Age Determination of the Hazel Grouse Based on Skull Pneumatization

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Skull pneumatization was examined in relation to actual age for 37 known-age Hazel Grouse *Bonasa bonasia* raised in an aviary. Although pneumatization advanced with increasing age, unpneumatized areas (UPA) were present on the cranial roof even in old adult birds. Five indices indicating the size of UPA, i. e. 1) length of UPA, 2) width of UPA, 3) length of UPA $\times$ width of UPA, 4) length of UPA/total length of skull, and 5) width of UPA/greatest width of skull, were examined. Of the five indices, the fifth index was a reliable criterion for separating first-year birds of 4–8 months of age from older birds of ≥ 15 months of age; the index value was 0.158 to 0.306 for the former and 0.063 to 0.145 for the latter. The value for separation is 0.15. This criterion was adopted to determine the age of Hazel Grouse killed during hunting seasons from 1 October to 31 January in Hokkaido, Japan. Of 49 birds examined, first-year and older birds accounted for 77 and 23% respectively.

Key words: Hazel Grouse, *Bonasa bonasia*, Skull, Pneumatization, Age determination

Age determination of wildlife is an important aspect of research in wildlife ecology. In the Hazel Grouse *Bonasa bonasia*, age may be determined by the number of white bars on the 9th primary (GAIDAR & ZHITKOV 1974), the width of the beige border at the tip of the innermost primary (STENMAN & HELMINEN 1974), or the layered structure of the mandible (MITANI & FUJIMAKI 1992). However, the spotting pattern on the 9th primary is not always a reliable criterion for age determination of the species because there are geographical variations in the spotting pattern of primary feathers (BONCZAR & SWENSON 1992). MITANI & FUJIMAKI's (1992) method requires complicated techniques and more time than other methods.

Skull pneumatization of the Hazel Grouse advances with increasing age, although the skull did not completely pneumatize and non-aerated areas were always present on the cranial roof even in old adult birds (WINKLER 1979). During the hunting season from 1 October to 31 January in Hokkaido, Japan, first-year birds are 4 to 7 months of age, and others are more than 15 months of age, because chicks hatch in early and mid-June (HAGA & TAKAMATA 1986). The objectives of this study is to examine the reliability of the size of unpneumatized areas (UPA) on the cranial roof as a criterion for separating birds less than 8 months of age from those 15 months of age and more and to determine the age of birds killed during the hunting seasons in Hokkaido.

Fig. 1. Measurements of the Hazel Grouse skull. TL=total length, GW=greatest width, AL=length of unpneumatized area, AW=width of unpneumatized area.

MATERIALS AND METHODS

Samples consisted of 37 known-age birds raised in an aviary and 49 wild birds killed during the hunting seasons of 1991/92 and 1992/93 in Hokkaido. The captive birds were raised under the same temperatures as natural conditions and were fed on a diet for young birds (SASAKA & FUJIMAKI 1990) until mid-September of the first year and then on a diet composed of pet food, hen feed, fish meal and vegetables (FUJIMAKI *et al.* 1994). The ages of captive birds ranged from 1 month to 5 years.

All skulls were thoroughly cleaned and were bleached in 10% hydrogen peroxide liquid for 5 to 10 minutes and then dried in the shade. Four cranial measurements were taken to the nearest length of 0.1 mm with digital calipers for each specimen: total length (TL) and greatest width (GW) of the skull, and lengths (AL) and greatest width (AW) of the right and left UPA (Fig. 1). When measurements of UPA were made, each skull was illuminated from bottom. Skulls have separate UPA on either side of the pneumatized areas adjacent to the median line. Although there were no skulls showing conspicuous asymmetry in non-aerated areas, the means of two AL and two AW were designated as the representative value of AL and AW respectively. The reliability of five indices indicating the size of UPA, AL, AW, $AL \times AW$, AL/TL and AW/GW , were examined in relation to actual age.

Mann-Whitney's U or Kruskal-Wallis tests were used to compare means between different age classes. Throughout the paper, means are presented with their standard deviations.

