Status Assessment and Population Trends of the Madagascar Pond-Heron (Ardeola idae) from 1993-2016

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Status Assessment and Population Trends of the Madagascar Pond-heron (*Ardeola idae)* from 1993-2016

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Abstract.—The Madagascar Pond-heron (*Ardeola idae*) is a migratory species that breeds exclusively in Madagascar and nearby islands (Europa, Aldabra and Mayotte). Changes in the population of this species were investigated over the last 23 years through literature reviews, field monitoring, and surveys undertaken from 1993 to 2016. Data from 111 sites were collected and analyzed for population assessment, including 11 known breeding sites in Madagascar ($n = 6$), Mayotte ($n = 4$), and Europa ($n = 1$). Trend analyses were done with surveys from 1993-2016 (omitting 1996) and population estimates from the last 5 years of surveys, 2012-2016. The species occurred in all types of wetlands including lakes, ponds, marshes, rivers, mangroves, pasture wet meadow, and rice fields. During the non-breeding season (May-September), many pond-herons migrate to eastern and central Africa; however, some birds (911 records) remained in Madagascar and Mayotte during austral winter. Data show the current population estimated at ~1100 breeding birds in the total breeding area. The population has declined significantly, with 41.6% and 52.9% declines, respectively, at the two colony sites in Tsimbazaza and Tsarasaotra parks with the longest history of breeding. Main threats to the species are habitat destruction, collection of eggs and fledglings, predation, and human disturbance at all breeding sites. *Received 31 March 2019, accepted 5 November 2019.*

Key words.—Aldabra, *Ardeola idae*, breeding colonies, Europa, Heron Crabier Blanc, Madagascar Pond-heron, Mayotte, non-breeding populations, population trends.

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The Madagascar Pond-heron (*Ardeola idae,* henceforth pond-heron) is listed as Endangered in the Red List of the International Union for the Conservation of Nature (IUCN) according to the first population estimate of 2,000-6,000 individuals in 2000 (Delany and Scott 2002; IUCN 2012) with roughly 1,300-4,000 mature individual birds (Dodman 2002). The species is widespread in Madagascar, but the population is low. In 1990, Burger and Gochfield (1990) considered it to be in drastic decline due to wetland exploitation (Birdlife International 2016).

The breeding season for the pond-heron starts in October and ends in March in Madagascar and the nearby islands of Aldabra, Mayotte and Europa (France) (Probst 1996; Bunbury 2014). During the non-breeding season, some of the population migrates to Africa with a large non-breeding range in Central and East Africa including the Comoro Islands, Mozambique, Zimbabwe, Zambia, Malawi, United Republic of Tanzania, Kenya, Uganda, Burundi, Rwanda, and the Democratic Republic of Congo. It is also a vagrant in Angola, Somalia, South Africa, and Socotra (Kushlan and Hancock 2005; Ndang'ang'a and Sande 2008; Sartain and Hawkins 2013).

Based on identified threats affecting the species throughout its range, an International Single Species Action Plan for the Conservation of the pond-heron was developed with participation of experts (Ndang'ang'a and Sande 2008). The action plan was adopted by the 4th Session of the Meeting of the Parties to Africa-Eurasia Waterbird Agreement in September 2008 and the 9th Session of the Conference of Parties to Convention

on Migratory Species in December 2008 (Ndang'ang'a and Sande 2008). The main purpose of the action plan was to improve the current conservation status and knowledge of the species within 10 years of its implementation, as identified by the 10 recommended priority actions (Ndang'ang'a and Sande 2008). In Mayotte, a national action plan for conservation was being developed and implemented in 2019. The objective of the present study is to report on three of the conservation priorities of the action plan (perform coordinated censuses throughout the country, implement field surveys, and identify all breeding colonies in Madagascar to meet the goal needed to at least maintain the current population level of pond-herons [Ndang'ang'a and Sande 2008]) and to estimate population size of breeding birds with data from surveys.

