK, Kobegenova SS, Berdikulov BT. 2025. Migratory connections of Coraciiformes of Kazakhstan based on bird ringing. Biodiversitas 26: 4706-4713.* This study provides the first long-term and comprehensive analysis of bird ringing data for four Coraciiformes species, Eurasian Roller (*Coracias garrulus*), Common Kingfisher (*Alcedo atthis*), European Bee-eater (*Merops apiaster*), and Blue-cheeked Bee-eater (*M. persicus*), captured in Kazakhstan between 1966 and 2025, with most data obtained from Shakpak Pass, a major migratory bottleneck in Central Asia. Over these 60 years, more than 26,000 individuals were ringed, yet only 35 recoveries were reported, highlighting the scarcity of long-distance encounter data in the region. The majority of recoveries involved *M. apiaster*, which demonstrated extensive migratory connectivity, including southward movements through Uzbekistan and Kyrgyzstan, westward passage toward the Caspian region, and remarkable long-distance encounters from Saudi Arabia, Syria, and even France. The latter represents a case of abmigration, providing evidence of population mixing between Central Asia and Europe. By contrast, *C. garrulus* and *M. persicus* were mainly documented as consistent passage migrants through Shakpak Pass, while *A. atthis* displayed signs of philopatry at local ringing sites. These findings emphasize the importance of Central Asia as a critical, yet understudied, segment of Eurasian migration systems. The exceptionally low recovery rates stress the urgent need to combine traditional ringing with modern tracking tools and to enhance public awareness and reporting to strengthen migration research and conservation.

Keywords: *Alcedo atthis*, bird migrations, bird ringing, *Merops apiaster*, *Merops persicus*

INTRODUCTION

Understanding bird migration requires reliable data across vast geographic and temporal scales. Bird ringing has been a foundational method for studying bird movements. Combined with modern tracking tools like GPS-trackers and geolocators, ringing continues to illuminate migratory connectivity in migration research, revealing routes, timing, philopatry, and demographic trends. This information is essential for conservation planning, land-use decisions, and monitoring disease transmission (Gavrilov and Gissov 1985; Treep et al. 2016; Franklin et al. 2022; Berdikulov et al. 2023; Fattorini et al. 2023; Gregory et al. 2023). Integrating ringing with complementary approaches such as stable isotope analysis, molecular genetics, and citizen science observations further enhances our understanding of population structure, dispersal patterns, and site fidelity across the annual cycle. Such multidisciplinary approaches are increasingly important given the rapid environmental changes affecting migratory corridors, including habitat loss, climate variability, and anthropogenic disturbances.

Kazakhstan, located along the Central Asian Flyway, is a critical migratory corridor linking Siberia and Central Asia with South Asia and Africa (Convention on Migratory Species/CMS 2025). Despite a long history of bird ringing in the country (since 1926), large-scale migration research has been limited to a few key sites, most prominently Shakpak (Chokpak) Pass in the Western Tien Shan, a major bottleneck where migrants concentrate. The annual bird ringing has occurred here since 1966 (Gavrilov and Gissov 1985; Gavrilov and Gavrilov 2014; Gavrilov et al. 2016; Gubin 2022; Kovshar 2023; Tashimova et al. 2024). In recent years, ringing has been complemented by tracking of Great Reed Warbler, Demoiselle and Common Cranes, Yellow-Eyed Pigeon, and Pallas's Gull (Brlík et al. 2020; Ilyashenko et al. 2023; Berdikulov et al. 2024; Ilina et al. 2025), and has contributed to detecting avian diseases such as H5N1, Newcastle Disease, and West Nile Virus (Iverson et al. 2011; Karamendin et al. 2019; Sultankulova et al. 2021). These long-term datasets provide unparalleled opportunities to explore demographic trends, inter-annual variability in migration timing, and the influence of environmental factors on species' survival and dispersal.

