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Satellite tracking of the migration routes of cranes from southern Japan

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Introduction

Cranes are large birds of marshlands and grasslands. They are known and popular in many parts of the world because of their beautiful appearance and graceful behavior. Most of them migrate long distances and stop over at several rest-sites on their way. They need extensive marsh or grasslands for existence, but their habitats have been decreasing and deteriorating worldwide in recent years. Specifically, their breeding and wintering grounds have been reduced and isolated, as well as their resting areas along migration routes. As a result, some species of cranes are endangered, and the protection of cranes is one of the most urgent wildlife conservation issues today. However, little is known about their migration routes or important resting, breeding, and wintering grounds.

There is a lack of information on all Asian cranes. Banding work of cranes has been conducted in Japan, China, and Russia, but only fragmentary data have been collected (Ozaki 1991a, b, Higuchi 1991). There is little information on which to base effective conservation measures of cranes.

Satellite tracking is an effective way to track moving objects over long distances, and has recently been used to show the migration routes and ecology of birds (Jouventin and Weimerskirch 1990, Nowak et al. 1990, Higuchi 1992, Higuchi et al. 1991a, b, Berthold et al. 1992).

We satellite-tracked White-naped and Hooded Cranes, *Grus vipio* and *G. monacha*, migrating north from Kyushu, southern Japan. Some of the cranes with transmitters were successfully tracked to their breeding grounds in China and Russia. This paper

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reports the migration routes, important areas along the routes, the separation of young from parents, and harnessing problems in those tracked cranes.

Study area and methods

1. Study area

Cranes were captured in Izumi (32°09′ N, 130°15′ E), southern Kyushu in 1991 and 1992. Izumi is a well-known wintering ground of White-naped and Hooded Cranes (Higuchi 1991, Ozaki 1991a). It faces the Yatsushiro Sea on one side and low hills border the other. Cranes feed in about 2,500 ha of developed paddy fields. Within that area there is a 51 ha artificial feeding site. The artificial site is occupied by thousands of cranes during the day, and all the cranes in Izumi roost there at night. Recently, about 8,000 Hooded and 2,000 White-naped Cranes winter in Izumi each year, as well as a few Common *G. grus*, Sandhill *G. canadensis*, and Demoiselle Cranes *Anthropoides virgo*.

2. Cranes captured

Cranes were captured by rocket nets in paddy fields outside the artificial feeding area. The cranes lived there in families. Transmitters were attached to five White-naped Cranes of two families on January 31 and February 1, 1991, and to six White-naped Cranes of three families and four Hooded Cranes of two families from January 28 to February 8, 1992. ID numbers of attached transmitters, sex and age of cranes captured, and other related information are shown in Table 1.

3. Transmitter and harnessing

Transmitters used in this study were developed by the Nippon Telegraph and Telephone Corporation (NTT). The transmitter used in 1991 (T-2038) was 80×60×35 mm in size with an antenna of 18cm, and weighed about 80 grams. Two of the five transmitters were glued with epoxy resin adhesive on the backs of cranes. The other three were attached to the backs of the cranes with a leatherette case and a Teflon tube. A cotton string was put through the tube to fix the case to the crane's body. A transmitter with its harness weighed about 130 grams, which is about 2 % of the body weight of an adult White-naped Crane.

The transmitter used in 1992 (T-2050) was smaller, 56×33×18 mm in size with an antenna of 18cm, and weighed 45-55 grams. It had four fringes with holes, and was attached to the backs of cranes with Teflon treated ribbon. The ribbon was put through the holes in the fringes, and crossed at a crane's breast (Fig. 1). The crossed part and both ends of the ribbon were fixed with clasps. One transmitter (ID No. 2665) was also glued by epoxy resin adhesive on the back of the crane. A transmitter with its harness weighed 60 to 70 grams, which is about 1 % of the body weight of an adult White-naped Crane and about 2 % of the body weight of an adult Hooded Crane.

All transmitters used in 1991 and 1992 cycled at six hours active and 12 hours inactive, and the pulse interval was 60 seconds. The battery life was expected to be

Table 1. A list of cranes equipped with transmitters in 1991 and 1992.

No.	Species	Age	Sex	Symbol of family	Capture date	Leg band No.	ID No. of transmitter	Attachment of transmitter
1	White-naped Crane	Young	Unknown	A	Jan. 31, 1991	M19	9374	Glued
2	White-naped Crane	Adult	Female	A	Jan. 31, 1991	M18	9375	Glued
3	White-naped Crane	Adult	Male	A	Jan. 31, 1991	M17	9376	Harnessed
4	White-naped Crane	Adult	Male ?	B	Feb. 1, 1991	M21	9377	Harnessed
5	White-naped Crane	Young	Unknown	B	Feb. 1, 1991	M23	9373	Harnessed
6	White-naped Crane	Adult	Male	C	Jan. 28, 1992	M25	2665	Harnessed
7	White-naped Crane	Young	Unknown	C	Jan. 28, 1992	M26	2666	Harnessed
8	Hooded Crane	Adult	Female	D	Jan. 31, 1992	K63	2669	Harnessed
9	Hooded Crane	Young	Unknown	D	Jan. 31, 1992	K65	2667	Harnessed
10	White-naped Crane	Adult	Female	E	Feb. 4, 1992	M28	2668	Harnessed
11	White-naped Crane	Young	Unknown	E	Feb. 4, 1992	M29	2673	Harnessed
12	White-naped Crane	Adult	Female	F	Feb. 7, 1992	M31	2670	Harnessed
13	White-naped Crane	Young	Unknown	F	Feb. 7, 1992	M32	2671	Harnessed
14	Hooded Crane	Adult	Female ?	G	Feb. 8, 1992	K67	2674	Harnessed
15	Hooded Crane	Young	Unknown	G	Feb. 8, 1992	K68	2672	Harnessed

Fig. 1. Harnessing a transmitter with a Teflon treated ribbon.

three months for the transmitters in 1991 and six months for those in 1992.

4. Data analysis

Location data were received through computer communications, and data on disks sent from the CLS/Service Argos in France were also checked later. Location classes ranged from 0 to 3. About 95% of the total number of locations fell into location classes 0 and 1, and the other 5 % into location classes 2 and 3. The higher the location class, the more accurate the location. According to Service Argos (1992), class 1 and 2 locations offer one-standard-deviation accuracy of 1 km and 350m, respectively, for stationary things.

Location class 0 data were included to show migration routes and breakup process of families, when the locations were considered appropriate from the nearest tracking time and locations. They were, however, excluded from the analysis where more accurate locations were required. There were some strange location data even for location class 1. They were considered mislocations in view of the successive locations and tracking time, and were excluded from consideration.