METHODS

Study Area

The study area consisted of Madagascar and the smaller islands of Mayotte, Aldabra, and Europa (Fig. 1). On Madagascar, we attempted to survey all wetland types such as lakes, marshes, rivers, mangroves, and estuaries with natural habitat, and especially any wetlands previously known to harbor nesting pond-herons (such as Tsimbazaza Park, Tsarasaotra Park, and Ravelobe Lake). In addition, transformed wetlands such as rice fields, artificial lakes, and ponds and channels used for agricultural purposes were included. On the three smaller islands, we also searched wetlands as potential habitat for the species. All information on habitat was recorded on data sheets: coordinates, types of wetlands, vegetation type and cover, wetland use and threats.

Census Work

Waterbird censuses have been conducted annually in Madagascar by non-government conservation institutional staff, field managers, and volunteers since 1993. Rivo Rabarisoa was the chief field biologist responsible for coordinating the census activities and collecting and checking the data for the duration of the study. In the field at each wetland site, a map was first drawn of the various habitats for possible nesting, loafing, foraging and roosting by the pond-heron. These areas were then searched by a 2-3-person team walking slowly through the habitat, spaced 2-5m apart. Three types of data were recorded: 1) the number of pond-herons that flushed (and approximately where each bird went, to avoid double-counting); 2) groups of nests were usually noted from afar (each nest and attending adults were subsequently counted as carefully as possible before they flushed; these numbers were tallied separately from pond-herons that were noted away from nesting areas); and 3) threats that were observed or known to have occurred at each visited wetland site. Field censuses usually started around sunrise and continued until 10:00 or 11:00 hr, and as needed from 16:00 hr to dusk at roosting sites. The number of sites that could be censused each year was constrained by limited numbers of staff and trained volunteers, geography, and budgets. There was no pre-set interval for re-censusing sites across years, and all sites could not be censused in a single year.

During our censuses, all bird species were recorded using International Waterbird Census methods (Perennou 1991), but in the present study, only information related to the pond-heron was used in the analysis. Censuses for pond-herons were conducted during January-February, the peak of the nesting season, when adults would be expected to be in nesting habitat and their numbers maximal. We considered as potential breeding sites the area where pond-herons were seen in breeding plumage but without signs of nesting and sites where nests were present. All information was entered into an Excel spreadsheet: site name, georeferenced locality, habitat type, noted threats, visitation date and the number of adult pond-herons at nests and away from nests. Winter counts of pond-herons were conducted opportunistically in July-August in a similar manner to that described above. Data from winter counts were only used for the Maxent prediction model (see below).

Population Distribution and Statistical Analysis

For predicting the population distribution of the pond-heron, Maximum-Entropy Techniques known as "Maxent Software" were used based on available habitat types (Phillips *et al.* 2004). This software predicts the species' distribution based on its presence/absence from point data and environmental variables (temperatures, precipitations, water level, etc.). The actual distribution was mapped using ArcGIS. For a population assessment, we used the maximum count from each known and potential breeding site recorded during the breeding season of the last five years of surveys from 2012 to 2016. Moreover, to complete the count, yearly missing values for the unvisited sites during this period were calculated using BIRDSTATs and indices through the Trends and Indices for Monitoring (TRIM) software. The data analyzed by TRIM are counts obtained from a number of sites at a number of time-points (years) with unobserved counts or missing values. TRIM is a freeware program, developed by Statistics Netherlands which analyzes time series of counts, using Poisson regression and produces estimates of yearly indices and trends (Ter Braak *et al.* 1994; Van Strien and Pannekoek 2005).