Despite this long history, no comprehensive analysis of Coraciiformes ringing has been undertaken in Kazakhstan. Only four species of this order breed in the country: Eurasian Roller *Coracias garrulus* (Linnaeus, 1758), Common Kingfisher *Alcedo atthis* (Linnaeus, 1758), European Bee-eater *Merops apiaster* (Linnaeus, 1758), and

Blue-cheeked Bee-eater *Merops persicus* (Pallas, 1773). While their general distributions are well established (Cramp 1985), their migratory connectivity in Central Asia remains poorly understood, compared to the European-African region. Rollers and Bee-eaters are long-distance migrants wintering mainly in sub-Saharan Africa, *M. apiaster* also wintering in South India and the Arabian Peninsula (Finch 2016, et al. 2017; Moura et al. 2019; Hahn et al. 2020; Kiss et al. 2024; Monti et al. 2024). This species also exhibits population mixing and abmigration (when a bird settles outside its natal breeding range), supported by a Kazakh-ringed bird later breeding in France (Gavrilov et al. 1999; Ramos et al. 2016; Moura et al. 2019). In contrast, the Common Kingfisher often undertakes short, often partial migrations, usually to avoid freezing conditions (Cramp 1985).

This study presents the first long-term (1966-2025), comprehensive analysis of ringing and recovery data for four species within Coraciiformes in Central Asia. This research aim to: (i) assess their spatial connectivity within the region, (ii) identify potential migratory routes and wintering areas, and (iii) evaluate the role of long-term ringing in clarifying the migration ecology of Coraciiformes in the eastern Palearctic. By integrating ringing with modern tracking technologies and long-term observational records, this study seeks to provide a baseline for future conservation strategies, regional monitoring, and management of migratory habitats that are increasingly threatened by climate change and land-use alterations.

MATERIALS AND METHODS

Study area and species

We analyzed bird ringing records in Kazakhstan from 1966 to 2025 for the four target Coraciiformes species. Over this period, a total of 26,911 individuals (across *C. garrulus*, *A. atthis*, *M. apiaster*, and *M. persicus*) were captured in Kazakhstan. Their ringing took place primarily at the Shakpak Pass in Southeastern Kazakhstan (42°31'N, 70°38'E), with additional ringing at Sorbulak Lake in Almaty region (43°46'N, 76°05'E), the Lower Ural River in West Kazakhstan (47°28'N, 51°40'E), and numerous other sites scattered around the country (Figure 1).

Capturing and ringing

Birds were captured using standardized techniques, which were refined over the five decades of fieldwork. The primary ringing site, Shakpak Pass, has operated continuously each spring and autumn since 1966.

The main trapping device used at Shakpak is a Heligoland-type stationary trap (an enlarged and upgraded version of the Heligoland trap). In addition to these traps, up to 10 mist nets are set up each season in the nearby shelterbelt forest (Gavrilov and Gissov 1985; Busse and Meissner 2015; Kovshar 2023; Newton 2023). Other major ringing efforts were conducted at Sorbulak Lake and in the lower reaches of the Ural River during periods of stationary fieldwork. These sites employed Heligoland traps, mist nets, and other trapping methods.

All captured birds were ringed with metal rings issued by the Russian and Kazakhstani Bird Ringing Centers. Data on captured individuals, including morphometric measurements and ring recoveries, are stored in the database of the Bird Ringing Center at the Institute of Zoology RK.

Ethical considerations

Bird capture and ringing activities were approved and coordinated by the Committee of Forestry and Wildlife Protection, as well as the Ministry of Science and Higher Education of the Republic of Kazakhstan. All handling followed standard ethical protocols to minimize stress and injury to the birds.

Data analysis

Ringing and recovery data were compiled and analyzed using R and MS Excel. Maps of ringing sites and recovery locations were produced with QGIS 3.30 using base maps from national sources and global databases.

