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Original article

Spring migration of mallards (*Anas platyrhynchos*) tracked with wild-trackers in East Asia

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ABSTRACT

Mallard is a dominant waterfowl species wintered in Korea. We researched the mallard spring migration route, stopover sites, and breeding sites. We used cannon nets in Central Korea to catch and attach 10 wild trackers (WT-200). The mallards' spring departure dates were from the end of March to early April. The spring migration route varied by individual mallards, with most moving through the North Korean east coast. Breeding sites were distributed among the interior of Northeastern China. The average distance to the breeding areas was 1,265 km [standard deviation (SD) = 491 km] and the average days spent from wintering site to breeding site was 25.3 days (SD = 19.2 days). The mallards used several stopover sites when on the spring migration route (average 3.3 ± 2.1, range 2–9). The time spent at the stopover sites was a minimum of 1 day to a maximum of 16 days. Wintering mallards in Korea showed various individual trends regarding spring migration timing, migration route, stopover sites, and usage days.

Introduction

Wild birds, especially waterfowl, are the primary vector of a highly pathogenic avian influenza. Avian influenza wildly spreads when moving through breeding sites and wintering sites (Newman et al 2009; Takekawa et al 2010). Mallard is a common water bird that migrates internationally and spreads avian influenza not only in East Asia but also in Europe (Keawcharoen et al 2008; Lee and Song 2013). The number of mallards, a dominant water bird species, that winter in Korea is around 100,000–200,000. Mallards winter in various environments such as bird sanctuaries, inland small rivers, and lakes (Kim et al 1997; NIBR 2012, 2013, 2015). Therefore, the possibility of spreading highly pathogenic avian influenza and the protection of water birds is based on the understanding of their moving patterns such as migration route, moving season, and breeding distribution (Krementz et al 2011). Wild animal migration research using a Global Positioning System (GPS) based transmitter is a method to track wild animals' habitat and migration of space and season. Based on international scale research, the GPS method can record a bird's migration season, route, and behavior (Aebischer and Robertson 1993; Yamaguchi et al 2008; Krementz et al 2011).

The home range of wintering mallards in Korea was narrow and showed very high water-dependent trends (Kang et al 2014). However, mallards in Japan use various migration routes and stopover sites (Yamaguchi et al 2008). To date, there is no detailed research in Korea or East Asia on mallards' long range migration and their habitat when migrating. We studied the mallards' migration route, distribution, stopover and breeding areas, and timing of migration movements using tracked wild trackers (WT-200; GPS-Mobile Phone based Telemetry, KoEco).

Materials and methods

Telemetry tracking

We captured 10 mallards using cannon nets in 2014 in central Korea along small rivers and attached wild trackers (WT-200). The wild animal tracking device (WT-200) attached areas are Icheon,

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Figure 1. Sites in Korea where mallards (*Ansa platyrhynchos*) were captured.

Cheonan, and Jeonju (Figure 1). These areas are in small rivers where the depth is shallow, velocity is slow, and there are multiple resting sand banks.

Captured mallards were immediately put on their backs for 10–20 minutes to stabilize them and were then selected by weighing the individual mallards. The maximum weight of the tracking device that can be attached and minimize the birds flying abilities is 5% of their body weight (Kenward 1985). Considering that the wild animal tracking device is 47 g (63 × 35 × 14 mm), we selected individuals that weighed over 1 kg. Wild animal tracking devices were attached in a back-pack style (Kenward 1985). For tracking mallards, WT-200 devices were used.

Wild tracker (WT-200), a newly invented telemetry device by the KoEco Inc. were used. The WT-200 is a new telemetry device based on the GPS (Global Positioning System) combined with WCDMA (Wideband Code Division Multiple Access) mobile phone system. This device when attached on wild animals will record the GPS coordinates at a given time interval and transmit the geographic coordinates at the presetting time of day using the public network of mobile phone system. Researchers can acquire the location data of tracking individual by accessing the tracking website. Therefore we checked the website to verify the mallards' survival and migration route. GPS locations were recorded once a day.

