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研究資料（Research material）

Imprisonment by glaze ice may have caused the death of a cavity-roosting marsh tit (*Parus palustris*)

Shigeru MATSUOKA[1)*] and Megumi KUDO[2)]

Abstract

The carcass of a marsh tit (*Parus palustris*) was found in a roosting hole whose entrance was covered with glaze ice and granular snow in a broadleaved deciduous forest in Sapporo, Hokkaido, Japan, on 15 February 2007. Because the ice was clear and covered by granular snow, freezing rain appears to have fallen first and formed an ice layer on the surface of the trunk; granular snow then followed. The entrance of the cavity opened to the south, and south and south–southwestern winds would have carried both glaze ice and granular snow into the roosting hole. Weather data observed near the forest indicate that glaze ice would have covered the hole's entrance around midnight on 14–15 February. The bird's body weight and appearance suggest that it was in good condition and did not die as a result of nutrient depletion, and the results of our necropsy do not rule out asphyxia. Thus, we conclude that glaze ice covered the entrance of the cavity after the tit roosted in the evening of 14 February, and the resulting barrier to aeration led to death of the tit by asphyxia.

Key words : roosting hole, marsh tit, *Parus palustris*, glaze ice, cause of death, asphyxia

Introduction

Bird populations change as a result of changes in the birth and death rates in a population. Information on the causes of death is thus as interesting as birth statistics to ornithological researchers. The causes of death in wild birds are diverse. Predation, food shortage, diseases, parasites, severe weather conditions, and collisions with man-made constructs are well-documented causes of death (e.g. Lack, 1954; Welty, 1962). Among severe weather conditions, snowstorms (Leopold, 1937; Scott, 1937; Tompa, 1971; Hendricks & Norment, 1992), prolonged periods of snow cover on the ground (Roseberr, 1962; Graber & Graber, 1979), and low temperature (Stewart, 1952; Pitts, 1978; Mart & Wagner, 1985) adversely affect bird life and sometimes become causes of bird death. In addition, heavy snow has been shown to occasionally imprison ground-roosting birds such as the bobwhite quail, *Colinus virginianus* (Leopold, 1937; Scott, 1937), resulting in death of the imprisoned birds.

Recently, we observed a different case of bird death that was probably caused by severe weather. In this paper, we report the death of a marsh tit (*Parus palustris*) that roosted in a natural tree cavity whose entrance became covered with glaze ice.

Study area and methods

We have studied cavity-nesting birds in the broadleaved deciduous forests of the National Agricultural Research Center for Hokkaido Region (NARCH; 42°59'44"N, 141°23'54"E, about 150 m above sea level) in southeastern Sapporo, Hokkaido since 1995. Details of the study area were provided by Kotaka and Matsuoka (2002).

From December 2006 to March 2007, we surveyed the study area to detect cavity nesting birds so as to provide information on their roosting behaviors. From about 1 hour before sunset, we followed cavity roosting birds with skis or waited for them near used nesting and roosting holes. Roosting holes were located when we observed individual birds entering the holes. Although the marsh tit was not the main research subject at this time of year, we also recorded their roosting sites and the times when they roosted whenever we found their roosting cavities.

Weather data from a distant weather station sometimes differs markedly from the conditions at a study site (Moore, 1945). Although we were not able to obtain specific weather data for the study site, we obtained data from the nearby NARCH weather observation field (1.8 km from the study area, 70 m above sea level) and used this information to infer the time when freezing rain fell and glaze ice formed on

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1) Hokkaido Research Center, Forestry and Forest Products Research Institute (FFPRI)
2) Sapporo Bird Clinic
* Hokkaido Research Center, Forestry and Forest Products Research Institute (FFPRI), Hitsujigaoka 7, Toyohira, Sapporo 062-8516, Japan; e-mail: shmatsu@affrc.go.jp

the roosting tree. Data on the daily minimum temperatures, air pressures, precipitation, wind speeds, and snow depths were downloaded from the NARCH Web site. Data on sunrise and sunset times in Sapporo were downloaded from the Web site of the National Astronomical Observatory of Japan.

