*J. Raptor Res.* 43(2):145–148


# CLOSE INBREEDING IN BLAKISTON'S FISH-OWL (*KETUPA BLAKISTONI*)

YUKO HAYASHI[1]
*Faculty of Law, Sapporo University, Sapporo 062-8520, Japan*

KEY WORDS: *Blakiston's Fish-Owl*; Ketupa blakistoni; *conservation*; *hatching success*; *inbreeding*; *Japan*.

Blakiston's Fish-Owl (*Ketupa blakistoni*) is one of the largest owl species in the world with a total mass of 3150–3450 g in males and of 3360–4600 g in females (Yamamoto 1999). Feeding mainly on fish, this species ranges from eastern Siberia, north to Magadan, including Sakhalin Island, the southern Kuril Islands, and the Amur Basin, Russia, possibly northeast China, and central and eastern Hokkaido (the northern-most main island of Japan; Collar 2001). Estimates of the global population range between a few hundred individuals (Collar 2001) and >800 pairs (Surmach 1998, Slaght and Surmach 2008).

Although the species was formerly widespread throughout Hokkaido until the 1950s (Hayashi 1999), it now occurs only in very restricted areas of the eastern and central parts of the island and has a population estimated at no more than 35 breeding pairs (Ministry of the Environment 2002). Once a territory has been established, the pairs are highly resident (Hayashi 1997 and this study), and no records of migration have been obtained in Hokkaido. The species was listed as ''endangered''on the 2008 IUCN Red List (IUCN Species Survival Commission 2008) and as ''critically endangered'' in Japan's Red Data Book (Ministry of the Environment 2002). The primary cause of population decline in Japan is thought to be the loss of suitable habitat since the 1950s (Hayashi 1999) and potentially a reduction in the availability of their fish prey.

Small and isolated populations are inherently more vulnerable to external environmental perturbations and chance fluctuations in local survival and fecundity (Keller and Waller 2002). Additionally, if wild populations become small and isolated, inbreeding and loss of genetic variation are inevitable (Frankham et al. 2002) and may affect the viability of the population (Keller and Waller 2002).

[1] Email address: hayashiy@sapporo-u.ac.jp

Data on inbreeding and inbreeding depression in wild raptor and owl populations are scarce. Inbreeding has been reported for Barn Owls (*Tyto alba*; Petty et al. 1986, Shaw and Dowell 1989, Taylor 1994), Burrowing Owls (*Athene cunicularia*; Millsap and Bear 1990), and Spotted Owls (*Strix occidentalis*; Gutiérrez et al. 1995, Carlson et al. 1998). However, detrimental effects of inbreeding have not hitherto been recorded. Given the current status of Blakiston's Fish-Owls in Hokkaido, the population has presumably been subjected to recurrent mating between close relatives (Hayashi 1997). Here, I document the breeding performance of a father-daughter pair, and report two more cases of close inbreeding during a 20-yr study of a single family of Blakiston's Fish-Owls.

## METHODS

This study was conducted from1987 to 2007 in the upper reaches of the Tokachi River in east-central Hokkaido, Japan (43°22′–43°27′N, 143°16′–143°22′E). This area, which is covered with dense forest, is located at the base of steep mountains. Elevation ranged from approximately 300 to 810 m asl. The climate is characterized by cold winters and hot summers. For example, in 1992, the minimum temperature recorded was −24.7°C (January) and the maximum temperature was 31.4°C (July). Snow cover generally persisted from December to March. Approximately half of the study area is coniferous plantation consisting of Sakhalin spruce (*Picea glehnii*), Japanese larch (*Larix leptolepis*) and eastern white pine (*Pinus strobus*). The remaining half is mixed forest, consisting of conifers including Yezo spruce (*Picea jezoensis*), and Sakhalin fir (*Abies sachalinensis*) and broad-leaved tree species such as katsura tree (*Cercidiphyllum japonicum*), painted maple (*Acer mono*), Japanese oak (*Quercus mongolica*), Japanese poplar (*Populus maximowiczii*) and basswood (*Tilia japonica*). Ground cover in the forest was primarily sasa bamboo (*Sasa nipponica*). A detailed description of vegetation in the study area is provided in Hayashi (1997).

A pair of Blakiston's Fish-Owls was observed breeding in the study area in 1986, although the area was likely occupied prior to 1986. Since 1986, the Environmental Agency of Japan has, by means of an artificially stocked pond, supplied fish to the owls to prevent possible starvation. One family of Blakiston's Fish-Owls has been monitored intensively there since May 1987.