Data analyses

To find the mallards' migration route we analyzed the departure date from the wintering site, the arrival date to the breeding site, and stopover sites. We also analyzed the number of days the birds took to get from the wintering site to the breeding site and the duration of days at the stopover sites. The departure date of the wintering site is considered as the date the birds left Korea. Mallards breed right after they arrive at the breeding site (Arzel et al 2006) and an area is considered as a breeding site if the mallards do not move over 30 km over a period of a month. We decided on an arrival date with this method. The stopover site is defined as a spot that is used for 24 hours without moving over 30 km (Yamaguchi et al 2008). To analyze the spring migration route we used location data from the date of the attachment of the tracker until July 31.

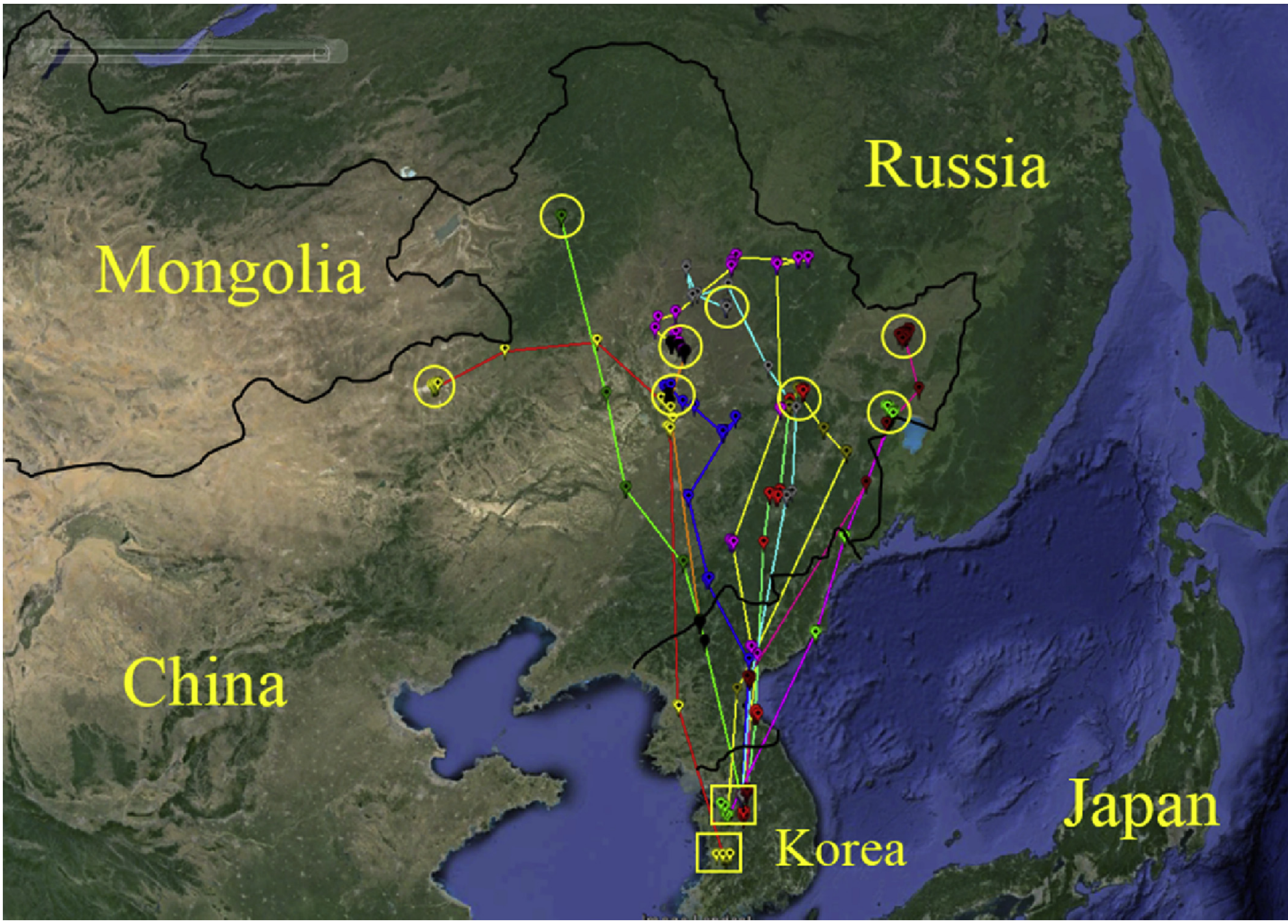

Figure 2. Spring migration routes of mallards tracked with wild-trackers (WT-200) starting from the wintering sites in Korea: circle = breeding site; square = wintering site.

Results

The mallards' spring migration route varied based on each individual and their wintering areas. Most mallards moved from the wintering site through the North Korean east coast to Northeastern China. However, a few individuals moved through North Korea's central or west coast. After the mallards moved through North Korea, a wide variation in the sites used in Northeastern China was recorded. Breeding sites were widely spread throughout Northeastern China (Figure 2).

The wintering site departure date and breeding site arrival date varied among each individual. Seven mallards started their spring migration on April 1 with a variation of 5 days. Most mallards departed from their wintering site in April. The earliest mallard to depart was on March 27 and the latest was on May 6 (Table 1).

