

The current status of Livingstone's flying fox (*Pteropus livingstonii*) in the Federal Islamic Republic (RFI) of the Comores

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Abstract: *Pteropus livingstonii* is an Old World fruit bat (Megachiroptera: Pteropodidae) from the RFI Comores. Recent surveys show a population estimate of around 400 individuals, with natural forest being its preferred habitat. *P. livingstonii* is currently categorized as Critically Endangered (A1c+2cd, B1+2c, C2a) in the IUCN Red List categories for animals. In light of the survey results and the known distribution of this species, it appears that this categorization may be over-cautious. Although more data are desirable, we conclude that Endangered (A1c+2cd, B1+2c, C2a) is presently a more appropriate category for this species.

Introduction

There are three fruit bat (Megachiroptera) species found in the Federal Islamic Republic of the Comores (Western Indian Ocean). These are the Comoros lesser flying fox, *Pteropus seychellensis comorensis* (Nicoll, 1908), Livingstone's flying fox, *Pteropus livingstonii* (Gray, 1866) and the Comoros rousette, *Rousettus obliviosus* (Kock, 1978). *P. s. comorensis* is abundant and is found on all four islands of the Archipelago (Cheke & Dahl 1981; Action Comores 1992, 1997). Little is known about the status of *R. obliviosus*, which has been recorded from Grande Comore, Moheli and Anjouan (Reason & Trehwella 1994). Of the three species, *P. livingstonii* is the rarest; it is found only on two of the four islands of the archipelago (Anjouan and Moheli) (Cheke & Dahl 1981, Reason & Trehwella 1994).

P. livingstonii was accorded the status Endangered (Priority Grade 1) in the IUCN Action Plan for Old World Fruit Bats (Mickleburgh, Hutson & Racey 1992). The IUCN Red List categories for animals were recently redefined (Mace & Lande 1991, IUCN 1996) and *P. livingstonii* is now categorized as Critically Endangered (A1c+2cd, B1+2c, C2a). A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of certain additional criteria (A to E), laid out in the IUCN Red List of Threatened Animals IUCN (1996). Mace & Lande (1991) believed that the old categories used in Red Data lists were too subjective. Hence they proposed their redefined categories in terms of the probability of extinction within a specific time period.

One of the major recommendations for the conservation of *P. livingstonii* in the Action Plan for Old World Fruit Bats was assessment and monitoring of the bat population. This project has been the priority of the non-governmental organization Action Comores, which was founded in 1992, and which is working closely with the

Comoran government, IUCN and Jersey Wildlife Preservation Trust in the conservation of this species. The aim of this paper is to present the latest survey results of Action Comores and to discuss these findings in relation to the IUCN criteria that categorize *P. livingstonii* as "Critically Endangered".

Roost Surveys and Habitat Requirements of Livingstone's Flying Fox

The status of Livingstone's flying fox was reviewed by Cheke & Dahl (1981). Their survey concluded that there were "no more than a few hundreds, and maybe less" of this species on Anjouan. Prior to this survey, there are only two published reports on the status of *P. livingstonii*. M. Humblot (cited in Milne-Edwards & Oustalet 1888) states that the bat "existed in abundance in the great forests which cover the summit of Anjouan's peak but is never seen in the lowland areas of the coast". Voeltzkow (1904) stated the bat was "rare" and seen "sometimes during the day flying above the tops of the highest mountains" but "is never seen in the banana plantations or the natives' gardens", unlike *P. s. comorensis*. Reports of sightings and surveys subsequent to that of Cheke and Dahl are summarized in Reason & Trehwella (1994) and Action Comores (1992).

Survey work in the dry seasons (June - August) of 1992, 1993 and 1994, by Action Comores personnel on expeditions from the United Kingdom, found two roost sites on Moheli and six on Anjouan. The maximum population estimate from these surveys was 20 bats on Moheli and 132 on Anjouan (Reason & Trehwella 1994). However, after these consecutive visits it became obvious that if such work was to be regular, repeatable and cost-effective, it had to be carried out by Comorans "in-situ", rather than by "ex-situ" scientists. In 1994 therefore, Action Comores established an *in-situ* roost monitoring programme (Action Comores 1995), which involved training groups of Comoran volunteers to survey the roosts. The *in-situ* survey protocol comprises twice-yearly visits (in the wet and dry seasons) to all known bat roosts, in order to undertake simultaneous counts of all bats. Each team of volunteers at each roost counts the bats they can see at around noon.

Table 1. summarizes the data from the 18th June 1995 biannual count on Anjouan. This gives a minimum noon population estimate for *P. livingstonii* on Anjouan

Table 1. Roost details and population counts for *P. livingstonii*.

