Dr Hatta stated in 1924 that *C. c. cygnus* moving from Lake Utonai to Lake Kutcharo at Hamatonbetsu were the ones that came from Lake Furen and he insisted that they flew to Lake Kutcharo instead of going back to Lake Furen. However, this is the route along which *C. c. bewickii* is mainly moving in spring and autumn, so *C. c. cygnus* is rare. Besides, no banded *C. c. cygnus* has been observed in Lake Kutcharo. Furthermore, no banded individuals that come to Lake Utonai from Lake Tofutsu, located in the south of the Sea of Okhotsk, fly to Lake Kutcharo. Judging from this, flocks of *C. c. cygnus* that came to Lake Utonai from the Okhotsk side of east Hokkaido in autumn cannot be assumed to fly to Kutcharo along the central axis.

Conclusion

We have proved three migration routes of swans — tne route between the Sea of Okhotsk and the Pacific Ocean, the route of the central axis and the coastal route by the Sea of Japan — by getting information from many people, from observations of banded individuals and from literature. Finally, the proof of these routes is not complete and we are going to continue our research and observations.

Summary

The paper reviews observations of migrating swans in Hokkaido and defines three routes used by *Cygnus columbianus bewickii.* Observations of neck-banded swans confirm the use of the routes and possible relationship of the routes to paleogeographical conditions is suggested.

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THE COLD AIR CURRENT IN THE KHABAROVSK AREA AND THE CORRELATION WITH SWAN NUMBERS AT LAKE HYOKO, JAPAN

A NAKANISHI

Introduction

Every winter Lake Hyoko, which is the birthplace of swan protection and is desig-

nated as a Natural Monument, is visited by hundreds of migrating swans. The maximum number of swans at Lake Hyoko occurs in the last third of February. In 1950, when swans first migrated to the lake, only 146 swans came, but in 1963, when there was a very heavy snowfall in the area, 315 swans came. In 1970, when the temperature had been low since the autumn, as many as 1019 swans were found there. This was the largest number ever recorded.

The winter of 1979 has been the warmest since the Meteorological Agency was founded in Japan, with the exception of Okinawa and Hokkaido where they had their eighth warmest winter. The largest number of swans (950) was at Lake Hyoko on 3 February. This was the second largest number in 29 years. We feel they came south because they were driven away by the cold air current in the Siberia and Sakhalin areas. Consequently, we tried to find out what kind of relationships there are between the average temperature in January and the number of swans at 12 points which are estimated to be on the courses of both swans and the cold air current.

Data and their processing

The data we used were obtained by Mr Shigeo Yoshikawa. The temperature in northern Japan, Siberia and Korea was the average temperature obtained from weather maps at 0900 in January from 1960 to 1979.

Fig 1 shows the correlation coefficient between the average temperature in January at Khabarovsk and the maximum number of swans at Lake Hyoko and its regression line. The confidence limit at $p = 0.01$ is -0.56, so the value $r = -0.59$ is significant. The linear regression showing the relationship between the two is: X (number of swans) = $-3109.3 - 156.2$ T (^{o}C).

The correlation coefficient between the average temperature in January in the areas other than Khabarovsk and the maximum number of swans at Lake Hyoko is low. Okhotsk (+0.11), Seoul (+0.12) and Sendai (+0.05) show insignificant plus coefficients. On the other hand, Niigata (−0.06), Aomori (−0.19), Vladivostok (−0.14), Irkutsk (−0.23) and Yakutsk (−0.33) show small minus coefficients. However, in Alexandrovsk the value is −0.47, which is significant at $p = 0.05$ level. In Sapporo (−0.43) and Nemuro (−0.39) the values are also significant. The correlation coefficient in Khabarovsk is the largest of the 12 points.

