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Distribution, habitat use and conservation of the endemic Chestnut-bellied Hill-partridge (*Arborophila javanica*) in fragmented forests of Java, Indonesia

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Abstract. The endemic Chestnut-bellied Hill-partridge (*Arborophila javanica*) occurs in the remaining fragmented mountain forests on Java, Indonesia. Its geographical and altitudinal distribution, habitat use and conservation status were assessed during surveys in 1994–2002. *A. javanica* was recorded at 30 sites in 11 forest areas across the island apart from the far eastern corner. It occurs exclusively in natural forest, but only on mountains higher than 1700 m above sea level. Abundance was positively related to altitude but not to degree of forest fragmentation or forest area above 1000 m above sea level. The species tended to be more common in the interior of forest areas than on the forest edge. There was no clear relationship between abundance of hill-partridges and protected area status, i.e. the species was not less common outside the protected area network. Continuing loss and degradation of habitat and trapping are of some concern to the survival of *A. javanica*, but its short-term future seems to be relatively secure.

Introduction

The island of Java, Indonesia's political and industrial centre, is one of the most densely populated areas in the world. The very fertile soils, which lend themselves to terracing for irrigated rice, sustain about 114 million inhabitants, at an average population density of 862 people km^{-2} (Whitten *et al.* 1996). Java is largely deforested and most of the remaining forest fragments cover (parts of) the numerous volcanoes on the island. Less than 10% of the original forest remains: 54% of the mountain forest (>1000 m above sea level), 19% of the hill forest (500–1000 m above sea level), and only 2% of the lowland forest (van Balen 1988). The remainder is essentially a mosaic of rice fields, agriculture, cities and villages.

In the remaining montane forest patches two allopatric species of *Arborophila* hill-partridges occur, i.e. *A. javanica* (the Chestnut-bellied Hill-partridge) and *A. orientalis* (the White-faced Hill-partridge) (Madge and McGowan 2002). Both species are endemic to Java; *A. orientalis* is known with certainty only from the far eastern corner of east Java whereas *A. javanica* occupies the remainder of the island (Madge and McGowan 2002). Distributional data are lacking from many parts of the range of *A. javanica*. In particular, data from the central part (van Balen 1992; Madge and McGowan 2002) and the easternmost part (Mees 1996) of the island are scant. Mees (1996) and Johnsgard (1988), for instance, draw the boundary between the distributions of the two species between Mt Liman-Wilis and Mt Arjuno, whereas van Balen (1992) and Madge and McGowan (2002) draw it 140 km to the east, between Mt Tengger-Semeru and Mt Yang (Fig. 1).

The altitudinal distribution and habitat use of *A. javanica* has hitherto not been studied in detail. Van Balen (1992) lists its altitudinal range as 300–3000 m above sea level, but according to Mees (1996: 97) its preferred habitat is the mountain forests above ~1000 m above sea level. Mees (1996) regards the occurrence of *A. javanica* as low as 300 m above sea level as exceptional, as 'otherwise the striking [intra-specific] geographical variation [in plumage characteristics] would be inexplicable'.

Limited information is available on its conservation status. The main problems are loss, degradation and resultant fragmentation of habitat, but trapping for bird trade and food pose an additional threat (van Balen 1992; McGowan 1994; Nijman and Sözer 1997). *A. javanica* was formerly classed as Vulnerable by the IUCN Partridge, Quail and Francolin Specialist Group (McGowan 1994; McGowan *et al.* 1995), but in the latest revision (Fuller *et al.* 2000) the species was considered no longer threatened. Given that we have equally limited data sets on the basic biology of a number of other south-east Asian hill-partridge taxa (e.g. Sumatran Hill-partridge, *A. sumatrana* [Sumatra]; Orange-necked Hill-partridge, *A. davidi* [southern Vietnam]; Sichuan Hill-partridge, *A. rufipectus* [central China]; White-faced Hill-partridge [eastern Java]) (Madge and McGowan 2002), increasing our knowledge on the habitat preferences and conservation status of *A. javanica* may be of direct relevance for the other species' conservation.