All individuals hatched after 1987 in the study area were identified by colored, numbered leg bands, which were attached just before or after the birds fledged (Hayashi and Nishida-Umehara 2000). The breeding pair (M and F) and one female hatched in 1986 (86F) were caught in mist nets and banded in 1987. All banded individuals were sexed using chromosomal methods and molecular genetic markers (Hayashi and Nishida-Umehara 2000).

In the autumn of 1988, I installed a cylindrical artificial nest box to facilitate breeding by the owls and to permit collection of detailed nesting data. The nest box was made of hollow basswood, 85 cm in height, with a diameter of 90 cm. Two CCD cameras were bolted to the roof to monitor the inside of the nest. The nest box was wired to a Japanese poplar about 5.5 m aboveground in riparian forest about 90 m from the stocked pond. The nest box has been used by the pair of owls since 1989. Thereafter, without disturbing the owls' breeding behavior, I could obtain their detailed nesting data, such as clutch size, hatching date and fledging date.

I used radiotelemetry, visual observations, and recording devices to monitor the location and behavior of owls (Hayashi 1997). When the offspring were found after their dispersal from the natal sites, I installed recording devices 200–400 m from suspected nest trees or roosts to collect information on the presence of presumed breeding pairs. If the pair called frequently from the same roost during spring, it was assumed that they had selected the nest tree and attempted to breed there, as intersexual vocalizations are associated with territorial advertising and intrapair communication (Brazil and Yamamoto 1989).

## RESULTS

After they were first observed breeding in 1986, the original male (M) and female (F) successfully reproduced four times between 1987 and 1991, producing seven fledglings. In 1987 they raised one daughter in a natural cavity, therefore I could not identify the clutch size. The genetic relationship between the pair members was not determined. Pairings of closely related owls are described below.

**Father-and-daughter Pair.** The original breeding female (F) disappeared in October 1991. Her daughter (86F), who hatched in 1986, dispersed in March 1988, and visited in the winter of 1988–89, returned to the natal territory in December 1991 after an absence of 32 mo and later mated with her father (Hayashi 1997). The pair attempted to breed every year from 1992 to 2003 and produced seven offspring in those five years. The hatching success of the M–86F pairing was substantially lower than that of the M–F pairing. All six of the eggs from the original M–F pairing (1989–91) hatched, whereas only 7 of 17 eggs (1992–2003) hatched following the change of the breeding female. As the genetic relationship between M and F was unknown, this reduced hatching success cannot confidently be ascribed to inbreeding depression. All of the hatchlings fledged successfully for both the original and the father-daughter pairs. Three offspring from the M–86F pair subsequently bred successfully at least once.

**Grandmother-and-grandson Pair.** Soon after the disappearance of the original male, M, in October 2003, he was replaced by his grandson (97M), who was hatched in 1997 in an adjacent territory occupied by a daughter (93F) of M and 86F. The nest from which 97M fledged was 8.8 km from his mother's natal site. The new pair (86F and 97M) formed in December 2003, the first time 97M had been detected since 1998. 93F and her mother (86F) shared the same father (M). The relatedness between 97M's parents was not determined because his father

(93F's mate) was not banded. This grandmother-grandson pair (86F and 97M) fledged one daughter in 2005. 97M disappeared in late 2006 and was replaced by a non-kin male. Based on his leg-band, I could identify that he was hatched 156 km distant from the study site in 2002.

**Sibling Pair.** Both members of this pair fledged from the same nest and shared the same parents (M and 86F). The male (94M) hatched on 4 April 1994, left the natal territory on 11 April 1995, and was not seen there again, apart from a brief reappearance on 8 November 1995. The female (00F) fledged on 1 June 2000 and left the natal territory on 31 March 2001 but settled in an adjacent area. On 19 May 2001, she was heard vocalizing with an unidentified male 3.5 km from her natal site, confirming that she had formed a pair. This was my only observation of pair formation involving a yearling female. Although 00F may have established a territory with a mate, on 7 November 2001 she was again found at her natal territory, and spent her second winter there. On 31 January 2002, 00F was observed at the territory of the previous spring. Although I did not monitor her intensively during 2002, a duet heard on 19 April implied that she was paired with a male again. A pair of owls, including 00F, was observed in the same location on 22 and 23 May 2003, but breeding was not confirmed in either year. On 14 June 2004, she was found drowned in a fishpond located 21.6 km from the apparent territory of 2002–03. A nest containing one nestling was found close to the fishpond, attended by 94M, who successfully raised the chick to fledging. This presumed mate of 00F was her 6-yr-senior brother, who may have settled there prior to 2003. 94M remained alone in the same territory from 2004–07.