A necropsy of the marsh tit was performed by the Companion Bird Laboratories, a department of examination of the Bird House (a veterinary hospital in Chiba Prefecture).

Results and discussion

Observations: We observed a marsh tit entering a cavity of a live Korean mountain-ash (*Sorbus alnifolia*, Rosaceae) at 16:03 on 4 January 2007. The cavity seemed to have resulted from a broken limb at the trunk rather than woodpecker excavation. The tit did not leave the cavity for several minutes before we completed our observations and left, and the time when the tit entered the cavity was within the range reported for this species in winter (Shigeru Matsuoka, unpublished data). On this basis, we judged the cavity to be a roosting site for the marsh tit. The tree's height and diameter at breast height were 10 m and 22.3 cm, respectively. The roosting height above the ground (to the lower edge of the cavity entrance) was 2.3 m, the roosting height above the snow surface was 1.4 m, and the diameter of the tree at the roosting cavity (calculated from the diameter at the lower edge of the entrance) was 25.1 cm. The diameter at the roosting cavity was larger than the diameter at breast height. The horizontal and vertical diameters of the entrance hole and its depth were, 26, 30, and 185 mm respectively.

Thereafter, for more than 1 month we confirmed that the marsh tit used the same roosting cavity during all of our irregular observations and roosted at or before sunset (Table 1). The tit was not marked with a color ring, so we are not sure that the same individual used the cavity in succession. However, based on our observations of the roosting behavior of marked marsh tits in this study area, individuals commonly used the same cavities for certain periods of time if they were not disturbed during their roosting behaviors (Shigeru Matsuoka, unpublished data). After our last confirmation of cavity roosting by the tit on 11 February, we investigated birds at other observation points in the study area on the following two evenings and did not return to the forest on 14 February because of strong winds and heavy snow.

When we returned to the forest on the morning of 15 February, we noticed that a thin layer of ice and granular snow had covered the southern side of many trees in the study area, and in the evening we found that the entrance of the marsh tit's roosting cavity had been completely covered by a layer of ice and granular snow (Photo 1A). We removed the granular snow, broke the ice layer with a ski pole, and found the carcass of a marsh tit in the cavity. The bird had closed its eyes, pointed its beak upward towards the entrance, and stayed near the entrance (5 cm between the entrance and the tip of its beak). The bird's feathers closely contacted the walls of the narrow cavity. We left the carcass undisturbed because we could not pick it up with fingers. The next morning, we confirmed that the bird had remained in the same place and in the same posture, and then removed it from the cavity using a three-clawed grasping tool (Photo 2). The feathers were dry, and no wounds were apparent. The bird's weight and wing length (convex distance) were 11.0 g and 65.5 mm, respectively. We kept the carcass in a freezer (at about –24°C) until it was possible to perform a necropsy.

Table 1. Observations of the roosting behavior of the marsh tit

Date in 2007	Behavior	Time	Sunset time in Sapporo
4 January	Roosting	16:03	16:13
5 January	Roosting	16:13	16:13
15 January	Roosting	16:18	16:24
16 January	Roosting	16:07	16:25
11 February	Roosting	16:38	16:59
15 February	Found dead	16:15	

