

The vanishing act: a history and natural history of the Javan Pied Starling *Gracupica jalla*

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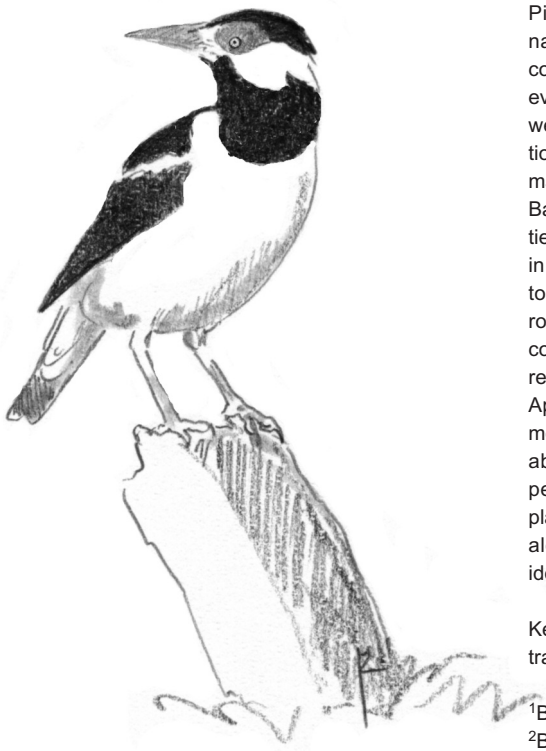
The Javan Pied Starling *Gracupica jalla*, a recent taxonomic split from Asian Pied Starling *G. contra*, has disappeared almost entirely unnoticed from its native range in Java and Bali, Indonesia; in a circumstance unique in bird conservation, the only known populations are held in bird shops. To provide an evidence base for any future endeavour to re-establish a population in the wild, we reviewed all published information on the species relevant to its conservation, supplemented by specimen label data, unpublished field notes, diaries and manuscripts. A population in eastern Sumatra (nine localities reported, including Bangka) had obscure origins. The species was widespread in Java (168 localities) and Bali (13 localities), and was described as one of the commonest birds in open, i.e. non-forest, lowland country (records up to 1600 m), having a high tolerance of disturbed habitats, especially agricultural areas, with often large roosts inside city limits. It fed mainly on terrestrial invertebrates and fruits, often consuming plant pests and frequently probing dung. It bred all year but chiefly in response to rains, with apparent peaks in January and May in West Java and April in East Java, building conspicuous untidy nests high in trees and laying mostly 3 (2–4) eggs. The cagebird trade is blamed for the massive decline that abruptly became apparent in the late 1990s and early 2000s, but the use of pesticides in Java and Bali's agricultural environment seems likely to have played an unseen role. Searches are needed to find any remnant populations, along with the creation of a programme of captive breeding and research to identify potential areas for reintroduction.

Key words: Sturnidae, critically endangered, ecology, Indonesia, Java, cagebird trade

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The island of Java in Indonesia belongs, with Sumatra, Borneo and the Malay Peninsula, plus associated smaller islands, to the biogeographical region of Sundaland, one of the top three biodiversity 'hotspots' in the world in terms of species uniqueness (endemism) and, based on the degree of habitat loss, conservation need (Myers *et al.* 2000). Apart from this regional endemism, however, each of the major components of Sundaland – the peninsula and three large islands – possesses its own complement of narrower endemism. The number of bird species in Java (with Bali) recently increased owing to the taxonomic revisions presented in Eaton *et al.* (2016) and del Hoyo & Collar (2016), giving it a considerably higher profile than before in

terms of conservation priority. In the same time-frame, the island has also emerged as the epicentre of the 'Asian songbird crisis', brought about by the relentless and ruthless trapping of wild birds throughout Indonesian Sundaland to meet the demand among Javanese for pets (Jepson & Ladle 2005, Eaton *et al.* 2015, Nijman *et al.* 2018, Marshall *et al.* 2020).

One of the species evidently affected by this trade is the Javan Pied Starling *Gracupica jalla*, a recent taxonomic split from Asian Pied Starling *G. contra* (del Hoyo & Collar 2016, Baveja *et al.* 2020) with a range across the islands of Java, Madura and Bali, plus a population in Sumatra widely believed to have resulted from escaped or released captive birds (see below). A



(A) Javan Pied Starling, one of four, most likely escapes, in Central Jakarta in 2011. (B) One of these same birds showing the position of the eyes, well adapted to its 'prying' technique (photos: B. Emmanuel and K. Yordan, 13 July 2011, National Monument (Monas), Central Jakarta).



Five cages holding Javan Pied Starlings (with two holding Black-winged Mynas *Acridotheres melanopterus*) for sale in Marangan village, near Yogyakarta, in February 2017 (photo N.J. Collar).

brief account of the plight of this species (Eaton *et al.* 2015) indicated that it is very probably already extinct in the wild, and in 2016 this information was used to establish its IUCN threat status as Critically Endangered (BirdLife International 2020). For a once-common bird to disappear completely from an area the size of Java and Bali (134,000 km²) without anyone raising the alarm is unique in avian conservation. The circumstance is also unique because there is no other case on earth in which a bird species has disappeared from the wild and yet is retained in captivity by commercial interests which have zero engagement with conservation agencies.

A conservation breeding programme is therefore urgently needed, using birds from this commercial stock, with a view to re-establishing a population in the wild in due course. However, such an endeavour would stand to benefit from as complete a knowledge of the species as possible, with decisions for its future management and safeguarding taken on the best available information. There have been no studies of the Javan Pied Starling, however, and no syntheses of whatever available information there might be. We therefore undertook to assemble and review all the evidence that might be relevant to a recovery programme for the species, aiming to profile its former distribution and abundance, its natural history, basic ecology and the threats to its survival.

METHODS

We consulted all documents, published and unpublished, which we believed might contain information on the Javan Pied Starling. Among the most valuable in this material were the field notes, diaries and manuscripts of Max E.G. Bartels spanning the years 1905–1931 (cited as Bartels unpubl.), August W. Spennemann for 1921–1935 (Spennemann unpubl.) and Jan-Hendrik Becking for 1940–1944 (Becking unpubl.), all held in the library at Naturalis Biodiversity Center, Leiden, The Netherlands. We also took label data from museum specimens (accessed through VertNet, by correspondence or by personal visits) and birdwatching trip reports, and corresponded with birdwatchers for recent evidence and opinions.

We used the structure of a ‘Red Data Book’ entry (see e.g. Collar *et al.* 2001) as a model to parse the information resulting from our review by subject (distribution, population, ecology, threats). We compiled a spreadsheet of localities and traced their coordinates through searches on the internet to form the basis

of the map (Figures 1 & 2, Suppl. Material). We sought to adjust the scientific names of plants and animals to modern taxonomy and nomenclature. We also researched the biology of the Asian Pied Starling for potential insights.

