ATOLL RESEARCH BULLETIN
NO. 343

INTERISLAND MOVEMENTS OF FRUIT BATS (PTEROPUS MARIANNUS) IN THE MARIANA ISLANDS

BY
G. J. WILES AND P. O. GLASS

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
SEPTEMBER 1990

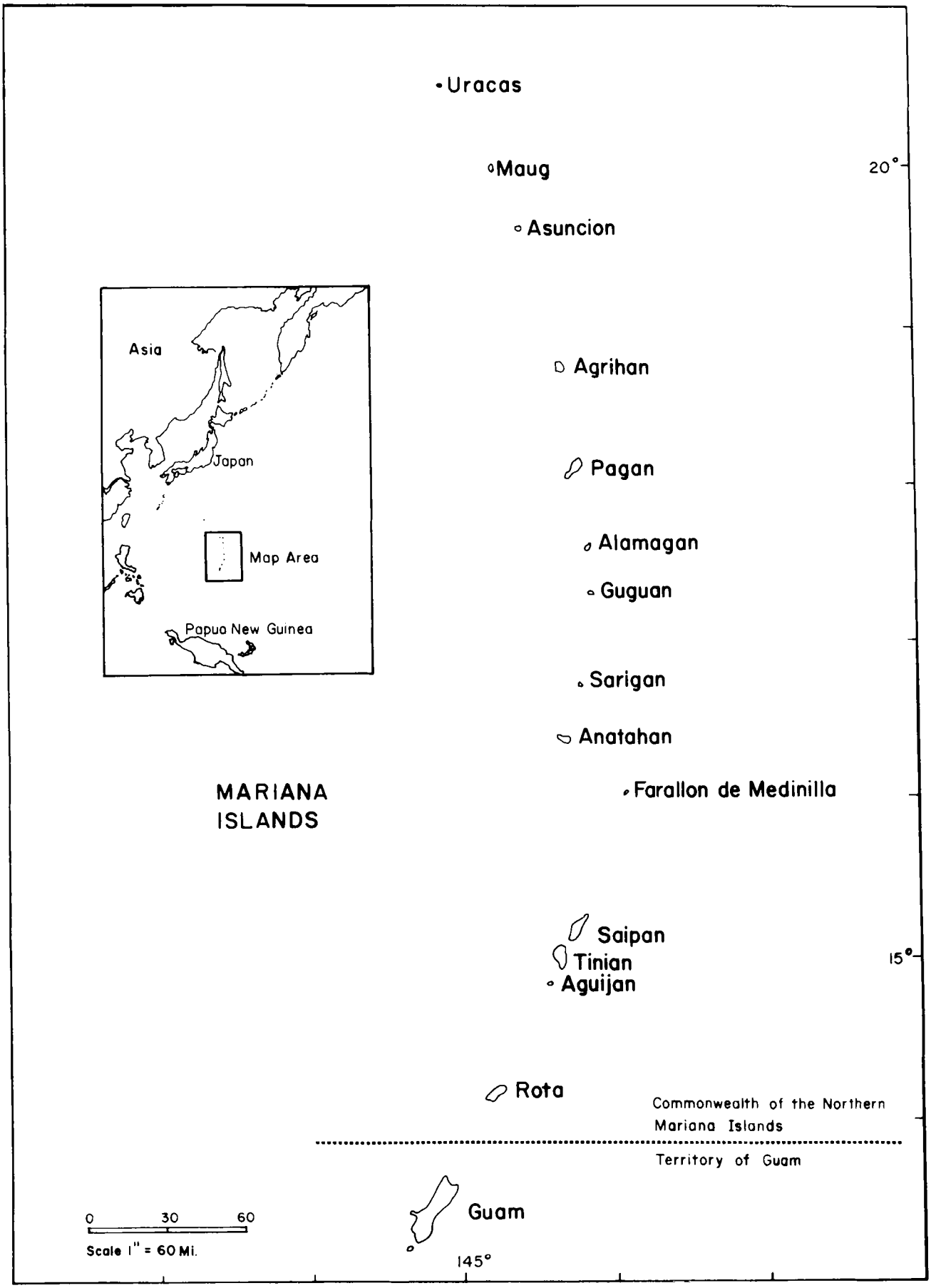

Figure 1. Map of the Mariana Islands.