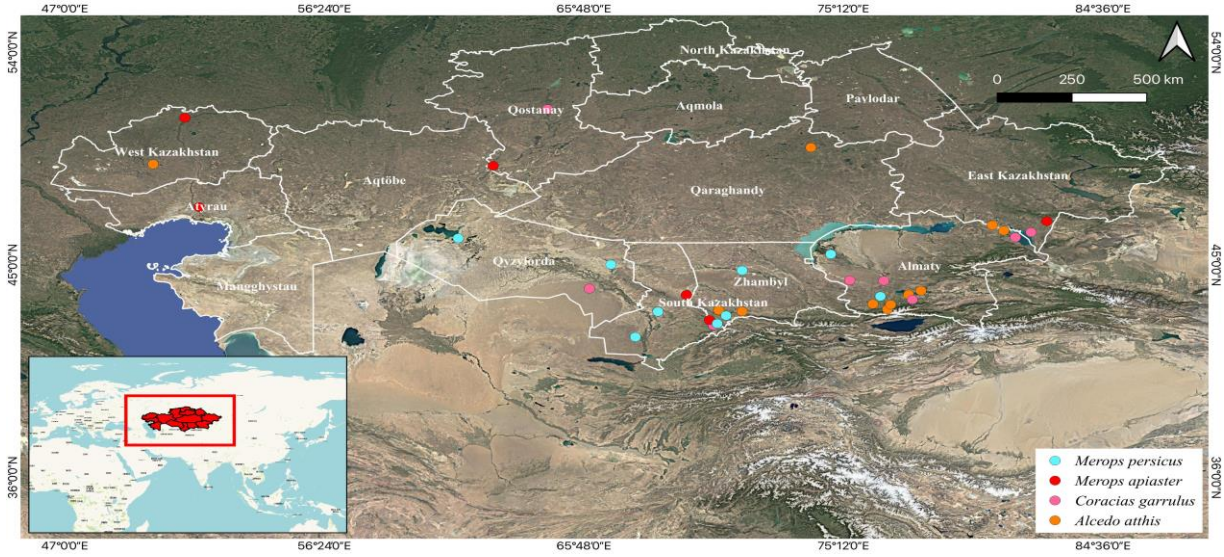

Figure 1. Ringing sites of Coraciiformes in Kazakhstan

RESULTS AND DISCUSSION

Ringing results

Between 1966 and 2025, a total of 26,911 Coraciiformes were ringed at various locations in Kazakhstan: 1,250 *C. garrulus*, 1,290 *A. atthis*, 23,854 *M. apiaster*, and 517 *M. persicus* (Table 1). The vast majority of these (25,150, ~93%) were captured at the Shakpak Pass (mainly European Bee-eaters and Rollers). Other sites contributed smaller proportions: Sorbulak Lake (877 birds, mainly Common Kingfishers), the Lower Ural River (56), and scattered locations (828). Ringing activity peaked in the late 1980s-1990s, coinciding with high Roller and Bee-eater captures at Shakpak, while Kingfisher ringing peaked in the 1980s at Sorbulak Lake. Other sites generally had low capture numbers, often only in some years.

Only 35 individuals were recovered: 6 *C. garrulus*, 1 *A. atthis*, 26 *M. apiaster*, and 2 *M. persicus*, corresponding to an overall recovery rate of just 0.13% (Table 1). Even for the most numerous species, the European Bee-eater, the recovery rate was only 0.11%. Most birds had been ringed at Shakpak Pass. Only Kingfishers were tagged on Sorbulak Lake, and one European Bee-eater was tagged on the Ural River. The majority of ring returns occurred in the 1970s (17 *M. apiaster* and 2 *M. persicus*), while other decades yielded only scattered returns.

More than half of Coraciiformes (21) were found alive: 17 birds (5 *C. garrulus*, 1 *A. atthis*, 13 *M. apiaster*, 2 *M. persicus*) were released, whereas 5 *M. apiaster* were not (one of them injured or sick). Among the European Bee-eaters, 9 individuals were found dead, 7 of which had been killed by humans. The interval between ringing and recovery ranged from 2 days to 4 years. 14 birds were encountered during the first year after ringing, half of them within the first two months. Another 14 birds were obtained in the second year, 4 in the third, and 3 in the fourth year (Table 2).

Half of the birds were recaptured at the ringing sites: 5 Rollers, 7 European, and 2 Blue-cheeked Bee-eaters at Shakpak Pass, one Kingfisher at Sorbulak Lake, and one European Bee-eater at the Lower Ural River. Most of them were recaptured after 1-3 years, although at the Ural River, a juvenile *M. apiaster* was recaptured only 21 days later (Table 3). European Bee-eaters were the only species recovered outside ringing sites: 10 in Kazakhstan and 8 abroad (2 in Uzbekistan, 3 in Kyrgyzstan, and one each in Saudi Arabia, Syria, and France) (Table 4, Figure 2).

In the vicinity of Shakpak Pass (<70 km), 1 *C. garrulus* and 4 *M. apiaster* had ring recoveries. A subadult Roller was recaptured 11 days after ringing in Kalinino village (3-4 km from the station), having gained 19.4 g in body mass (from 98.6 to 118 g) (Table 3, Figure 3). Two European Bee-eaters were encountered 60-66 km southwest of Shakpak within one month (in Zhynyshke after 2 days, in Aksu after 26), with flight speeds of 30 and 2.5 km per day, respectively. Two others were found the following year, ~ 20 km northeast of the Pass, in late May and mid-June (Table 4, Figure 3).