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The aim of the present study was therefore to assess the geographical and altitudinal distribution of the endemic *A. javanica*, its gross habitat preferences, the effects of habitat fragmentation, and its conservation status.

Methods

Study areas

The study covered 22 isolated forest areas in Java, from its westernmost tip at Ujung Kulon to Mt Penanggunang in East Java. Combined, these areas constitute >70% of all remaining natural forest on this part of Java, and it is likely that they are representative of the remainder. Survey areas included low- and high-altitude forest, from sea level to >3000 m above sea level. In addition to natural forest areas, adjacent forest plantations were surveyed. In order to gain access to natural forests considerable distances had to be crossed, often in man-made habitats. A forest area is defined as a large (>30 km^2), more or less continuous tract of forest that is isolated from other similar areas by a gap of non-forest area >5 km wide (mostly <1000 m above sea level). Within forest areas several sites were visited. Sites are typically bordered by certain geographical features (rivers, ridges, valleys), and are small enough to be surveyed on a single day (i.e.~5–10 km^2).

Field surveys

A. javanica was studied during all months of the year, i.e. March–September 1994 (with assistance from R. Sözer), June–July 1995 (some with S. van Balen), August–September 1997, September 1998 – January 1999, July 1999 – February 2000, July–August 2000, October–November 2001, and March–April 2002. Most forest areas were visited for at least four days and up to several months; the total survey effort comprised 340 days.

A. javanica is secretive and difficult to observe, but its far-carrying vocalisations are distinct. Vocalisations, including duetting, can be heard throughout the year (van Balen 1992; see Table 1), possibly indicating a long breeding season (McGowan 1994). Hill-partridges call throughout the day, most frequently during the first hours of the day, with possibly a second peak in the late afternoon, and they can be heard even after sunset (Bartels 1906). Surveys were conducted at all hours from sunrise to sunset, but mostly during the morning. Data were normally collected under good weather conditions, although heavy rain prevented observations for short periods. On the basis of vocalisations, abundance was subjectively classed on an ordinal scale, i.e. occasional (one or few birds heard on fewer than half of all days), frequent (few or several birds heard on more than half of the days), and common (several birds heard almost daily) (cf. Thewlis *et al.* 1998). Note that this assessment is independent of survey effort; long-term observations in a number of study areas (Mt Gede-Pangrango, Mts Dieng, and Mt Arjuno: see Fig. 1) have shown that abundance classes remained stable over time.

Information about the occurrence of, and threats to, hill-partridges was collected by semi-structured interviews (in Indonesian) with people living near the forest, bird catchers and officers of the Forestry Department. Additionally, regular visits were paid to bird markets and bird traders in major cities and villages, and the occurrence of captive hill-partridges was opportunistically recorded.

Analysis

Two types of analysis were executed, the first related to presence/absence of *A. javanica* and the second related to correlates of abundance in areas where it was present. Size of the forest area (in km^2), maximum altitude of the area (in 500 m intervals), and time of year and duration of survey were tested as predictors for the presence of *A. javanica*. The inclusion of false negatives (i.e. areas where I did not record the presence of hill-partridges yet they were present) were reduced by comparing my data with those from the literature and other biologists (most notably S. van Balen and R. Sözer); analysis, however, is based on my data set only.

Following van Steenis (1972), forest types were classified as lowland (<500 m above sea level), hill (500–1000 m), lower montane (1000–1500 m), montane (1500–2400 m), and sub-alpine (>2400 m). Forest area and the amount of forest >1000 m was estimated after MacKinnon *et al.* (1982), RePPProT (1990: scale 1:250000), Whitten *et al.* (1996: p. 731–741) and my own data.

Following van Balen *et al.* (2001), for each forest area the degree of forest fragmentation was qualitatively classed into large (one large compact area), intermediate (several medium-sized, interconnected forest areas), or small (several small to intermediate forest areas, with or without adjacent smaller areas).

For 18 sites in nine areas the relationship between abundance of *A. javanica* (occasional, frequent, common), altitude (classed in bands of 100 m from 700–2400 m asl), degree of fragmentation (small, intermediate, large), edge-effect (forest interior, forest edge), forest area above 1000 m (in km^2) and protected status (national park and nature reserve or unprotected) was assessed with Spearman Rank Correlation tests (R_S) and binomial tests.