INTERISLAND MOVEMENTS OF FRUIT BATS (PTEROPUS MARIANNUS) IN THE MARIANA ISLANDS

BY

G. J. WILES[1] AND P. O. GLASS[2]

Fruit bats of the genus Pteropus are considered to be strong fliers (Kingdon, 1974; Nowak and Paradiso, 1983), with some species commuting distances of 10-50 km between day roosts and feeding areas (Breadon, 1932; Ferrar, 1934; Hall, 1983; Lim, 1966; McWilliam, 1985-1986; Ratcliffe, 1932; Taylor, 1934; Walton and Trowbridge, 1983). Longer seasonal movements of $\geq$ 100 km are known for several species of Australian Pteropus, which change roosting sites in response to shifting patterns in the availability of flowers and fruits (Nelson, 1965). However, for most members of the genus, movements remain poorly understood. This is especially true for populations of Pteropus in the Pacific Ocean, many of which are restricted to small islands or small island groups.

Islanders in the Mariana Islands of the western Pacific occasionally report Marianas fruit bats (P. mariannus) flying between islands, but their sightings have never been substantiated by biologists (Perez, 1972; Wiles et al., 1989). Because these fruit bats regularly fly along the shorelines of islands and may fly $\geq$ 1 km out to sea before returning to land, casual observers may mistakenly interpret this behavior as indicative of bats arriving from or departing for a neighboring island. Herein, we document recent evidence of interisland movements of P. mariannus in the southern Marianas based on information collected from 1978 to 1988. Because of recent declines in populations on these islands (Wiles, 1987a; Wiles et al., 1989), it is necessary to understand the extent to which populations on different islands intermingle and whether declines on one island affect population sizes on neighboring islands.

The Mariana Islands are composed of 15 islands extending from 13°14'N, 144°45'E to 20°33'N, 144°54'E, a north-south distance of 750 km (Fig. 1). Descriptions of individual islands appear in Fosberg (1960) and Wiles et al. (1989). Most islands in the southern Marianas are considerably larger (Guam, 540 km^2; Rota, 85 km^2; Aguijan, 7 km^2; Tinian, 102 km^2; and Saipan, 123 km^2) than the 10 northern islands, which range in size from 1-48 km^2. Distances between neighboring southern islands are: Guam to Rota, 60 km; Rota to Aguijan, 78 km; Aguijan to Tinian, 9 km; Tinian to Saipan, 5 km; Saipan to Farallon de Medinilla, 85 km; and Saipan to Anatahan, 119 km. In the northern Marianas, interisland distances range from 29-100 km. All islands have a maximum elevation ranging from 168-965 m with the exception of Farallon de Medinilla, which has a maximum elevation of 81 m. All islands are visible in clear weather from the tops of adjacent islands.

[1]Division of Aquatic and Wildlife Resources, P. O. Box 2950, Agana, Guam 96910

[2]Division of Fish and Wildlife, Department of Natural Resources, Saipan, MP 96950. Present address: U. S. Fish and Wildlife Service, 17629 El Camino Real, Suite 211, Houston, TX 77058

Manuscript received 10 January 1990; revised 29 March 1990

Pteropus mariannus, a relatively large fruit bat with a forearm length of 135-154 mm, a wingspan of 860-1,085 mm, and a weight of 330-620 g, inhabits all islands from Guam to Maug. Two subspecies of this bat are recognized in the Marianas, with P. m. mariannus inhabiting the islands from Guam to Saipan (Kuroda, 1940) and P. m. paganensis occurring on Pagan and Alamagan (Yamashina, 1932). The precise taxonomic status of P. mariannus on the remaining islands north of Saipan has not been determined. A second smaller species, P. tokudae, is endemic to Guam and is believed to be extinct (Wiles, 1987a).

