DISTRIBUTION AND ABUNDANCE OF THE ALPINE ACCENTOR *PRUNELLA COLLARIS* BREEDING IN THE HAKUSAN MOUNTAIN RANGE

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白山山系で繁殖するイワヒバリ *Prunella collaris* の分布と個体数

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ABSTRACT

The Alpine Accentor *Prunella collaris* on Mt. Hakusan is considered to be at risk because this mountain is isolated from other mountains of the Japan Alps and is located in the westernmost part of the species' distribution in Japan. Furthermore, the alpine-zone area, its breeding habitat, is much smaller than that of other mountains. From of old, mountain climbers have concentrated in the summit area and the resulting destruction of vegetation along the mountain roads has created sandy areas. To provide the conservation plan for this species, we studied the abundance and distribution in the whole area of Hakusan mountain range in 1993-1996 breeding seasons. We ringed 17 adults and confirmed seven groups (40 adults) in the intensive study area set on the summit area. The distributions of group home-ranges and 17 nests were concentrated on the alpine zone (2,480-2,702 m alt.). There were nine groups (at least 31 adults) on the surrounding mountains and six groups of them were distributed in the subalpine zone (2,000-2,400 m alt.). The sizes of the groups distributed in the alpine zone were larger than those in the subalpine zone. The areas where we found Alpine Accentors always contained large snowbanks even in the subalpine zone and the birds foraged for insects mainly on the snow surfaces. On Mt. Hakusan, many insects are found on the surfaces of the snowbanks and they are brought by upward air currents from the lower part of subalpine zone and lowland. Thus, in order to conserve Alpine Accentors in the Hakusan mountain range, we should preserve not only the alpine zone, but also the subalpine zone and lowland of this mountain.

INTRODUCTION

Birds with very restricted ranges are extremely vulnerable to extinction for three reasons. First, they usually have a small population size and small populations are always more vulnerable than large ones because of the high probability that stochastic changes in their demography (e. g., skewed sex ratios or skewed age structure) can cause extinction (Ryan & Siegried, 1994). Second, their habitat itself may be vulnerable and even a small environmental stochasticity removes all their available habitat (Elmes & Thomas, 1992). Third, their population is usually isolated from others and the geographical isolation may cause extinction through genetic stochasticity, including the reduction of heterozygosity, genetic drift, and inbreeding (Denniston 1978, Meffe & Carroll 1994).

The Alpine Accentor *Prunella collaris* breeding on Mt. Hakusan fulfills some of the above conditions. First, this species breeds exclusively in the alpine zone (above *ca.* 2,400 m alt.), which is a severe habitat due to low temperatures and unstable weather conditions. Second, Mt. Hakusan is isolated from other mountains of the

Japan Alps (about 80 km in a straight line) and this mountain is located in the westernmost part of the species' distribution (during the breeding season) in Japan. Third, the alpine-zone area of Mt. Hakusan (about 400 ha) is much smaller than that of other mountains (e. g., about 2,100 ha on Mt. Norikura). Under such circumstances, another alpine bird, the Rock Ptarmigan *Lagopus mutus*, has already become extinct on Mt. Hakusan (Hanai & Tokumoto, 1976) and, like the Rock Ptarmigan, the Alpine Accentor has a relatively small clutch for its body size (2-3 eggs for 36.9-40.3 g, Nakamura, 1990). From of old, mountain climbers have tended to concentrate in the summit area and the resulting destruction of vegetation along the mountain roads has created sandy areas. Thus, the Alpine Accentors on Mt. Hakusan are considered to be at risk.

The Mt. Hakusan area is designated one of the UNESCO Man and the Biosphere (MAB) program of worldwide Biosphere Reserves and the Alpine Accentor is the only alpine bird of the mountain. Nevertheless, the population size and distribution of this species are poorly known due to the inherent difficulties in observing the bird in its harsh habitat. Ueuma (1985) estimated the population size to be at least 33 birds. However, his study was inadequate because the study periods and areas were fragmentary, and because birds were not individually color ringed. A prerequisite for the conservation of a species is to estimate as exactly as possible the population size and map the distribution. In this study, based on data from ringed birds, we report the number and distribution of Alpine Accentors breeding in the whole area of Hakusan mountain range.