Since most data collected were not normally distributed or were ordinal, and as to increase the generality of the conclusions, non-parametric tests were used (Siegel 1956). For testing whether observed frequencies of occurrence are homogeneously distributed over all classes, G-tests of goodness of fit were used. To obtain a better approximation to χ^2 William's correction to G was applied ($G_{adj.}$: Sokal and Rohlf 1995).

Results

Geographical distribution and numbers

Excluding forest areas of less than 30 km^2 and areas separated by a gap of <5 km, *A. javanica* has been recorded from 20 isolated forest areas (Fig. 1). These forest areas range from ~50 km^2 (e.g. Mt Sawal) to ~500 km^2 (Mt Halimun) totalling some 3500–4000 km^2 (excluding continous lowland sections). The median nearest distance from one forest area where the presence of *A. javanica* was confirmed

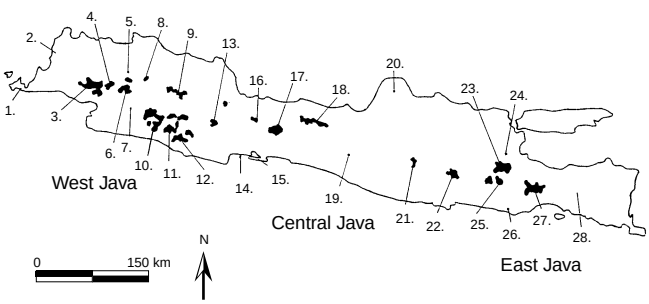

Fig. 1. Geographical distribution of *A. javanica* on Java, Indonesia, with localities mentioned in the text. In black are the areas where hill-partridges have been recorded (data from van Siebers 1929; Bartels 1937; van Balen 1992; Mees 1996; Nijman and Sözer 1997; Rombang and Rudyanto 1999; this study). 1, Ujung Kulon; 2, Mt Aseupan; 3, Halimun; 4, Mt Salak; 5, Mt Pancar; 6, Mt Gede-Pangrango; 7, Takokak; 8, Sanggabuana; 9, Tangkuban Perahu; 10, Mt Tilu-Simpang; 11, Mt Patuha; 12, Mt Papandayan; 13, Mt Sawal; 14, Pangandaran; 15, Nusa Kambangan; 16, Pembarisan Mts; 17, Mt Slamet; 18, Dieng Mts; 19, Mt Merapi; 20, Mt Murio; 21, Mt Lawu; 22, Mt Liman-Wilis; 23, Mt Arjuno; 24, Mt Penanggunang; 25, Mt Kawi; 26, Balekambang; 27, Mt Tengger-Semeru; 28, Yang Highlands.

to another forest area where it was also present was 14 km (range 5–75 km).

In the present study, *A. javanica* was recorded at 30 sites in 11 forest areas distributed over almost the entire length of the island (Table 1; Fig. 1). At another 11 areas no hill-partridges were recorded, though at one site (Mt Tangkuban Perahu) they have been recorded and collected (van Balen 1992; Mees 1996). Mt Arjuno is the easternmost locality where *A. javanica* was sighted. Areas with hill-partridges did not differ in size from areas without the species (Mann–Whitney U, $n_1 = 11$, $n_2 = 11$, $P > 0.10$, median forest area 150 km^2). In over half of the forest areas hill-partridges were sighted; in the remaining areas only calls were recorded. At most sites (66%), the presence of hill-partridges was confirmed on the first day and in almost all sites (87%) within two days (Fig. 2). There was no significant difference in survey length between areas where *A. javanica* was recorded and where it was not (Mann–Whitney U, $n_1 = 11$, $n_2 = 11$, $P > 0.10$, median duration of survey: 9 days). Calls of *A. javanica* were heard in all months of the year and the frequency of recording versus not recording the species did not differ over the months ($G_{adj.} = 10.5$, d.f. = 11, $P > 0.30$).