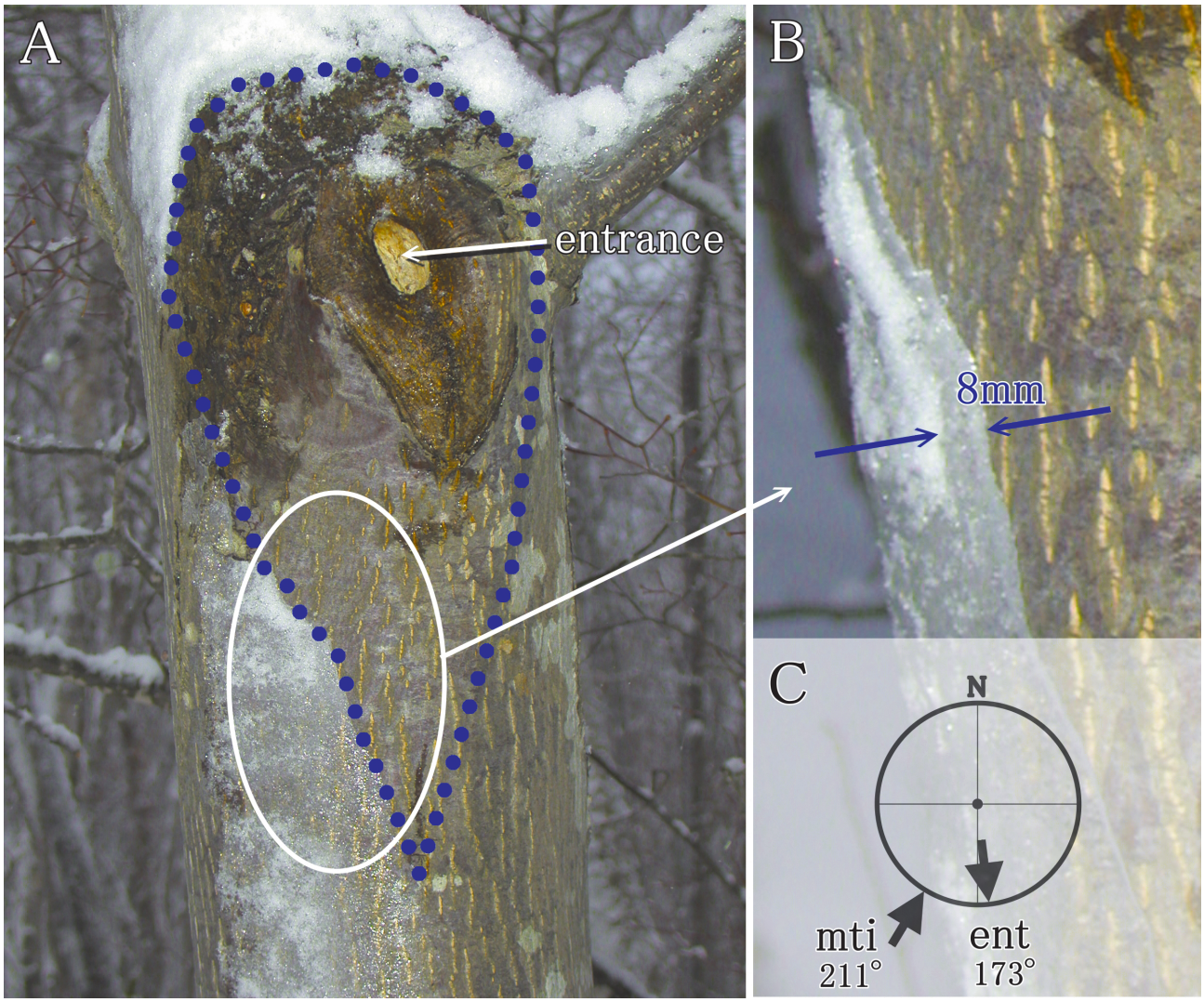

Photo 1. The roosting tree of the marsh tit that we found imprisoned in a cavity by glaze ice. (A) Part of the area from which we removed the layer of ice and granular snow that coated the tree (dotted line). (B) An enlarged view of part of the maximum thickness of the ice layer (photograph taken from a different angle from "A"). (C) Directions of the opening of the entrance (ent) and of the maximum thickness of ice (mti). (Angles were measured clockwise from the north.)