Time in the text is shown at the Japan time (Greenwich Mean Time plus nine hours). The period of stay at a particular site was calculated as the difference between the first day of arrival at the site and the first day of arrival at the next site.

Results and Discussion

1. Migration routes and breakup of family

1) 1991 tracking

A total of 253 locations were obtained from January 31 to April 13. The number of locations obtained each day from one individual ranged from 0 to 4, having a mean ± SD of 1.29 ± 1.17.

Of the five White-naped Cranes, three with harnessed transmitters were not tracked because harnessing was not successful and the transmitters fell off the cranes while they were in Izumi. The remaining two with glued transmitters were tracked to the North Korean-South Korean border, where the transmitters ceased to function. The migration routes of these two cranes, mother and the young, are described below (see Fig. 2).

ID No. 9375 (mother) was last located by satellite in Izumi at 2:11, February 25, and was in northern Tsushima Island (34°21′N, 129°19′E), Japan, at 17:22, the same day.

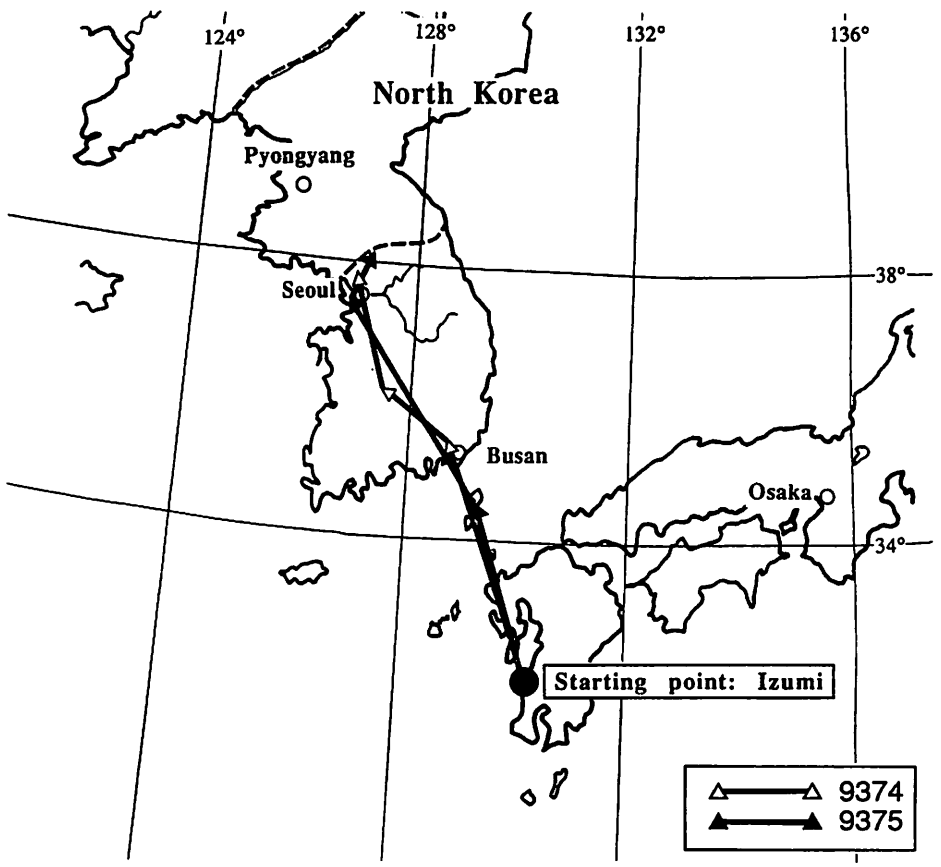


Fig. 2. Migration routes of one parent (ID No. 9374) and its young (ID No. 9375) White-naped Cranes tracked in 1991. Beginnig in Izumi, southern Japan, and ending with transmitter failure near the North Korean-South Korean border. Location class 0 data were included.

She departed there the following morning, February 26, and was located near Busan (35°47′ N, 128°32′ E) in the southern end of South Korea at 13:23 of the same day. She then moved near Seoul (37°19′ N, 127°23′ E), and spent that night. The following day, February 27, she moved to Chorwon south of the North Korean-South Korean border (38°04′ N, 127°25′ E), and was located around there until April 13, when the transmitter ceased to function.

No. 9374 (young) was last located by satellite in Izumi at 4:01, February 24. It was next located near Busan (35°31′ N, 128°53′ E) at 15:06, February 26. It was near Tajon (36°04′ N, 127°23′ E) in central South Korea on the following day, February 27. It then moved to Panmunchom near the North Korean-South Korean border (37°53′ N, 126°48′ E) between February 28 and March 4, and was located around there until March 22, when the transmitter ceased to function.

These two cranes took a similar course of migration, but apparently migrated north separately.

2) 1992 tracking

A total of 1,312 locations were obtained from January 28 to July 2. The number of locations obtained each day from one individual ranged from 0 to 5, having a mean $\pm$ SD of 1.37 ± 1.12.

Of the six White-naped and four Hooded Cranes marked, four White-naped and two Hooded Cranes were successfully tracked to their breeding grounds. One White-naped Crane was tracked only to the South Korean-North Korean border. The transmitters of one White-naped and two Hooded Cranes ceased to function while the cranes were still in Izumi.

The general migration routes of the five White-naped and two Hooded Cranes tracked are shown in Figs. 3 and 4, and the migration patterns through time are shown in Fig. 5. The details of the migration routes are described as follows.

(1) White-naped Cranes

(1-a) The family of ID Nos. 2668 (mother) and 2673 (young)

The two cranes left Izumi in the early morning of March 7. The last time they were located in Izumi by satellite was 5:07 for No. 2668 and 3:28 for No. 2673. No. 2668 was located in Busan (35°19′ N, 128°52′ E), the southernmost part of the Korean Peninsula, at 20:54 on the same day, and probably spent that night there. After having a stopover at Cheongji (36°48′ N, 127°9′ E) on the west coast of the Korean Peninsula in the afternoon of March 8, she was located in Kumya-gun on the east coast of North Korea at 2:51, March 10. The young No. 2673 was not effectively located for some time, but was located at the same site in Kumya-gun on the same day as No. 2668. They were probably migrating together from March 7 to 10.