## DISCUSSION

In this study, I documented close inbreeding in Blakiston's Fish-Owls. The father-daughter pair (M and 86F) was probably facilitated by philopatry of the young female and site fidelity of the established male. The birds may have recognized each other because the daughter (86F) had returned after dispersing the previous winter and was tolerated by her parents. Although the postindependence period of parent-offspring recognition for Blakiston's Fish-Owls is unknown, the repeated return of another daughter (93F) even after breeding (Y. Hayashi unpubl. data), suggests that it may be relatively long. In the other two cases of close inbreeding, there was no evidence that the birds involved recognized their kinship when they mated. The grandmother-grandson pair (86F and 97M) was probably facilitated by breeding-territory fidelity of the resident and the short dispersal distance of the young male. The movements of 00F were exceptional for Blakiston's Fish-Owls because established adults are generally sedentary and show strong philopatry. It is possible that the further dispersal or death of her mate at the 2002–03 site may have initiated her additional dispersal. The pairing of full-siblings from different years (94M and 00F) seemed to be a result of both dispersal behavior and chance occurrence. These birds likely had no opportunity to meet prior to mating, because 94M had left the natal territory before 00F was hatched.

Given that the population of Blakiston's Fish-Owls in Hokkaido is estimated to be less than 150 individuals, the occurrence of close genetic pairs is not surprising. All three pairs reported in this study produced young, but there was some evidence of lowered hatching success in the father-daughter pairing.

Inbreeding depression due to reduced hatching rates has been documented in some landbirds (reviewed in Keller and Waller 2002). Reduced hatching success is a common characteristic of endangered or insular bird species with small population sizes (e.g., Keller 1998, Jamieson and Ryan 2000). In New Zealand, hatching failure was significantly greater among species that had passed through bottlenecks of <150 individuals (Briskie and Mackintosh 2004).

The reduction in hatching success associated with pairs of closely related individuals shown in this study might be a matter of concern for conservation of this threatened species. Previously, I documented the male-biased sex ratio among fledglings of Japanese populations of Blakiston's Fish-Owls that could possibly be a consequence of small population size (Hayashi and Nishida-Umehara 2000). Consideration of the long-term consequences of small population size may be necessary for conservation and management of the population.

## ENDOGAMIA ESTRECHA EN *KETUPA BLAKISTONI*

RESUMEN.—*Ketupa blakistoni* es una especie amenazada que alguna vez estuvo ampliamente distribuida en Hokkaido, la isla principal más septentrional de Japón, pero actualmente presenta una población estimada de 35 parejas reproductivas con una distribución muy local. Detecté tres casos de endogamia estrecha durante un estudio de 20 años de duración sobre una familia de esta especie. El primer caso sucedió entre un macho y su cría hembra, después de la pérdida de su pareja anterior. Esta pareja padre-hija produjo siete crías entre 1992 y 2003. La tasa de eclosión de los huevos de esta pareja fue sólo del 41.2%, sustancialmente menor que la de la pareja original (100%). El segundo caso de endogamia sucedió poco después de la pérdida del macho original de la misma pareja en 2003. Su nieto, que había eclosionado en 1997, apareció y se apareó con su abuela. Esta pareja abuela-nieto produjo un volantón hembra en 2005. El último caso sucedió entre dos hermanos en un lugar distante de su territorio natal. El macho y la hembra habían emplumado en 1994 y 2000, respectivamente, del mismo nido y compartían los mismos padres. Ellos produjeron un volantón en 2004. Propongo que la posible reducción en el éxito de eclosión asociada con parejas de individuos cercanamente emparentados podría ser un factor de preocupación en relación con la conservación de esta especie amenazada.

[Traducción del equipo editorial]

ACKNOWLEDGMENTS

I thank all the participants of Blakiston's Fish-Owl conservation programs in Japan, especially Hisashi Abe, Yuzo Fujimaki, Masaru Takada, Hajime Nakagawa, Sumio Yamamoto, Norihisa Kondo, Shuichi Wakisaka, Masao Hashimoto, Ryoji Shimura, Keisuke Saito, Takeshi Takenaka, and Yukiko Watanabe. Many people assisted my field research and particular thanks are extended to Masateru Umemoto, Hisashi Takeda, Mitsuru Ikehata, Katsutoshi Suzuki, Toshimitsu Kawagoshi, Makoto Maeda, and Toshihito Kondo. Shigeru Matsuoka kindly allowed me to use his digital Mini Disc recorder. This research was supported by WWF Japan (1990–95), Fujiwara Natural History Foundation (1992–94), Sasagawa Scientific Research Grant from The Japan Science Society (1993–95), Hokkaido Shinbun Wildlife Fund (1993), Showa Shell Sekiyu Foundation for Promotion of Environmental Research (2000), Nippon Life Insurance Foundation (2001–02), and Sapporo University Academic Research Grant (2003). Thanks to Richard Noske for improving the English on an earlier draft. Teaching and Learning Services of Lincoln University helped improve the English on a revised manuscript. I also thank Jonathan Slaght and an anonymous reviewer for their valuable comments on an earlier version of the manuscript.