We use double quotation marks for statements, including those translated into English from other languages; all translations are by SvB.

RESULTS

Distribution

With the exception of confirmed escapes in Medan and Padang, Sumatra (Groeneveldt 1939, van Marle & Voous 1988), and two small islands, all known locality records of the species, totalling 190, are collated with sources in the Suppl. Material, and the positions of localities on Java and Bali are shown on Figures 1 and 2. One bird seen at Palangkaraya, West Kalimantan, in August 1984, was presumed to be an escape (Holmes & Burton 1987).

The records from Sumatra present a puzzle. There is simply too little evidence to judge if the species was long-established on the island, if it formed feral populations by escaping from captivity or if it colonised naturally, as van Marle & Voous (1988) speculated, in response to “the extension of cultivation and deforestation”. With the far-flung records from Medan and Padang clearly of anthropogenic origin and that for the island of Bangka also suspect, the species is otherwise represented by eight fairly scattered localities in the south-east of the island. We speculate a little on this circumstance in the Discussion.

The records from Java and Bali demonstrate that the species was spread widely throughout the islands (Figure 1). This evidence confirms statements, a century apart, by Bernstein (1861; “one of the most widespread... birds on Java”), and Hoogerwerf (1969–1971; “widely distributed in the cultivated parts of Java”). The numerous records from urban centres reflect the assertions that the species was present in “many” (Koningsberger 1915) or indeed “all” (Groeneveldt 1939) large towns on Java. The concentration of records in West Java simply reflects the presence there of most observers.

Population

The only two comments on the abundance of the starling in Sumatra came from one observer in Lampung province: D.A. Holmes (in van Marle & Voous 1988) described the species as “common in 1975–77” but

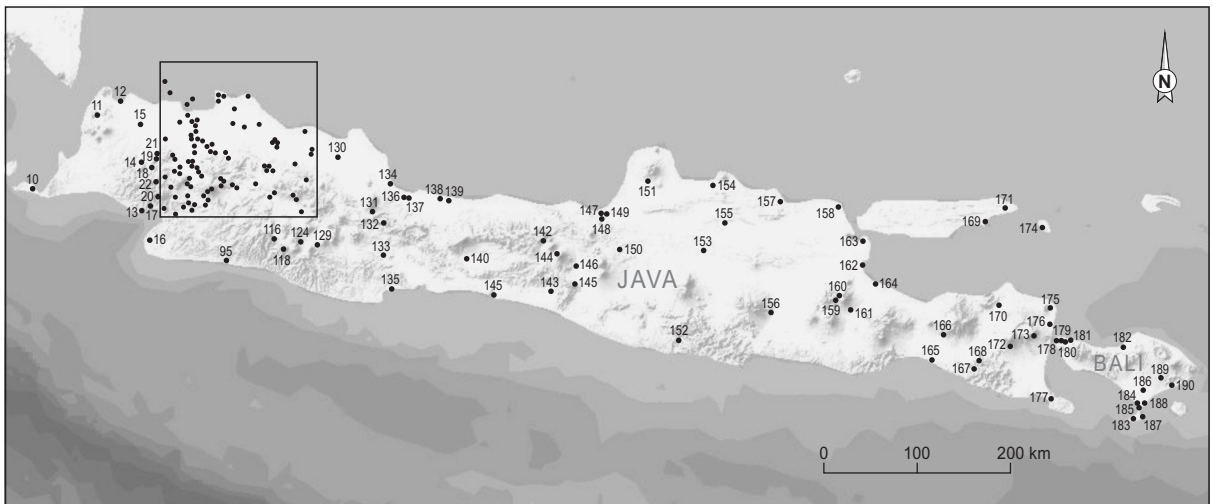


Figure 1. Localities on Java and Bali where the Javan Pied Starling was recorded. Numbers correspond to those in the Supplementary Material. Numbers in the square over West Java are in Figure 2.

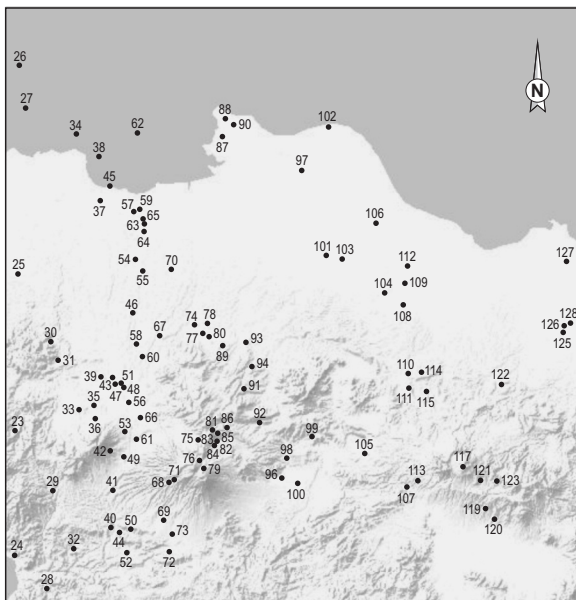


Figure 2. Enlargement of the square in Figure 1 to show localities in part of West Java where the Javan Pied Starling was recorded. Numbers correspond to those in the Supplementary Material.

then (in Holmes 1996) as possibly “dying out, either as an unsuccessful colonist or through trapping”. There appear to be no reports from the island since 1994 (Eaton *et al.* 2015).

On Java the species was clearly a main component of the lowland non-forest avifauna. Bernstein (1861) found it “one of the most... common birds on Java, found everywhere where humans have settled”.

Vorderman (1886) described it as “abundant along the north coast of Java” and mentioned Brebes and Tegal as two towns where the species was commonest, with thousands of birds gathering to roost (Vorderman 1892). Koningsberger (1915) reported thousands and Groeneveldt (1939) hundreds in the larger towns of the island. Bartels (1902, unpubl.) also saw thousands gathering to roost at Kediri, found the species “numerous” in Surabaya, and considered it “among the most conspicuous feathered residents of Java’s cultivated land, ...quite impossible to overlook”. Hoogerwerf & Siccama (1937–1938) judged it and Sooty-headed Bulbul *Pycnonotus aurigaster* the commonest birds in the city of Jakarta after Tree Sparrow *Passer montanus* and swiftlets *Collocalia* spp. It was very common between Jakarta and Bogor and within Bogor itself (Bartels unpubl., Sody 1927a).

