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AGE DETERMINATION OF THE AZURE-WINGED MAGPIE, *CYANOPICA CYANA* (AVES) BY MOULT PATTERNS OF ALULAE, SOME WING-COVERTS AND RECTRICES

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ABSTRACT. - Methods of age determination by plumage were studied of the Azure-winged Magpie (*Cyanopica cyana*) in central Japan. I marked 186 nestlings and subsequently recaptured eight juveniles before starting their postjuvenile moult, 20 subadults from the postjuvenile moult to the first postnuptial moult, and 14 adults after the completion of the first and subsequent postnuptial moults. Data include six other adults which underwent two or more postnuptial moults after their first capture. I examined alulae, greater primary and secondary coverts, and rectrices on both left and right sides. Through the postjuvenile moult, all subadults retained juvenile greater primary coverts and rectrices, but 11 of all subadults replaced all juvenile feathers of the alulae and greater secondary coverts with adult-like feathers. The magpies attained full adult plumage in the first postnuptial moult. Greater primary coverts and rectrices provide useful criteria to determine age. Furthermore, the number of replaced alula feathers, greater secondary coverts and rectrices in subadults correlated negatively with hatching dates. Thus age in months or less can be determined by the extent of moult in subadults.

KEY WORDS. - Age determination, Azure-winged Magpie, *Cyanopica cyana*, hatching date, postjuvenile moult.

INTRODUCTION

Many studies have been conducted to determine age of birds using the plumage (Ginn & Melville, 1983; Svensson, 1992). The Azure-winged Magpie (*Cyanopica cyana*) is a group-living bird that is resident in Japan (Hosono, 1989). In the course of a study of social organization of the magpies, I investigated moult patterns of the birds of known age to find methods for determining age by their plumage.

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Postjuvenile moult usually provides a useful method of separating age classes in birds (Ginn & Melville, 1983). In corvids, postjuvenile moult is partial; body feathers, some wing-coverts and sometimes some inner secondaries and rectrices are replaced (Pitelka, 1945; Seel, 1976; Bancroft & Woolfenden, 1982; Ginn & Melville, 1983; Goodwin, 1986). In postjuvenile moult of the Azure-winged Magpies, two central rectrices and inner secondaries are replaced (Stegmann, 1931). Juveniles of the magpies usually moult all their feathers except for primaries, secondaries, greater primary coverts and rectrices, but some juveniles moult several rectrices (Yamashina, 1934). Cruz et al. (1991, 1992) reported the extent of postjuvenile moult and its sexual dimorphism in the Iberian subspecies *C. c. cooki* Svensson (1992) also presented methods of aging the magpies based on colour and white tips of all wing coverts and rectrices. I examined alulae, greater secondary coverts, greater primary coverts and rectrices of the magpies of known age, and obtained satisfactory results that greater primary coverts and rectrices provide useful criteria to determine their age.

It has been suggested that hatching date is one of the factors affecting variation in the extent of postjuvenile moult (Newton, 1966; Bell, 1970; Dhondt, 1973; Baillie & Swann, 1980; Shmutz & Hoffman, 1991). Nevertheless, no study has been done on the relationship between the extent of postjuvenile moult and hatching dates of individual birds. If the extent of postjuvenile moult is related to hatching date, we can estimate hatching date by the extent of postjuvenile moult and can determine age much more precisely.

MATERIALS AND METHODS

The study was conducted at Azumino (36° 18'N, 137° 52'E), Nagano Prefecture in central Japan, on the population previously studied by Yamagishi (1986) and Yamagishi & Fujioka (1986). Out of 186 nestlings marked in the nest during four breeding seasons from 1986 to 1989, 36 birds were recaptured at least once. My data include six other birds, the exact age of which could not be determined when they were first captured, but which were known to be beyond two postnuptial moults when they were recaptured. Juveniles were caught in August and September. The older birds were caught from November to the following June, mainly in March and April, after completion of their autumn moults. Thus, most birds were examined at about six months after completion of their autumn moults. Birds were caught with clap nets (see Bub, 1978) or mist nets.