Table 1. The number of ringed Coraciiformes in Kazakhstan and the percentage of ring recoveries

Species		Ringing sites				Total	% of ring recoveries
		Shakpak Pass	Sorbulak Lake	Lower Ural River	Other		
Coracias garrulus	Ring	1154	22	18	56	1250	0.48
	Ring recovery	6	0	0	0	6	
Alcedo atthis	Ring	11	844	0	435	1290	0.08
	Ring recovery	0	1	0	0	1	
Merops apiaster	Ring	23565	10	38	241	23854	0.11
	Ring recovery	25	0	1	0	26	
Merops persicus	Ring	420	1	0	96	517	0.39
	Ring recovery	2	0	0	0	2	
Total number of ringed individuals		25150	877	56	828	26911	0.13
Total number of ring recoveries		33	1	1	0	35	

Table 2. Conditions and circumstances of Coraciiformes at a repeat meeting

Species	Condition and circumstances	Time after ringing (years)				Total
		In 1st	In 2nd	In 3d	In 4th	
Coracias garrulus	Alive	1	2	1	1	5
	Unknown	1	0	0	0	1
Alcedo atthis	Alive	0	0	1	0	1
Merops apiaster	Alive	3	4	1	1	9
	Alive, not released	3	0	0	0	3
	Injured or sick; not released	1	0	0	0	1
	Recently died, killed/shot by a human	3	4	0	0	7
	Dead (unknown how long)	1	0	0	1	2
	Unknown	1	2	1	0	4
Merops persicus	Alive	0	2	0	0	2
Total		14	14	4	3	35

Table 3. Recaptures of Coraciiformes

Species	No	Sex	Age	Capture date	Recapture date	Time (days)	Place of ring and recapture	Condition
Coracias garrulus	1	I	HY	15.09.1969	26.09.1969	11	Shakpak Pass (from camp to Kalinino)	Unknown
	2	I	AHY	14.05.1980	09.05.1983	1090 (3y)	Shakpak Pass	Alive
	3	I	AHY	05.05.1981	06.05.1982	366 (1y)	Shakpak Pass	Alive
	4	I	AHY	11.05.1981	02.05.1982	356 (1y)	Shakpak Pass	Alive
	5	♂	SY	05.05.1997	04.05.1998	364 (1y)	Shakpak Pass	Alive
	6	♀	AHY	07.05.2006	09.08.2009	1190 (3y 3m)	Shakpak Pass	Alive
Alcedo atthis	1	I	AHY	05.06.1983	07.06.1985	733 (2y)	Sorbulak Lake	Alive
Merops apiaster	1	I	HY	12.09.1978	22.09.1979	375 (1y)	Shakpak Pass	Alive
	2	I	HY	05.09.1982	19.09.1983	379 (1y)	Shakpak Pass	Alive
	3	♀	AHY	17.09.1992	22.05.1994	612 (1y 8m)	Shakpak Pass	Alive
	4	♀	AHY	22.05.1995	06.09.1997	838 (2y 3m)	Shakpak Pass	Alive
	5	♂	AHY	08.05.1998	16.05.2001	1104 (3y)	Shakpak Pass	Alive
	6	♀	AHY	11.09.1999	06.09.2000	361 (1y)	Shakpak Pass	Alive
	7	♂	AHY	04.09.2023	09.09.2024	371 (1y)	Shakpak Pass	Alive
	8	I	JUV	23.07.1975	13.08.1975	21	Lower Ural River	Alive
Merops persicus	1	M	AHY	09.09.1972	17.05.1974	615 (1y 8m)	Shakpak Pass	Alive
	2	M	AHY	09.09.1972	17.05.1974	615 (1y 8m)	Shakpak Pass	Alive