Population trends were analyzed for two areas where multiple annual counts were conducted: Tsarasaotra Park (13 annual counts) and Tsimbazaza Park (18 annual counts). Poisson regression was conducted on the annual pond-heron count data using a log link func-

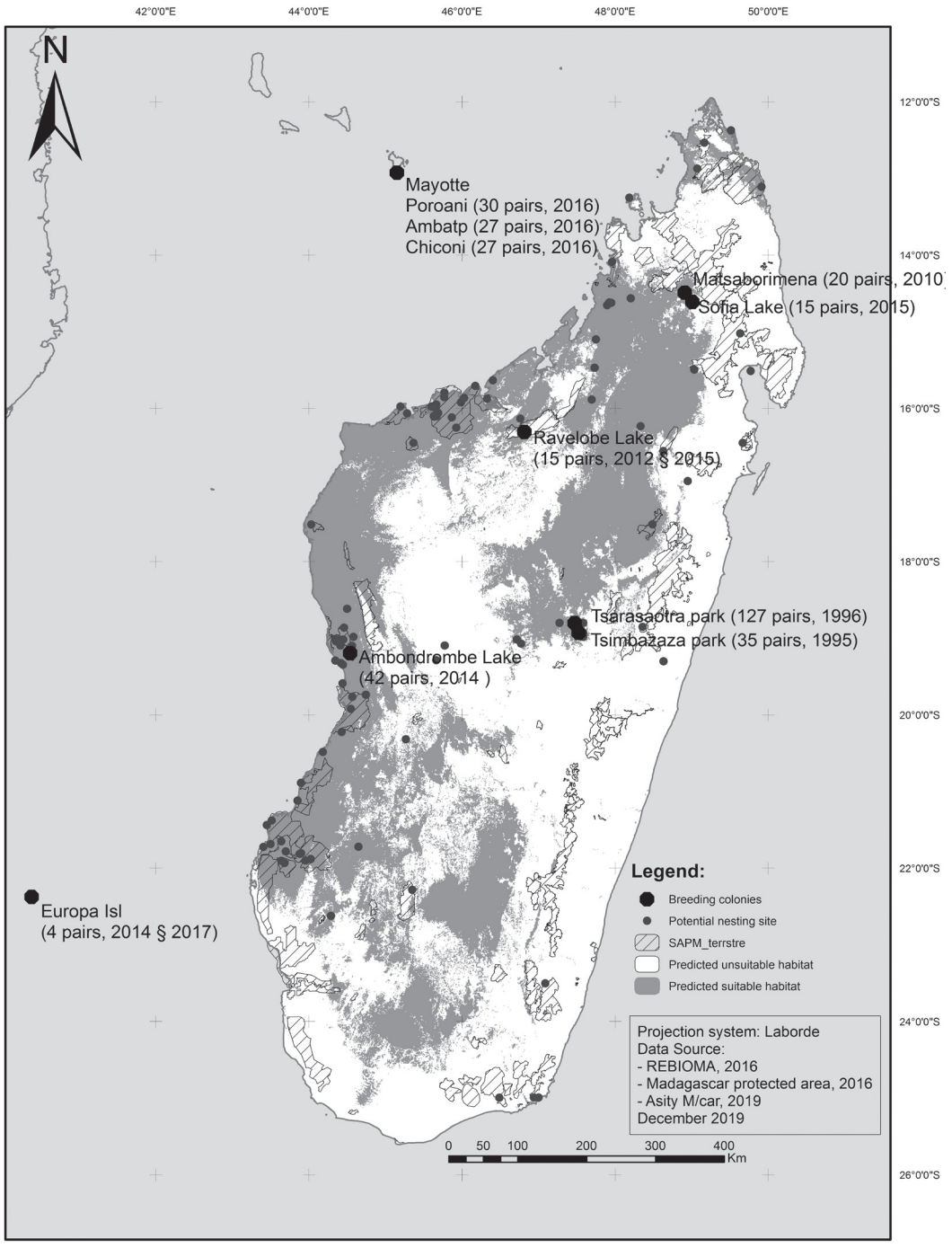

Figure 1. Distribution of potential nesting sites and active breeding colonies of the Madagascar Pond-heron (*Ardeola idae*) in Madagascar, 1993-2016.

tion (PROC GENMOD, SAS/STAT Institute 2009) using data recorded during January-February, 1993-2016 (omitting 1996), when most of the birds were assumed to be at or near their breeding site. To get the best prediction because of the relatively small number of censused sites each year, the analysis was conducted at sites with the longest history of breeding colonies, samples that had repeat annual counts (>10).