Hatching dates of the nestlings were estimated from the laying date of the first egg, adding one day for each egg in the clutch and 15 days for incubation, or by aging nestlings in appearance (Hosono, 1966, 1971). The nestlings that were marked during the breeding seasons were all found to have hatched between 1 June and 1 September.

I examined the alulae, (upper) greater secondary coverts and (upper) greater primary coverts on both left and right wings, and rectrices of each individual. Differences in colour and presence or absence of juvenal and adult feathers on these tracts were recorded. The outermost feather of greater primary coverts was so small that colour and moult of the feather could not be examined. Carpal coverts were not examined. I used "Naturalist's Colour Guide" (Smithe, 1974, 1981) to describe colour of feathers. In this paper, the colour name and colour number are given in parentheses.

RESULTS

AGE CLASSES. - Three age classes were distinguished by plumage: juveniles, subadults from postjuvenile moult to the first postnuptial moult (i.e., first-year birds) and adults after the first postnuptial moult (i.e., second-year birds and older). In Azure-winged Magpies, no prenuptial moult was observed. Eight juveniles, 20 subadults and 20 adults were examined. Subadults consisted of birds from six to 12 months old. Adults included 11 second-year birds, two third-year birds, and one fourth-year bird, and also included three birds that had undergone at least two postnuptial moults, one bird that had undergone at least three postnuptial moults, and two birds that had undergone at least four postnuptial moults after their first capture. Because no difference in plumage was found between the second-year and the older birds, these birds were pooled as adults.

JUVENILES. - The alulae consist of three feathers on each wing. The shortest feather and inner vanes of the longest two feathers were brownish gray (Drab, Colour 27) or gray (Dark Natural Gray, Colour 83), not bluish (Fig. 1-i-J). Only outer vanes of the longest two feathers were bluish gray (Light Sky Blue, Colour 168D). All alula feathers of juveniles had narrow white tips (1-2 mm wide).

The greater secondary coverts consist of 10 feathers on each wing. The feathers were brownish gray or gray, but not bluish. All of the feathers had buff or white tips in 2-3 mm width (Fig. 1-ii-J).

The greater primary coverts consist of 10 feathers on each wing. The outermost feather was so small that the colour and moult could not be examined. Colour of greater primary coverts was the same as the longest two feathers of the alulae; the outer vanes were bluish gray, but the inner vanes were gray, not bluish. All of the feathers had very narrow white tips, at maximum 1 mm wide (Fig. 1-iii-J).

The rectrices consist of six pairs of feathers. The first (central) rectrices were relatively narrow, short and loosely textured. The second rectrices were the longest (Fig.1-iv-J). The colour of all rectrices was bluish gray. Clear difference of colour was not found among age classes. All rectrices had white tips, though white tips on the first rectrices were not so clear. The width of the white tips was 2-3 mm in the first rectrices, and about 5 mm in the other five outer rectrices. The tips of all rectrices except for the central pair were relatively pointed.

SUBADULTS. - Newly replaced alula feathers were sky blue (Sky Blue, Colour 66) on both vanes, without white tips. The feathers could not be distinguished from those of adults. Old feathers had white tips, though the white tips were very narrow, possibly because of abrasion (Fig. 1-i-S). Colour of the old feathers was the same as those of juveniles. Early-hatched birds replaced more alula feathers than later-hatched birds (Fig. 2-i). All of the 11 subadults which hatched in June replaced all feathers with new feathers. All subadults which hatched in August had all of the old feathers with white tips. The other birds, which hatched in July, replaced none of the feather, or the shortest one or two of the feathers on each wing. The number of replaced alula feathers correlated significantly with their hatching dates (Kendall's coefficient of rank correlation, $\tau = -0.742$, $P < 0.001$, two-tailed).