LITERATURE CITED

BRAZIL, M.A. AND S. YAMAMOTO. 1989. The behavioural ecology of Blakiston's Fish Owl *Ketupa blakistoni* in Japan: calling behaviour. Pages 403–410 *in* B.-U. Meyburg and R.D. Chancellor [EDS.], Raptors in the modern world: proceedings of the III World Conference on Birds of Prey and Owls. World Working Group on Birds of Prey and Owls, Berlin, Germany.

BRISKIE, J.V. AND M. MACKINTOSH. 2004. Hatching failure increases with severity of population bottlenecks in birds. *Proc. Nat. Acad. Sci. USA* 101:558–561.

CARLSON, P.C., W.S. LAHAYE, AND A.B. FRANKLIN. 1998. Incestuous behavior in Spotted Owls. *Wilson Bull* 110:562–564.

COLLAR, N.J. [ED.]. 2001. Threatened birds of Asia: the BirdLife International red data book. BirdLife International, Cambridge, U.K.

FRANKHAM, R., J.D. BALLOU, AND D.A. BRISCOE. 2002. Introduction to conservation genetics. Cambridge University Press, Cambridge, U.K.

GUTIÉRREZ, R.J., A.B. FRANKLIN, AND W.S. LAHAYE. 1995. Spotted Owl (*Strix occidentalis*). *In* A. Poole and F. Gill [EDS.], The birds of North America, No. 179. The Academy of Natural Science, Philadelphia, PA and The American Ornithologists' Union, Washington, DC U.S.A.

HAYASHI, Y. 1997. Home range, habitat use and natal dispersal of Blakiston's Fish-Owls. *J. Raptor Res.* 31:283–285.

———. 1999. Past and present distribution of Blakiston's Fish-Owl (*Ketupa blakistoni*) in Hokkaido, Japan – based upon museum specimens –. *J. Yamashina Inst. Ornithol.* 31:45–61. (In Japanese with English summary.)

——— AND C. NISHIDA-UMEHARA. 2000. Sex ratio among fledglings of Blakiston's Fish-Owls. *Jpn. J. Ornithol.* 49:119–129.

IUCN SPECIES SURVIVAL COMMISSION. 2008. The IUCN Red List of Threatened Species 2008. http://www.iucnredlist.org (last accessed 30 October 2008).

JAMIESON, I.G. AND C.J. RYAN. 2000. Increased egg infertility associated with translocating inbred takahe (*Porphyrio hochstetteri*) to island refuges in New Zealand. *Biol. Conserv.* 94:107–114.

KELLER, L.F. 1998. Inbreeding and its fitness effects in an insular population of Song Sparrows (*Melospiza melodia*). *Evol.* 52:240–250.

——— AND D.M. WALLER. 2002. Inbreeding effects in wild populations. *Trends Ecol. Evol.* 17:230–241.

MILLSAP, B.A. AND C. BEAR. 1990. Double-brooding by Florida Burrowing Owls. *Wilson Bull.* 102:313–317.

MINISTRY OF THE ENVIRONMENT. 2002. Threatened wildlife of Japan. Red data book, Vol. 2: Aves, Second Ed. Japan Wildlife Research Center, Tokyo, Japan.

PETTY, S.J., B. LITTLE, AND D. ANDERSON. 1986. Incestuous breeding and abnormal movement by a female Barn Owl *Tyto alba*. *Ringing Migr.* 7:23–24.

SHAW, G. AND A. DOWELL. 1989. Breeding by closely related Barn Owls. *Ringing Migr.* 10:98.

SLAGHT, J.C. AND S.G. SURMACH. 2008. Biology and conservation of Blakiston's Fish-Owls (*Ketupa blakistoni*) in Russia: a review of the primary literature and an assessment of the secondary literature. *J. Raptor Res.* 42:29–37.

SURMACH, S.G. 1998. Present status of Blakiston's Fish-Owl (*Ketupa blakistoni* Seebohm) in Ussuriland and some recommendations for protection of the species. *Rep. Pro Natura Found.* 7:109–123.

TAYLOR, I.R. 1994. Barn Owls. Cambridge University Press, Cambridge, U.K.

YAMAMOTO, S. 1999. Shima-fukuro - The Blakiston's Fish-Owls. Hokkaido Shinbun Press, Sapporo, Japan. (In Japanese.)

Received 24 August 2008; accepted 21 January 2009
Associate Editor: Joseph B. Buchanan