Island	Roost	Altitude	Vegetation	count
Anjouan	Lingoni	690-800 m	Natural forest	103
	Hombo	780 m	Natural forest	7
	Dindi	780 m	Cultivation with dense tree cover	9
	Salamani	920 m	Cultivation under natural forest	85
	Plaideau's	450 m	Cultivation with light tree cover	0
	Enteritis	450 m	Cultivation	1
	Matulabe	580 m	Cultivation under natural forest	44
	Ouzini	1000 m	Natural forest	40
	Trondroni	650 m	Natural shrub/creepers	-
	Kangani	650 m	Cultivation under natural forest	43
Moheli	Ouallah 1	150 m	Cultivation with dense tree cover	~ 60
	Mlédjélé	680 m	Natural forest	-

of 332 individuals from nine roosts. It was not possible to survey Moheli simultaneously, however, at least 60 *P. livingstonii* were counted at 13:00 on 7th July 1995 at the 'Ouahllah 1' roost on Moheli. A minimum population estimate on Anjouan in December 1996, from roost counts deemed to be reliable, was calculated as 372 *P. livingstonii*.

Table 1 also summarizes the positions of all known *P. livingstonii* roost sites. These positions were determined either by GPS or by triangulation, with information on vegetation type and altitude obtained from the Carte d'Occupation des Terres aux Comores (Agrar und Hydrotechnik 1987) and Carte de l'Archipelago des Comores (1/50000) (Institute Geographique National 1995).

Table 1 shows that all the roosts on Anjouan (maximum altitude 1595m) are at or above 450m in altitude, and that those on Moheli (maximum altitude 790m) are at or above 150m. The majority of roosts are in either a natural vegetation type or in an area of subsistence cultivation under natural forest, as judged from the Carte d'Occupation des Terres aux Comores. On Anjouan, no sightings have been made below 300m. On Moheli, bats have been seen feeding at a site with an altitude of 40m, and on one of the coastal islands. Preliminary investigations suggest *P. livingstonii* feeds more on native tree species than does *P. s. comorensis* (Action Comores 1992).

It seems reasonable to conclude from the data on roost preferences and sightings (see Fig. 1), and from the historical reports of M. Humblot (cited in Milne-Edwards & Oustalet 1888) and Voeltzkow (1904), that *P. livingstonii* is a species that prefers natural forest areas at higher altitudes.

***P. livingstonii* and the IUCN Red List Categories**

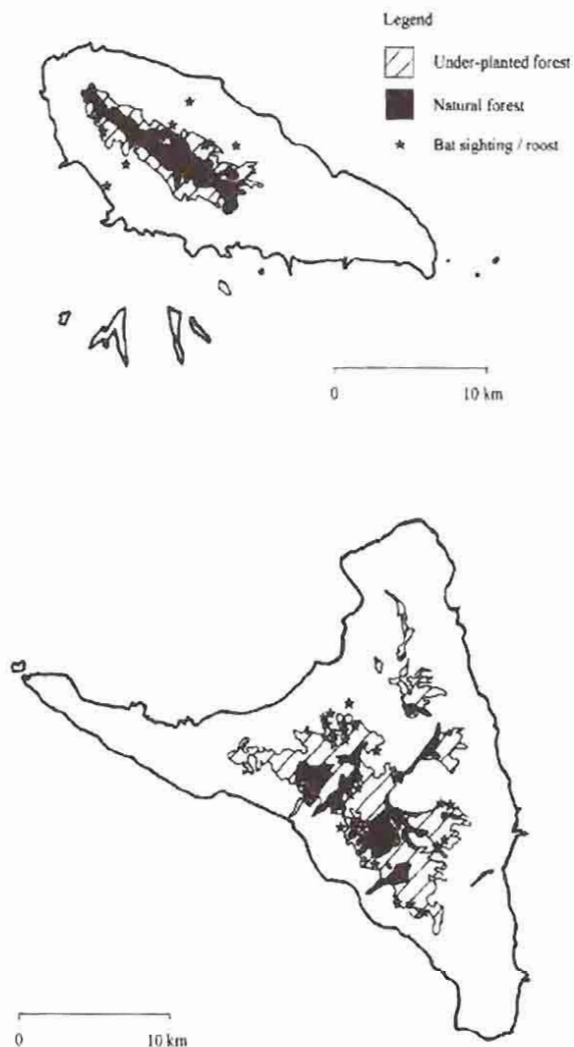
According to IUCN (1996), a taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by certain criteria (see below). These criteria are discussed for *P. livingstonii* in light of the recent survey work, and additional information on the biology of *P. livingstonii* and other *Pteropus* species.