RESULTS

Data for both sexes were combined because of the small numbers of birds, 2 to 5, in each class. The mean TL and GW increased significantly from 42.3 ± 2.5 mm ($n=5$) and 19.8 ± 1.1 mm at 1 month of age to 51.7 ± 0.7 mm ($n=6$) and $23.1 \pm 1.$

1 mm at 4–5 months of age, respectively ($H=11.142$ for TL, $H=11.328$ for GW, $P<0.01$). The mean TL and GW at 4–5 months of age did not differ from those at 8–10 (51.8 ± 1.4 and 23.0 ± 1.4 , $n=6$) and ≥ 12 months of age (52.4 ± 0.8 and 23.9 ± 0.5 , $n=11$, $H=2.755$ for TL, $H=4.835$ for GW, $P>0.2$). These facts indicate that TL and GW of young birds attained adult size by 4 months of age.

The mean AL was 9.1 ± 0.7 mm ($n=5$) at 1 month of age, and it decreased gradually after that with fairly large individual variations to 5.9 ± 1.7 mm ($n=5$) at ≥ 24 months of age (Fig. 2). The mean AL/TL also showed a similar decrease with age, changing from 0.217 ± 0.025 ($n=5$) at 1 month of age to 0.112 ± 0.032 ($n=5$) at ≥ 24 months of age (Fig. 3). The mean AL $\times$ AW decreased from 71.5 ± 7.4 ($n=5$) at 1 month of age to 31.6 ± 6.8 ($n=4$) at 5 months of age, and then decreased slightly to 17.0 ± 7.6 ($n=5$) at ≥ 24 months of age (Fig. 2). The mean

Fig. 2. Variations of three indices (AL, AW, and AL $\times$ AW) indicating the size of unpneumatized area in relation to actual age. Sample sizes for each age class are indicated above the vertical bars.

AW and AW/GW decreased from 7.8 ± 0.3 mm ($n=5$) and 0.395 ± 0.031 ($n=5$) respectively at 1 month of age to 2.6 ± 0.7 mm ($n=5$) and 0.115 ± 0.032 ($n=5$) at 9–10 months of age, after which the values did not show apparent change (Figs. 2 and 3).

Comparing five indices between two age classes, 4–8 and ≥ 15 months of age, because birds at these age are killed during hunting seasons in Hokkaido, there were significant differences in AW, $AL \times AW$ and AW/GW between two age classes (Table 1). However, AW ranged from 3.4 to 7.2 mm in the former age class and from 2.0 to 3.4 mm in the latter, overlapping partly between two age classes.

Fig. 3. Variations of two indices (AL/TL and AW/GW) indicating the size of unpneumatized area in relation to actual age. Sample sizes for each age class are indicated above the vertical bars.

Table 1. Comparison of five indices of unpneumatized areas on cranial roof between two age classes of Hazel Grouse

Age in months					
Indices		4-8		≥15	
AL	n=8	7.6±0.9	n=7	6.2±1.7	U=15.0, P>0.05
AW	n=8	4.7±1.3	n=7	2.9±0.5	U=2.0, P<0.01
AL×AW	n=8	35.8±11.9	n=7	18.7±7.7	U=4.0, P<0.01
AL/TL	n=8	0.145±0.017	n=7	0.120±0.032	U=16.0, P>0.05
AW/GW	n=8	0.203±0.054	n=7	0.121±0.023	U=0, P<0.01

Fig. 4. UPA-size distribution of the Hazel Grouse killed between October and January, 1991/92 and 1992/93, in Hokkaido, Japan. 1=birds less than 8 months old, 2=birds over 14 months old.

AL $\times$ AW value also overlapped between two age classes, ranging from 12.1 to 14.9 in the former and 7.1 to 15.4 in the latter. On the other hand, AW/GW values did not overlap between two age classes, ranging from 0.158 to 0.306 in the former and from 0.063 to 0.145 in the latter. Of five indices, AW/GW is the most reliable criterion for separating young birds from older ones, the value for separation being 0.15.

AW/GW of 49 wild birds killed between 1 October and 31 January ranged from 0.07 to 0.418. When 0.15 was used as a criterion, 33 birds (67%) were designated as first-year birds, having 0.197–0.418 of AW/GW, and 16 birds were older birds, having 0.07–0.148 of AW/GW. AW/GW values were in the ranges of 0.26–0.41 for the great majority of first-year birds and 0.11–0.15 for older ones (Fig. 4).

DISCUSSION

The Hazel Grouse grows up adults size by the end of September (SEMENOV-TYAN-SHANSKII 1959, GAVRIN 1969, SASAOKA *et al.* 1990). Skull size also attains adult one by this time. However, the unpneumatized area on the cranial roof continues to decrease in size by 9 to 10 months of age. If the birds less than 8 months of age are distinguished from older ones by the indices examined, these indices are accepted as a criterion for sorting out the first-year birds killed during hunting seasons from older ones.