At 13 sites in seven areas *A. javanica* was frequently or commonly seen and/or heard, whereas at five sites in five areas the species was rarely recorded. Overall, within its limited range the species seems to be fairly common (Table 1). *A. javanica* was generally observed in pairs or small parties with up to six members, while single indivi-

Table 1. Localities and sites where *A. javanica* was recorded during the present study (1994–2002)

Localities are listed in sequence from west to east. Areas where the species was not recorded (listed from west to east, numbers refer to Fig. 1): 1, Ujung Kulon; 2, Mt Aseupan; 5, Mt Pancar; 7, Takokak; 9, Mt Tangkuban Perahu (known to be present); 14, Pangandaran; 15, Nusa Kambangan; 19, Mt Merapi; 20, Mt Murio; 25, Mt Penanggunang; 26, Balekambang.

Area[A]	Site	Status[B]	Coordinates (South, East)	Altitude (m)	Recording[C]	Month	Abundance[D]
3. Halimun	Cikaniki	NP	6°38′, 106°36′	900	Voc.	VIII	–
4. Mt Salak	Kawah Ratu	Unp.	6°32′, 106°42′	1245	Voc.	IX	F
	Sukamantri	Unp.	6°36′, 106°45′	910	Voc.	VIII	–
6. Mt Gede-Pangrango	Pasir Pogor	Unp. NP	6°42′, 106°47′	900–1050	Voc.	IV, V	O
	Bodogol	NP	6°47′, 106°47′	900	Voc.	IX	–
	Cilember	Unp.	6°35′, 106°50′	1300	Sight., Voc.	III	C
	Pondok Halimun	NP	6°51′, 106°54′	1455	Sight., Voc.	IX	–
	Telaga Warna	Unp. NR	6°38′, 106°55′	1500	Voc.	III, IX	C
	Kandang Batu	NP	6°45′, 106°58′	1950	Sight., Voc.	IX	C
	Cibodas	NP	6°45′, 107°00′	1450–1800	Sight., Voc.	VI, IX	C
	Gn Geulis	Unp.	6°47′, 107°10′	1400	Voc.	IV	–
11. Mt Patuha	Situ Patengan	Unp.	7°11′, 107°21′	1550–1640	Voc.	VII, VIII	O
13. Mt Sawal	Cibolang	NR	7°14′, 108°19′	1070	Voc.	VII	C
	Cipakuh	NR	7°16′, 108°21′	820, 915	Sight., Voc.	VII	–
16. Pembarisan Mts	Gn Segara	Unp.	7°08′, 108°50′	600–700	Voc.	VII	–
17. Mt Slamet	Pekandangan	Unp.	7°12′, 109°10′	1730	Sight., Voc.	VII	F
	Pancuran Tujuh	Unp.	7°18′, 109°13′	700–950	Voc.	IV, VI	O, F
	Blambangan	Unp.	7°16′, 109°16′	2210	Voc.	VI	–
18. Dieng Mts	Linggo	Unp.	7°04′, 109°38′	600–900	Sight., Voc.	VI–III	O, F
	Gn Lumping	Unp.	7°10’, 109°41′	900–1300	Sight., Voc.	VI–I	C
	Kembang Langit	Unp.	7°10′, 109°47′	900–950	Voc.	II–III	–
	Gn Kemulan	Unp.	7°14′, 109°49′	950–1140	Voc.	II–III	F
	Gn Prahu	Unp.	7°22′, 110°01′	2375–2455	Sight., Voc.	III, VI–VII	C
21. Mt Lawu	Cemoro Sewu	Unp.	7°38′, 111°13′	1640	Voc.	VII	–
	Mojosemi	Unp.	7°40′, 111°15′	1850	Voc.	VI	O
22. Mt Liman-Wilis	Picis	NR	7°47′, 111°30′	1250,1300	Sight., Voc.	VII	C
	Sigogor	NR	7°49′, 111°42′	1270, 1365	Voc.	VII	–
	Sendang	Unp.	7°53′, 112°25′	740–1140	Voc.	VIII	–
23. Mt Arjuno	Ratu Suryo	GF	7°43′, 112°32′	1450–1800	Voc.	IX, XI	–
	Cangar	GF	7°44′, 112°34′	1660–1750	Sight., Voc.	IX, XI	F

[A]Locality numbers refer to Fig. 1.