Population reduction (Criteria: A1c+2cd)

A. Population reduction in the form of the following:

1. An observed, estimated, inferred or suspected reduction of at least 80 % over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
 - a. direct observation
 - b. an index of abundance appropriate for the taxon
 - c. a decline in area of occupancy, extent of occurrence and/or quality of habitat
 - d. actual or potential levels of exploitation
 - e. the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
2. A reduction of at least 80 %, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

Fig. 1 *P. livingstonii* sightings and roosts in relation to forest habitat.



Before commenting on any discussion on population reduction, it is necessary to estimate which is the longer for this species: 10 years or three generations? Pierson & Rainey (1992) reviewed *Pteropus* reproductive biology and found little variation in the observed patterns in 23 species. Females reach sexual maturity at 1.5 to 2.0 years, have only one offspring per year and have an average gestation period of 5.5 months. From

observations on captive *Pteropus*, females become sexually mature at about 2.5 years of age, the birth interval is just under one year, and the gestation period is six months (J Seyjagat, pers. comm.). Thus generation time is around 2.5 to 3.0 years, and three generations may therefore be assumed to equate approximately to 10 years.

There is, as yet, insufficient direct survey data to comment on the population status of these bats over the last 10 years, although regular *in-situ* surveys may provide these data in the future. Regular monthly counts at one roost (Lingoni) between 1992 and 1996 show a stable population over this period.

There has been documented loss in the preferred forest habitat of this species, though again no recent habitat surveys exist. The area of natural forest on Anjouan has declined from 120km² in 1925, through 80.8km² in 1972 to 21.6km² in 1987. This represents a 73% loss in the time period 1972-1987. On Moheli, an area of 33.3km² of natural forest in 1969 has declined to 15.5km² in 1987, representing a 53% loss over this time period.

Without current estimates of the extent of natural forest, it is not possible to predict the present rate of forest habitat loss, but there is no cause for anything other than pessimism. Pressure on this habitat from Comorans seeking land for cultivation and timber for fuel and construction continues to increase. Cyclones may also pose a threat to the bats, either directly by injuring bats, or indirectly by damaging their roosts or feeding sites. In 1979, Mungroo (1979, cited in Carroll, 1988) estimated that cyclone Cleine II resulted in a 50 % reduction in the *P. rodricensis* bat population on Rodrigues Island. Cyclones have had a devastating effect on the vegetation of the Comoros Islands (Battistini & Vérin 1984), and a serious cyclone is recorded every 10 years or so, according to Benson (1960). Direct exploitation of the bats is probably the least important threat to *P. livingstonii*, as there is little evidence that this species is hunted at present (Action Comores 1992).

Extent of occurrence of *P. livingstonii* (Criteria: B1+2c)

B. Extent of occurrence estimated to be less than 100 km² or area of occupancy estimated to be less than 10 km², and estimates indicating any two of the following:

1. Severely fragmented or known to exist at only a single location.
2. Continuing decline, observed, inferred or projected, in any of the following:
 - a. extent of occurrence
 - b. area of occupancy
 - c. area, extent and/or quality of habitat
 - d. number of locations or subpopulations
 - e. number of mature individuals.
3. Extreme fluctuations in any of the following:
 - a. extent of occurrence
 - b. area of occupancy
 - c. number of locations or subpopulations
 - d. number of mature individuals.

An estimate for the potential extent of occurrence of this species is the total area of natural and underplanted forest on Anjouan and Moheli, since Fig. 1 shows a correlation between bat sightings and these forest types. This gives an area of 82.8km² on Anjouan and 34.6km² on Moheli; a total of 117.4km² as of 1987.

The area of natural forest on Anjouan has become fragmented as it has declined. Much of the central area around the mountain N'Tingui above 400m used to be covered in natural forest, but this is now limited to non-contiguous areas above 800m. The topography of Moheli is such that forest habitat loss has not resulted in such dramatic fragmentation.

The significance of this fragmentation cannot be determined without further studies on the feeding ecology and movements of this species. Other *Pteropus* species studied to date have been shown to feed on a wide variety of fruits and flowers (Pierson & Rainey 1992), although individual species show a preference for certain foods on a seasonal basis and can be regarded as "sequential specialists" (Marshall 1985). The implication of this for *Pteropus* in general is that, on islands with low floral diversity, the loss of critical plant species through deforestation may affect the survival of these bats (Pierson & Rainey 1992). This situation may apply to for *P. livingstonii* since the natural forest habitat has become so fragmented. Protection of the remaining natural forest patches should be considered as a major component of the long-term management of this species.