RESULTS

The Censuses

We compiled 220 data points (counts), including zero counts, at 106 sites over 24 years. The number of data points (annual counts) for each site ranged from 1 to 18; however, 59.4% of sites (n = 63) were only censused once, 17.0% (n = 18) were censused twice, 13.2% (n = 14) were censused three times, 3.8% (n = 4) censused 4 times, and only 6.6% (n = 7) were censused five or more times. The maximum number of pond-herons at each site ranged from 1-468 (Appendix 1), with most of the sites (54.7%, n = 58) having only 1 or 2 pond-herons (Table 1). We were aware at the time that the highest count for a colony site in 1996 (468 birds), was exorbitantly high; however, all nests were individually checked carefully during the census to avoid double-counting and identification error (confusion with other species), and we believe the estimate to be correct. However, given that the 1996 count at this site was vastly higher than prior and subsequent years, this data point was not included in trend analyses nor population estimates. The number of pond-herons at each site from the most recent surveys, considering the last five years 2012-2016, ranged from 1-84, with most of the sites (43.6%, n = 17) having only 1 or 2 pond-herons censused (Table 1). Both the number of visits per site and the number of pond-herons censused per site were heavily skewed to two or less.

Table 1. Frequency distribution of the maximum number of birds at colony sites of Madagascar Pond-herons (*Ardeola idae*) during breeding seasons from 1993-2016 (the years from which trends were evaluated), and separately for 2012-2016 (the years from which populations were estimated).

	No. of Colony Sites	
Maximum No. Birds	1993-2016	2012-2016
1	13	12
2	15	7
3	3	2
4	5	3
5	1	1
6-10	7	4
11-15	3	3
16-20	6	4
21-25	2	1
25-50	2	1
>50	3	1
Total	106	39

Numbers and Distribution of Occurrence Sites

From 1993 to 2016 (24 years), pond-herons were found at 111 sites within the species breeding range during the January-February census period: 106 sites on Madagascar and a total of 5 sites on Mayotte and Europa. For Aldabran, a small number of breeding birds was recorded during the 1970s (Benson and Penny 1971) and 20-50 pairs in 2001 (Racamora and Skerrett 2001; Sartain and Hawkins 2013). On Madagascar, pond-herons occurred throughout the country, but they were more numerous in the western and central parts of the island where the most suitable habitat was found; few birds were recorded in the eastern part of the country (Fig. 1) which had limited suitable habitat. Approximately 60% of recorded pond-heron sightings were located at sites in the western part of Madagascar and most of the sites are within the protected areas system (Fig. 1).

Known Nesting Sites

Eleven nesting sites of pond-herons were found from 1993 to 2016 in the study area and comprised the species breeding range; six of the sites were in Madagascar: Tsarasaotra Park, Ambondrombe Lake, Tsimbazaza Park, Matsaborimena Lake, Sofia Lake, and Ravelobe Lake (Fig. 1; Appendix 1). The other five sites were on Mayotte (n = 4; Ambato Lagoon; Chiconi and Mangajou; Ironi Be; Poroani/Malamani) and Europa (n = 1) islands. Although we did not visit Aldabra during this study, 20 to 50 pairs of pond-herons were recorded in 2001 (Sartain and Hawkins 2013) nesting with Little Egret and Cattle Egret. This site should be investigated in the future to confirm its importance.

In Madagascar, pond-herons nested mostly in dense emergent aquatic vegetation

(*Phragmities*, *Typhus*, and *Papyrus*). The only exception was at Tsimbazaza Park, where the heronry was located in trees, *Ficus* sp. from 5-12 m tall. On Mayotte, most nests were built in the tops of mangrove trees. The mangrove on Mayotte, which covers 650 ha, is an important nesting site for the pond-heron and other species of herons, such as the Madagascar Heron (*Ardea humbloti*) which was discovered breeding here for the first time outside of Madagascar. Information on the nesting areas, including habitat type, site status, the number of active pairs, and number of nests is summarized in Appendix 1.