Table 4. Ring recoveries of European Bee-eaters

Sex	Age	Capture date	Recapture date	Time (days)	Recovery place	Distance (km)	Direction	Speed (km/d)	Condition
Kazakhstan									
Near Shakpak Pass									
♂	AHY	10.05.1975	18.05.1976	374 (1y)	B. Momyshuly	13	NE	-	Unknown
♀	HY	05.09.1972	15.06.1973	283 (9m)	Nurlykent	22	NE	-	Shot by a human
I	HY	29.08.1989	31.08.1989	2	Zhynyshke	60	SW	30	Alive; not released
♀	AHY	07.09.1980	03.10.1980	26	Aksu	66	SW	2.5	Dead (unknown how long)
Far from Shakpak Pass									
♂	AHY	29.08.1977	03.09.1977	5	Atakent	253	SW	50.6	Alive; not released
♀	AHY	27.04.1985	26.05.1986	394 (1y)	Uspenovka	335	E	-	Shot by a human
♀	AHY	06.09.1969	06.09.1970	365 (1y)	Kordai	363	E	-	Unknown
♀	AHY	11.05.1975	25.08.1975	106 (3m)	Sorbulak Lake	463	E	-	Shot by a human
I	HY	07.09.1979	15.05.1980	251 (8m)	Almaty	526	E	-	Injured or sick; not released
I	HY	08.09.1980	06.10.1980	28	Aktau	1573	W	56.2	Alive; not released
Uzbekistan									
♀	AHY	07.09.1980	15.10.1980	38	Manas	310	SW	8.6	Unknown
♂	AHY	10.05.1975	25.04.1979	1446 (4y)	Bulung'ur	416	SW	-	Dead (unknown how long)
Kyrgyzstan									
♂	AHY	01.09.1971	20.07.1972	323 (10m)	Pokrovka	83	E	-	Shot by a human
♀	AHY	12.05.1977	27.05.1978	380 (1y)	Talas	132	E	-	Shot by a human
I	HY	09.09.1970	22.05.1972	621 (1y 8m)	Dzhangy Pakhta	302	E	-	Shot by a human
Saudi Arabia									
♂	AHY	15.05.1970	01.07.1971	412 (1y 1m)	Nebak	2716	SW	-	Shot by a human
Syria									
I	HY	11.09.1978	04.10.1980	754 (2y)	Shahba	3152	SW	-	Unknown
France									
♀	HY	10.09.1993	14.07.1994	307 (10m)	Vistre River, Gard	5236	SW	-	Alive

At distances of 80-1500 km, 11 Bee-eaters were recovered (Figures 2 and 4). Three individuals were found southwest of Shakpak: two during autumn migration in Atakent (253 km, 5 days; 50.6 km/day) and Manas (310 km, 38 days; 8.6 km/day), and one four years later during spring migration in Bulung'ur (416 km). Seven were recovered 83-526 km east of Shakpak: three within a year (Sorbulak after 3 months; Almaty and Pokrovka after 8-10 months), the rest during the following year. Breeding-season encounters (May 27, July 20) were recorded in Pokrovka and Talas. One bird was recaptured 1,573 km west of a Shakpak, in Aktau, on the eastern Caspian coast after 28 days (speed 56.2 km/day).

Three long-distance recoveries of European Bee-eaters were reported from abroad (Figure 2). One adult male was found in Saudi Arabia near Nebak village (40 km south of Salwa) in early July, a year after being ringed at Shakpak during spring migration. Another was recovered in Syria near Shahba (15 km north of Suwayda) in early October, two years after ringing. A third female was captured in a breeding colony in southern France (Gard department, near the Vistre River) in mid-July, 10 months after ringing.