After staying there for about 11 days, they traveled northward through the east coast of the Korean Peninsula to Sonbon-gun (42°21′ N, 130°40′ E), North Korea, near the North Korean-Russian border. Then they traveled inland, passed through Lake

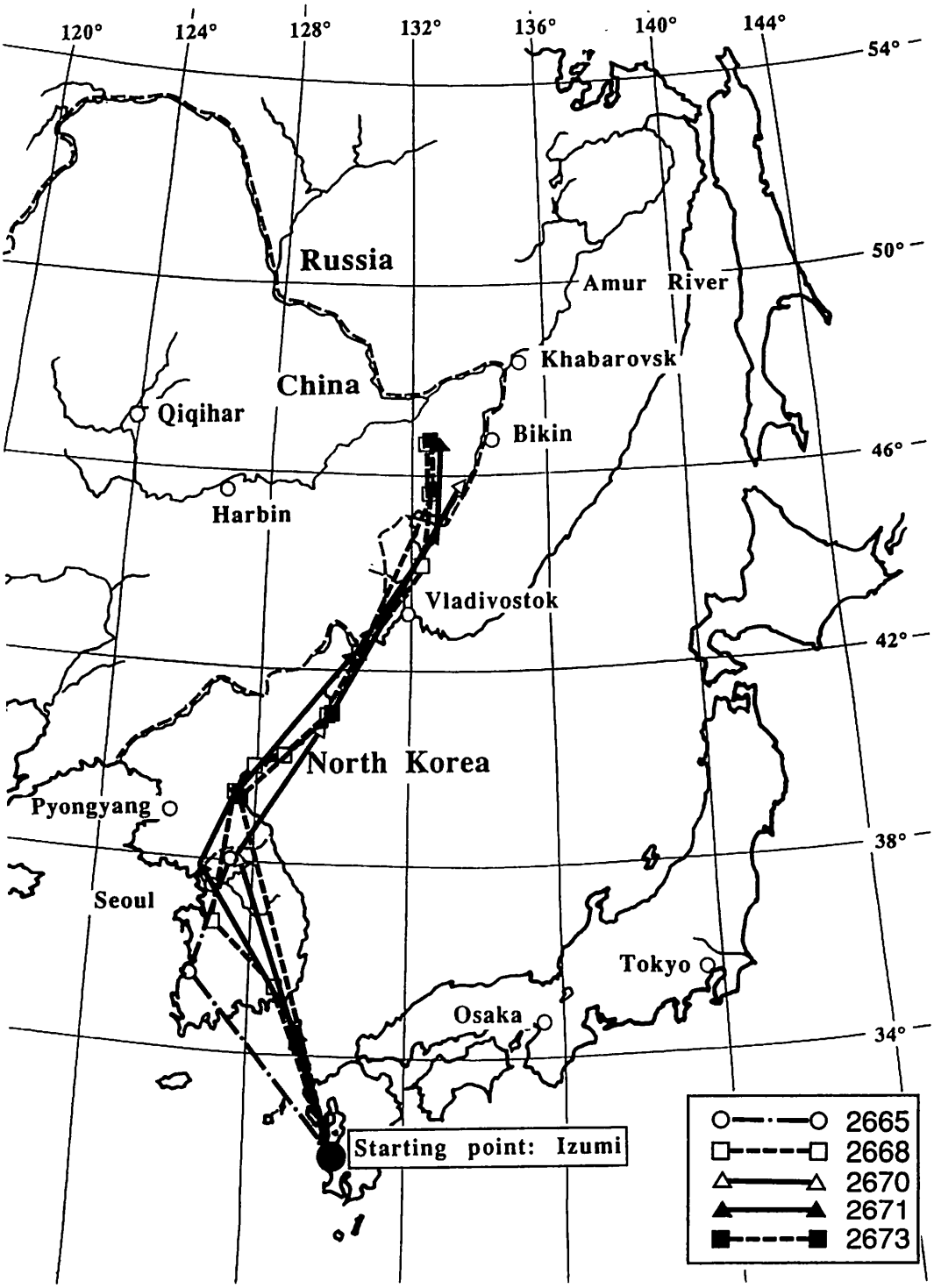
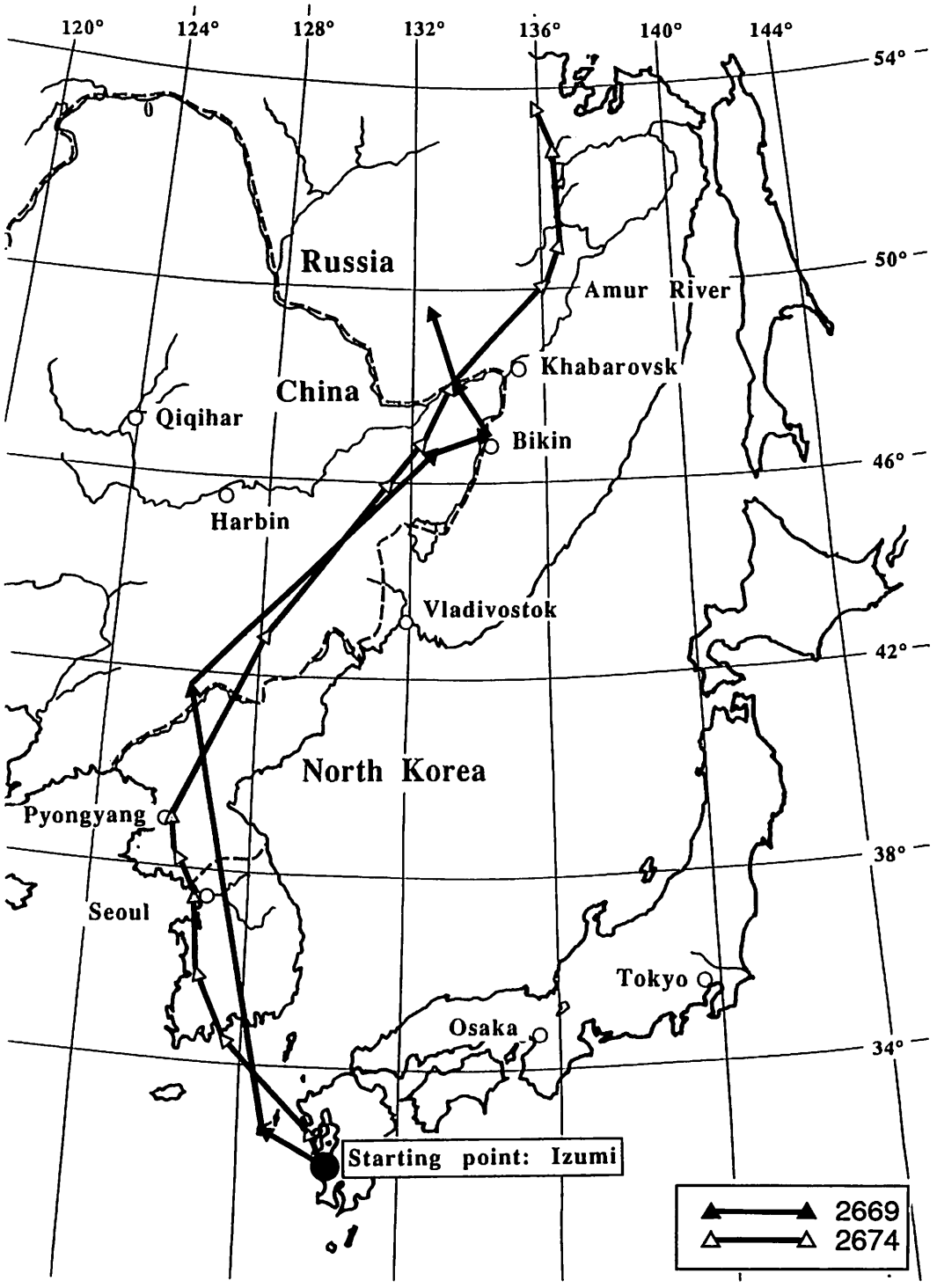