The decline of the species through the middle of the twentieth century was probably slow enough to go unnoticed, as an instance of the ‘shifting baseline syndrome’ (Papworth *et al.* 2009). Despite no more reports of thousands at roosts, the species remained locally common, which perhaps confounded perceptions of its declining status: it was “plentiful” around 1950 (ter Pelkwijk 1953), 300 were seen at a roost on Pulau Dua in May 1975 (Harvey 1976), it was still frequent in Jakarta in 1989 (G.C.L. Dutson pers. comm.) and in East Java it was very common at Bondowoso in 1977 and the commonest starling at Tuban in 1979 (D.A. Holmes unpubl. data), hence “quite common” overall in open country, albeit having “become rather scarce along the populous northern

plains” (Holmes & Nash 1989). However, Diamond *et al.* (1987) recorded a marked decline of the species in the relatively well-studied Botanical Gardens (Kebun Raya) in Bogor, where it went from being common in 1932–1952 to a mere 4–5 individuals, and rare in the surrounding countryside, in 1980–1985. There have been no sightings in recent decades in Semarang city and regency (Baskoro 2018).

At Gilimanuk on Bali the species was abundant on cattle pastures in the 1920s (van der Paardt 1926), and across the island it was judged common and widespread below 200 m around 1980, with sightings from 14 (20%) out of 72 10-km squares on Bali during >8 months of survey in 1981 and 1982 (J.S. Ash unpubl. data). However, a 7.5-week survey in 1990 resulted in only two sightings of five and three birds in Bali Barat National Park (J.S. Ash unpubl. data).

Evidence of the decline of the species on Java and Bali can be recovered from birdwatchers’ trip reports and bird market surveys. Of the reports we have obtained which involved fieldwork taking longer than a week and visits to at least three localities, we find totals of seven reports for the period 1981–1990 with two (29%) mentions of the Javan Pied Starling, 12 for 1991–2000 (two mentions, 17%), 17 for 2001–2010 (two mentions, 12%) and 17 for 2011–2020 (no mention). We speculate that the mentions in the 2001–2010 reports, including a few (unspecified if Javan or Asian Pied Starlings) seen in 2003 during a train journey between Jakarta and Gunung Bromo (H. Matheve, M. Schuurmans & W. Heylen unpubl. data), as well as those listed for sites 176 and 187 in the Suppl. Material, refer to escapes. Data from bird markets also reflect the decline of the species. Surveys of Ngasem bird market in Yogyakarta found it common, making up 7% of the total number of birds offered for sale, in 1980 (W. Bongers & A. van Wijngaarden unpubl. data), but proportions fell in later years to 0.9–3.1% between 1987 and 2008 in West Javan markets (Basuni & Setiyani 1989, Haryoko 2010) and 0.6–4.1% in 2014–2015 throughout Java (Chng *et al.* 2015, Chng & Eaton 2016), when most of these were probably captive-bred or possibly imported Asian Pied Starlings. Searches of Surabaya, Gresik and Sidoarjo bird markets have produced no freshly trapped birds (C. Bocos pers. comm. 2020).

Ecology and life history

HABITAT

From multiple sources the Javan Pied Starling emerges as a generalist with a high tolerance of disturbed habitats, which is clearly reflected in its former wide distri-

bution and high abundance (see above). In fact, there is almost no record of its use of a habitat not created or heavily influenced by human activity. Bernstein (1861) described it as “found everywhere where humans have settled and cultivated the soil... especially freshly worked fields and garden-beds”, but also favouring small or large areas of short grass, thus only avoiding “extensive rain forest and higher altitudes”.

Koningsberger (1901) reported it from rice-paddy (“sawah”) dykes and open areas between crop fields. Mason & Jarvis (1989) also indicated its presence in “seasonally dry sawah”. Bartels (unpubl.) noted it in slightly flooded harvested rice fields and on an airfield. SvB saw it in a zoological garden. Spennemann (1935) mentioned its use of both agriculture fields and pastures, and in his diaries recorded seeing birds inside a small stand of Teak *Tectona grandis* (Spennemann unpubl.). Sody (1953) found it in rubber estates and common in areas near Teak forest. Among non-anthropogenic habitats SvB found it breeding at the edge of mangroves on Bali, J.S. Ash (unpubl. data 1982) and Mason & Jarvis (1989) referred to its use of limestone areas on the Bukit Peninsula, Bali, and Bartels (unpubl.) found it foraging among low coastal bushes, on an estuary beach among stranded banana trunks, on a coral bank at low tide and on the bottom of a dry fish pool.

The description by Hoogerwerf (1969–1971) of the Javan Pied Starling as “widely distributed in the cultivated parts of Java from sea level to at least 1500 m” can thus be seen to represent an accurate if very basic generalisation, indicating that like many sturnids the species is fully adapted to what Holmes & Nash (1989) simply called “open country”. However, again like many open-country starlings, the species also had a strong urban presence, being found in “all” or “many” large towns in Java, roosting in the tallest trees at night and dispersing to “gardens” by day (Koningsberger 1915, Groeneveldt 1939; see under ‘Roosts, predators, movements’).

The highest recorded elevation appears to be 1600 m at Kledung, Temanggung (Docters van Leeuwen 1929). On Sumatra the highest was 800 m (van Marle & Voous 1988), while in Bali it was common below 200 m but with no upper limit mentioned (J.S. Ash unpubl. data).

FOOD

The Asian Pied Starling has been characterised as an opportunist omnivore (Feare & Craig 1998, Craig & Feare 2009), but it is “less of a dietary generalist than most other largely ground-feeding starlings and mynas, probing more in short vegetation and pasture to take

proportionately more soft-bodied, non-insect invertebrates" (Round *et al.* 2014). *Gracupica* starlings share the features of a group of narrow-headed, long-billed sturnid species that are specialised for 'prying', a foraging technique involving the probing of a substrate and the forceful opening of the bill to ease access to deeper-positioned prey (Craig & Feare 2009). Observations of captive Javan Pied Starlings reveal that they constantly 'pry' and that if they have no opportunity to do so their bills commonly overgrow, suggesting the primacy of this foraging technique and therefore indeed a specialisation on earth-dwelling soft-bodied invertebrates (S. Bruslund pers. comm.). On Java, favoured foraging substrates for animal food are grass lawns, fields, pastures, fallows, part-flooded new-ploughed paddy fields and paddy field dykes, with birds turning over leaves with their bills and readily manoeuvring around digging labourers and following ploughs (Bartels unpubl., Groeneveldt 1939).

The animal component of the diet, as documented by Koningsberger (1908–1910) and H.J.V. Sody in Becking (1989), involves what are almost entirely terrestrial organisms: grasshoppers and crickets (Orthoptera), tenebrionid and scarabaeid beetles (Coleoptera; including *Onthophagus* dung beetles and melolonthine white larvae), termites (Isoptera), fly larvae (Diptera), caterpillars and larvae (Lepidoptera; including noctuid moths *Agrotis* and *Leucania*), earthworms (Annelida) and the Common Blind Snake *Indotyphlops braminus*. In addition, centipedes (Chilopoda), water snails (Gastropoda; consumed with their shells), water bugs (Nepomorpha) and their larvae and small crabs (Brachyura) have been reported (Koens 1913, Bartels unpubl., Hoogerwerf 1949).