STUDY AREA AND METHODS

This study was conducted from May to September in 1993-1996. The Hakusan mountain range (above 2,000 m alt.), located in the southern region of Ishikawa Prefecture, consisted of the summit area and the surrounding mountains. Since some birds and nests were already recorded on the summit area (Ueuma, 1985), we established an intensive study area (375 ha) on the summit and observed the behavior of ringed individuals. The primary breeding unit of the Alpine Accentor is a group consisting of about seven members (mean : 3.9 males, 3.1 females, Nakamura, 1990). Group members share a large territory, but they do not always move around together within it (Nakamura, 1995). Thus, unless the birds are ringed, it is difficult to determine the size of the group and its territory. The Alpine Accentor lacks any sexually dimorphic traits in plumage. However, so long as the birds are captured, we can easily determine the sex by the external characteristics of the cloacal protuberance : males and females form either a bulbous or a cylindrically-shaped protuberance (Nakamura, 1990).

To capture birds and facilitate observation of their behavior, we established seven artificial feeding grounds (with millet seeds in an area of 30 cm×30 cm) within the intensive study area. These were set at places where the birds naturally aggregated. In the intensive study area, 12 adults (9 males and 3 females) and one young that came to eat at the feeding ground were captured with a clap net. Five adults (3 males and 2 females) were captured using mist-nets set on rocky slopes. Moreover, four nestlings were captured by hand in the nest. Each captured bird was given an individually numbered aluminum ring and a unique combination of colored leg rings. In this paper, Ra, Ua and Uy indicate a ringed adult, unringed adult and unringed young, respectively.

Since 17 adults had been ringed by 1995, we visited the intensive study area for 14 days from June to August in 1995 and studied the number of groups, group sizes and the distributions of territory, based on the behaviors of ringed adults. We determined the group sizes and studied the individual behaviors in June because this month corresponds to the mating period of this species, when the members of a group move around together within their territory (Nakamura, 1995).

Nest sites were located from June to August in 1995 and 1996. We could not determine the exact ranges of group territories because of the short study periods and unstable weather conditions peculiar to the alpine area. Thus, two or three members of a group were observed for at least 30 minutes and the home range was estimated by plotting their outermost positions, including all flying routes, on maps of the study area.

To map the distribution and to count the number of birds inhabiting the surrounding mountains, we walked once or more over all mountain roads above 2,000 m alt., searching for Alpine Accentors. When we found them, the position and group size were recorded on maps. Since the birds on the surrounding mountains were not ringed, we considered that a bird belonged to a group when it occurred within 10 m of other conspecifics and moved synchronously with them in the same direction for at least 10 minutes. The population survey was conducted on 7, 17, 25, and 29 June, and on 26-28 July 1995.

RESULTS

1. Summit area

We confirmed the presence of 40 adults (and 23 young) in the intensive study area and they belonged to seven different groups. We named the seven groups: Groups A (including 5 Ra's, 1 Ua, 4 ringed nestlings and 4 Uy's), B (2 Ua's and 2 Uy's), C (4 Ra's, 2 Ua's and 4 Uy's), D (6 Ua's and 4 Uy's), E (4 Ra's, 4 Ua's and 4 Uy's), F (2 Ra's, 4 Ua's and 3 Uy's) and G (2 Ra's, 4 Ua's and 2 Uy's). The average group size was 5.7 (± 1.8 SD). The sex ratios of group members were even in Group A and biased toward males in Group C (4 males and 2 females), but the ratios of the remaining five groups were unknown because not all of the members could be captured.