Potential Breeding Sites

Apart from the six identified nesting sites in Madagascar, pond-herons in breeding plumage but without nests were recorded at 100 other sites (Fig. 1). The locations (with GPS coordinates), habitat characteristics, maximum number of breeding-plumaged birds, and the number of visits to each of those sites are given in Appendix 1. These sites were distributed throughout the island, but the pond-herons showed no signs of nesting; however, we considered these to be potential nesting sites for pond-herons. Elevated numbers (four or more individuals) of pond-herons were seen at nine sites, all of which were located along the western coast and in the central area of Madagascar (Table 2). Birds in breeding plumage were seen at these sites, but most of the sites were not accessible during the breeding season (January-February) because of flooding during this rainy season period. The same was true for the Mangoky Ihotry Wetland Complex, Manambolomaty Wetland Complex, and Sofia Lake.

Bird Status Outside the Breeding Season

During the non-breeding season (austral winter from May to September), pond-herons migrate to eastern and central Africa; however, large numbers of them (911 records at 53 sites) were recorded in Madagascar as part of this study (R. Rabarisoa, unpubl. data; Table 2). During this period, birds were mostly seen solitarily at both roosting and foraging areas, and most of them were restricted to the western portion of the country. They were noted at various types of wetlands throughout the country: streams, rivers, lakes, marshes, mangroves, pasture wet meadow and especially rice fields. Also, during this season, only a few birds frequented the six known nesting areas in Madagascar; pond-herons were mostly seen foraging in surrounding areas (R. Rabarisoa, unpubl. data). Roosting areas of pond-herons were located in both aquatic emergent vegetation and tall trees near wetlands. Details on subsequent work on wintering birds is being prepared for publication at a later date.

Estimate and Trends of Breeding and Potentially Breeding Populations

Most of the censused pond-heron population, about 77.2%, were found in Madagas-

Table 2. Sites with elevated numbers (at least four individuals) of adult Madagascar Pond-herons (*Ardeola idae*) recorded along the western coast and high central area of Madagascar during breeding season (January-February) from 1993-2016; and sites with >7 individuals during the non-breeding season (July-August) from 1993-2016.

	Maximum no. of birds (year of observation)	
Sites	Breeding season	Non-breeding season
Tsiribihina River and Delta	4 ind. (Jan 2001)	—
Loza River estuary	4 ind. (Feb 2016)	15 ind. (2005)
Torotorofotsy Marsh	4 ind. (Mar 2016)	—
Mandrozo wetlands	8 ind. (Jan 2010)	—
Baly Bay	9 ind. (Jan 2009)	9 ind. (2009)
Manambolomaty Wetland Complex	13 ind. (Jan 2003)	9 ind. (2003)
Begara mangrove	17 ind. (Dec 2014)	—
Mangoky Ihotry Wetland Complex	26 ind. (Dec 2006)	57 ind. (2005)
Matsaborimena Lake	>50 ind. (Dec 2016)	—

car. During the census period, the number of recorded birds varied from year to year (Fig. 2). In order to estimate the number of birds within 106 sites, we used the maximum survey count from each site during the last five years (2012-2016). There were 39 sites surveyed during this period (36.8 % of all sites), giving a total of 330 breeding birds. Calculating missing values for the 67 unvisited sites during the same period, using indices from monitoring data, gave a maximum value of 76 additional birds. Therefore, a total of 406 birds was calculated for the overall 106 sites. The survey was conducted at 106 sites out of the more than 200 possible areas frequented by the pond-herons. If we estimate that we visited and censused approximately 50% of the potential breeding habitat in Madagascar (data in Appendix 1), we arrive at an estimated total of 812 birds in breeding plumage. In addition, 250 birds were found on Mayotte and Europa Island. Thus, our analysis shows an estimate of 1,062 breeding birds was probably present overall, which we assume is the equivalent of about 531 breeding pairs.