The audacity of the species in entering houses and hotel kitchens for food scraps (Koningsberger 1901, Groeneveldt 1939) speaks to its high dietary opportunism and flexibility; the local name 'jalak barekbek', heard on Madura (Safioedin 1977, SvB), meaning "well-fed starling", presumably reflects its swaggering gait and "tubby belly" (van Dorth 1918). However, the predominance of terrestrial insects in the diet caused Dammerman (1929) to consider the species beneficial to agriculture, and another name, 'jalak urèt' (van Oort 1910), means "beetle larva starling", 'urèt' being the white larvae mentioned above of the scarabid *Apogonia destructor*, a serious pest in sugarcane, corn and grass fields (van Deventer 1906). A third name, 'jalak cacing', heard near Brebes (SvB), means "worm starling", 'cacing' presumably applying to any small soft-bodied elongate animal (but earthworms may in fact be a specialism; see above). Van Dorth (1918) referred to

the species eating "worms and insects harming our plants", and Spennemann (unpubl.) reported that local farmers used to burn the leaves of *Desmodium heterocarpum* as a way (not explained) of attracting Javan Mynas *Acridotheres javanicus* and Javan Pied Starlings to eat the caterpillars devouring their growing rice.

The habitual extraction of insect food from mammal faeces (cattle, horse, dog and human) has been widely observed and reported (J. de Visart de Bocarmé unpubl. data, Bernstein 1861, Bartels unpubl., Spennemann 1925, Olivier 1929, SvB), evidently resulting in another local name, 'jalak tahi' ("dung starling"; Jansz 1913). However, a report of the species habitually perching on the backs of buffaloes (H. Boie in Susanna 1834) was perhaps a case of mistaken identity, since Bernstein (1861) found that it showed a far less frequent association with cattle than Javan Myna, and Spennemann (1930) never saw it on the backs of cattle, attributing this to dietary differences.

The known vegetable component comprises fruits of *Ficus* spp. (including *F. glabella* = *F. virens*), *Glochidion obscurum*, *Muntingia calabura*, *Manilkara zapota* and the palm *Roystonea regia*, plus the nectar of *Erythrina*, *Butea monosperma*, *Spathodea campanulata* and *Bombax anceps* (Koningsberger 1908–1910, Koens 1913, 1915, Spennemann unpubl., Porsch 1924, van de Meer Mohr 1925, Beumée 1925, de Voogd 1926, Becking 1989). The berries of the exotic shrub *Lantana camara*, when available, constituted their staple food, with insects and other animal food consumed only secondarily (Bartels unpubl.). Javan Pied Starlings were surprisingly absent at flowering 'randu alas' *Gossampinus heptaphylla* = *Pseudobombax septenatum* trees, which are much visited by other nectar-feeding birds including three other starling species (Spennemann 1932), but de Voogd (1926) reported them as the only starling species attending one such tree, although he could not be sure if the target in the large flowers was nectar or rainwater. Porsch (1924) seldom saw this and other flower-visiting birds drinking at running or standing water; rather, they nearly always took water from small cavities in trees or from flowers.

In captivity Javan Pied Starlings show a marked preference for animal over vegetable food, and it is possible that the nectar-feeding behaviour reported above involved birds that were in reality probing flowers for invertebrate prey (S. Bruslund pers. comm.).

BREEDING

Javan Pied Starlings have been recorded breeding in every month of the year (Figure 3), in disagreement with the "Sept–Oct" given in Craig & Feare (2009), but

in accordance with the perception that the few bird species that breed all year in Java are inhabitants of cultivated land (Voous 1950). However, the distribution of records suggests two peaks of breeding activity in West Java and one in East Java (with too few data for Central Java); the peaks in West Java occur in January and May, with a trough from July to October; the peak in East Java occurs in April, with no records from July to November (Figure 3), again in accordance with Voous's (1950) finding that dry periods on Java inhibit breeding activity. Rainfall in Java follows a simple annual curve that peaks between November and April, so the starling data from East Java reflect this regime better than those from West Java. However, the small drop in nests found in West Java from February to April (Figure 3) may perhaps be an artefact of sampling effort.

Breeding Javan Pied Starlings are noisy throughout the day, and when foraging in pairs on the ground or resting on paddy dykes or trees the male sings continuously in an upright stance with erected crown feathers (Koningsberger 1901, Bartels unpubl.). They also make song-flights and sing on their nest (Spennemann unpubl.).

As in the Asian Pied Starling, nests of Javan Pied Starlings are bulky, untidy globular or oblong structures, at the top, side or base of which the narrow entrance is located (Bernstein 1861, Bartels unpubl., Hoogerwerf 1949, 1950a,b, 1969–1971). They are made of grass, straw, rice stems, fibres, rootlets, dry leaves and often grass-blades with seed fluff, sometimes also rags, poultry feathers, goat hair and sheep wool (Hoogerwerf 1949), and are typically placed high in densely foliated trees and tall bushes (once as low as

3 m; SvB). A favoured position is an axil of the Pinang or Betel Palm *Areca catechu* (Bernstein 1861, Bartels unpubl., Sody 1955). Other trees used include *Agathis alba* (= *A. dammara*), *Tamarinda indica*, *Vitex* spp., *Grewia eriocarpa* and *Lagerstroemia speciosa*, as well as bamboo (Bambusoideae) clumps and epiphytes including mistletoe *Loranthus* sp. (Bartels unpubl., Spennemann unpubl., Hoogerwerf 1950a,b).

Clutch size has been reported as 2–4 but mostly three eggs (Hoogerwerf 1950a,b, 1969–1971), and this is confirmed in *Naturalis*, where 87 clutches consist of 1 egg (11; but these were presumably all incomplete), 2 (26), 3 (36) and 4 (14); the report in Bernstein (1861) of “mostly 4, seldom 5, sometimes just 3 eggs” is presumably a *lapsus*. There is no information on incubation or nestling periods, second broods or length of juvenile dependency. Fledglings are fed by one parent each, while foraging on grass fields; the parent birds return with their young to their nest or nest tree for the night in at least the first two weeks after fledging (Spennemann unpubl.).