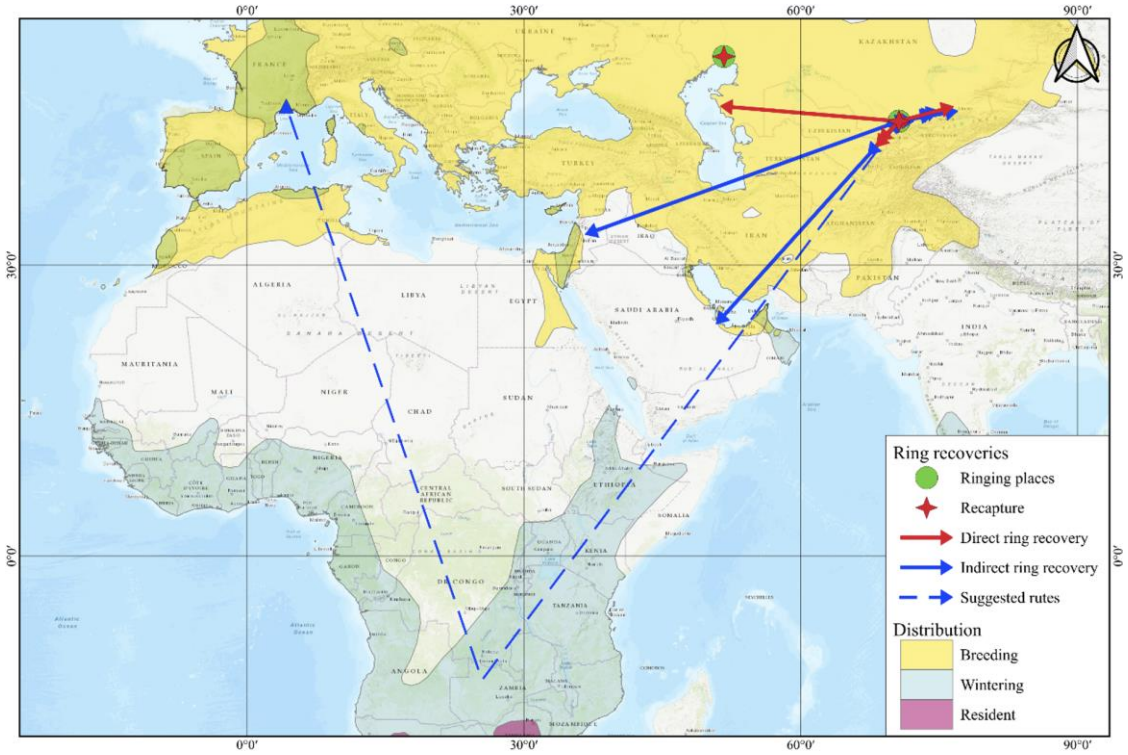

Figure 2. Global scale of *Merops apiaster* ringing sites and ring recovery points. The distribution map of the species is taken from the IUCN Red List, with additions of summer and winter meetings from the GBIF

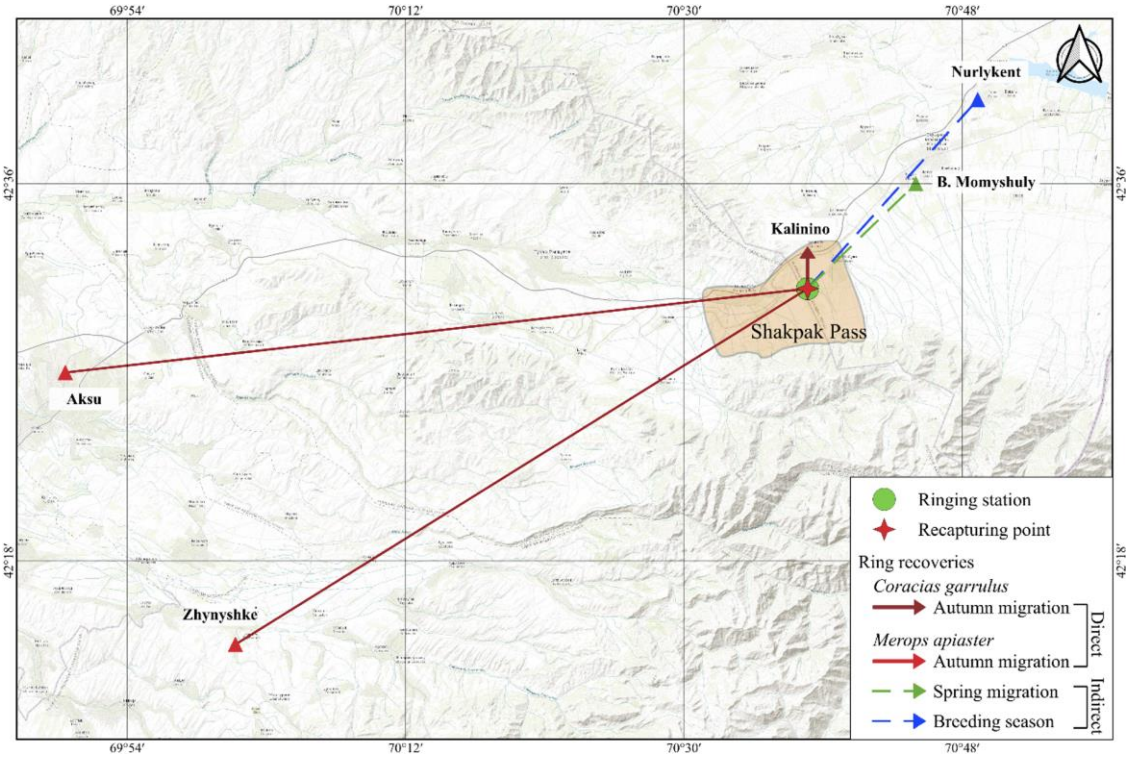

Figure 3. Recaptures and close ring recoveries of Eurasian Rollers and European Bee-eaters