Much of our data on movements involves large groups of from 50 to several hundred P. mariannus traveling between islands in the southern Marianas. The fruit bats of these islands have been studied in greater detail than those of the northern Marianas, and their population sizes have been estimated about once a year or more often, by use of techniques similar to those described in Wiles (1987a). Numbers of fruit bats on Guam grew from < 50 animals to approximately 850-1,000 bats between 1978 and 1983 (Wheeler and Aguon, 1978; Wiles, 1987a), but have fluctuated between 400 and 800 bats since then. Nearly all bats on Guam live at the northern end of the island in a single colony, which occasionally divides into several smaller aggregations. Since 1984, virtually all young bats on the island have been lost to heavy predation by an introduced species of snake (Boiga irregularis) (Wiles, 1987b). Initial observations of bats on Aguijan, Tinian, and Saipan in 1983 and 1984 revealed populations of < 25-50 bats on each island. Numbers increased to about 75-100 animals on Saipan in 1985 or 1986 and to about 300 animals on Aguijan in 1987 or 1988. Several attempts to census fruit bats on Rota were made between 1979 and 1985 (Wheeler, 1980; Wiles et al., 1989), but we believe that these preliminary surveys underestimated the population there. From 1986 to 1988, more reliable counts were conducted 2-4 times per year and detected a sudden decline in numbers from about 2,500 to 1,300 animals during 1988. Populations of P. mariannus were censused infrequently on only a few of the northern islands since the surveys of Wiles et al. (1989) in 1983 and 1984.

Our conclusion that significant numbers of Marianas fruit bats fly between islands in the southern Marianas on an irregular basis is supported by strong circumstantial evidence and eyewitness accounts. Six examples are based on noticeable and sudden increases in the numbers of bats too large to be explained solely by other factors such as natural recruitment within the resident population on individual islands. In addition, based on information obtained independently from local residents or other biologists, several of these movements closely followed disruptive disturbances at colonies on adjacent islands. Also, several fishermen provided accounts of interisland flights. Two of the fishermen were in boats $\geq$ 5 km offshore when they saw bats flying overhead.

Known flights of large groups of fruit bats between islands in the southern Marianas since 1978 usually involved bats originating from Rota. Wiles (1987a) reported evidence of two groups of bats flying to Guam from Rota. The first of these probably occurred in early 1979 (wrongly reported as 1980 in Wiles, 1987a), when a colony of about 225-250 bats was discovered on Pati Point, Guam, following a period of several years when the island had no known bat colonies and the entire population was believed to contain < 50 animals (Wheeler and Aguon, 1978). Continued observations of this colony revealed that it temporarily split into two groups located 1.1 km apart in 1981. The estimated combined number of animals at both sites rose from 240 bats in early April 1981 to 508 bats in mid-May 1981. The appearance of the colony in 1979 and its more than doubling in size in 1981 almost certainly resulted from two separate emigrations of bats from Rota, the closest island to Guam and the only island in the southern Marianas with a sizable population of P. marinannus at the time. The movement in 1981 most likely was caused

by human disturbance. Supporting evidence came from a fruit bat hunter interviewed on Rota who, with three other men, killed about 60 bats with shotguns at a roost on the island's southwestern cliffline, and then watched the remainder of the colony, about 150-250 bats, fly south over the ocean toward Guam. The approximate date of the incident coincided within several weeks of the date when the increase in bats was first noted at Pati Point.

A third instance of bats moving between Rota and Guam occurred in 1988, with an abrupt increase in numbers of fruit bats occurring on Pati Point between 26 January and 28 January, when the colony grew from approximately 400 to 709 bats. Before this, Guam's entire population of P. mariannus was estimated at about 500 bats. This change in number occurred about 14 days after Rota was devastated by heavy winds from Typhoon Roy, a severe storm that defoliated most of the island's forest canopy. After the storm, large numbers of bats foraged widely around the island during daylight hours, a highly unusual occurrence. Also, a dramatic increase in illegal hunting occurred during this period. On 26 January, during a study of the effects of the storm on the bat population, biologists inadvertently disturbed a colony on the southwestern side of the island when shifting winds blew their odor to the colony. They observed approximately 250 bats take flight and head over the ocean in the direction of Guam.

In May 1988, the number of fruit bats on Pati Point declined from about 700 to 400 animals. Subsequent ground searches and an aerial survey of northern Guam detected no other colonies. Presumably, the missing bats had departed for Rota, but counts made there in July and November 1988 were not sufficiently reliable to substantiate this. One or more similar movements may have occurred in 1973 or 1974, and are a potential explanation for the apparent absence of colonies on Guam between 1974 and 1979 (Wheeler and Aguon, 1978; Wiles, 1987a).

In July 1985, a small colony of about 50 P. mariannus appeared on Aguijan (D. T. Aldan, pers. comm.), where previously a population of < 10 fruit bats was present (Wiles et al., 1989). The bats probably emigrated from Rota, rather than the nearby islands of Tinian or Saipan. This increase in numbers was first noticed about a week after a poaching incident at a colony at Uzulon Hulo on Rota's north coast. Subsequent annual counts of bats on Aguijan indicated that bat numbers remained fairly steady through 1987. A second larger increase in the island's bat population was reported by visiting goat hunters in March 1988, and was substantiated 3 months later in a survey in which about 300 bats were estimated to be on the island. This movement possibly was caused by the extensive hunting on Rota that continued for several months after Typhoon Roy.