The distributions of group home-ranges were concentrated on the summit area being 2,480 -2,702 m alt. (Fig. 1). During the study period, June, the greater part of the summit area was covered with deep snow and snow free areas, e. g. rocky slopes and rocky deserts sparsely populated by the Dwarf Pine *Pinus pumila*, were patchily distributed. Alpine Accentors were found mainly on the snow surfaces. The home ranges were spaced out, except for those of Groups C and E

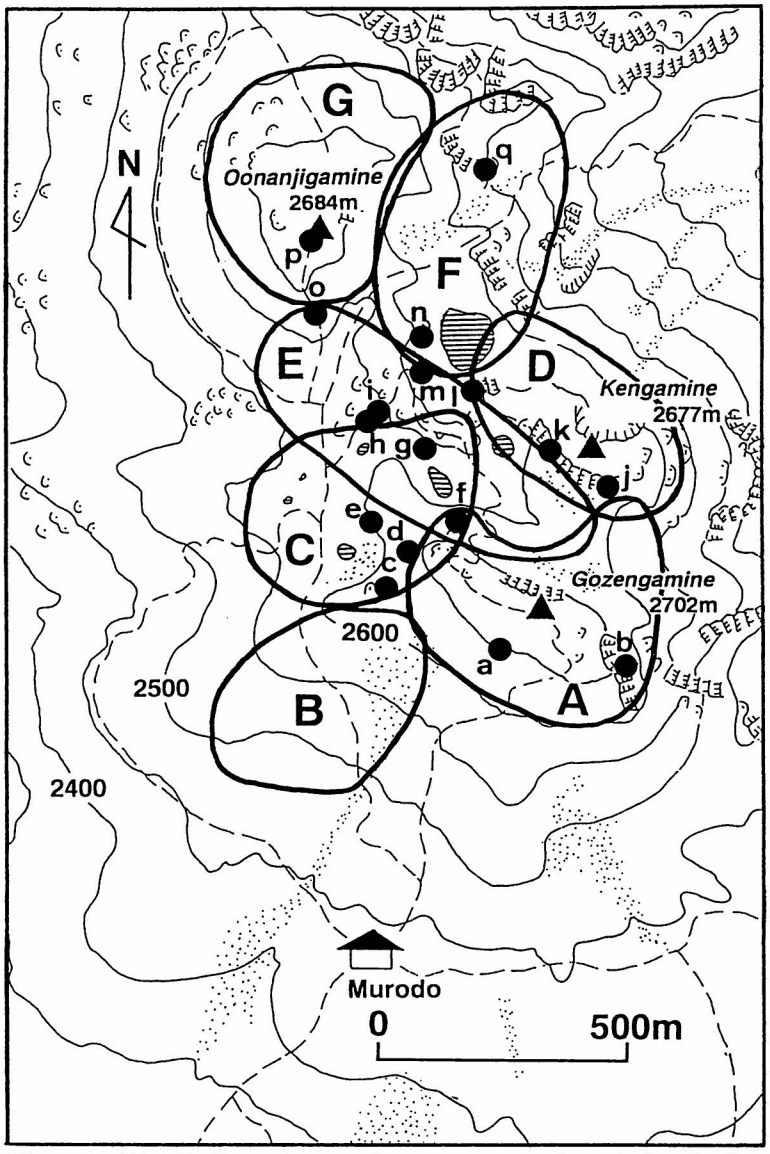

Figure 1. **Distribution of group home-ranges and nest sites in the intensive study area.**
Capital letters indicate group names. Nest sites are shown by solid circles with small letters. Dotted lines indicate mountain roads and solid lines with figures show contour lines (m alt.). Hatched and dotted areas indicate ponds and snow-patch bare grounds, respectively.

(Fig. 1). This was because some members of Group C sometimes used the feeder set within the home range of Group E.