Newly replaced feathers of greater secondary coverts were sky blue without buff or white tips (Fig. 1-ii-S). Old feathers had white tips. Colour of the old feathers was the same as those of juveniles. Early-hatched birds replaced more feathers of greater secondary coverts

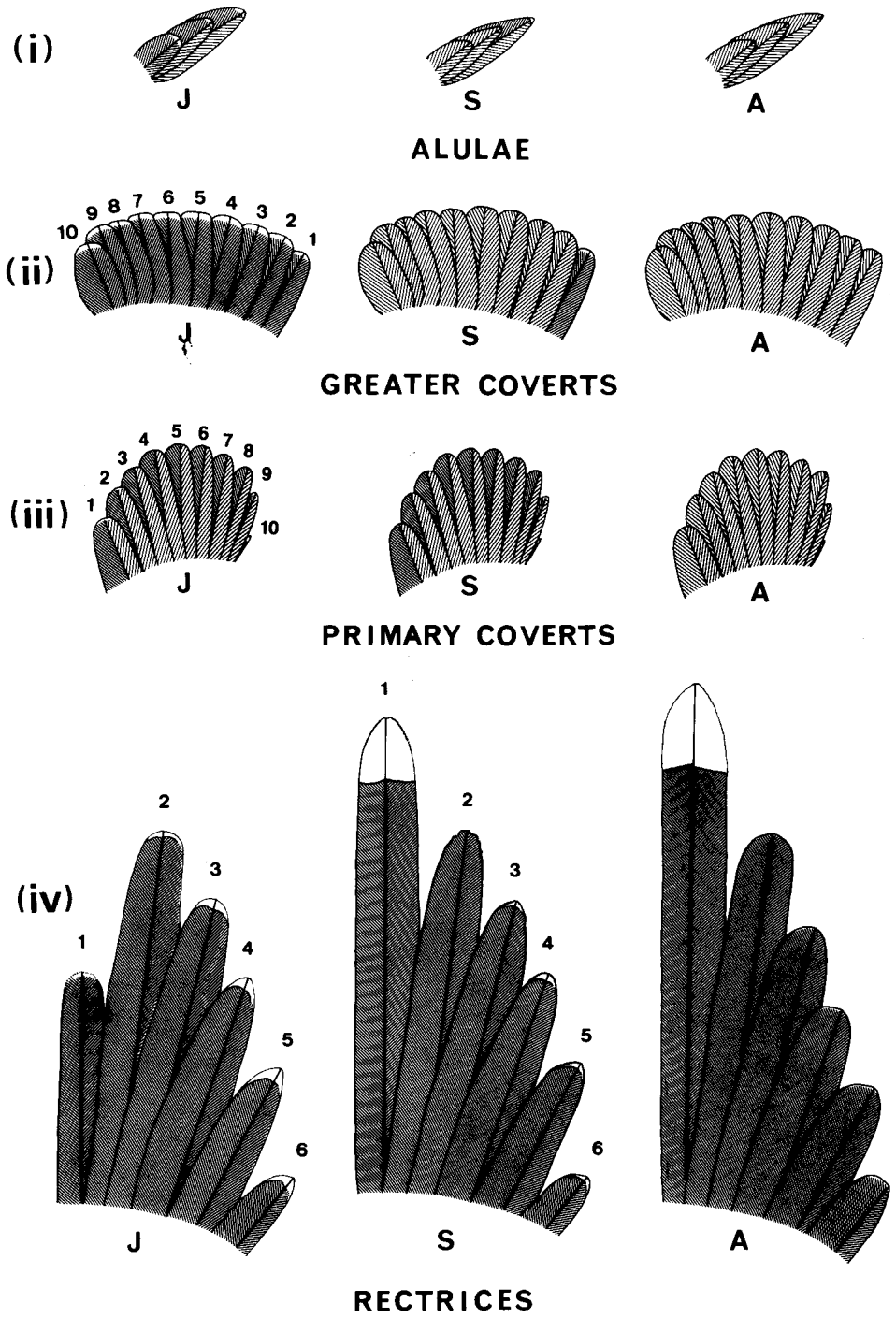

Fig. 1. Ventral views of the right half of alulae, greater (secondary) coverts, (greater) primary coverts and rectrices in three age classes of Azure-winged Magpies. J:juvenile, S:subadult, A:adult, shown by the same bird from upper to lower in each age class. The subadult, which is indicated with open circles in Fig. 2, retained juvenile feathers on the longest alula feather, the outermost greater covert, all primary coverts and five outer rectrices. The second rectrix abraded so severely that the white tip disappeared.