Clearly *P. livingstonii* exists in more than a single location, with at least 10 recorded roosts sites on Anjouan and two on Moheli. The two islands are 50km apart at their nearest point, although the distance between the two closest roosts on Anjouan and Moheli is nearer 90km. As an approximation, Rainey & Pierson (1992) state that island populations of *Pteropus* separated by more than 100km of open water will not experience movements sufficient to substantially influence population size.

Further studies will need to be undertaken to determine the rate of decline in the area, extent and/or quality of this species' preferred forest habitat.

Population size (Criterion: C2a)

- C. Population estimated to number less than 250 mature individuals and either:
1. An estimated continuing decline of at least 25 % within 3 years or one generation, whichever is longer or
 2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
 - a. severely fragmented (i.e. no subpopulation estimated to contain more than 50 mature individuals)
 - b. all individuals are in a single subpopulation.

The population estimate from the 12 known roosts is approximately 400 individual adult bats, based on counts in 1995 and 1996. The limited evidence from surveys since 1991 fails to show any directly observed current decline in bat numbers (Action Comores 1997).

It is believed that this estimate represents the majority of the total population. Most of Anjouan has now been surveyed, and it is unlikely that many more large roosts will be found. Although only one roost site was known in 1988, by 1992 this had increased to four and by 1995, as a result of the *ex-situ* and *in-situ* surveys, to 12. One potential 'new' roost area has been reported on Anjouan (Action Comores 1997) but not yet verified. Further roosts may exist on Moheli, as it is less well surveyed than Anjouan. The survey protocol (simultaneous counts at all known roosts) also reduces the possibility of bats moving between roosts during the count, and so affecting the accuracy of the count.

It is not known how (or whether) the *P. livingstonii* population is divided into sub-populations. The distances between the two islands are less than those suggested as delineating separate populations (Rainey & Pierson 1992). At least five of the roosts in the June 1995 count on Anjouan are of more than 50 bats, as is the largest roost on Moheli.

Conclusions

The survey work has produced a reliable minimum population estimate of around 400 individual *P. livingstonii* and shown that this species prefers natural forest areas.

This information is not sufficiently complete to verify the current IUCN category for this species, as it lacks sufficient detail on population stability and/or recent changes over the last 10 years in habitat quality. However a provisional assessment of the IUCN category can be made. The classification Critically Endangered (A1c+2cd, B1+2c, C2a) seems over-cautious for several reasons. There is no evidence for any dramatic population decline over the last 10 years and, although habitat destruction continues, it is unlikely to have been at the rate of 80% in this time period. The extent of occurrence is likely to exceed 100km² and the population exists on two islands and at 12 roosts. The population exceeds 250 mature individuals and several of the roosts regularly contain more than 50 bats. It would seem more logical, therefore, from the available data to classify *P. livingstonii* as Endangered (A1c +2cd, B1+2c, C2a). The additional criteria are similar to those of the Critically Endangered category, except that (A) population reduction is of 50% over 10 years / three generations, (B) extent of occurrence is estimated to be less than 5000km² and (C) the population is estimated to be less than 2500 mature individuals.

This study clearly reveals where further work is needed if an accurate assessment of the IUCN Red List categories is to be made, and if the long-term conservation of this species is to be assured.

- Long-term population monitoring is essential and it is planned to reinforce the *in-situ* monitoring scheme in 1998. Population and Habitat Viability Analyses (PHVA) could help predict future population trends, though such modelling studies will be dependent on the quality of data available.
- Up-to-date, and repeatable, vegetation cover maps are needed to assess the rates of habitat loss. A GIS project to assess habitat requirements is planned for 1998.

- There is no information on the population dynamics and age structure of *P. livingstonii*. This paucity of information unfortunately extends to almost all *Pteropus* species.
- There is no knowledge of what constitutes a subpopulation for *P. livingstonii*, or the degree of movement between roosts and / or islands.
- More information is needed on the feeding ecology of *P. livingstonii*; specifically to see if the fragmented forest cover poses a threat to provision of a reliable food supply throughout the whole year.

Mace & Lande (1991) suggest that a species should be downgraded in category (i.e. from Critically Endangered to Endangered) only when the criteria of the lower risk category have been satisfied for a time period equal to that spent in the original category, or if it is shown that past data were inaccurate. The survey work outlined here suggest the latter reason for down grading *P. livingstonii*, although it might be wise to wait for the results of further surveys, the GIS project and PHVA analyses before this is done.

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