Fig. 3. Migration routes of five White-naped Cranes tracked from Izumi, southern Japan, in 1992. Location class 0 data were included.


120°
124°
128°
132°
136°
140°
144°
54°
50°
46°
42°
38°
34°
Russia
Amur River
Khabarovsk
China
Qiqihar
Bikin
Harbin
Vladivostok
North Korea
Pyongyang
Seoul
Tokyo
Osaka
Starting point: Izumi
2669
2674

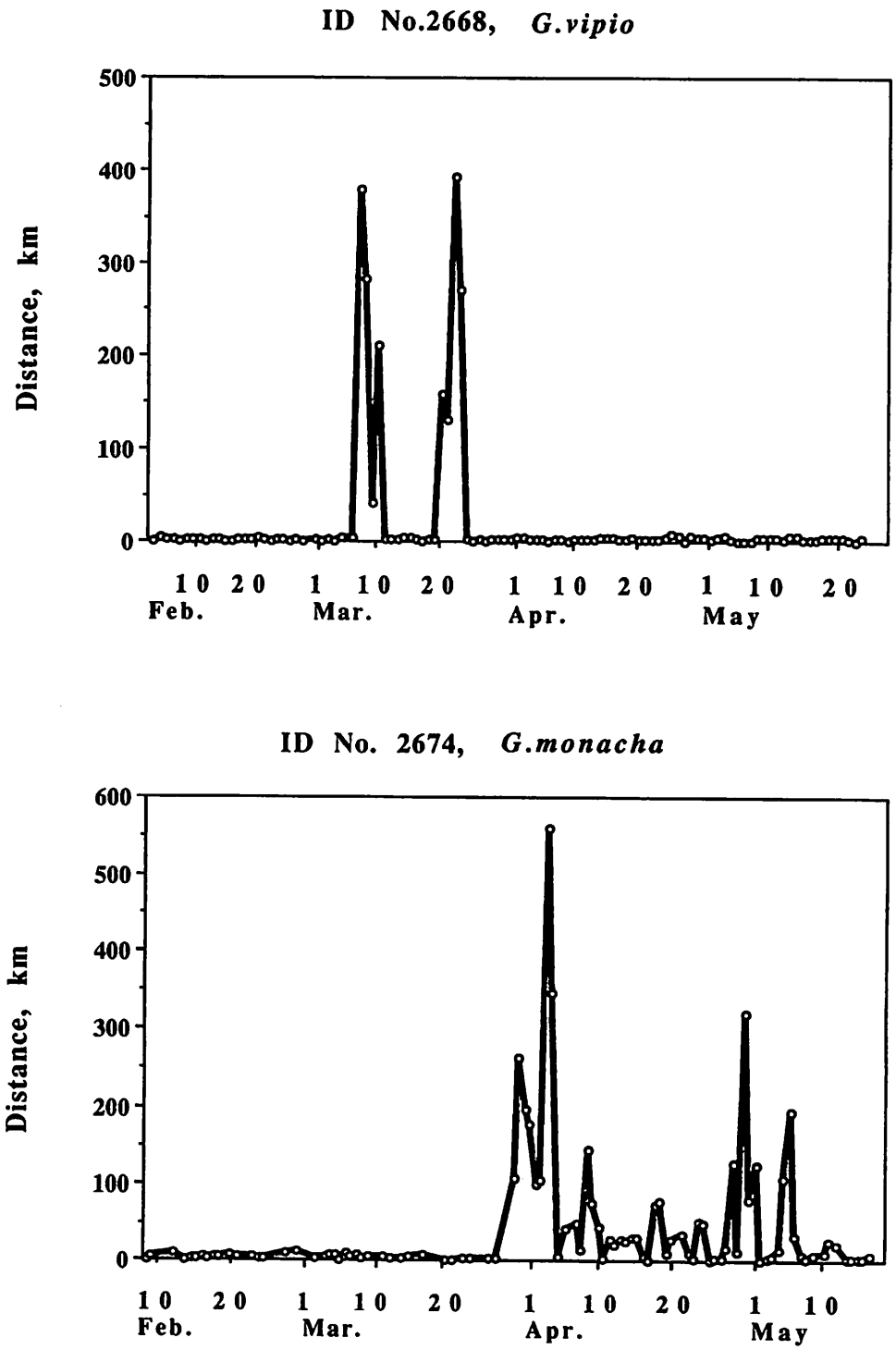


Fig. 5. Migration distances between successive days for one individual crane during the course of migration in 1992. Two representative cases are shown. Location class 0 data were included.

Khanka (44°23′ N, 132°14′ E), and arrived together on March 23 at the Three Rivers Plain breeding site (46°50′ N,132°17′ E) in northeastern China. It took about 17 days from the start to the end of migration.

Soon after arrival at the breeding site, they separated until they were about 30 km away from each other (Fig. 6-a). This shows that the mother and young crane parted after they had finished their migration. The young moved away from the parent but the adult did not significantly change its location after March 23 (Fig. 7).

A total of 285 locations were obtained from February 4 to June 14 for No. 2668 and a total of 208 locations from February 5 to July 2 for No. 2673 (Table 2). The life of the batteries were 132 days for No. 2668 and 150 days for No. 2673. The accumulated tracking distance was 2029.0km for No. 2668 and 2290.3km for No. 2673.