We found 17 nests (from Nests a to q) in the intensive study area (Fig 1). They were built in crevices in cliffs or rocks, or between boulders. Three of the 17 nests contained nestlings, but the remaining 14 nests were old. Within Alpine Accentor groups, cooperative polygynandry is common; females copulate frequently with several male members and the males help to feed the chicks of several females with whom they have copulated (Nakamura 1990; Davies et al. 1995). Two ringed males helped to feed four nestlings of a ringed female at Nest a. At two nests (l and m), at least one adult fed two nestlings of each nest but none were ringed. In all groups, except Group B, we observed polygynandrous mating relationships between members; females solicited mating with cloaca-presenting displays (Nakamura, 1990) toward several males and the males copulated with them.

2. Surrounding mountains.

There were nine groups (Groups H-P, at least 31 adults and 5 young) on the surrounding mountains (Fig. 2): Groups H (4 Ua's), I (4 Ua's and 2 Uy's), J (4 Ua's and 2 Uy's), K (2 Ua's and 1 Uy), L (5 Ua's), M (2 Ua's), N (2 Ua's), O (6 Ua's) and P (2 Ua's). Groups H, I and J were distributed in the alpine zone, but the remaining six groups were patchily distributed in the subalpine zone (2,000m to 2,400 m alt., see Fig. 2). This zone contained snowbanks and rocky slopes populated by the Erman's Birch *Betula ermanii* and the Maries's Fir *Abies mariesii*. Elevated peaks and ridges are among the windiest environments and the snow is redistributed by the wind in the alpine and subalpine areas. The accumulation of this windblown snow on the lee slopes of crests creates or maintains snowbanks. The snowbanks in the subalpine zone did not melt even in August. The areas where we found Alpine Accentors always contained large snowbanks and rocky slopes. The birds foraged for insects mainly on the snow surfaces.

The average group size in the surrounding mountains (3.4±1.5) was significantly smaller than that in the intensive study area (Mann-Whitney U-test, $U_{9,7}$= 9.5, $P<0.05$). In the whole area of Hakusan mountain range, the sizes of the groups distributed in the alpine zone (5.2± 1.7, n=10) were larger than those in the subalpine zone (3.2 ± 1.8, n=6, $U_{10,6}$=12.5, $P<0.05$). Group L was found in the subalpine zone on 5 June 1995, but not thereafter. Group P was found by Ueuma in 1987 and the group size was seven, but only two birds from that group were recorded in this study. Ueuma also found Groups Q (3 Ua's) and R (2 Ua's) in 1987, and S (1 Ua and 2 Ua's) in 1983, and T (6 Ua's) in 1972. However, we did not confirm these groups in this study.

DISCUSSION

In this study, we confirmed 16 groups including 71 adults in the Hakusan mountain range: seven groups including 40 adults in the summit area and nine groups including at least 31 adults on the surrounding mountains. They were distributed in areas between 2,000m and 2,702m alt. (see also Ohsako & Nakai, 1997).

Alpine Accentors are usually distributed in several mountains with altitudes of greater than 2,400m in central Honshu, Japan (Kankyocho, 1981). The only other mountain in Japan on which Alpine Accentor populations have been studied in detail is Mt. Norikura. On this mountain, 14 groups including 90-100 adults were distributed over areas of 2,650-3,027 m alt., but no group was found in the subalpine zone (Nakamura 1990, 1995). Thus, it is interesting that Alpine Accentors in the Hakusan mountain range were recorded even in the subalpine zone. The altitude of the subalpine zone on Mt. Hakusan area (about 1,700-2,400 m) does not differ greatly from that on other mountains. However, Mt. Hakusan area has much snow in winter due to the air mass modification over the Japan Sea during the outbreak of the cold air mass from