Five indices showing the size of UPA were examined in relation to actual age. Of them, AL and AL/TL were not suitable for separating the first-year birds because these values decreased gradually up to 24 months of age. AL $\times$ AW and AW values decreased to 9 months of age and then remained rather constant, and there were significant differences in the means for birds of 4–8 and ≥ 15 months of age. However, these two indices were also not appropriate for separating the first-year birds because of overlap in values between two age classes. Of the five indices, the AW/GW value can be used as a reliable criterion in determining the age of the

Hazel Grouse.

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た。育雛期間を通して日中の給餌とくに集中した時間帯は見られなかった。育雛後期のヒナに対する餌動物をビデオ装置による記録 ($n=802$) から同定したところ、鱗翅目幼虫がもっとも多く、ついでクモ類、双翅目成虫の順となった。

巣内および巣立ち後のヒナについて、体重およびふ蹠長について計測を行ったところ、ふ蹠長の発達はかなり早く、巣立ち日ですでに成鳥の98.9%に達していた。

ヤブサメの育雛期には突然つがい雄 (α 雄) とは異なる雄 (β もしくは γ 雄) が出現することが OHARA & YAMAGISHI (1984, 1985) によってすでに報告されているが、筆者らの育雛期を観察できた25巣のうち、12巣 (48.1%) でもやはり β もしくは γ 雄の出現が確認された。 α 雄は一般に育雛期間にはさえずらず、ヒナへの給餌のみを行ったが、 β 雄は育雛前期に出現すると、ヒナの巣立ちまで巣の近くでさかんにさえずった。また時折り、つがい以外の侵入個体を攻撃したり、ヒナへ給餌をするのも観察された。さらに、つがい雄への攻撃を行うものも見られた。しかし、 β 雄の行動に対してつがいはほとんど直接的な攻撃もしくは防衛行動を示さなかった。 α 雄はヒナの巣立ちと同時に、再びソングエリア内をさかんにさえずりながら、巣立ちヒナへの給餌を行い、頻繁に雌とともに行動した。これは α 雄による2回目の繁殖への受精可能期を迎えた雌の防衛行動であると思われた。繁殖初期から観察できた28巣のうち、一羽でも巣立ちできた巣は21 (75.0%) とかなり繁殖成功率は高かった。

自分の巣が抱卵中に、巣とかなり離れた場所で捕獲された雄が11例記録された。これは、遠出をすることにより侵入先での雌とつがい外交尾を成功させるための戦略と思われたが、侵入した縄張り内での雌が受精可能期にあるものはわずかに36.4%であった。したがって、遠出をする雄は、自分の巣の抱卵期に隣接する巣の雌の繁殖状態を単にモニターしているものと思われた。調査期間中に5つがいが、同じペアで一繁殖期に2回の繁殖を成功させたが、1回目と異なるつがい相手を見つけた例はなかった。育雛期間中につがい以外の雄が頻繁に現れるにもかかわらず、一繁殖期間内における離婚率がかなり低いことは、1回目の繁殖を成功させたことが、雌に同じ雄を2回目も選択させたものと思われた。また、本調査地におけるヤブサメの高い繁殖成功率は、餌量が豊富なことと捕食率が低いことが原因と思われた。今後は繁殖成功率の低下した場合における、繁殖システムに変化が起きるかどうかについて追求する必要がある。

頭骨含気化状況にもとづくエゾライチョウの齢査定

(Age Determination of Hazel Grouse Based on Skull
Pneumatization. 45: 17-22)

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エゾライチョウ *Bonasa bonasia* の齢査定法としては初列風切羽9番目の暗色縞の数、初列風切羽1番目の先端部のベージュ色の幅、下顎骨に見られる層構造の数による方法がある。しかし、前2方法で用いられる形質には地理変異があり、必ずしもよい齢査定の基準とはいえず、下顎骨を用いる方法は手数がかかる。エゾライチョウの頭頂の未含気化部は成鳥になっても消失することはなく、成長するとともに小さくなる。この部分の大きさが齢査定の基準として有効かどうかを、飼育で齢の明らかな37羽 (1か月齢～5年齢) を用いて検討し、その結果を1991/92, 1992/93の狩猟期に捕獲された49羽に適用してみた。