Our study confirmed that the populations of the pond-heron decreased significantly during the last 24 years (from 1993-2016) at the two colonies with the largest number of pond-herons and the longest history of breeding activity (Fig. 3): Tsarasaotra Park with an overall decline of 52.9% and annual rate of decline in the $\log_{10}$ number of birds = -0.136 (95% CI = [-0.149, -0.123]; $P < 0.0001$); and Tsimbazaza Park with an overall decline of 41.6% and annual rate of decline in the $\log_{10}$ number of birds = -0.086 (95% CI = [-0.107, -0.065]; $P < 0.0001$) (Fig. 3). Pooling together data at these two sites, we get significant annual rate of decline in the $\log_{10}$ number of birds = -0.164 (95% CI = [-0.177, -0.151]; $P < 0.0001$). Four sites in the vicinity of the capital city of Antananarivo (Imerimanjaka Marsh, Dorodosy Marsh, Sabotsy Laniera, and Farahantsana), where colonies of pond-herons were recorded during the first 10 years of the census (1994-2003), showed no nesting activity during the last 10 years of the study (2007-2016), indicating that all four sites had been abandoned.

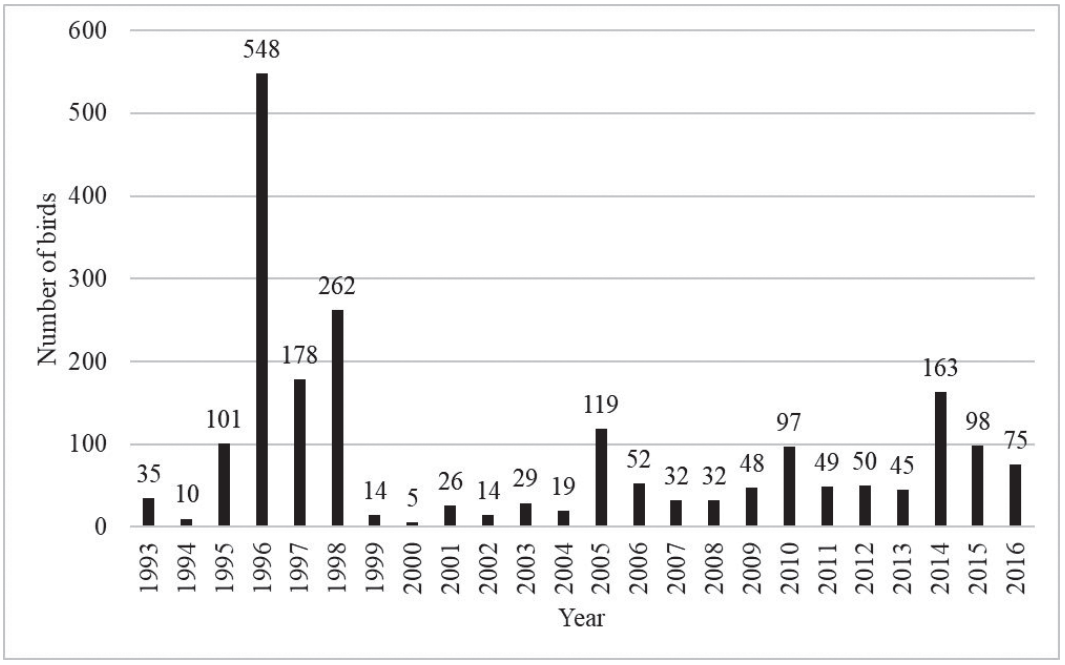

Figure 2. Annual variation of the number of Madagascar Pond-herons (*Ardeola idae*) recorded during the breeding season, 1993 to 2016.