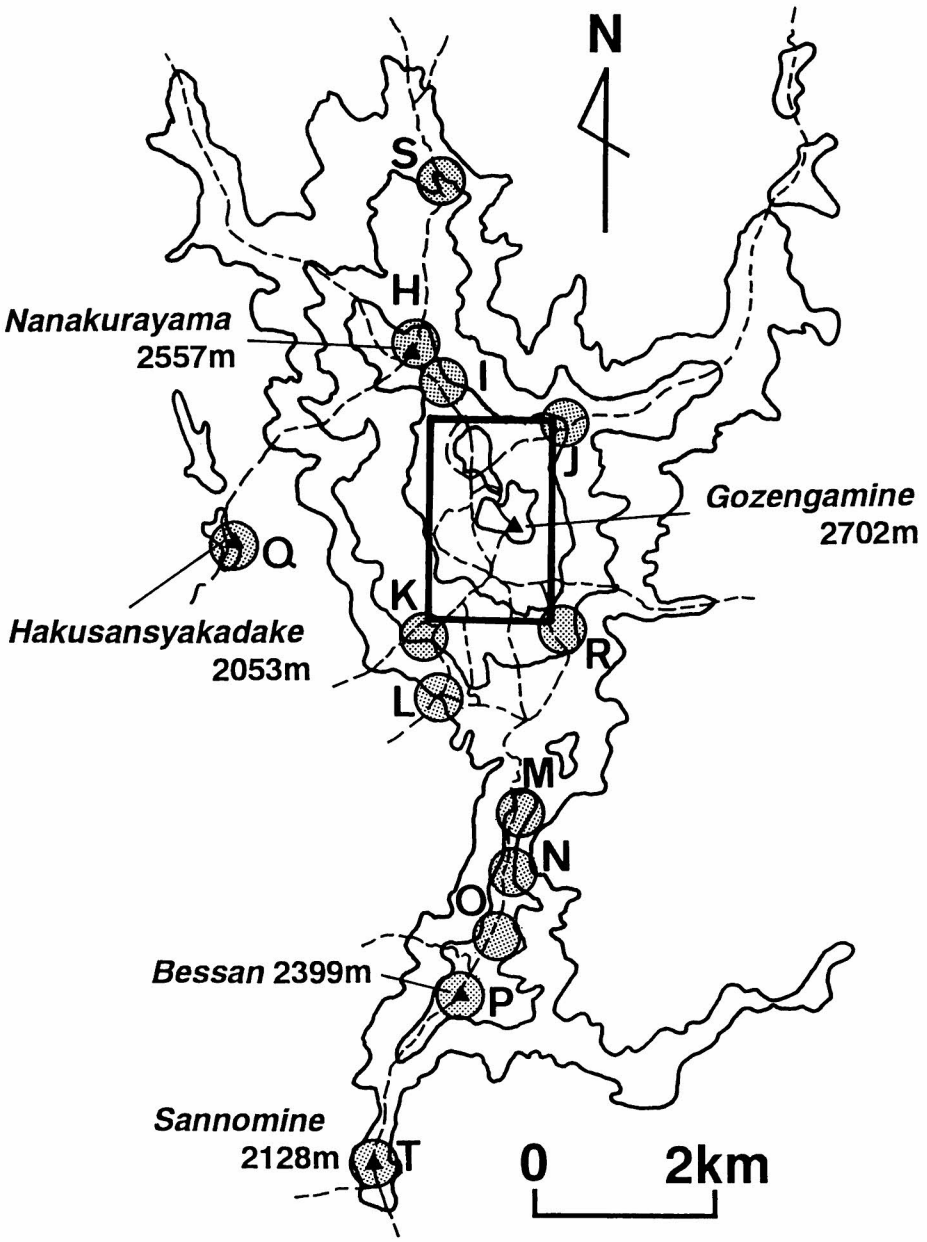

Figure 2. **Distribution of groups confirmed in the Hakusan mountain range being above 2,000m alt.** Positions of groups are shown by shaded circles. Capital letters indicate group names. Dotted lines indicate mountain roads and solid lines show contour lines at intervals of 200m. A rectangle indicates the intensive study area.

eastern Siberia across the Japan Sea into Honshu Island. Consequently, the snow remains as snowbanks until summer even in the subalpine zone on Mt. Hakusan.