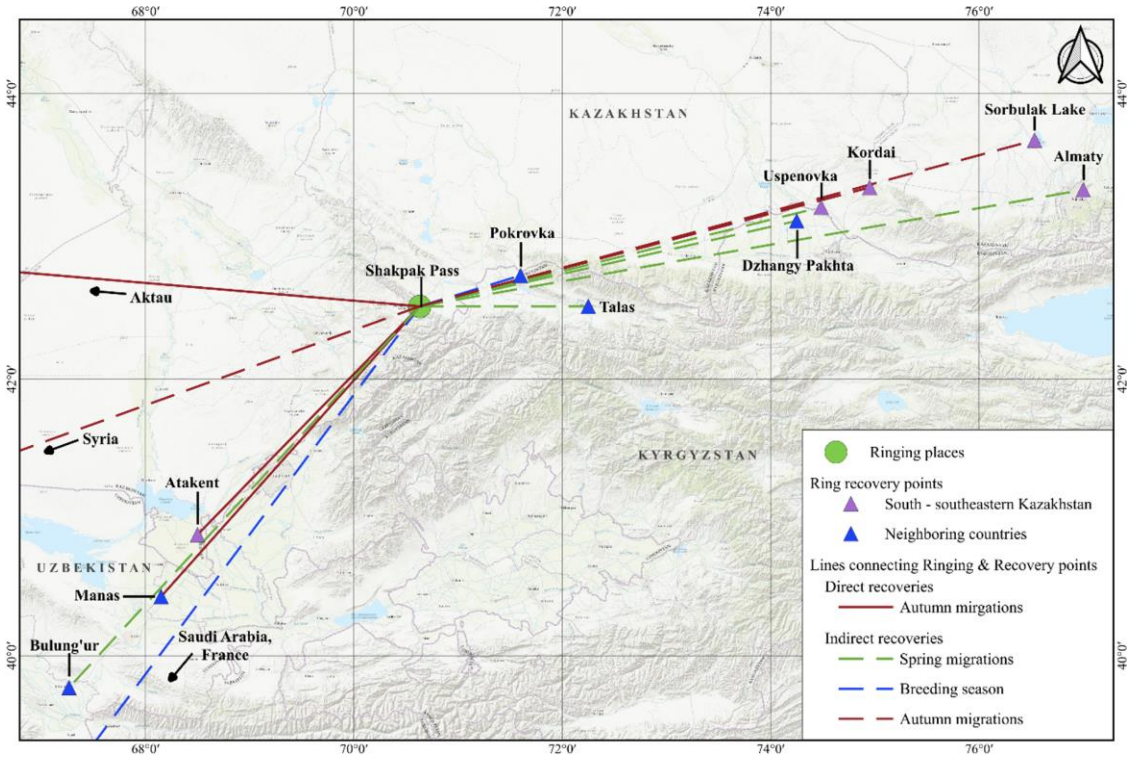

Figure 4. Regional scale of *Merops apiaster* ringing sites and ring recovery points (south-southeastern Kazakhstan, Uzbekistan, and Kyrgyzstan)

Discussion

Over the past 60 years, Kazakhstan has accumulated a vast amount of bird ringing data, much of which remains under-analyzed. The majority of ringing activity has taken place at Shakpak Pass in the south of the country. However, important work was also carried out at other sites along migratory pathways, including Sorbulak Lake in the southeast and the Ural River in the west. However, the effort at these latter sites was limited in duration and scale, which explains why Shakpak records dominate the dataset. Three Coraciiformes species (*C. garrulus*, *M. apiaster*, and *M. persicus*) were ringed mainly at Shakpak, while *A. atthis* was only captured at Sorbulak.