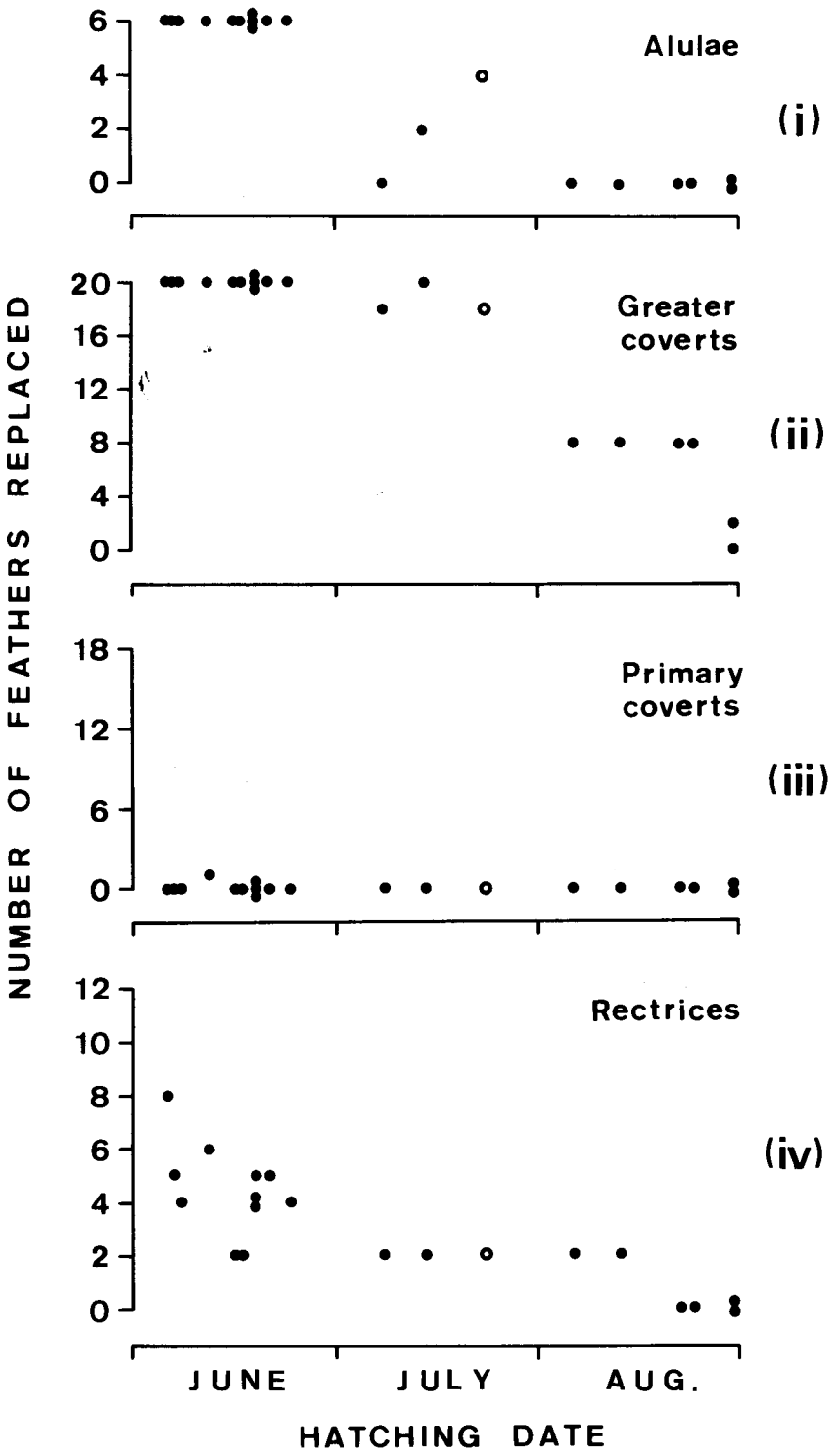

Fig. 2. Number of replaced feathers on alulae, greater (secondary) coverts, primary (secondary) coverts and rectrices of subadults and their hatching dates. Number of feathers are shown in both sides. The outermost feather of primary coverts is not counted on either side. An individual whose plumage is shown in Fig. 1 is indicated with open circles here.

than later-hatched birds (Fig. 2-ii). All of the 11 subadults that hatched in June replaced all feathers with new feathers. Subadults that hatched in August replaced less than eight feathers (four feathers on each wing). Replacement of the old feathers occurred in inner nine (2-10th), four (7-10th) or one (10th) greater secondary coverts on each wing. The number of replaced greater secondary coverts also significantly correlated with their hatching dates ($\tau = -0.773$, $P < 0.001$, two-tailed).

Colour of greater primary coverts in subadults was the same as those of juveniles. The bluish outer vanes were duller than those of adults. The white tips of the feathers were less conspicuous than those of juveniles, probably because of abrasion. Usually, a few of the inner and outer feathers were found with white tips (Fig. 1-iii-S). Out of all feathers on subadults examined, one feather, the 5th innermost feather on right wing of an individual, changed to a sky blue colour on both vanes (Fig. 2-iii). The colour was the same as one of adults. The feather appears to have been replaced accidentally because of its asymmetrical and irregular replacement.

The new central rectrices were the longest and had broad white tips, as in adults (Fig. 1-iv-S). Other new rectrices lacked a white tip, and the tips were rounded in shape but were not worn, as in adults. Old rectrices were abraded but usually retained white tips. However, no white tip was found in several inner and longer feathers, because of their heavy abrasion (Fig. 1-iv-S). These feathers had been abraded so heavily that they could be distinguished from