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Short Communication

Near threatened? First report of unsuspected human-driven decline factors in the Ryukyu flying fox (*Pteropus dasymallus*) in Japan

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ABSTRACT

Japan hosts the largest population of the threatened Ryukyu flying fox (*Pteropus dasymallus*), which, in Taiwan, suffered a drastic decline leading to local extinctions and, in the Philippines, remains only on three small islands. Conservation of the species in Japan is therefore crucial. National and international assessments have been based only on local anthropogenic factors, such as habitat degradation, electrocution on power lines, and accidental entanglements.

Using face-to-face interviews of farmers of the Yaeyama islands (southwestern part of the Ryukyu archipelago), we discovered that other significant human-driven causes of decline were overlooked in assessments. Most importantly, we report here for the first time on the illegal killing of this species by farmers because it feeds on crops. The bat has been killed by intense poisoning, beating, and netting. Other cases of illegal infringement of animal welfare principles by the general population were also encountered (i.e. confinement and mistreatment) but could not be quantified. Furthermore, we also determined the historical use of flying fox meat as a food source, which has also never been documented before. Finally, we identified emerging threats that were previously neglected in the assessments of the species' conservation status, namely predation by feral or semi-feral cats and dogs, whose populations have been booming in recent years. These unexpected factors, especially the ongoing killing of *P.d. yayeyamae*, call into question the IUCN downlisting (EN→NT) decided in 2008, when poisoning campaigns were actually culminating, and lead us to recommend the initiation of conservation actions (particularly population monitoring), education campaigns, as well as the provision of technical assistance to farmers in need of it.

Flying foxes have been known to be key pollinators and seed dispersers in insular ecosystems, in which they are critical for the regeneration of native forests and hence indirectly important for the conservation of the fauna that depends on them (Cox, 1991; Fujita and Tuttle, 1991). Through these services, they also contribute significantly to the local economy of the Asia-Pacific region (Fujita and Tuttle, 1991). Climatic events, such as heat-waves (Welbergen et al., 2008) and typhoons (Craig et al., 1994; Esselstyn et al., 2006), as well as anthropogenic disturbances, especially poaching (e.g. Scheffers et al., 2012), have proven to impact strongly the demographics of these k-selected species, especially on tropical islands. They should therefore be the focus of careful monitoring and responsive conservation measures.

The Ryukyu flying fox (*Pteropus dasymallus*) is a medium-sized solitary fruit bat (140 mm forearm length, ~430 g). Four allopatric subspecies are peculiar to the Ryukyu archipelago in Japan (Fig. 1), while the fifth one (*P.d. formosus*) is endemic to Taiwan (where it has been brought to near extinction by hunting; Mickleburgh et al., 1992) and to the islands of Batan, Dalupiri, and Fuga in the Philippines (Heaney et al., 2008). In Japan, *P. dasymallus* is one of only two pteropodids (the other one being the Bonin flying fox, *Pteropus pselaphon*, which is known only from the remote Ogasawara islands in the Pacific ocean) and has been protected by both national and prefectural regulations. The Daito subspecies, *P.d. daitoensis*, and the Erabu subspecies, *P.d. dasymallus*, have been considered critically endangered (CR) in both the National Red Data Book and the prefectural list, and have even been elevated to the status of Natural Monument (DoD, 2010; RDB, 2012). *P.d. inopinatus* and *P.d. yayeyamae*, on the other hand, are not considered as

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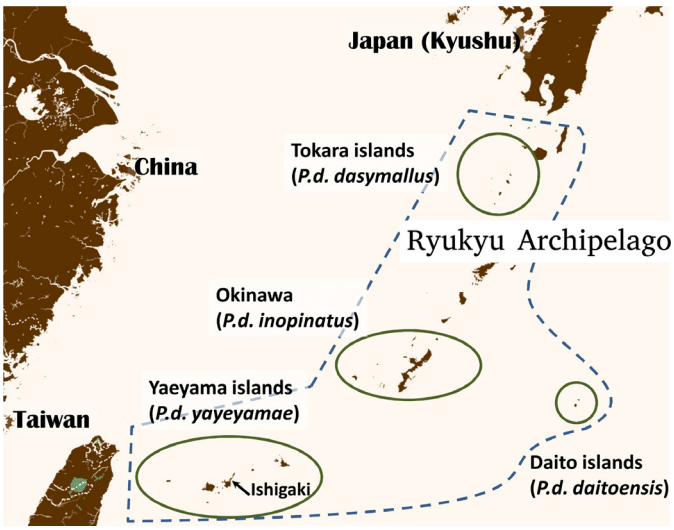

Fig. 1. Distribution of *P. dasymallus* in the Ryukyu archipelago situated along the Nansei-shoto Trench, which runs from Kyushu (Japan) to Taiwan. This study was performed in the Yaeyama islands (bottom of the map), which host the *P.d. yayeyamae* subspecies.