(1-b) The family of Nos. 2670 (mother) and 2671 (young)

In contrast with Nos. 2668 and 2673, Nos. 2670 and 2671, another mother and her young, migrated separately. They left Izumi toward the end of February. The final location for both cranes before leaving Izumi was received at 19:47, February 25. No. 2670 was not located well for some days, but was in Chorwon (38°19′ N, 127°17′ E) on the South Korean-North Korean border at 4:39, March 1. It suggests that she had already arrived at the site by the previous day, February 28. On the other hand, the young No. 2671 was located on Tsushima Island (34°32′ N, 129°29′ E), Japan, at 3:34, February 27. The next day it arrived in Panmunchom near the South Korean-North Korean border to the northwest of Seoul (37°52′ N, 126°41′ E), which is about 50km west of Chorwon where its mother No. 2670 arrived.

They stayed in their respective sites near Chorwon and Seoul for about 20 days. After this, each travelled northward, taking similar courses but choosing different sites for resting. No. 2670 stopped over at Orang-gun (42°21′ N, 130°38′ E) on the east coast of North Korea on March 22. On the following day, March 23, she arrived near Tartashevka (45°59′ N, 133°19′ E) between the Ussuri River in Russia and the northeast of Lake Khanka in China, and finished her migration there. It took 28 days from the start to the end of migration. The young No. 2671 was located in Kumya-gun (39°25′ N, 127°28′ E) on the east coast of North Korea at 15:01, March 23. It continued to travel along the east coast of North Korea as far as Spassk-Dalni (44°44′ N, 132°36′ E) in Russia, which is to the south of Lake Khanka. It stayed there for about 10 days, and on April 7 reached the Three Rivers Plain (46°42′ N, 132°23′ E) to the southwest of Fuchin. This place is more than 100km away from Tartashevka where its mother No. 2670 finished migration (Fig. 6-b). No. 2671 took 42 days to reach the Three Rivers Plain from the start of migration.

The process of migration in Nos. 2670 and 2671 shows that this mother and her young separated at the outset of their migration. The parent did not significantly change its location after it reached the Three Rivers Plain, while the young moved further within a limited area (Fig. 7).

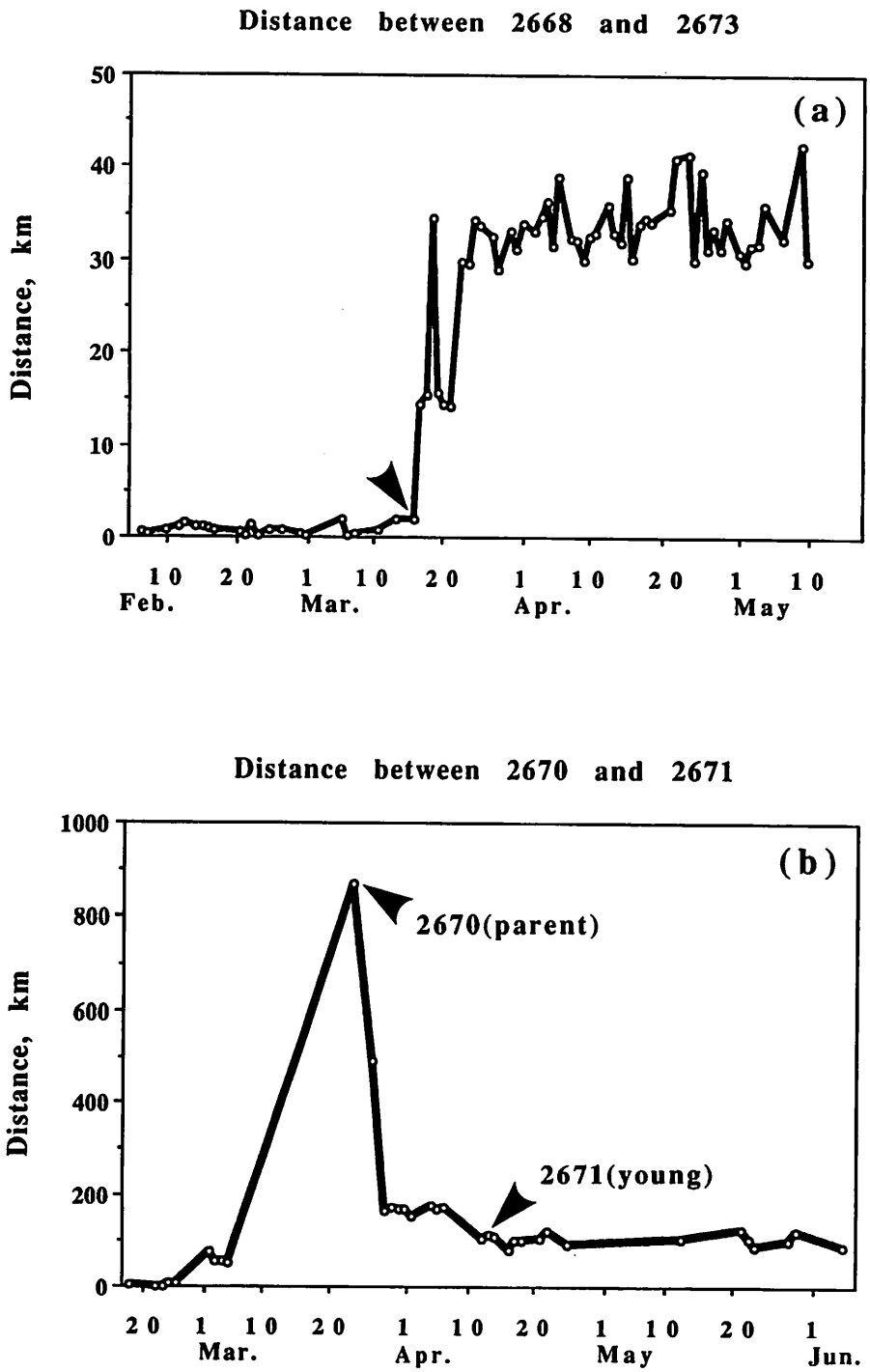


Fig. 6. Distances between the parent and its young White-naped Cranes during the course of migration in 1992. Arrows indicate the arrival of cranes at the breeding sites. (a) pair migrated together and separated at the breeding site, (b) pair made initial separation at the outset of their migration. Location class 0 data were included.