The average distance between wintering site to breeding site was 1,270 km [standard deviation (SD) = 194 km). The shortest distance was 1,009 km and the longest distance was 1,968 km (Table 2). The average days it took to get from the wintering site to the breeding site was 25.3 days (SD = 19.2 days). The shortest duration was 11 days and the longest duration was 77 days. The average number of stopover sites between the wintering sites and the breeding sites was 3.3 sites. Most individuals used two to three stopover sites. Stopover sites were wetlands such as rivers, streams,

Table 1. The detailed tracking information of mallards.

No.	Sex	Deployed areas	GPS record/d	Deployed date (2014)	Last analyzed date (2014)
1	Male	Jeonju	1	Mar. 1	Jul. 31
2	Male	Icheon	1	Mar. 4	Jun. 19
3	Male	Icheon	1	Mar. 4	Jul. 31
4	Male	Icheon	1	Mar. 4	Jul. 31
5	Female	Icheon	1	Mar. 4	Jul. 31
6	Male	Icheon	1	Mar. 4	Jul. 31
7	Male	Icheon	1	Feb. 22	May 28
8	Female	Cheonan	1	Mar. 4	Jul. 31
9	Female	Cheonan	1	Feb. 21	Jul. 2
10	Male	Cheonan	1	Mar. 18	Jul. 31

GPS = Global Positioning System.

Table 2. The information of spring migration of each mallard in 2014 (duration of migration is the migration between two stopover sites).

No.	Departure date	Arrival date	Period (d)	Distance (km)	Duration of migration (d)	No. of stopover sites
1	May 6	May 21	15	1,736	5	3
2	Apr. 4	Apr. 26	22	1,125	4	2
3	Mar. 27	Apr. 07	11	1,009	5	3
	May 30	Jun. 03	4	180	–	–
4	Mar. 30	Jun. 14	77	1,968	9	9
5	Mar. 31	Apr. 22	23	1,590	9	4
6	Apr. 5	Apr. 25	20	1,470	5	3
7	Apr.1	Apr.16	15	1,055	3	2
8	Apr. 09	Apr. 22	13	1,244	5	2
9	Apr. 12	Apr. 30	18	1,162	5	2
10	May 1	Jun. 5	35	1,114	5	3
Average			25.3 ± 19.2	1,265 ± 194	5.5 ± 2.0	3.3 ± 2.1