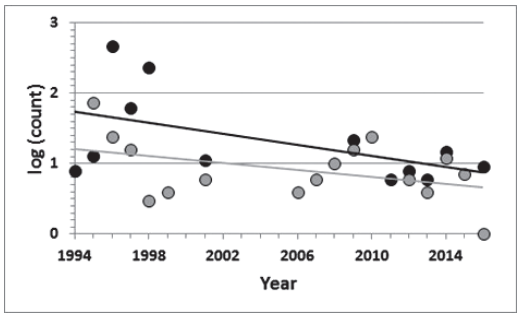

Figure 3. Number of individuals surveyed and population trends for Madagascar Pond-herons (Ardeola idae) surveyed in Tsarasaotra Park (in black) and Tsimbazaza Park (in grey), Madagascar, during the breeding season (January-February), 1993 to 2016. Y-Axis: log10 (count) of birds.

Species Threats

The main threats to the pond-heron at the 11 known nesting sites were the collection of eggs and fledgling birds, and human disturbance. These threats were present at 73% of the sites (Table 3). Predation and swamp fires were threats at 23% of the sites during the study period.

DISCUSSION

At most of the monitored breeding sites in Madagascar, the number of recorded pairs varied from year to year; this was especially noticeable for Tsimbazaza Park and Tsarasaotra Park, where sites were monitored for multiple years. This variation was probably due to various factors such as the level of anthropic pressure, predation, and nest site availability. Studies should be carried out to understand this fluctuation and evaluate pond-heron productivity. The results showed that pond-herons were found at 100 sites during the breeding season where they were not previously known to occur. These sites constitute potentially new nesting areas for this species. This information suggests there may be small breeding colonies in many wetlands in Madagascar. Research should be conducted at these potential breeding areas to confirm the presence of nesting.

Our results, spanning 24 years (1993 to 2016), show an evident decline of the pond-heron population. About 550 breeding pairs, equivalent to at least 1,100 mature individual birds, are estimated to comprise the entire breeding population on Madagascar and nearby islands as of 2016. Around Antananarivo, Madagascar's capital city, two (Mandroseza and Imerimanjaka) of the four existing nesting sites and colonies recorded in the 1990s (Sartain and Hawkins 2013) are no longer present. The numbers declined drastically at the two remaining colonies located in Tsarasaotra Park (63% decline: 30 pairs in 1990 [Langrand 1990] to 11 pairs in 2009) and Tsimbazaza Park (80% decline: 50 pairs in 1990 [Langrand 1990] to 8 pairs in 2009). Although we did not visit Aldabra during this study, a small number of breeding pond-herons was recorded there during the 1970s, and 20-50 pairs were estimated in

Table 3. Recorded threats to the Madagascar Pond-heron (*Ardeola idae*) at breeding sites in Madagascar, Mayotte and Europa Island from 1993-2016.

Breeding sites	Collection of eggs/ fledglings	Predation	Human disturbance	Swamp fire	Nest competition with other herons
Matsaborimena Lake	No	Yes	No	No	No data
Ambato Lagoon	Probably	No	Yes	Yes	No data
Ambondrobe Lake	Yes	No	Yes	Yes	Yes
Chiconi/Mangajou	Probably	No	Yes	No	No data
Europa island	No	no info.	No	No	No data
Ironi Be	No	No	No	No	No data
Poroani/Malamani	Probably	No	Yes	No	No data
Ravelobe Lake	Yes	Yes	Yes	No	Yes
Sofia Lake	Yes	No	Yes	yes	No data
Tsarasaotra Park	Yes	Yes	Yes	No	Yes
Tsimbazaza Park	Yes	No	Yes	No	Yes
Total no. of sites	8 sites	3 sites	8 sites	3 sites	4 sites

2001 (Racamora and Skerrett 2001; Sartain and Hawkins 2013); this suggests a noteworthy increase. The four sites in the vicinity of the capital city (Imerimanjaka Marsh, Dorodosy Marsh, Sabotsy Laniera, and Farahantsana; Salvan 1972) had been natural marshes; however, they were converted into rice fields or developed for housing, so the breeding habitat was destroyed. No data are available to confirm a change in the numbers of pond-herons on Mayotte and Europa Island, but a critically important number exist there with a maximum of 125 pairs, inferring significant conservation value to these islands. The Mayotte breeding population seems to have increased during the last 12 years from about 20 pairs in 2003 to 121 pairs in 2015, but it is difficult to determine if this is due to improved population dynamics or to improved monitoring effort (Jeanne *et al.* 2015).