The shape of the cavity was a bottle with a narrow neck. We found packed, hard snow coating the bottom of the roosting cavity. However, this condition is common because snow often blows into tree cavities during the daytime or when birds enter the cavity carrying snow that had accumulated at its entrance during daytime hours. Thereafter, snow often remained in the cavity for some time during the winter season.

Weather conditions: The ice that covered the cavity tree was clear, and some parts were coated with a thin layer of granular snow. The maximum thickness of the ice layer was 8 mm (Photo 1B). The entrance opened to the south (173° measured clockwise from the north), and the maximum thickness of ice was recorded in a south–southwest direction (211°; Photo 1C). These details suggest that freezing rain from the south–southwest direction hit the tree surface and formed glaze ice, and that granular snow subsequently covered the layer of glaze ice. Although the direction of the entrance differed slightly from that of the maximum thickness of the ice layer, the configuration of the entrance and arrangement of the branch near the entrance might have affected the airflow, leading the ice and snow to cover the entrance.

The changes in weather conditions during the 4 days between our last confirmation of cavity roosting by the marsh tit (11 February) and our discovery of the carcass (15 February) are shown in Fig. 1. Because we observed other parts of the study area on the evenings of 12 and 13

Photo 2. The carcass of the marsh tit that we removed from the roosting cavity.

February and did not observe ice on tree trunks, the ice layer must have formed after the evening of 13 February and before the morning of 15 February, when we first noticed ice on the tree trunks. A south or south–southwest wind blew from the evening of 13 February to the early morning of 14 February, and around midnight on 14–15 February (Fig. 1). During the former time period, however, no precipitation was recorded. This evidence suggests that the freezing rain fell, the ice layer formed, and granular snow fell around midnight on 14–15 February, when a low pressure area passed over Hokkaido, strong south winds blew, and temperatures were around the freezing point.

Necropsy and the cause of death: The results of a necropsy of the bird are summarized in Table 2. The bird seemed to be in good condition and not excessively skinny. Her body weight (11 g) was within the range of measurements for this species measured on February mornings in this study area (11 to 14 g, median = 12 g, n = 14). The body weight of marsh tits increases by an average of 8.9% from dawn to sunset in winter as a result of foraging (Lilliendahl, 2002), thus her body weight would also have increased during the daytime. Furthermore, male marsh tits are usually heavier than females (Cramp & Perrins, 1993). On this basis, her body weight was normal for birds roosting in that season. The necropsy revealed no injury to her body and no wound or sign of external bleeding around the base of her beak. This evidence suggests that the tit did not peck something hard, did not rush or move around forcefully in the cavity, and did not deplete her nutrient reserves before she died.

The emptiness of the proventriculus and gizzard indicates that the tit died after having completely digested any food obtained during the daily foraging. Because tits usually forage actively until just before they roost in cavities, this emptiness suggests that it took some time between the bird's last intake of food just before roosting and her subsequent death. At least 7 hours would have passed from her roosting in the cavity to midnight, when the glaze ice was thought to have covered the entrance of the cavity.

When ice and granular snow covered the entrance of the roosting cavity, there would have been no aeration to introduce fresh air because the cavity walls were live, airtight wood, and packed hard snow coated the bottom of the cavity. Under these conditions, the roosting bird's respiration would gradually deplete the cavity's oxygen and increase carbon dioxide levels, leading to death by asphyxia. The hydropic conditions of the lungs and the slight hypertrophy of the heart described in the necropsy report do not preclude the possibility of asphyxia. The willow tit *Parus montanus* (Reinertsen & Haftorn, 1983), a closely related Old World species of the marsh tit, and the Carolina chickadee *Parus carolinensis* (Mayer et al., 1982) and the black-capped chickadee *Parus atricapillus* (Smith, 1991), two small New World *Parus* species, are known to enter nocturnal hypothermia and lower their body temperature and oxygen consumption rates with decreasing ambient temperature during night roosting in winter. If Japanese marsh tits adopt the same metabolic strategy as willow tits, it would take longer between ice and snow coverage of the cavity entrance and the bird's death than if the bird had been imprisoned on a warmer day. However, we believe that the tit died before sunrise (when it would resume its diurnal activity) because there was no evidence of nutrient depletion or wounding.