[B]Status: NP = National Park (Taman Nasional); NR = Strict Nature Reserve (Cagar Alam); GF = Greater Forestry Park (Taman Hutan Raya); Unp. = unprotected or forest ‘protected’ for hydrological reasons (Hutan Lindung).

[C]Recording: Voc. = Vocalisations; Sight. = Sightings.

[D]Relative abundance: C = common, F = frequent, O = occasional (see text for details); for entries that received more than one category of abundance the first category refers to lower altitudes, the second to the higher.

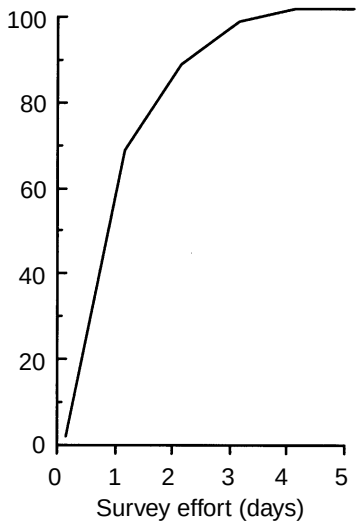

Fig. 2. Establishing the presence of *A. javanica* at study sites ($n = 30$) in relation to survey effort; within four days at all sites the presence of hill-partridges was confirmed.

duals were rarely encountered. For 16 groups for which the group size could be established with confidence, the median was 3.0 (range 1–6) (Fig. 3).

Altitudinal distribution

No hill-partridges were observed in lowland forest areas (<500 m above sea level). Records were from altitudes between ~600 and ~2500 m above sea level, with most records from the (lower) montane forest above 1000 m above sea level (Table 1). In those areas where the species was recorded below 1000 m above sea level the forest always extended into the montane zone. The lowest mountains from where *A. javanica* was recorded were Mt Sawal (1764 m above sea level) and Mt Pembarisan (highest peak Mt Kumang, 1812 m above sea level).

A. javanica was recorded in nine out of 11 areas with the highest peak above 2000 m above sea level but in none of the five forest areas where the highest peak is below 1500 m above sea level. The difference between the expected and observed frequencies is significant ($G_{adj.} = 12.4$, d.f. = 2, $P < 0.01$); exclusion of Mt Tangkuban Perahu (2076 m above sea level) as a false negative does not alter this result. Fig. 4 depicts a logistic regression model of presence/absence data in relation to the altitude of the highest peak ($\chi^2 = 13.4$, d.f. = 1, $P = 0.0002$; deviance explained by model = 44.1%).

In areas where *A. javanica* was recorded its frequency increased with altitude (Spearman Rank Correlation Coefficient, $R_S = 0.41$, $n = 18$, $P < 0.09$; median altitude 1300 m above sea level), and the ratio between common, frequent and occasional occurrence differed significantly between sites above and below the 1000-m altitude line (Fisher's Exact Probability Test, $P = 0.05$).

Habitat use

A. javanica was recorded only in natural forest areas. The species was never recorded in the extensive Sumatran pine (*Pinus merkusii*), rubber (*Hevea brasiliensis*), damar or kauri (*Agathis dammara*), or mahogani (*Swietenia* sp.) plantations that often fringed the natural forest. It was not recorded in the sub-alpine meadows or shrublands that cover the higher parts of mountains (above 2400 m), not even in areas where the species is abundant in the adjacent (upper) montane forest (e.g. the summit of Mt Prahu). Forest areas above 1000 m elevation showed no correlation with degree of forest fragmentation ($R_S = 0.08$, $n = 9$, $P > 0.40$). There was no clear relationship between the size of the natural forest above 1000 m altitude and the abundance of *A. javanica* ($R_S = 0.08$, $n = 9$, $P > 0.40$; median forest area 121 km^2), i.e. the species was not more common in large forest areas. Likewise, there was no significant relationship between degree of forest fragmentation and the abundance of *A. javanica* ($R_S = 0.08$, $n = 9$,