Despite over 26,000 individuals ringed, Coraciiformes still represent only a small proportion of the total migrant flow at Shakpak compared to other groups. In the 20th century, they accounted for ~0.5% of spring migrants and ~2% of autumn migrants. In the 21st century, these proportions rose to ~3% and ~5%, mainly due to sharp declines of sparrows (*Passer hispaniolensis* (Temminck, 1820) and *P. indicus* (Jardine & Selby, 1831)) rather than increases in Coraciiformes numbers (Gavrilov and Gissov 1985; Tashimova et al. 2024).

Ring recoveries from this order are extremely scarce (only 35, most from *M. apiaster*), which is probably caused by low awareness of bird ringing among the population and the lack of ringing stations in Central Asia, reflecting both low reporting awareness in Central Asia and the lack of ringing stations across the region. In Europe, by contrast, recoveries number in the hundreds or thousands for the same species. The most extended interval recorded here was four years, far below the 12-year lifespan documented for *M. apiaster* in European data (du Feu et al. 2009). Most live birds were recaptured at ringing sites or breeding colonies (e.g., the Ural River, southern France). Elsewhere, recoveries involved European Bee-eaters that were either killed or injured, often linked to conflict with beekeepers, a recognized conservation concern (Moreno-Opo et al. 2018; Bota et al. 2020).

Many recoveries confirm the constancy of migratory flyways (as well as philopatry) through the Shakpak Pass and Sorbulak Lake. Some summer recoveries may confirm breeding sites: *A. atthis* at Sorbulak Lake, *M. apiaster* in the vicinity of Shakpak Pass, Talas River Valley, northern Tien Shan foothills, Almaty region, and the Ural River valley.

The migration routes of Coraciiformes, like those of many species breeding in Western Siberia and the eastern half of Kazakhstan, follow the northern Tien Shan foothills through Shakpak Pass and onward across southern Kazakhstan and Uzbekistan to wintering grounds spanning India to Africa (Cramp 1985; Ilyashenko et al. 2023; Ilina et al. 2025). Notably, *M. apiaster* showed both southward movements through Uzbekistan and westward detours toward the Caspian Sea, illustrating a broad-front strategy. Recoveries further document onward passage via Syria and the Arabian Peninsula (where part of the population winters) toward Africa. Population *M. apiaster* mixing between Europe and Central Asia in shared wintering grounds has been demonstrated genetically (Ramos et al. 2016; Moura et al. 2019). This is confirmed by the case of abmigration of a Kazakh female in France (Gavrilov et al.

1999). Another notable case was the recovery of a European Bee-eater in Saudi Arabia. According to the literature, *M. apiaster* is not known to breed in Arabia (Cramp 1985, IUCN 2024). However, numerous summer records from the region are listed in GBIF (2023). Our recovery, therefore, provides direct confirmation that Bee-eaters may spend the summer in Arabia. What remains unclear is whether such individuals are breeding there. If the recovered bird (at least three years old at the time) was a non-breeder, this case suggests that non-breeding European Bee-eaters may spend summer either in their natal areas or in parts of the wintering range. However, if it were breeding, this would represent another example of abmigration. Current data do not allow us to distinguish between these possibilities.

Our data also highlights movement ecology. Autumn migration speeds in *M. apiaster* varied from 2-56 km/day, showing both rapid long-distance flights (30-50 km/day) and slow, opportunistic advances (2-8 km/day). This pattern is consistent with trophic migration, where progress depends on local food availability. Such slower strategies in Central Asia contrast with the high-speed flights (90-500 km/day) observed when crossing ecological barriers such as the Mediterranean or Sahara (Cramp 1985; Hahn et al. 2020; Costa et al. 2021).

In conclusion, although the number of recoveries is limited, this study contributes new insights into the migration ecology of Coraciiformes in Central Asia. It documents the broad-front migrations of *M. apiaster* across Central Asia, connectivity with Western Asia and Europe, and cases of abmigration. Notably, the dominance of Shakpak Pass in the dataset reflects concentrated ringing effort rather than uniquely high migratory significance, highlighting the urgent need to expand monitoring to other flyway points. To overcome low recovery rates, future work should integrate ringing with modern tracking technologies (geolocators, GPS/GSM), strengthen regional collaboration, and improve public awareness of ring reporting. Comparative analyses with European populations will be critical to position Central Asian birds within global migration systems and to develop effective conservation strategies along the Central Asian Flyway.

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