Although we have no direct observational data or other indications of the precise time and cause of death of the marsh tit, the circumstantial evidence (weather conditions and the results of the necropsy) support a hypothesis that the marsh tit died as a result of asphyxia due to imprisonment by the glaze ice that covered the entrance of the roosting cavity around midnight on 14–15 February.

A typical air pressure pattern that occurs in winter in Japan (high pressure to the west and low pressure to the east) brings prevailing cold northwest winds (Minato, 1977) and dry light snow in this study area. The directions of roosting cavity entrances of marsh tits, however, vary widely (Shigeru Matsuoka, unpublished data). If the tits roosted in cavities whose entrances opened to the south, they would be at least partially sheltered from strong and cold northwestern winds and would be more likely to have dry cavities with only light snow. However, they might then occasionally encounter dangerous situations in which a low pressure front passes over the tree and brings freezing rain or heavy and wet snow. Although glaze ice occurs rarely in this study area, cavities whose entrances open toward the

Table 2. Summary of necropsy performed on the marsh tit*

Macroscopic findings	Result
Sex	Female
Appearance	Eutrophic (not skinny), no lesions, and no injury around the base of the beak
Proventriculus	Empty
Gizzard	Empty except for grit
Trachea	Stagnation of dark-red liquid in trachea just above the tracheal bifurcation
Lungs	Dark-red and moderately hydropic in the peripheral part of the dorsal area, dark-red and markedly hydropic in all ventral areas
Heart	Mild hypertrophy, blackish red
Head	Mild bleeding from centriciput occiput and right temple, but no damage to brain