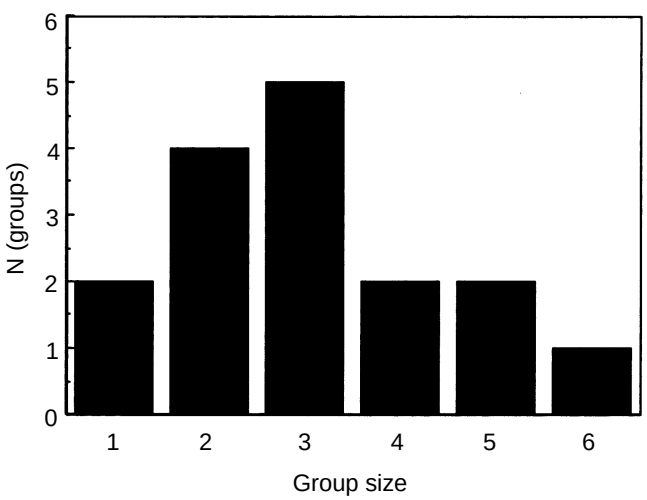

Fig. 3. Group size in *Arborophila javanica*.

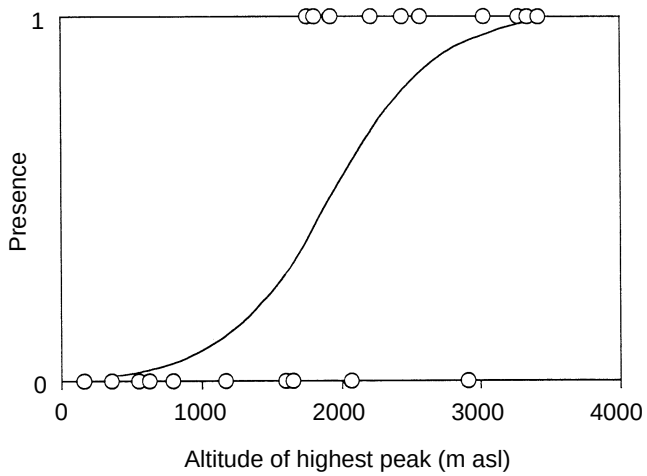

Fig. 4. Logistic regression of the occurrence of *A. javanica* in forest areas with different altitudinal ranges.

$P > 0.40$), i.e. the species was not less common in more fragmented forests. For 11 sites in eight areas where abundance was assessed close to the forest edge and in the forest interior (>500 m in a straight line from the edge), *A. javanica* showed a tendency to be more common in the interior than along the edge (Binomial test, $X = 11$, $n = 2$, $P = 0.07$).

Threats

The only direct threat to the survival of hill-partridges recorded during this study was hunting and trapping of birds for food and the cage bird trade. In most forest areas people regarded the meat as palatable, although it was rarely sought after. *A. javanica* was recorded at many of the (local) bird markets visited (mostly in singles or pairs) or it was said to be easily obtainable. Also at the larger bird markets in cities the species is offered for sale regularly mostly singly or in pairs, but occasionally up to seven birds at a time (Table 2).

Another threat to the survival of *A. javanica* is habitat destruction. However, owing to the nature of the study, it is difficult to assess how hill-partridges are directly affected. Over the course of the study, in a number of areas where *A. javanica* occurred, considerable areas of lower and montane forest were lost to a combination of illegal, small-scale logging, encroachment and extension of bordering plantations (tea *Camillia sinensis*, coffee *Coffea* sp., rubber, Sumatran pine). The abundance of *A. javanica*, as measured by the categories 'common', 'frequent' and 'occasional', does not differ between protected and unprotected forest areas ($G_{adj.} = 2.6$, d.f. = 1, $P > 0.10$).