ROOSTS, PREDATORS, MOVEMENTS

In towns it was common for the species to roost communally and repeatedly in particular individuals or stands of ornamental *Tamarinda indica* trees, including the town square Koningsplein (Monas/Medan Merdeka) in Jakarta, where an estimated 1000+ birds would gather (Siccama 1941, Sody 1955), and in Semarang (Spennemann unpubl.). Bamboo clumps were also used for roosts, the birds dispersing in the morning in pairs or small flocks for several hours, retreating into the shelter of a tree canopy over the midday hours, dispersing again until sunset, and then flying straight back to their nocturnal roost trees in the same small groupings as when they departed in the morning (Bartels unpubl.).

The flight of the species is usually direct with continuous wingbeats, not very fast, although capable of acceleration when needed, such as at the appearance of a Brahminy Kite *Haliastur indus* (Bartels unpubl.). They mob birds of prey fiercely, including Brahminy Kites and Grey-faced Buzzards *Butastur indicus*, but were often found in the stomachs of raptors, and Peregrine Falcons *Falco peregrinus* were observed catching them on Java's north coast (Bartels unpubl., Spennemann unpubl.). They have also been seen chased away by the slightly larger Black-winged Starlings *Acridotheres melanopterus* from feeding grounds and the latter's nest trees (Spennemann unpubl.).

The only evidence to modify the description of the Javan Pied Starling, when treated as a subspecies of

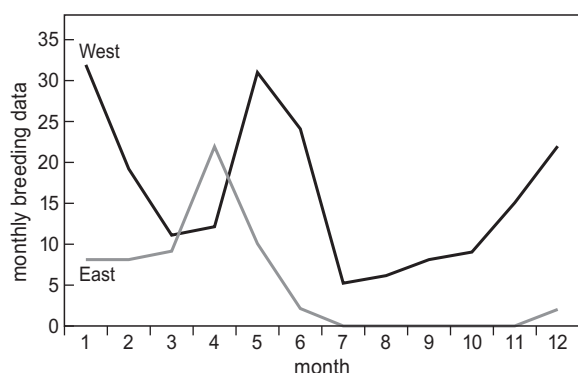


Figure 3. Monthly breeding data for Javan Pied Starling in West (196 clutches of eggs) and East (61 clutches) Java, based on dates of these clutches taken by Sody (1927b, 1930), Hoogerwerf (1949), Bouma (1936), J.H. Becking in *Naturalis* Biodiversity Center, Leiden, The Netherlands and M.E.G. Bartels in Hellebrekers & Hoogerwerf (1967).

Asian Pied Starling, as resident (e.g. Feare & Craig 1998, Craig & Feare 2009) are reports suggesting a possible seasonal movement from south-east Bali (relatively few there from the end of March to August) to limestone areas on the Bukit Peninsula (J.S. Ash unpubl. data) as well as in “seasonally dry sawah” (Mason & Jarvis 1989).

Threats

CAGEBIRD TRADE

An early (perhaps the first) comment on the status of the Javan Pied Starling as a target of the Indonesian cagebird industry suggested that trade was not a problem: Spennemann (1907) reported that the species was present at Semarang on the north coast of Java in large numbers, but that “it is never kept in captivity by the Javanese, and only very rarely by the Europeans”. Moreover, it commanded a price of only 10–20 cents per bird at a time when Black-winged Starlings, also rarely found in trade, were sold for 75–200 cents (Spennemann 1907).

Whether this was a local or an island-wide lack of interest in the species has not been possible to gauge from sources. However, 28 years later the same observer reported that “Jalak starlings... are very popular cagebirds, and... no single brood is allowed to fledge, unless a well-concealed nest has been constructed” (Spennemann 1935). In another 18 years the species was reportedly “perhaps one of the most popular cagebirds kept by the native population”, albeit still “plentiful and tame” (ter Pelkwijk 1953).

As noted under Population above, the species was common in the Yogyakarta bird market in 1980 but became rarer in the late 1990s. This observed decline in numbers of captive stock coincided with the adoption of the species, because of its role as a ‘master bird’ (used for training other species to be entered in song competitions), as the key component of a cooperative bird-breeding enterprise at Klaten village, near Yogyakarta (Jepson *et al.* 2011). By 2006 the captive population of largely captive-bred birds in six large cities (Jakarta, Bandung, Yogyakarta, Semarang and Surabaya in Java and Denpasar in Bali) was estimated to comprise 13,626–26,832 birds (Jepson & Ladle 2009). Klaten was identified as the source for many pied starlings – presumably *G. jalla* – on sale in markets in Sumatra in early 2017 (Chng *et al.* 2018).

A disturbing aspect of captive breeding of the Javan species for commercial purposes is that it might be crossed with imported Asian Pied Starlings. The latter may be considered more attractive, with the red bases to their bills and the greater amount of white in their

crowns, so hybridisation may be a commercial inducement among breeders. The loss of phenotypic and presumed genetic distinctiveness in Javan birds would represent a major setback to its long-term conservation.

PESTICIDES

Information on the use of pesticides in Javan agricultural areas is difficult to find, but given the starling’s dominant use of these areas (see ‘Habitat’ above) it is important to investigate the possibility that the species might have been severely impacted by chemicals deployed by farmers to improve yields in the past half-century, in spite of the programme of integrated pest management that lasted 1986–1999 and was designed to reduce pesticide loads on the farmed environment (Whitten *et al.* 1996, Thorburn 2014). Beginning in the 1960s, pesticide use “concurred with the decrease, and sometimes total disappearance, of many typical rice field birds of Java” (van Balen *et al.* 1993). In the two decades 1979–1998, Indonesia’s agricultural sector experienced a tenfold increase in pesticide use, in particular herbicides; in 1996 the country used 26,570 tons of herbicide, an increase of 395% on the quantity used in 1991, and in 2006 the three most frequently used insecticides, comprising 73.2% of total use, were pyrethroids, carbamates and organophosphates (Soejitno 2000, Ardiwinata & Nursyamsi 2012). Recent studies near Brebes, a former stronghold of the Javan Pied Starling (see above), reveal that “pesticides are used in massive and continuous quantities” (Joko *et al.* 2020) and that more than 80% of shallot farmers there have reported a complete loss of earthworm biomass in their soils (Joko *et al.* 2017). If the starling is indeed specialised on earthworms and other topsoil-dwelling invertebrates (see ‘Food’ above), it could well have suffered disproportionately from the deployment of pesticides, as well perhaps as the use of heavier ploughing machinery, across the farmlands of Java over the past 50–60 years.

The overall effect of these toxic chemicals on the biological diversity of agricultural landscapes in Java appears not to have been reported. We can make no comment, but note that a recent review identified pesticides as the single largest cause of declines in North American farmland birds (Stanton *et al.* 2018), and we simply mention that the endemic race *javanus* of the Black Drongo *Dicrurus macrocercus*, a species like the starling of open agricultural land up to 1600 m (Eaton *et al.* 2016) but unlike the starling not exploited in the bird trade, has almost entirely disappeared in recent decades (SvB).