計測部位は頭骨全長 (TL)、頭骨最大幅 (GW)、未含気化部の長さ (AL) と幅 (AW) の4か所

である。未含気化部の大きさの指標として、AL, AW, ALXAW, AL/TL, AW/GWの5つの値を用い、これらと実際の齢との関連を調べた。

TL と GW の平均値は1か月齢のそれぞれ 42.3 ± 2.5 ($n=5$, 平均値 $\pm$ SD, 以下同様), 19.8 ± 1.1 mm から 4-5 か月齢の 51.7 ± 0.7 ($n=6$), 23.1 ± 1.1 mm に増加したが, その後は 8-10 か月齢で 51.8 ± 1.4 と 23.0 ± 1.4 mm ($n=6$), ≥ 12 か月齢で 52.4 ± 0.8 と 23.9 ± 0.5 mm ($n=11$) で, 頭骨の大きさは4か月齢で成鳥の大きさに達した。

AL の平均値は1か月齢で 9.1 ± 0.7 mm で, その後徐々に減少し, ≥ 24 か月齢で 5.9 ± 1.7 mm となった。AL/TL の平均値も1か月齢の 0.217 ± 0.025 から ≥ 24 か月齢の $0.112 \pm 0.032\%$ に変化し, AL と同じような減少のしかたを示した。ALXAW の平均値は1か月齢の 71.5 ± 7.4 ($n=5$) から 5 か月齢の 31.6 ± 6.8 ($n=4$) に減少したが, その後は ≥ 24 か月齢の 17.0 ± 7.6 ($n=5$) に徐々に減少した。AW と AL/GW の平均値は1か月齢のそれぞれ 7.8 ± 0.3 mm, $0.395 \pm 0.031\%$ から 9~10か月齢の 2.6 ± 0.7 mm, 0.115 ± 0.032 に変化し, それ以後には大きな変化は見られなかった。

エゾライチョウは6月に孵化するが, 北海道におけるエゾライチョウの狩猟期は10月1日~1月31日なので, 狩猟で捕獲される個体で, 1年未満のものでは4~7か月齢, 1年以上のものはすでに15か月齢以上である。そのため, 上述の5つの指標でこれらの2つの齢群を区分できるかどうかを検討した。ただし, 7か月齢の個体がいなかったため, 若齢群を4~8か月齢とした。4~8か月齢と ≥ 15 か月齢との間で5つの指標を比較すると, AW, ALXAW, AW/GW の3指標の平均値には有意な差が認められた。しかし, AW と AL $\times$ AW は2つの齢群の間でそれぞれ一部重複するため, 指標としては不適である。AW/GW の平均値は2つの齢群の間で有意な差が認められ, 範囲も若齢群で $0.158 \sim 0.306$, 成鳥群で $0.063 \sim 0.145$ で重複しなかった。これらの結果から, 4-8か月齢と ≥ 15 か月齢とを区分するのに適切な指標は, AW/GW で, 区分する基準値は 0.15% とできる。

この方法を, 狩猟で捕獲された49羽に適用したところ, 33羽 (67%) が1年未満, 16羽 (33%) が1年以上の個体であった。

1 シーズンに多回繁殖するヒメアマツバメの産卵タイミング

(Timing of Laying in Multiple-brooded Little Swifts
Apus affinis. 45 : 23-30)

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温帯に生息する多くの鳥類種で, より早く営巣する個体ほど1年に多く繁殖を試み, 多くのヒナを育てることが知られている。日本中部に周年生息するヒメアマツバメ (*Apus affinis*) は, 4月から12月にかけて2回から3回繁殖する。ヒメアマツバメは気象条件に著しく影響を受ける飛翔性昆虫を餌としている。ヒメアマツバメの産卵日と産卵以前の気象条件との関係について調査した。

調査は, 1986年から1989年まで, 静岡県清水市有度山にあるコロニーで行った。営巣ペア数は, 28 (1986), 30 (1987), 38 (1988), 49 (1989) であった。1981年よりほとんどすべての成鳥と幼鳥に足環を着け, 1985年よりすべての巣内ヒナに足環を着けた。初列風切や尾羽における換羽や摩耗の程度から, 足環のない個体の年齢を査定した。成鳥は2歳と3歳以上に分けた。気象データは, 調査コロ

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