Discussion

Geographical range

The present study showed that *A. javanica* ranged from Mt Halimun in the west of Java to Mt Arjuno in the east. Madge and McGowan (2002) commented that the species' presence has been confirmed in most montane forests above 1200 m, but remark that, strangely, the species has not yet been recorded in the central mountains of the Dieng Plateau. In fact, the Dieng Plateau itself is largely deforested and in the present study the species was not recorded in any of the tiny forest fragments left on the plateau. However, Nijman and Sözer (1997) reported the species on Mt Prahu, the highest peak in the Dieng Mts and situated a few kilometres north of the plateau (cf. Nijman and van Balen 1998). During the present study *A. javanica* was found at five sites in the Dieng Mts and in two of these the species was classed as common. The central Javan distribution gap, as presumed by, for example, van Balen (1992), Mees (1996) and Madge and McGowan (2002), must have been due to the paucity of ornithological research in the area. Mees (1996) questioned van Balen's (1992) record of *A. javanica* from Mt Tengger-Semeru (as species confirmation was based on information from local people) and consequently included this mountain complex, together with Mt Arjuno–Mt Kawi, in the range of the White-faced Hill-partridge. The present study shows that it is indeed *A. javanica* that is present on Mt Arjuno (and given its close proximity, most likely also on Mt Kawi, cf. Rombang and Rudyanto 1999). Hence, in all probability, *A. javanica* occurs on Mt Tengger-Semeru, and the White-faced Hill-partridge ranges from Mt Lamongan, in the western part of the Yang Highlands, eastwards (Nijman in Collar *et al.* 2001).

Table 2. Numbers of *A. javanica* encountered at bird markets and bird traders during 1994–2002
Only visits when hill-partridges were observed are included

Province and city	Total birds (number of occasions)	Median (per visit)	Range (per visit)
West Java			
Jakarta	12 (4)	3	1–7
Bogor	16 (9)	1	1–5
Sukabumi	10 (4)	2.5	1–4
Central Java			
Salem	3 (1)	3	–
Pekalongan	4 (3)	1	1–2
Semarang	2 (1)	2	–
East Java			–
Malang	1 (1)	1	–
Total	46 (22)	2	1–7

Altitude and habitat

Kuroda (1936) gives the altitudinal range of *A. javanica* as 0–2450 m [0–8000 ft] above sea level, but gives no detailes of sources. Hoogerwerf (1948) gives a range of 1000–>3000 m above sea level, noting that in certain areas the species is living permanently between 2500 and >3000 m. The putative lower limit of the species' altitudinal range of 300 m above sea level, listed by van Balen (1992) and adopted by McGowan (1994) and Madge and McGowan (2002), was inferred on the basis of the locality of collected specimen(s) by Robinson and Kloss (1924) (S. van Balen, personal communication). As this represents the sole record below 600 m above sea level, following Hoogerwerf (1965) and the results of the present study, the altitudinal range of *A. javanica* is most likely between ~600 and 3000 m above sea level. However, it occurs almost exclusively on mountain complexes on which the highest peak reaches over 1700 m. Here the species can descend down to 600 m. It is not found on mountain ranges where the highest elevation is below 1700 m, except for Sanggabuana, with its highest peak Mt Sanggabuana (1287 m) (van Balen 1992). The forests on Sanggabuana are isolated from those of the Mt Gede-Pangrango-complex by a >20-km-wide gap of cultivated land, of which ~5 km is below 500 m.

The almost exclusive occurrence of species on high mountains where they reach their lower limit at much lower elevations is known as the mountain mass elevation effect (van Steenis 1961). This effect is ~1100 m for *A. javanica*, or

~700 m when taking into account the Sanggabuana record. The mountain mass elevation effect has been noted for few Javan birds (e.g. Island Trush *Turdus poliocephalus*: Mees 1996; Pink-headed Fruit-dove *Ptilinopus porphyreus*: V. Nijman and S. van Balen, unpublished data), but it is well known for plants (van Steenis 1972). A number of species of hill-partridges are confined to montane areas and do not occur below a certain altitudinal limit (e.g. Sichuan Hill-partridge, 1100 m: Dai Bo *et al.* 1998; Red-billed Hill-partridge, *A. rubrirostris*, 900 m: van Balen 1992; Necklaced Hill-partridge, *A. torqueola* 600 m: Madge and McGown 2002). If, indeed, these species do occur at lower levels due to the mountain mass elevation effect this might facilitate future surveys for additional localities of these little-known species. Furthermore, the mountain mass elevation effect might have to be taken into consideration in future conservation and management plans. As an example, foresters in south China, when establishing broadleaf tree plantations, leave small strips of natural forest along ridges and on steep slopes. For local populations of Sichuan Hill-partridges these strips are vital for maintaining connectivity along certain elevational ranges (Dai Bo *et al.* 1997). By the same token, in relation to the conservation of the White-faced Hill-partridge, Collar *et al.* (2001) argued for the maintanance of forest linking Meru Beteri National Park (essentially a lowland forest area) and the Ijen Highlands, as the latter area was thought to be the source for birds occurring in the former.