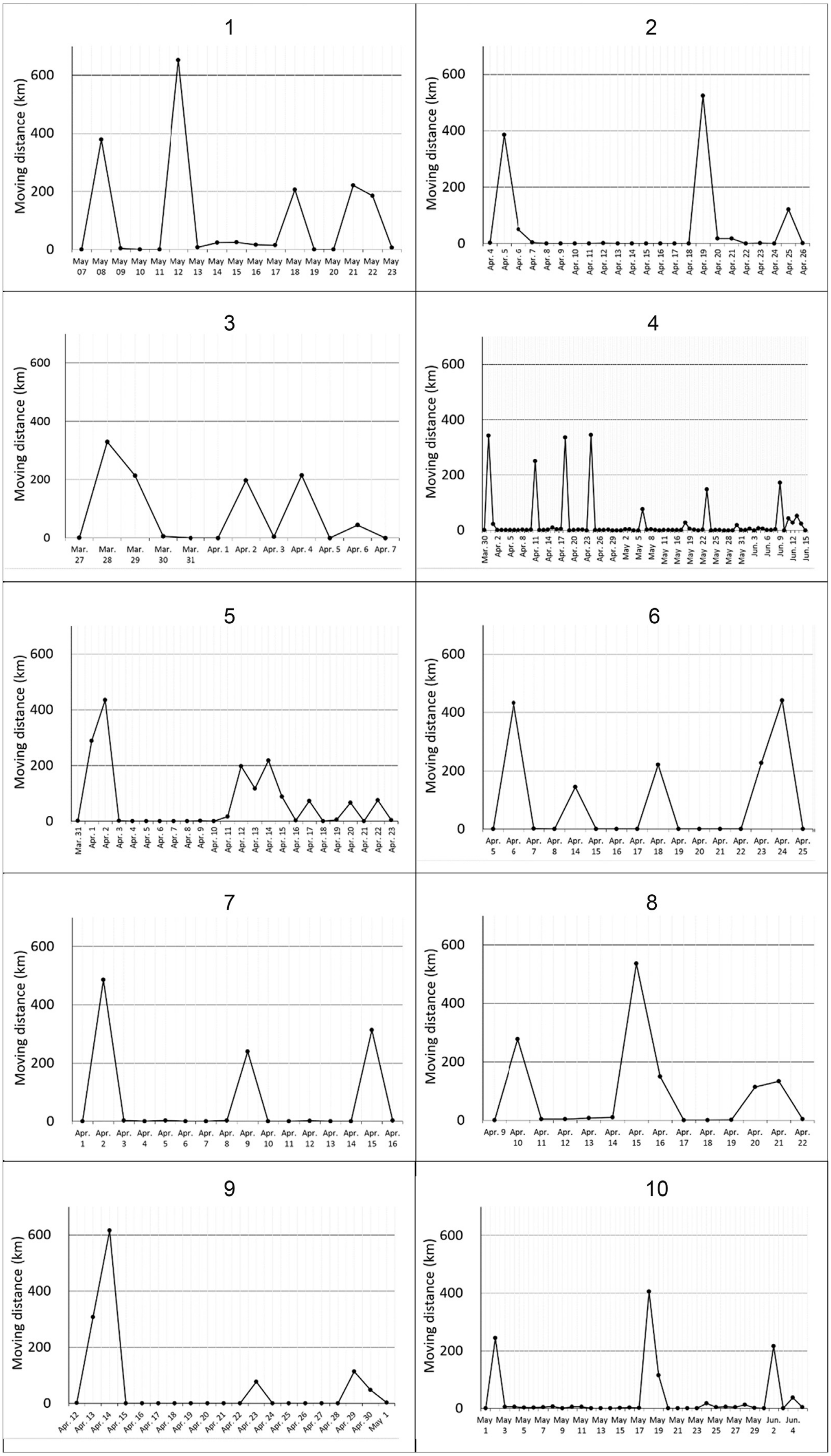

Figure 3. Usage days at stopover site and flying distance during spring migration (from wintering site to breeding sites).

reservoirs, and marshes. The longest distance between each stopover site was 650 km. The average number of migration days between two stopover sites was 5.5 days. The usage days of the stopover sites varied with the shortest duration being 1 day and the longest being 16 days (Figure 3). Breeding areas were wildly spread in Northeastern China. Breeding sites were assumed to be wetlands like rivers, streams, reservoirs, and marshes. Mallards that used the same wintering site often used different breeding sites.