new feathers with no abrasion. None of all eight old feathers in the central rectrices, which had had narrow white tips in juveniles, had white tips. Fourteen of 18 old second rectrices, which had been the longest in juveniles, had no white tip. Four of 35 old feathers had no white tip in third rectrices. The other old feathers had white tips.

Replacement of rectrices with new feathers proceeded symmetrically from the inner feathers outward. However, abnormal replacement of feathers occurred in five feathers of four subadults which hatched early in the season and replaced six or five feathers. The abnormal replacement included four feathers which were replaced in irregular order and asymmetrically, and included one feather which was replaced in regular order but asymmetrically. The former replacement may be due to accidental moult, although the latter possibly is not due to accidental moult. Fig. 2-iv shows the number of replaced rectrices in relation to hatching dates. Early-hatched birds replaced more rectrices than later-hatched birds. Subadults that hatched in June replaced from eight to two feathers, those that hatched in July and the first half of August two feathers and those that hatched in the second half of August no feather. The number of replaced rectrices correlated with hatching date significantly ($\tau = -0.709$, $P < 0.001$, two-tailed).

Adults. - All feathers of the alulae were sky blue on both vanes, and lacked white tips (Fig. 1-i-A). All greater secondary coverts were sky blue with no buff or white tips (Fig. 1-ii-A). All greater primary coverts were sky blue on both vanes, without distinct white tips (Fig. 1-iii-A). Some inner and outer feathers of greater primary coverts did have very narrow white tips. Central rectrices were the longest and had broad white tips (about 20 mm wide). Other rectrices had no white tips, were rounded on the tips, and usually had no abrasion, although some feathers had unclear white tips which became gradually white toward tips (Fig. 1-iv-A).