Concerning threats, the taking of fledgling birds was recorded at most of the breeding sites (J. Ramanampamonjy, pers. obs.), except at the Matsaborimena Lake, which is well protected. This threat is strongly suspected in Mayotte, where cases of poaching have been recorded for Cattle Egrets (*Bubulcus ibis*) breeding in the same areas as pond-herons. At Sofia Lake, the aquatic vegetation is mainly composed of papyrus (*Papyrus cyperus)* covering about 282 ha, which could support an important nesting colony for heron species. Nest competition should not happen at this site but nest numbers do fluctuate, probably as a result of human perturbation through the use of swamp fire for conversion of marsh to rice fields and the collection of papyrus (L. Andrianaina, pers. commun.). At the beginning of the breeding season, in October 2015, more than one hectare of papyrus was burned at Sofia Lake for rice cultivation (Raminoarihenintsoa 2015). The same thing happened for most of the Mayotte sites, i.e. the conversion of marsh for cultivation of banana and/or taro (F. Jeanne, pers. commun.). In terms of hunting, there is no recorded evidence of specific hunting activity for the pond-heron, but traditional trapping, mainly for waterbirds such as rails, ducks, and herons, was seen at some wetlands (Razafimanjato *et al.* 1997; Rabarisoa 1999, 2007; L. Andrianaina, pers. obs.).

For other types of threats, predation is attributed mainly to birds of prey taking eggs and fledgling herons; attacks have been observed by the Madagascar Harrier-Hawk (*Polyboroides radiatus*) at Ravelobe Lake (R. Rabarisoa, pers. obs.), Madagascar Harrier (*Circus macrosceles*) at Matsaborimena Lake (L. Rene de Roland, pers. obs.) and by Peregrine Falcon (*Falco peregrinus*), which attacked a pond-heron at Tsarasaotra Park (R. Raveloson, pers. obs.). The impact of rats (*Rattus* sp.) has not yet been evaluated in Mayotte, but there is no evidence of this type of predation currently. Away from the breeding site in the capital city, urbanization is a threat; for example, a huge area of wetland, mainly rice field used as a foraging site by the pond-heron, was plowed up during the last 20 years. This may have been one of the reasons for the species' dramatic population decline and fragmentation into two smaller breeding sites in the capital city. Populations of pond-herons are affected primarily by the general degradation of wetland habitat in Madagascar. However, a pond-heron and a Squacco Heron (*Ardeola ralloides*) were observed together in January 1999 at one nest at the Tsimbazaza Park (J. Ramanampamonjy, pers. obs.), so the possibility of hybridization should be investigated.

The current research reported here has fulfilled three of the six objectives of the single species action plan for the pond-heron (Ndang'ang'a and Sande 2008): 1) to increase the species' profile in its range so that all the breeding sites obtain legal protection, either as a protected area or a community management area; 2) to determine the species' population size and trends; and 3) to establish the extent of the species' range and distribution with a focus on identifying all breeding sites.

In terms of new conservation measures to stop or limit the decline of the pond-heron population, the species action plan should be reinforced with emphasis on the following aspects: 1) renewed conservation actions at all breeding sites to reduce and manage

human disturbance through a) a strong education-outreach programs, b) restoration of aquatic habitats, and c) support local people on alternative economic activities as sources of income; 2) complete research on the bio-ecological needs of the species and investigate all potential breeding areas; and 3) undertake further field observations for evidence of hybridization (between *Ardeola idae* and *A. ralloides*) and collection of DNA material (eggs or feathers) of suspected hybrid nests or young.

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APPENDICES

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APPENDIX 1

Maximum counts of Madagascar Pond-heron (*Ardeola idae*) at breeding sites in Madagascar, Mayotte and Europa from 1993 to 2016.