Discussion

Most duck species are known to migrate between wintering sites and breeding sites, with various departure dates and durations (Arzel et al 2006; Krementz et al 2011). This research shows that mallards' spring migration starts in late March to early April; however, there was an individual that departed in early May. The result concurs with the mallards' migration period in Japan. The mallards in Asia migrate late compared with mallards in Arkansas, USA, who migrate in mid-February to mid-March (Krementz et al 2011). For Mallards that winter in Korea, their spring migration routes mostly pass through the North Korean east coast, but each migration route varies. This result is similar to the migration route of the mallards that winter in America (Krementz et al 2011). They also use different routes from the wintering site to the breeding site. The breeding sites of wintering mallards in Korea are widely spread through Northeastern China. Migration route and breeding sites are similar to birds from Kyushu in Japan that migrate though the Korean east coast to breeding sites in the Northeastern China. These results differ from results in Honshu, Japan, where birds migrate through the East Sea and move to East Russia (Yamaguchi et al 2008). The results from our research show that mallards' breeding sites were widely spread in Northeastern China and the average distance from the wintering site to the breeding site was 1,265 km (SD = 491 ㎞, range 1,009–1,968 ㎞). The breeding sites of wintering mallards in Korea and Japan are widely spread in Eastern Russia and Northeastern China (Yamaguchi et al 2008; Cho et al 2013). This research shows similar results to previous research. Mallards of Korea and Kyushu, Japan, migrated to Northeastern China, but mallards of Honsu, Japan, migrated to Eastern Russia. This research shows that the variance in wintering sites results in different breeding sites. Further research is required to analyze the correlation between wintering site and the breeding site and migration route.

Mallards that use the same wintering sites in Korea showed different spring migration routes, stopover sites, and breeding sites. The result was similar to Japan where mallards migrate using various routes and stopover sites. Yamaguchi et al (2008) showed migration in spring, some individuals use the same stopover sites. However, our research did not show individuals using the same stopover sites. The mallards' stopover sites were wetlands such as rivers, streams, and reservoirs (Arzel et al 2006; Yamaguchi et al 2008; Krementz et al 2011), which were similar to the results of waterfowl that use stopover sites. It is known that some waterfowl use specific stopover sites (Black et al 1991; Boyd and Fox 1992). Mallards select wetlands such as rivers, streams, and reservoirs. This research showed an interesting result in that most mallards use wetlands in the east coast area in North Korea during the migration period.

The spring migration pattern of wintering mallards in Korea is to move a long distance and stay for a long period of time within the stopover site. The result is similar to previous research in that mallards move quickly and stay for a long time in the stopover site. Water birds use the stopover site for energy supply. Energy supply from the stopover site is important for persistent migration and breeding. The usage rate of stopover sites is related to the body condition and breeding success rate at the stopover site, food amount, and quality (Arzel et al 2006; Yamaguchi et al 2008). Therefore usage of stopover sites during the spring migration route is important for persistent migration, energy supplies, and breeding success rate. Each individual's duration at a stopover site is based on body condition, the quality of the stopover site habitat, supplement amount, and factors disrupting rest.

Mallards use various migration routes and stopover sites on route to the breeding site. This migration pattern and the fact that individuals that use other wintering sites use the same stopover sites indicates that wetlands in East Asia are related to each other and consist of a broad network. It is necessary to analyze the network and importance of wetlands of the mallard's migration pattern so it can be used as base data for its protection and habitat management of wetland. This migration database would also be used for preventive measures for the highly pathogenic avian influenza.

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