It is known that snow surfaces on high mountains entrap many arthropods originating from lowland populations often several kilometers distant, which arrive as a result of 'fall-out' after being brought there by wind (Edwards, 1987). On Mt. Hakusan, many aerially dispersing insects (particularly aphids) are found on the surfaces of the snowbanks in the alpine and subalpine areas (Togashi, 1982), and Alpine Accentors feed on these fallout insects (Nakamura & Ueuma, 1996). Snowbanks and abundant insects on the snow surfaces, therefore, seem to

be important factors allowing Alpine Accentors to inhabit the subalpine zone. Furthermore, the subalpine zone of Mt. Hakusan area may be suitable for Alpine Accentors because this zone includes alpine environments due to many rocky slopes and poor development of coniferous forests. However, the subalpine zone might be less suitable habitat than the alpine zone because snowbanks in the subalpine zone were smaller than those in the alpine zone and the snow thawed rapidly as the breeding season progressed (Nakamura & Ueuma, 1996). This may be the reason why the sizes of the groups distributed in the subalpine zone were smaller than those in the alpine zone.

A part of insects occur in the alpine zone, but most of them are brought by upward air currents from the lower part of subalpine zone and lowland (Togashi 1982; Nakamura & Ueuma, 1996). Thus, in order to conserve Alpine Accentors in the Hakusan mountain range, we should preserve not only the alpine zone, but also the subalpine zone and lowland of this mountain.

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* Titles are translated into English by the authors.

和文抄録

白山はイワヒバリの繁殖分布の西限に位置し，独立山塊であるため近隣の繁殖地から隔離されている。また，本種の主な生息地である山頂部の面積は，他の山岳に比べて極端に狭い。更に登山者による室堂や山頂部の集中利用により，山頂部の特に登山道沿いの植生破壊が進み，個体数の減少が懸念されている。白山山系で繁殖するイワヒバリ個体群の保護の基礎資料とするため，1993－1996年の繁殖期に山頂部とその周辺山岳において本種の分布と個体数を調査した。

山頂部には精密調査区を設定し，無双網とかすみ網により成鳥17羽（雄12，雌５個体）を捕獲し，足環により個体識別した。精密調査区では，識別個体の行動から群れ数，群れサイズと行動圏を調査するとともに巣の発見につとめた。周辺山岳では，標高2,000m以上に存在するすべての登山道を一回以上歩き，発見できた群れのサイズと位置を地図上に記録した。

山頂部では７群40個体（成鳥）の生息と17巣を確認した。17巣中14巣は古巣だった。繁殖が確認できた３巣のうち１巣では識別した雌１羽と雄２羽が４羽の雛に給餌し，残り２巣では少なくとも１個体の未識別成鳥がそれぞれの巣で２羽の雛に給餌していた。周辺山岳では少なくとも９群31個体（成鳥）を確認した。山頂部では，標高2,480－2,702mの高山帯に行動圏と巣が集中する一方，周辺山岳では残雪が８月まで残る標高2,000－2,400mの亜高山帯にも分布していた。群れサイズは，高山帯より亜高山帯に分布する群れのほうが小さかった。高山帯・亜高山帯ともイワヒバリが発見された場所には広い残雪と岩場があり，個体は主に残雪の上で採食していた。

白山山系では高山帯だけでなく亜高山帯上部でもイワヒバリの生息が確認された。日本海側山地の特性として，白山では冬期に降る多量の雪が，発達した針葉樹林を欠く亜高山帯上部の斜面に，雪渓として夏期まで残る。さらに白山の高山帯・亜高山帯の残雪上には，高山帯で発生した昆虫以外に低山や亜高山帯下部から上昇気流で吹き上げられた昆虫類が多量に存在し，これらは本種の重要な食糧源となっている。白山のイワヒバリが亜高山帯上部でも生息できる要因として，豊富な残雪と残雪上に吹き上げられた多量の昆虫類や，亜高山帯における高山的環境が重要と考えた。白山山系に生息するイワヒバリを保護するためには，生息地となる高山帯・亜高山帯上部だけでなく，上昇気流で吹き上げられる昆虫類の供給源である亜高山帯下部から低山を含む山域全体の自然保護が必要と考えた。