A. javanica was recorded in only natural forest areas, and it was not found in any of the open areas on the upper parts of the mountains. No correlation was found between abundance and forest area above 1000 m or degree of forest fragmentation, suggesting a tolerance to a certain degree of habitat disturbance. However, at a smaller scale, forest fragmentation and reduction of forest area will undoubtedly have its effect on abundance. The abundance of *A. javanica* was higher in the interior of the forest. The total absence of the species in forest plantations, even when bordering natural forest, is a further indication that the species might prefer the interior above the edge. Total dependence on natural forest has been reported for some partridges, e.g. the Sichuan Hill-partridge and the Hainan Hill-partridge (*A. ardens*) (Collar *et al.* 2001). Dai Bo *et al.* (1998) assessed densities of the Sichuan Hill-partridge in different habitat types and concluded that the species was able to survive in replanted and secondary forest (but always <500 m from primary forest), but not in coniferous plantations. Other hill-partridges, including some globally threatened species, however, seem to survive or even thrive in secondary habitats and plantations (e.g. Orange-necked Hill-partridge: Atkins and Tentij 1998; Collar *et al.* 2001).

Conservation

Java has a long history of cultivation and deforestation (Whitten *et al.* 1996). By the end of the 19th century the natural forest was severely fragmented and at the beginning of the last century virtually all forests that currently contain hill-partridges were isolated from each other. Far less forest has been lost in the mountains than in the lowlands and over the last few decades the decrease in forest area has been slow (Smiet 1990). The finding that *A. javanica* was not found in any of the forest plantations, let alone any other man-made habitat, indirectly indicates that loss of habitat must have greatly reduced its numbers. The species is, however, still present on most higher mountains and a considerable proportion of its habitat is included in the protected area network (Rombang and Rudyanto 1999). Even though almost none of these parks and reserves is secure from illegal logging, extraction of non-timber forest products, encroachment, hunting or trapping it seems that the species is equally common (or equally rare) within and outside of the protected area network.

A number of conservation measures for *A. javanica* have been proposed including the reduction or total cessation of hunting and trapping (e.g. McGowan *et al.* 1995), and captive breeding (Madge and McGowan 2002). Hunting and trapping of *A. javanica* is a disorganised business, occurs in remote regions, and involves few birds at a time. The species is not protected by Indonesian law (Sözer *et al.* 1999), and is frequently encountered in the many bird markets. Prevention of hunting and trapping for the bird trade, although potentially valuable, are at present unrealistic. Over the last three decades the Indonesian conservation authorities have largely failed to safeguard legally protected species inside conservation areas, and they have been unable to reduce their trade (e.g. Orang-utan, *Pongo pygmeus*: Rijksen and Meijaard 1999; Proboscis Monkey, *Nasalis larvatus*: Meijaard and Nijman 2000; Bali Starling, *Leucopsar rothschildi*: van Balen *et al.* 2000; Javan Hawk-eagle, *Spizaetus bartelsi*: van Balen *et al.* 1999). The odds for effective protection of less charismatic and legally unprotected species that occur largely in unprotected areas, such as *A. javanica*, have to be very slim indeed.

The results of the present study clearly indicate that *A. javanica* is still a common bird within its restricted habitat (cf. van Balen 1992; MacKinnon *et al.* 1999) and there seems to be no justification for setting up captive breeding as part of a conservation programme, as suggested by Madge and McGowan (2002). The preservation of large forest areas where hill-partridges are secure because of their remoteness is the key to their survival.

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