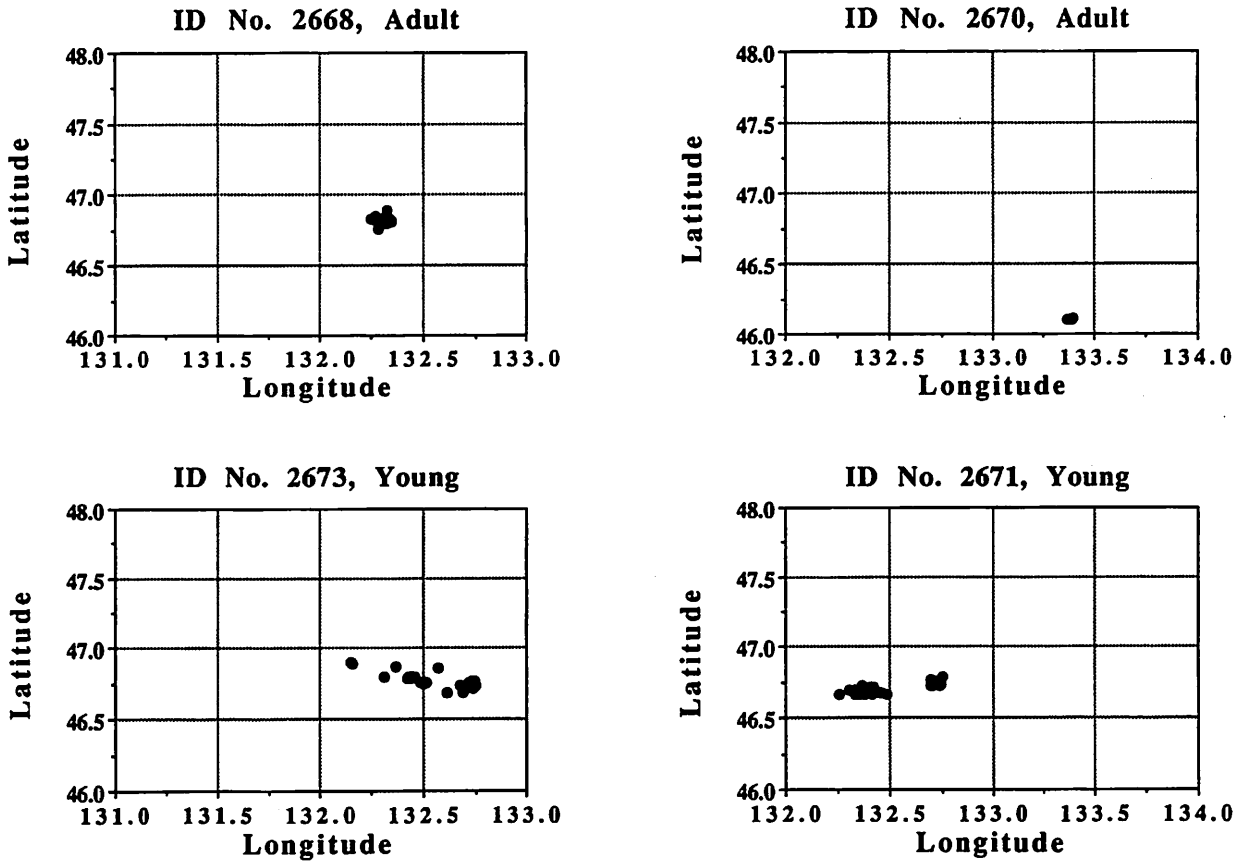


Fig. 7. Location of the parent and its young after the arrival at the breeding site of the Three Rivers Plain in northeastern China. Two cases (Nos. 2668 and 2673, Nos. 2670 and 2671) of White-naped Cranes are shown. Location class 0 data were excluded.

Table 2. Tracking period, tracking distance, and days needed for migration in six cranes that were successfully tracked to their breeding grounds in 1992.

No.	Species	ID No.	Age	Sex	Tracking period	Life of battery (days)	No. of locations obtained	Tracking distance (km)	Days needed for migration
1	White-naped Crane	2668	Adult	Female	Feb. 4 - Jun. 14	132	285	2028.99	17
2	White-naped Crane	2673	Young	Unknown	Feb. 4 - Jul. 2	150	235	2290.32	17
3	White-naped Crane	2670	Adult	Female	Feb. 7 - Jun. 5	120	66	1820.31	28
4	White-naped Crane	2671	Young	Unknown	Feb. 7 - Jun. 5	120	244	2579.85	42
5	Hoooded Crane	2669	Adult	Female	Jan. 31 - Jun. 1	123	39	3166.90	32
6	Hoooded Crane	2674	Adult	Female?	Feb. 8 - Jul. 18	162	240	3800.33	38

A total of 66 and 244 locations were obtained for Nos. 2670 and 2671, respectively, from February 7 to June 5 (Table 2). The battery life was 120 days for both Nos. 2670 and 2671. The accumulated tracking distance was 1820.3km for No. 2670 and 2579.8km for No. 2671.

(1-c) ID No. 2665, an adult male

This male was last located in Izumi at 3:46, February 26. After having a stopover at Guan (35°37′ N, 126°10′ E) in the southwest of the Korean Peninsula in the afternoon of February 27, he arrived in Suwon (37°01′ N, 126°57′ E) south of Seoul in the late afternoon of the same day. He was located in the west of Suwon at 9:05 the following day, February 28, and spent that night in Panmunchom (37°52′ N, 126°38′ E) on the South Korean-North Korean border north of Seoul. On March 2, he moved near Chorwon (38°20′ N, 127°07′ E), on the national border, in the center of the Korean Peninsula. He stayed around there for a week, but his transmitter ceased to function on March 9.

(2) Hooded Cranes

The spring migration of Hooded Cranes from Izumi was generally about two weeks later in 1992 than in regular years (Matano, S. pers. comm.), probably because of a long rain in March. Nos. 2669 and 2674 stayed in Izumi until the end of March. However, once on their way, they flew north fast along the Korean Peninsula, and continued their northward journey through northeastern China to Russia (Fig. 4).

(2-a) No. 2669, an adult female

This crane was last located in Izumi at 19:33, March 25. It stopped over on Fukue Island (32°44′ N, 128°41′ E) of Japan on March 29, passed through Hunjang (41°44′ N, 126°01′ E) near Chinese-North Korean border on April 2, and reached the Three-Rivers Plain (46°43′ N, 132°25′ E) in China on April 10. After moving several times within the plain until April 23, it moved to the northeast of Tongjiang (47°52′ N, 131°54′ E) along the Amur River in China on April 24, passed near Tyrma (50°19′ N, 133°38′ E) in Russia on April 26, and on April 27 reached the southwest of Tyrma (49°51′ N, 132°50′ E), probably its breeding site. It took 32 days to reach the breeding site from the start of migration. After arriving at the breeding site, it did not move significantly.