DISCUSSION

A review of the literature concerning the Asian Pied Starling suggests there are no differences in behaviour and ecology between that species and Javan Pied Starling other than that the former has a larger clutch size, given as “4–6 eggs in much of range” (Craig & Feare 2009); this is probably related to its less equatorial distribution. The slightly lower reproductive rate of the Javan species, presumably compensated by a slightly longer adult life expectancy, would be disadvantageous in circumstances where its population is suffering losses to a targeted anthropogenic pressure such as trapping. Apart from this, one insight of potentially great value to the understanding of the disappearance of Javan birds is that, in Thailand, Asian Pied Starling has “undergone a major decline and range contraction nationwide... possibly due to the reduction in pasture used for grazing livestock” (Round *et al.* 2014). Changes in extent of pastoral habitats in Java and Bali appear to be undocumented, but the considerable expansion of agricultural land in the past 50 years (Verburg *et al.* 1999, Fuglie 2010) may have constrained the extent of lowland grazing lands.

Three decades ago, *Gracupica jalla* was described to the birdwatching world as “a common bird of the cultivated lowlands” (MacKinnon 1990, MacKinnon & Phillipps 1993), and even only just over a decade ago it was said to be “common in Sumatra, Java and Bali” (Craig & Feare 2009). This latter information was, of course, based on earlier synthetic work by the same authors (Feare & Craig 1998), doubtless drawing on MacKinnon (1990), but it illustrates how little the decline of the species had been registered and how sudden its disappearance appears to have been. Only MacKinnon *et al.* (2000), published in Bahasa Indonesia and therefore unsurprisingly missed by Craig & Feare (2009), registered a change: “now rarely encountered in the cultivated lowlands due to excessive trapping”.

It is known that groups of bird-trappers will coordinate their activities in order to maximise their captures in given areas over a short period of time: for example, the probable extinction of the representative form *opisthochra* of White-rumped Shama *Kittacincla malabarica* on Lasia in the West Sumatran Islands has been attributed to “hundreds of Javanese trappers descending upon the island and catching thousands of shamas” (Eaton *et al.* 2015). However, such a model would seem unworkable on an island the size of Java, where the speed and completeness of the starling’s disappearance pose major challenges to our understanding of the

stewardship of wildlife and the environment throughout its former range. Ecological opportunism has been seen as a characteristic of the sturnid genera *Acridotheres* and *Gracupica* (Feare & Craig 1998), and it is here confirmed that *G. jalla*, being highly adapted to agricultural and other anthropogenic landscapes, was both widespread and common, even within towns and cities, in the first half of the twentieth century. Three questions therefore arise. (1) Has the species disappeared completely from the wild? (2) Is trapping for the bird trade responsible for its plight? (3) What can be done to save it?

The complete extinction of any species is hard to demonstrate unless its range is very small and very well known. Whether the starling occurred naturally in south-east Sumatra, was introduced there or, as van Marle & Voous (1988) surmised, colonised with the spread of agriculture and felling of forests, cannot now be discovered. (We speculate that the spread of farming on Java itself might have produced a population explosion in the species that drove its expansion west into Sumatra.) In any case, its occurrence on the sixth largest island in the world presents a particular challenge when attempting to prove its extinction there. Nevertheless, the far-flung and long-past records from Medan and Padang, which were said to have involved escaped or released birds, have never been repeated, while multiple observers active in Jambi and Lampung, where more recent records were made, have failed to see the species (Eaton *et al.* 2015).

The same is true across Java, where a survey of 100 correspondents yielded two reports of single birds (probably escapes), one report of three escapes, and one unconfirmed report of birds being trapped in limestone hills (Pacitan, site 150 in Figure 1) in Central Java in 2010 (Eaton *et al.* 2015). Correspondents and contacts on the island have all subsequently failed to report a bird in the wild (SvB), and a ‘Big Month’ of competitive birdwatching across Java in January 2020, involving hundreds of observers, produced no records (T. Squires pers. comm.). Always accepting that small populations might survive in the remotest parts of the island, we judge that a precautionary and appropriate response is to instigate searches for them while otherwise behaving as if the starling is indeed totally extinct the wild.

Although trapping has severely reduced populations of many bird species in Indonesia and particularly on Java (see Eaton *et al.* 2015), no traded species is known to have experienced so acute a decline as the Javan Pied Starling. Reasons why it should have suffered disproportionately include its fearlessness,

large conspicuous nests, prolonged singing at the nest and post-fledging use of the nest by family parties. These factors combine to render the species extremely vulnerable, allowing trappers to capture virtually every nesting pair in an area. Even so, this was a common and familiar species of gardens and fields, so its large-scale exploitation would surely have been reported with greater concern by more witnesses, and the numbers in markets would have reflected this more strongly, along with the prices that birds might have commanded as they became rarer. Yet no serious concerns were registered and then, shortly before the start of this century, the species abruptly and entirely vanished. Given the (at least apparent) ability of commercial enterprises to breed these starlings in captivity, it seems improbable that trappers would have found it worthwhile to hunt down the very last wild pairs. We have therefore to consider that another factor might have compounded the effects of trapping, and the most obvious possibility in relation to a species occupying agricultural and horticultural habitats is chemical biocides.

In answering our third question, then, our first point is to call for an urgent review of the use of biocides in the Javanese environment, with an assessment of the status of other bird species that might be likely to suffer from the loss of their invertebrate prey base. This is important in order to factor in or rule out the problem, as and when reintroductions of captive-bred birds are being developed. Clearly searches are also needed, using social media and teams of willing volunteers, for remnant populations in areas identified in various ways as most likely to retain them, which could, based on the evidence assembled here, be anywhere on Java or Bali. Research is needed in order to understand more fully the numbers and management of birds held in commercial institutions. Some of these institutions will need to be harnessed to a programme of breeding birds of sufficient quality and in sufficient quantity to establish a representative genetic sample of the surviving captive population and to permit, in due course, a series of experiments aimed at creating a free-living wild colony. Searches will be needed to identify the most appropriate sites in terms of ecology and security for these experiments to take place.