The characteristics of the weather in January 1962 when the number of swans at Lake Hyoko was small were:

(1) there was a prominent pressure peak over the west coast of Canada and a small number of areas of low atmospheric pressure moving toward the Aleutian Islands;

(2) because the high pressure area near Lake Baikal developed to some extent and

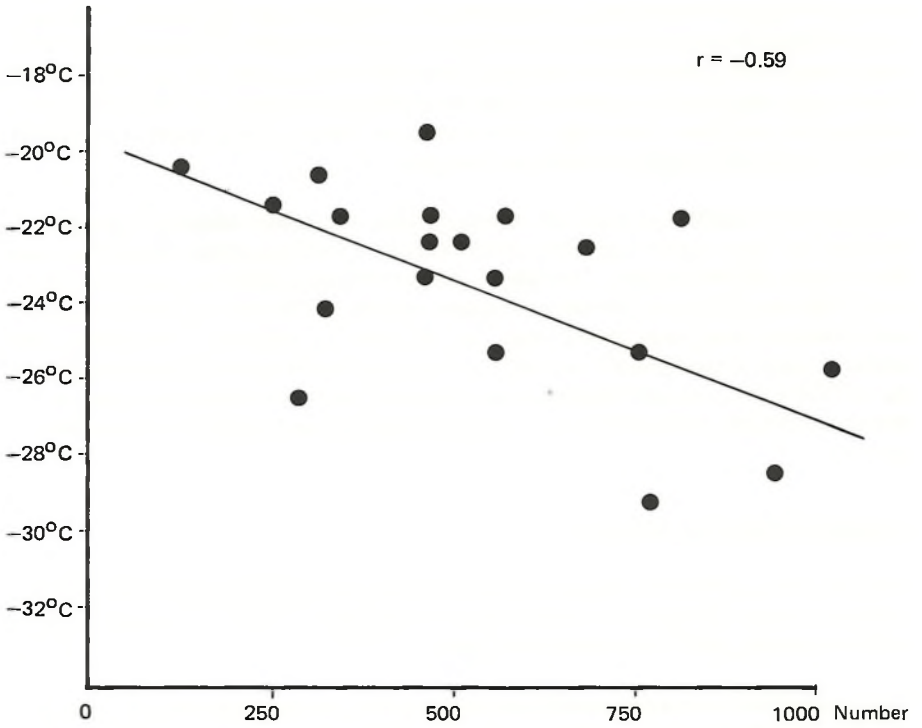

Fig 1. The correlation coefficient between the average temperature in January at Khabarovsk and the maximum number of swans at Lake Hyoko.

a trough of low pressure arose over the eastern Sea of Japan, the cold air current came down to the western part of Japan;

(3) the unusually high temperature over the whole of Siberia continued from the previous month, with its centre located near Lake Baikal. The temperature on the eastern Siberian peninsula registered +11°C. The low temperature area extending from South China to the southern Sea of Japan was the most prominent since the war. In northern Japan the temperature was 11.2°C higher than the average of past years, while it was low in Shikoku and Kyushu and about the same as average in the area from Kanto to Kinki and San-in.

The characteristics of the weather in January 1970 when the number of swans was large at Lake Hyoko were:

(1) the cold air current nucleus coming south from Manchuria reached the Sea of Japan on the night of 16 January, and the temperature at 500 millibars above Wajima registered −44.5°C. As a result, the temperature stood −6.2°C at Matsue

and −8.0°C at Maizuru on 20 January, each of which was the lowest January temperature registered;

(2) various places in northern Japan were hit by the lowest atmospheric pressure area and great damage was done to a wide region. In Tokyo 58.5 mm of rain were registered, the heaviest single rainfall that year;

(3) the ridge of the pressure developed in Siberia in the first ten days of January and a cold air mass from the North Pole moved over the Sea of Okhotsk. In the area of the Pacific Ocean, the altitude of 500 millibars was generally low and a great deal of the polar air of Siberia came south. The temperature in Kinki and the western part of Todaido was the same as the average of past years, while it was low in Hokkaido and its vicinity.

Conclusion

It is obvious that the number of swans coming to Lake Hyoko increases as the temperature at Khabarovsk, Alexandrovsk, Sapporo and Nemuro goes down. The fact that individual swans at Lake Hyoko come from Hokkaido has been confirmed by observing their neck-bands.

Acknowledgements

For comments and suggestions we would like to thank Dr Hisano Hatakeyama, Dr Koichiro Takahashi, Prof Masatoshi Yoshino and Mr Masao Ouchi.

Summary

The routes of cold air currents and average temperatures in January since 1960 were examined to show that high numbers of swans at Lake Hyoko coincide with low temperatures in Khabarovsk (correlation coefficient −0.59), Alexandrovsk (−0.47) and Sapporo (−0.43).

Editorial note

The paper presented to the Symposium had originally been published with many meteorological maps which could not be reproduced in these Proceedings. The full text can be obtained from the author.

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