A total of 39 locations were obtained from January 31 to June 1. The life of the battery was 123 days (Table 2). The accumulated tracking distance was 3166.9km.

(2-b) No. 2674, an adult

The last location received for this crane in Izumi was at 13:37, March 30. It passed through Nagasaki (32°32′ N, 129°14′ E), Japan, at 15:19 on the same day, and spent that night in Yosu (34°09′ N, 128°16′ E) on the south end of the Korean Peninsula. It then migrated north along the west coast of Korea, passed through Sariwon (38°33′ N, 125°56′ E) and Sukchon (39°24′ N, 125°28′ E) in North Korea and near Fuchin (46°11′ N, 131°28′ E) in China, and arrived at the Three-Rivers Plain (46°10′ N, 131°33′ E) on April 6. It moved several times within the plain for about three weeks, and then

continued to migrate north. It entered Komsomol'sk na Amure (50°04′ N, 136°21′ E) in Russia on April 29, passed near Gorin (51°08′ N, 136°55′ E) and Duki (51°40′ N, 135° 58′ E) in the beginning of May, and reached the northeast of Imeni Poliny Osipenko (53°37′ N, 135°54′ E), probably its breeding site, on May 5. It took 38 days to reach the breeding site from the start of migration. Once at the breeding site, it did not move significantly.

A total of 213 locations were obtained from February 8 to July 18. The battery life was 162 days, and the accumulated tracking distance was 3800.3km (Table 2).

2. Important areas for cranes

Table 3 shows a list of areas visited by the cranes equipped with transmitters. All these areas will be important for the cranes, but we may evaluate the importance of each area based on the length of stay. Of these resting locations for migrants, five are areas (Nos. 12, 13, 15, 22, and 26 in Table 3) where a crane stayed for more than 10 days. Two of the five areas are on or adjacent to the Demilitarized Zone (DMZ) along North Korean-South Korean border, and were visited by six cranes. There are two areas (Nos. 20 and 23) where a crane stayed for 5-10 days, and 24 areas where a crane stayed for less than five days.

It is noted that Panmunchom and Chorwon of the DMZ, Yonfun Bay on the east coast of North Korea, and around Lake Khanka are particularly important for White-naped Cranes on migration, and that the Three-Rivers Plain is crucial as the breeding ground of White-naped Cranes and as the resting ground of Hooded Cranes. Further study will show more accurately the importance of each area not only by the length of stay but also by the number of visiting cranes.

Habitat characteristics and conservation issues of the areas shown in Table 3 will be discussed elsewhere.

3. Harnessing and related problems

In 1991, three White-naped Cranes cut the cotton strings that fixed the ends of Teflon tube. As a consequence, the transmitters fell down within 11 days after attachment. One male White-naped Crane did not fly after capture and release. This male was recaptured 8 days after release to monitor its health in captivity. An injury was found on its wing. However, it did not seem serious, and he was released 18 days after recapture. He then migrated north, and was resighted with his mate in Izumi in the next wintering season.

In 1992, one male White-naped Crane had temporary difficulty in flying after release. This was the only adult male that had a transmitter attached to its back with both glue and a harness. This male did not fly for 9 days after transmitter attachment. But we observed him flying on the tenth day when we attempted to recapture him. He then migrated north to the North Korean-South Korean border. It is likely that he did not

Table 3. A list of the main areas visited by cranes with transmitters in 1991 and 1992. Sites probably located on the fly were not shown. Location class 0 data were included.

No.	Country	Locality	Latitude	Longitude	Habitat	Crane species visited (ID No.) [1]	Approximate days of stay [2]	Kind of use
1	Japan	Nagasaki	32°32′	129°14′	Seashore	H (2674)	1	Resting
2	Japan	Goto-Reto	32°44′	128°41′	Seashore	H (2669)	3-4	Resting
3	Japan	Tsushima	34°20′-34°45′	129°12′-129°20′	Seashore	W (9375)	1	Resting
	Japan	Tsushima	34°32′-34°36′	129°20′-129°29′	Seashore	W (2671)	1	Resting
4	S.Korea	Yosu	34° 9′-34°30′	127°41′-128°16′	Seashore	H (2674)	1	Resting
5	S.Korea	Around Busan	35°19′	128°52′	Mouth of river	W (2668)	1	Resting
6	S.Korea	Busan	35°31′	128°53′	Mountainous areas	W (9374)	1-2	Resting
	S.Korea	Busan	35°47′	128°32′	River	W (9375)	1	Resting
7	S.Korea	NE. of Cheongju	36° 4′	127°23′	Mountainous areas	W (9374)	4-5	Resting
8	S.Korea	Kunsan	36°11′	127° 1′	River	H (2674)	1	Resting
9	S.Korea	Suwon	37° 0′	126°57′	Mouth of river	W (2665)	1-2	Resting
10	S.Korea	SE. of Seoul	37°18′-37°31′	127°22′-127°23′	River	W (9375)	1	Resting
11	S.Korea	SW. of Seoul	37°27′-37°37′	126°42′-127° 7′	River	W (2668)	1	Resting
12	S.Korea-N.Korea	Panmunchom (DMZ)	37°34′-37°55′	126°19′-126°58′	River	W (9374)	19+	Resting
	S.Korea-N.Korea	Panmunchom (DMZ)	37°43′	126°25′	Mouth of river	H (2674)	1	Resting
	S.Korea-N.Korea	Panmunchom (DMZ)	37°43′-37°52′	126°34′-126°38′	Mouth of river	W (2665)	3-4	Resting
	S.Korea-N.Korea	Panmunchom (DMZ)	37°50′-38°13′	126°34′-126°58′	Plain	W (2671)	23-24	Resting
13	S.Korea-N.Korea	Chorwon (DMZ)	38° 4′-38°18′	127° 2′-127°25′	Plain	W (9375)	46+	Resting
	S.Korea-N.Korea	Chorwon (DMZ)	38° 8′-38°27′	127° 5′-127°34′	Plain	W (2665)	7+	Resting
	S.Korea-N.Korea	Chorwon (DMZ)	38°13′-38°23′	127°12′-127°24′	Plain	W (2670)	20-21	Resting
14	N.Korea	Sokchon	39°23′-39°24′	125°22′-125°28′	Mouth of river	H (2674)	1	Resting
15	N.Korea	Kumya	39°23′-39°25′	127°25′-127°30′	Marsh	W (2668)	11	Resting
	N.Korea	Kumya	39°24′-39°35′	127°25′-127°47′	Marsh	W (2673)	11	Resting
	N.Korea	Kumya	39°24′-39°25′	127°28′-127°31′	Marsh	W (2671)	3-4	Resting
16	N.Korea	NE. of Tanchon	40°22′	128°52′	Mouth of river	W (2668)	1	Resting

Table 3. continued.