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SAMENVATTING

De verdwijning van de Javaanse Eksterspreeuw *Gracupica jalla*, recent afgesplitst van de (Aziatische) Eksterspreeuw *G. contra*, uit zijn oorspronkelijke verspreidingsgebied op Java en Bali, Indonesië, is vrijwel geheel onopgemerkt gebleven. In dit voor de vogelbescherming unieke geval bevinden de enige nog bekende populaties zich in de vogelhandel. Om een database bijeen te brengen, nodig voor eventuele pogingen om de wilde populatie te herstellen, hebben we alle gepubliceerde relevante informatie over de soort onderzocht, aangevuld met gegevens van labels van voorwerpen in musea, niet-gepubliceerde veldnotities, dagboeken en manuscripten. De oorsprong van een populatie in oostelijk Sumatra (negen locaties, inclusief het eiland Bangka) is onduidelijk. De spreeuw was wijdverspreid op Java (168 locaties) en Bali (13 locaties) en werd beschreven als een van de meest voorkomende vogels van open landschap (d.w.z. niet-bos) in het laagland (tot 1600 m b.z.n.), met een hoge tolerantie voor habitatverstoring, vooral in landbouwgebieden, en

met vaak grote aantallen bijeen op slaapplekken, tot in de grote steden toe. Hij voedde zich voornamelijk met vruchten en op de grond levende, veelal voor de landbouw schadelijke ongewervelden, en doorzocht hiertoe vaak dierlijke uitwerpselen. Het broedseizoen besloeg het hele jaar, maar voornamelijk in samenhang met plaatselijke regenval, met ogenschijnlijke pieken in januari en mei in West-Java, en april in Oost-Java, waarbij opvallende, slordige nesten hoog in bomen werden gebouwd met meestal 3 (2–4) eieren. De enorme achteruitgang die eind jaren negentig en begin 2000 plotseling bleek te hebben plaatsgevonden, wordt geweten aan de handel in kooivogels, maar het gebruik van landbouwgif op Java en Bali heeft vermoedelijk ook een ongeziene rol gespeeld. Er zijn zoekacties nodig om eventuele restpopulaties te vinden, in combinatie met het opzetten van een kweekprogramma, en onderzoek om potentiële gebieden voor herintroductie aan te wijzen.

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SUPPLEMENTARY MATERIAL

Sources of coordinates

Unless indicated with superscripts, coordinates of localities have been retrieved from Schoel (1931), Sandy (1986), 1:50,000-scale maps of the Netherlands-Indies Topographic Service, and relevant publications and field notes. ¹Google; ²Maplandia; ³read from Google Maps; ⁴Wikimapia; ⁵Wikipedia. Two names joined by a dash indicates an observation between two places. Only the year of the most recent record of the species is listed, with earlier dates and their sources omitted.

Codes for sources

A = J.S. Ash (unpubl. data 1980–1982); AMNH = American Museum of Natural History, New York, USA; ANSP = Academy of Natural Sciences of Philadelphia, USA^{*}; B = M.E.G. Bartels (unpubl.); FMNH = Field Museum of Natural History, Chicago, USA^{*}; H = D.A. Holmes (unpubl. data 1977–1997); M = G.F. Mees (unpubl. data 1946–1949); MCZ = Museum of Comparative Zoology, Cambridge, USA^{*}; MVZ = Museum of Vertebrate Zoology at Berkeley, California, USA; MZB = Museum of Zoology, Bogor, Indonesia; N = Naturalis Biodiversity Centre, Leiden, The Netherlands; NHMW = Naturhistorisches Museum Wien, Austria; S = A.W. Spennemann (unpubl.); SvB = S. van Balen pers. obs.; USNM = United States National Museum, Washington, DC, USA; vMV = van Marle & Voous (1988); ZSM = Zoologische Staatssammlung, Munich, Germany.

^{*}data retrieved from www.vertnet.org

Sumatra: 1. Berbak NP^{*}, 1991 (Rusila 1991, Holmes 1996); 2. Bukit Barisan NP^{*}, 1994 (J. Tobias & L. Phelps unpubl. data); 3. Sumberjaya, undated (vMV); 4. Wai Lima, 1926 (MZB, Kloss 1931); 5. Gunungsugih, 1901 (ANSP); 6. Telukbetung ('Telog Betong'), undated (N); 7. Seputih, 1908 (ZSM); 8. Way Kambas NP^{*}, 1985 (vMV); **Bangka:** 9. Sungai Liat, 1898 (ANSP; 'erroneous' in vMV without explanation); **Java:** 10. Ujung Kulon NP^{*}, pre-1939 (Hoogerwerf 1969–1971); 11. Rawa Danau, 1979 (H); 12. Pulau Dua, 1985 (Milton & Mahardi 1985); 13. Sawarna, 1918 (B); 14. Pasir Ayunan (Sajira), 1931 (B); 15. Cikande, 1879 (Forbes 1885); 16. Cijaringao (Cikepuh), 1986 (SvB); 17. Cislok, 1927 (B); 18. Jasinga, 1931 (B); 19. Yanlapa, 1986 (SvB); 20. Kiarakoneng, 1949 (M); 21. Bolang, 1931 (B); 22. Gunung Halimun, 1922 (N); 23. Nanggung¹, 1979 (H); 24. Pelabuhanratu, 1931 (B); 25. Cideng², 1911 (N); 26. Payung Island, 1906 (Bartels 1908); 27. Bagbagan, 1927 (B); 28. Lancang Island, undated (B); 29. Citarik, 1922 (N); 30. Sampay (presumed = Sampay Girang²), 1942 (N); 31. Gobang, 1949 (M); 32. Bantargadung, 1927 (B); 33. Gunung Bunder (part of Gunung Salak), 1909 (USNM), but including untraced Cijulang, indicated as on Gunung Salak, 1943 (N); 34. Rambut Island, 1920 (B); 35. Warungloa, 1987 (SvB); 36. Pasirpacar-Pasawahan, 1882 (Vorderman 1886); 37. Cengkareng,