Age determination in subadults. - Subadults replaced various number of feathers on alulae, greater secondary coverts and rectrices. The number of replaced feathers was correlated

negatively with hatching date. Thus age in months can also be determined for subadults, because their hatching month can be estimated by the number of replaced feathers. The hatching season can be divided into the following four periods by combination of the number of replaced feathers on alula, greater secondary coverts and rectrices, though a few exceptions are found: (1) In June; all alula feathers and greater secondary coverts are replaced. Usually four to six, rarely two or up to eight, rectrices are replaced. (2) In July; no or some alula feathers and two rectrices are replaced. Almost all greater secondary coverts are usually replaced. (3) In the first half of August; no alulae and two rectrices are replaced. Eight greater secondary coverts are usually replaced. (4) In the second half of August; no alulae, no rectrices and few greater secondary coverts are replaced. The second and third periods may not be so distinct because only a few birds in these categories were examined.

DISCUSSION

Juveniles of the Azure-winged Magpie had white or buff tips on all feathers of alulae, greater secondary coverts, greater primary coverts and rectrices, and had shorter central rectrices than the second innermost rectrices. The retention of white tips on all feathers can distinguish juveniles from the older birds, although a few subadults hatched in late August could not be distinguished from juveniles because they retained white tips on all feathers of these tracts examined. Juveniles can also be distinguished from the older birds by white mottling on their black cap, as Yamashina (1934) and Goodwin (1986) suggested.

About half of subadults replaced all juvenal feathers with new feathers on alulae and greater secondary coverts. The new feathers could not be distinguished from those of adults. Therefore, the alulae and greater secondary coverts are not useful criteria to discriminate between subadults and adults. On the other hand, greater primary coverts and rectrices are useful criteria to discriminate between them, because all subadults retained all juvenal feathers of greater primary coverts and some or all juvenal rectrices. The methods to discriminate between subadults and adults are summarized as follows: Subadult; greater primary coverts are bluish gray on the outer vanes and are gray on the inner vanes, and rectrices have white tips on several outer feathers. Adult; greater primary coverts are sky blue on both vanes and rectrices have no white tips except for central rectrices. The white tips of the greater primary coverts were not a reliable criterion, because the tips were very narrow in width and abraded easily, and some greater primary coverts of adults had white tips.

The methods of age determination or the results in the extent of postjuvenile moult were similar to those of Svensson (1992) and Yamashina (1934). In postjuvenile moult of Iberian subspecies Cruz et al. (1992) found that no complete moult of primaries and secondaries occurred in all birds, and that complete or no moult of greater primary coverts occurred in 17% or 70% of the birds, respectively, and that the central pair of rectrices replaced in all birds and complete molt of them occurred in 34% of the birds. However, no complete moult was found on the coverts and rectrices in this study.

The method to determine age of subadults by the extent of moult may be applicable to other species. Cruz et al. (1992) found a significant correlations between age of young birds and moult development, regardless of fledging date. The onset of postjuvenile moult is related to age (Dolnik & Gavrilov, 1980; Saint Jalme & Guyomarc'h, 1995; King & Mewaldt, 1987; Schmutz & Hoffman, 1991), though birds that begin moult early in the season tend to replace feathers at a slower rate than those that begin moult late in the season (Dolnik & Gavrilov,

1980; Linz, 1986). Juveniles hatched later replace fewer juvenile feathers than those hatched earlier, in jays (Ligon & White, 1974; Bancroft & Woolfenden, 1982) and other passerines (Newton, 1966; Bell, 1970; Dhondt, 1973; Wiseman, 1977). Therefore, in those species in which postjuvenile moult is partial, the extent of postjuvenile moult is likely to be affected by hatching date. The extent of postjuvenile moult may provide useful methods to determine not only age in years but also age in months in the species which postjuvenile moult is partial.

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