No.	Country	Locality	Latitude	Longitude	Habitat	Crane species visited (ID No.) [1]	Approximate days of stay [2]	Kind of use
17	N.Korea	Around Odaejin-Nodongjagu	41°22′	129°40′-129°42′	Mouth of river	W (2668)	1	Resting
18	N.Korea	Orang	41°22′-41°24′	129°42′-129°42′	Marsh	W (2673)	2-3	Resting
19	N.Korea-Russia-China	Sonbon	42°25′-42°33′	130°27′-130°46′	Mouth of river	W (2671)	1-2	Resting
	N.Korea-Russia-China	Sonbon	42°21′	130°40′	Mouth of river	W (2668)	1	Resting
20	China	Hunjang	41°44′	126° 1′	Plain	H (2669)	8-9	Resting
21	China	Autu	43°49′	128°34′	River	H (2674)	1	Resting
22	China	Three Rivers Plain	45°52′-46°10′	133° 4′-133°47′	Marsh	W (2670)	75+	Breeding
	China	Three Rivers Plain	46° 8′-47°14′	131°19′-132°53′	Plain	H (2674)	23-24	Resting
	China	Three Rivers Plain	46°26′-46°49′	132° 6′-132°45′	Marsh	W (2671)	60+	Breeding
	China	Three Rivers Plain	46°33′-46°54′	132°10′-132°56′	Marsh	W (2673)	102+	Breeding
	China	Three Rivers Plain	46°43′-47° 3′	132°16′-132°28′	Marsh	W (2668)	84+	Breeding
	China	Three Rivers Plain	46°43′	132°25′	Marsh	H (2669)	6-7	Resting
23	China-Russia	NE. of Tonjiang	47°24′-47°52′	132°36′-134° 0′	River	H (2669)	7-8	Resting
24	China-Russia	Fuyuan	48°19′	133° 0′-133°11′	River	H (2674)	1-2	Resting
25	Russia	SE. of Lake Khanka	44°23′	132°14′	Lake	W (2668)	1	Resting
26	Russia	S. of Lake Khanka	44°38′-44°47′	132°36′-132°54′	Marsh	W (2671)	10-11	Resting
27	Russia	SW. of Tyrma	49°36′-50° 9′	132°19′-133° 6′	Marsh	H (2669)	36+	Breeding
28	Russia	Komsomol'sk na Amure	50° 4′	136°21′-136°24′	Marsh	H (2674)	1	Resting
29	Russia	Tyrma	50°19′	133°38′	Plain	H (2669)	1	Resting
30	Russia	W. of Komsomol'sk na Amure	50°41′	135°43′	River	H (2674)	1	Resting
31	Russia	Gorin	51° 2′-51°14′	136°50′-137° 8′	Marsh	H (2674)	3-4	Resting
32	Russia	Duki	51°35′-51°40′	135°43′-135°58′	River	H (2674)	1	Resting
33	Russia	NW. of Imeni poliny osipenco	53°20′-53°46′	135°28′-135°57′	Plain	H (2674)	75+	Breeding

1. H : Hooded Crane W : White-naped Crane

2. One day shown here includes the case of one night (i.e. less than 24 hours).

fly for some time due to some kind of stress resulting from capturing or harnessing.

Two juvenile Hooded Cranes cut their Teflon ribbons. This happened 40 and 44 days after attaching the transmitters to the cranes. Those transmitters stopped working close to the time the ribbons were cut. One juvenile White-naped Crane removed the coating of the antennae, and the transmitter seemed to stop shortly after that. This removal of coating occurred about two days after attaching the transmitter.

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Summary

1. We attached transmitters to 11 White-naped Cranes and five Hooded Cranes wintering in Izumi, southern Japan in 1991 and 1992. Among them, four White-naped and two Hooded Cranes were successfully tracked to their breeding grounds.

2. The four White-naped Cranes migrated north through the Demilitarized Zone (DMZ) and Yonfun Bay of the Korean Peninsula to the Three Rivers Plain in northeastern China. The two Hooded Cranes migrated north through the Korean Peninsula and the Three Rivers Plain to southeastern Russia.

3. Panmunchom and Chorwon of the DMZ, Yonfun Bay on the east coast of North Korea, and around Lake Khanka were particularly important for White-naped Cranes on migration. The Three Rivers Plain was crucial as the breeding ground of White-naped Cranes and as the resting ground of Hooded Cranes.

4. In one family of White-naped Cranes, the parent and its young migrated together during the course of migration, but parted soon after they had finished their migration. Another mother and her young White-naped Cranes had already separated at the outset of their migration.

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要　約

九州出水から渡るツル類の衛星追跡

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1．1991年および1992年の2～7月に，鹿児島県の出水から北上するツル類の渡りの経路と親子の分離過程を，衛星追跡によって調査した．1991年にはマナヅル5羽に送信機を装着し，2羽を朝鮮半島の非武装地帯付近まで，1992年にはマナヅル6羽，ナベヅル4羽に送信機を装着し，マナヅル4羽とナベヅル2羽をそれぞれ中国東北部とロシア東南部の繁殖地まで追跡した．

2．繁殖地まで追跡できたマナヅルは，出水を飛びたったのち韓国に入り，その後，非武装地帯などを経由して北朝鮮の東海岸沿いを北上し，ハンカ湖周辺から中国東北部の三江平原に到達した．一方，ナベヅルは，朝鮮半島を北上し，北朝鮮の西海岸などを経由して中国東北部の三江平原に入り，そこでしばらく休息したのち，ロシアの東南部に到達した．

3．滞在期間の長さから，マナヅルの渡りの中継地として朝鮮半島の非武装地帯の板門店付近や鉄原付近，北朝鮮東海岸のヨンフン湾，ロシア・中国国境のハンカ湖付近が，またマナヅルの繁殖地とナベヅルの中継地として，中国東北部の三江平原がとくに重要であると考えられた．

4．親子の分離過程について調査できたマナヅル2家族のうち1家族では，親子は渡り期間中は一緒であったが，繁殖地に着いてまもなく分離し始めた．一方，もう1つの家族では，親子は渡りの開始直後から分離していた．

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