1908 (van Oort 1910), 1986 (SvB); 38. Sakit (now Bidadari) Island, 1906 (Bartels 1908); 39. Darmaga, 1986 (van Balen *et al.* 1986); 40. Pasir Randu, 1929 (B); 41. Parungkuda–Tinggarjaya, 1929 (B); 42. Citugu⁴–Cigombong, 1944 (N); 43. Gunungbatu, 1943 (N); 44. Cibungur, 1926 (B); 45. Muara Angke, 1986 (SvB); 46. Depok, 1909 (USNM); 47. Kebun Raya, 1989 (T. Andrews unpubl. data); 48. Sawah², 1944 (N); 49. Cikanggaleuh–Cigombong¹, 1944 (N); 50. Sukamaju, 1923 (B); 51. Bogor, 1926 (Sody 1927a), including Semplak, 1897 (ANSP), Daru, 1909 (MCZ) and Cipinanggading, 1948 (FMNH); 52. Cikembar, 1926 (B); 53. Cibalong¹, 1912 (N); 54. Kemang, 1942 (N); 55. Ragunan Zoo, 1996 (D. Philippe pers. comm.); 56. Tajur, 1981 (SvB); 57. Monas, 2001 (J. H. Hansen unpubl. data); 58. Cibinong, 1929 (B); 59. Weltevreden, 1929 (Kuroda 1930); 60. Cijujung¹, 1924 (N); 61. Cigaleuh¹–Cigombong, 1941 (N); 62. Edam (now Damarbesar) Island, 1920 (N); 63. Jakarta, 1908 (van Oort 1910), 1989 (G. C. L. Dutson pers. comm.); 64. Salemba, undated (Koens 1913); 65. Sentiong¹, 1909 (N); 66. Gadog ('Gadok'), undated but from nineteenth century (N); 67. Gunungputri, 1928 (B); 68. Ciheulang, undated (Bartels 1902, 1906); 69. Cisaat, 1925 (B); 70. Taman Mini, 1979 (SvB); 71. Pasir Datar, 1929 (B); 72. Cikundul¹, 1943 (N); 73. Sukabumi, 1929 (Kuroda 1933); 74. Wanaherang, 1931 (B); 75. Cibeureum¹, 1925 (N); 76. Gunung Pangerango, 1922 (N); 77. Dayeuh¹, 1930 (B); 78. Cileungsi, 1931 (B); 79. Gunung Gede, 1898 (AMNH); 80. Situ Palahlar, 1930 (B); 81. Puncak, 1976 (W. G. Harvey unpubl. data); 82. Cibodas, 1943 (N); 83. Ciloto, 1943 (N); 84. Cimacan, 1941 (N); 85. Rarahan, 1947 (N); 86. Gegerbentang, 1944 (N); 87. Muara Gembong, 1925 (N); 88. Muara Wetan, 1923 (B); 89. Jonggol, 1931 (B); 90. Muara Bungin, 1926 (N); 91. Tinggarjaya, 1931 (B); 92. Kubang¹, 1942 (N); 93. Cibarusa, 1949 (M); 94. Cariu, 1929 (B); 95. Sindangbarang–Palsatu, 1987 (SvB); 96. Karangtengah, 1925 (N); 97. Batujaya, 1949 (M); 98. Cimatis, 1930 (B); 99. Cikalongkulon, 1949 (M); 100. Ciranjang, 1929 (B); 101. Kedunggedeh, 1949 (M); 102. Tanjung Sedari, 1923 (B); 103. Karawang, 1929 (B); 104. Kosambi, 1930 (B); 105. Cilangkap, 1978 (van Helvoort 1981); 106. Lemahduhur¹, 1947 (N); 107. Gunung Masigit¹, 1921 (N); 108. Lemahabang–Purwakarta (Cikampek chosen), 1930 (B); 109. Tirtasari, 1910 (N); 110. Purwakarta, 1928 (B); 111. Cikao, 1929 (B); 112. Lemahabang, 1930 (B); 113. Tagog Apu, 1928 (B); 114. Ciranji¹, 1930 (B); 115. Pasirbuah–Parakansalam, 1930 (S); 116. Parabon², 1944 (N); 117. Sangkuriang (Tangkuban Parahu⁵), 1921 (N); 118. Hanjawa¹, 1942 (N); 119. Cipaganti¹, 1921 (N); 120. Bandung, 1995 (N); 121. Lembang, 1956 (M. M. J. van Balgooy unpubl. data); 122. Dawuan¹, 1943 (N); 123. Cikidang, 1978 (van Helvoort 1981); 124. Gunung Papandayan, 1929 (Stresemann 1930); 125. Pagaden–Situ Nagrog (midpoint chosen), 1923 (S); 126. Pagaden Baru, 1936 (S); 127. Pamanukan, 1986 (SvB); 128. Kacepet, 1929 (S); 129. Garut, 1928 (N); 130. Babakan Maja, 1936 (S); 131. Cidulang¹, 1943 (N); 132. Selajambe¹, 1933 (N); 133. Banjar, 1907 (N); 134. Cirebon, 1927 (AMNH); 135. Pangandaran, 1993 (M. Philippe pers. comm.); 136. Pabuaran¹, 1941 (N); 137. Ciledug³, 1933 (Bouma 1936); 138. Brebes, 1910 (van Dedem 1912); 139. Tegal, undated (Vorderman 1892); 140. Purwokerto, 1925 (N); 141. Karangbolong, 1920 (Robinson & Kloss 1924); 142. Dieng Plateau, 1983 (J. J. Madsen unpubl. data); 143. Purworejo, 1925 (N); 144. Kledung, 1927 (Docters van Leeuwen 1929); 145. Borobudur, 1929 (Kuroda 1930); 146. Magelang, 1922 (N); 147. Bulu³, 1922 (S); 148. Tinjomoyo, 1992 (reported to SvB); 149. Semarang, undated (Vorderman 1900); 150. Gedangan, 1940 (Sody 1953); 151. Candi Baru¹, 1929 (Kuroda 1933); 152. Pacitan, 1979 (H); 153. Trinil, 1908 (ZSM); 154. Sulang², 1924 and/or 1929 (MVZ); 155. Cepu, 1926 (N); 156. Kediri, undated (Bartels 1902); 157. Tuban, 1979 (H); 158. Ujung Pangkah, 1990 (SvB); 159. Gunung Arjuno, 1927 (AMNH); 160. Prigen, 1890 (NHMW); 161. Lawang, 1886 (AMNH); 162. Sidoarjo, 1927 (Anon. 1927); 163. Surabaya, 1986 (SvB); 164. Pasuruan, undated (Vorderman 1900); 165. Kencong, 1988 (SvB); 166. Klatakan¹, 1941 (N); 167. Jember golf course (assumed to be Glantangan¹), 1977 (H); 168. Dampar², between 1930 and 1951 (N); 169. Saronggi, 1970 (MZB); 170. Sampean Baru¹, 1977 (H); 171. Batang (presumed Batang-batang), 1970 (MZB); 172. Gunung Raung, 1917 (N); 173. Ijen Plateau, 1977 (H); 174. Sapudi Island, 1965 (MZB); 175. Baluran NP*, before 2011 (Winassis *et al.* 2011); 176. Bajulmati, 1920 (Robinson & Kloss 1924); 177. Alas Purwo NP*, present on park species lists (Grantham 2000); **Bali**: 178. Gilimanuk, 1994 (SvB); 179. Sumberklampok, 1990 (A; also Kusumanegara *et al.* 2015); 180. Tegalbundar, 1992 (SvB); 181. Goris, 1981 (SvB); 182. Lovina and Kalibukbuk, 1997 (L. Conole pers. comm.); 183. Bukit Peninsula, 1982 (A); 184. Petitenget, 1982 (A); 185. Kuta, 1938 (N); 186. Nusa Dua, 2003 (M. Schellekens pers. comm.); 187. Ubud, 1938 (N) and before 1985 (Mason 1985); 188. Suwung, 1981 (A); 189. Rendang, 1911 (Stresemann 1913); 190. Padangbai, 1982 (A).

*National Park