threatened in the national Red Data Book, and have been listed as NT in prefectural assessments only (Okinawa Pref., 2012b). However, to date, outside of local initiatives to save *P.d. daitoensis*, which lives only on two small islands, no real conservation programme has been implemented, and an alarming lack of knowledge persists about this species (e.g. no estimate of the size of populations). As early as 1992, the IUCN SSC-BSG Action Plan for Old World Fruit Bats called for an assessment of the state of populations of Ryukyu flying fox and the start of conservation planning (Mickleburgh et al., 1992). In spite of this, the IUCN downlisted the species from EN to NT in 2008 and observed once more that factors of endangerment in Japan would solely be attributable to habitat destruction, electrocution on power cables, and to some extent accidental entanglement in nets (Heaney et al., 2008). We report for the first time that significant anthropogenic factors of decline have been neglected until now. Considering the context – i.e. upcoming countermeasures to mitigate the economic impact of *P. dasymallus* on agriculture (Okinawa Pref., 2012a), candidacy of part of the Ryukyu archipelago as a UNESCO World Natural Heritage – it is vital that these unsuspected threats be taken into account urgently in a new assessment and that more tailored conservation options be considered.

We conducted 53 face-to-face interviews of farmers (with 63 respondents, as four interviews had to be grouped) on Ishigaki-jima and Iriomote, as well as smaller islands of the Yaeyama archipelago (Kohama, Taketomi, Kuroshima, Hateruma) in March 2013 and 2014. These islands host the subspecies *P.d. yayeyamae*. Most of the interviews were carried out in the context of a general survey on agricultural issues. To encourage communication and memory flow, we carried out semi-structured interviews, in which we inquired about (i) demographic trends of the flying fox population, (ii) damage by *P.d. yayeyamae* on crops, (iii) the countermeasures taken, and (iv) causes of mortality. Although we guaranteed that sources would remain anonymous, we realized that respondents were very reluctant to give information, because of the protected status of the species among other factors. Whenever possible, existing contacts on the island were used to inspire the trust of interviewees. We also took time to converse at length with interviewees, and the topic of *P.d. yayeyamae* was always brought up late in the talk. We believe that the expertise and integrity of the interviewees chosen as well as the strong consistency between answers allow us to draw some early conclusions. This study was not designed to be quantitative, but we summarize the key statements encountered as well as their percentage of observations in our sample (Table 1).

Table 1
Key statements by respondents and their frequency of observation in the sample. Asterisks denote observations also supported by personal observations by the authors in the field. Note that these results should be interpreted qualitatively, as low observation frequency is by design not synonymous of low occurrence.

	Key statements	Observation frequency
Population trend	"Strong decline in the *P.d. yayeyamae* population"	38%
	"Observation of large groups of *P.d. yayeyamae* in the past"	13%
Impact on local agriculture	Feeding of *P.d. yayeyamae* on various plantations	62% (*)
	"Negligible impact on agricultural activity"	34%
	"Minor impact compared to other species"	47% (*)
	"Losses insignificant because of the current low number of *P.d. yayeyamae*"	13%
	"Link between strength and timing of typhoons and crop damage due to *P.d. yayeyamae*"	15%
Killing of *P.d. yayeyamae*	"Flying foxes were beaten to death when approaching plantations"/	9%
	"Flying foxes are still beaten to death when approaching plantations"	6%
	"Flying foxes were being poisoned using lannate/methomyl until 2008"/	11%
	"Flying foxes are still poisoned using lannate/methomyl"	6%
	"Netting of flying foxes has been taking place to protect plantations"	6%
	"*P.d. yayeyamae* was used as bushmeat on Yaeyama islands" (until ~30 years ago)	24%
Other factors of decline	Predation by (semi-)feral animals	3% (*)
	Animal welfare issues	5%

Many interviewees, most of whom were natives (ca. 80%) and spent their whole life farming, have observed a strong decline in the number of Ryukyu flying foxes on the islands: e.g. the interviewee with the strongest credentials on the matter as both lifelong hunter and farmer went as far as to estimate that a decrease of 90% took place in the last 40 years. This sharp decline has been conspicuous over decades but has also been felt by most interviewees over recent years. These results confirm clear impressions of decline reported by inhabitants of Ishigaki during a systematic social survey (Vincenot et al., 2015). Furthermore, Kuroshima and Hateruma-jima hosted critically small flying fox populations (in 4 night stays, we estimated the populations to be less than 10 individuals on these islands), to the point that, on the latter, many interviewees were not even aware of the presence of *P.d. yayeyamae*. Interestingly, on Ishigaki and Iriomote, several respondents also mentioned that *P. dasymallus*, a species believed to be solitary, could be seen in large groups in the past, which is difficult to interpret with certainty but might suggest the former existence of colonies on some islands.

Conflicts with *P.d. yayeyamae* were reported on all islands visited, except Kuroshima, where agriculture focuses on cattle production. We found that *P.d. yayeyamae* frequently fed in plantations of sugarcane, pineapple, banana, guava, loquat (*Eriobotrya japonica*), and citrus. Mangos and papayas were also potential targets, but they were generally not accessible to bats because they are now all cultivated in greenhouses. In the case of sugarcane, we were told and could observe ourselves that *P.d. yayeyamae* fed on the edge of