* Necropsy performed by the Companion Bird Laboratories

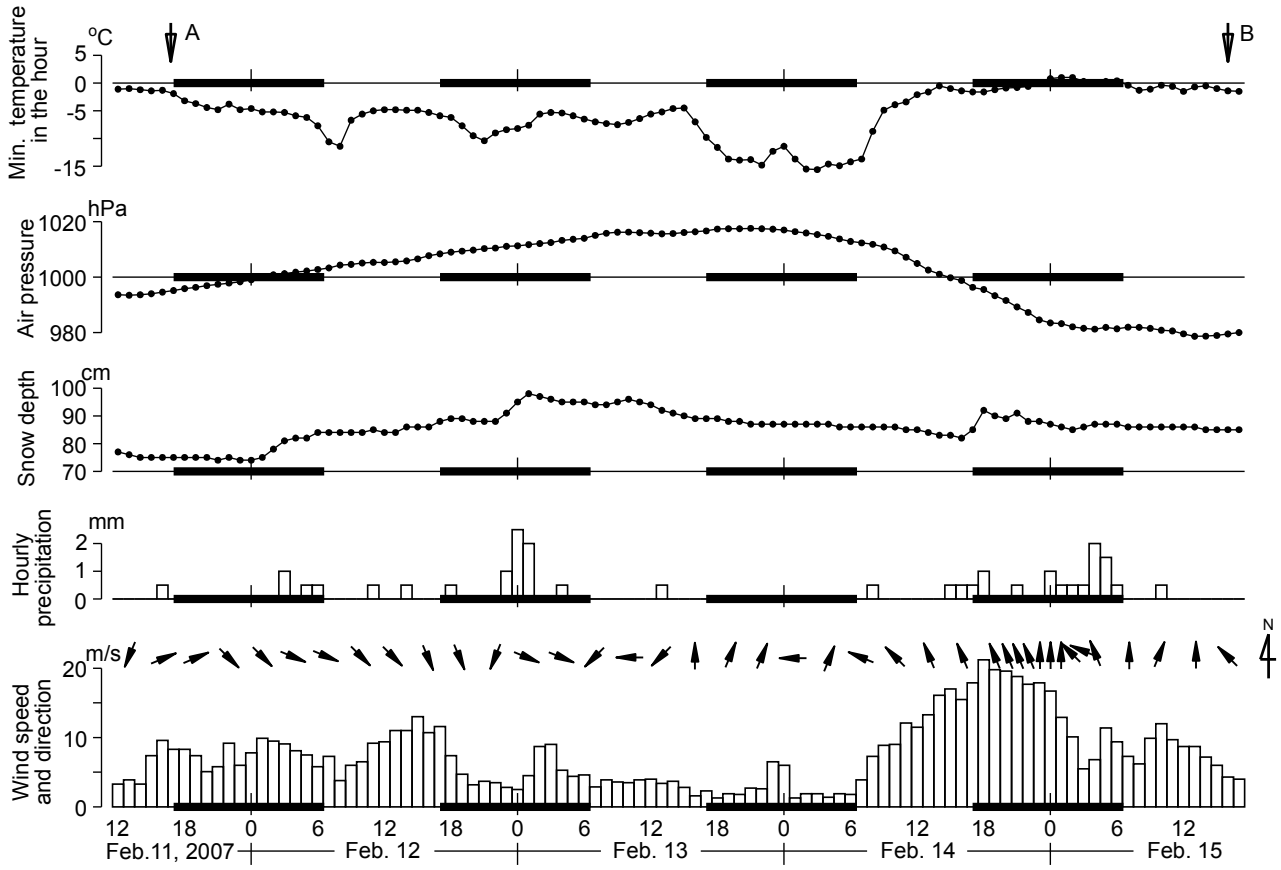

Fig. 1. Changes in weather conditions from the last observation of cavity roosting by a marsh tit (A) to our discovery of the bird's carcass in the cavity (B). Air pressure and snow depth represent values on the hour. Wind speed represents the maximum instantaneous wind speed in the hour, and wind direction represents the mean vector measured for 10 minutes before the hour, and is expressed by 16 wind directions. Wind directions are shown every three hours, but done hourly around midnight on 14-15 February. Bold lines represent the period from sunset to sunrise.

south are thus not necessarily safe place for cavity-roosting birds during the winter.

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雨氷が封鎖したねぐら樹洞で発見されたハシブトガラ *Parus palustris* の死体とその死因について

松岡　茂[1)*]，工藤　慈[2)]

要旨

2007年2月15日，北海道札幌市の落葉広葉樹林で，入り口が氷とざらめ雪に覆われたねぐら樹洞内で，ハシブトガラの死体を発見した．氷は透明で，その上をざらめ雪が覆っていたことから，最初に雨氷が降って木に氷が付着し，後にざらめ雪が降ったものと考えられた．ねぐら穴の入り口の方向と，氷の付着方向から，南から南南西の方向の風による着氷，着雪と考えられた．調査地近くで観測された気象データからは，着氷雪の発生は2月14－15日にかけての真夜中ごろと推察された．また，鳥類病院の検査部門に委託した病理解剖の結果は，ハシブトガラは消耗による死亡ではなく，内臓器官の状態からみて，窒息による死亡所見と矛盾しないことを示した．これらの状況証拠から，ハシブトガラが14日の夕方にねぐらに入った後に着氷雪が発生し，入り口を塞いだために通気がとまり，窒息死に至ったと推察された．

キーワード：ねぐら穴，ハシブトガラ，*Parus palustris*，雨氷，死亡原因，窒息

1) 森林総合研究所北海道支所
2) さっぽろ小鳥のクリニック
* 森林総合研究所北海道支所　〒062-8516　北海道札幌市豊平区羊ヶ丘7番地　e-mail:shmatsu@affrc.go.jp