Between 1985 and 1986, the fruit bat population on Saipan increased from < 50 bats to about 75-100 bats. This growth was probably related to immigration and limited natural recruitment. There are two reliable reports from fishermen of small numbers of fruit bats flying to Saipan in May and July 1985. Both men were fishing on the island's northernmost coast and saw bats flying directly in from the north. One man saw a single group of three bats whereas the other observed several groups of two or three bats each in an hour-long period at dusk. The bats probably came from Anatahan, which has the largest population of P. mariannus in the Marianas (Wiles et al., 1989). Farallon de Medinilla, the next island north of Saipan, is small (0.9 km^2), has almost no suitable habitat for fruit bats, and is not known to support bats.

Other sightings have been made of P. mariannus flying singly or in small groups between islands in early evening or at night. Wiles et al. (1989) twice observed individual

bats 3 km south of Guguan at dusk flying toward Sarigan, 63 km distant. A fisherman, who was 5 km south of Rota, saw several small groups of bats flying at night toward Guam on two occasions in the early 1980s. Several decades ago, another fisherman saw a single bat fly over his boat at sea between Alamagan and Pagan, which are 41 km apart.

Movements of P. mariannus between islands may be prompted by overpopulation, dispersal of young, or seasonal variations in food supplies, particularly on small islands with a low diversity of food plants. Typhoons may also cause temporary reductions in the abundance of fruits and flowers eaten by fruit bats, possibly resulting in the emigration of bats to other islands. It is unknown whether bats on certain islands in the Marianas ever commuted daily to feed on nearby neighboring islands, e.g. between Saipan and Tinian, or Tinian and Aguijan. There is no evidence of a seasonal periodicity in the movements of P. mariannus, such as reported for other species of fruit bats in Australia and Africa (Nelson, 1965; Thomas, 1983).

Interisland movements probably occurred more frequently in former times when bat populations were larger. At present, populations of P. mariannus in the southern Marianas are extremely small with densities ranging from about 0.2 to 29.4 bats per km^2 (Wiles et al., 1989). Because of their reduced numbers, the relatively few remaining fruit bats presumably have abundant food resources and probably face seasonal food scarcities only on rare occasions. Under these conditions, animals may have little need to disperse to other islands. In contrast, fruit bats may travel more frequently among the northern Mariana Islands where bat populations are considerably larger.

Hunting and other forms of human disturbance at roosts were probably responsible for at least four of the six movements of large groups described herein. Illegal hunting is a serious problem in the southern Mariana Islands (Wiles et al., 1989), with major bat roosts visited by hunters one to several times per year on Rota and Guam. P. mariannus is sensitive to human odor and easily frightened while roosting, perhaps because the species has been hunted for centuries by islanders. Colonies are particularly vulnerable to disruption by people and normally react by relocating to another site on the same island, although occasional flights to other islands can result.

In the instances reported herein, fruit bats had a tendency to emigrate to islands that were directly visible from their colonial roosts. Examples of this included flights by two groups of bats from roosts in southern Rota to Guam, and another group in northern Rota that departed northward to Aguijan.

Rota is one of several key islands in the Marianas where efforts to conserve fruit bats are essential. The island has the only viable population of P. mariannus in the southern Marianas and is a major source of dispersing bats, which can recolonize neighboring islands. It is necessary that Rota's bats receive adequate protection from overhunting and that a population of 2,500 or more animals be maintained on the island.

In light of the interisland movements described herein, wildlife managers should consider all fruit bats in the southern Marianas as belonging to one contiguous population. P. mariannus currently is protected by local legislation throughout the island chain, but only the population on Guam is officially listed as endangered by the U. S. Fish and Wildlife Service. Populations on Aguijan, Tinian, and Saipan are candidate endangered species (category 1) and are scheduled for listing at an undetermined future date by the U.S. Fish and Wildlife Service. Fruit bats on Rota are a category 2 candidate endangered

species, a designation that requires additional information on status before listing can occur.

The presence of two subspecies of P. mariannus in the Mariana Islands indicates that two separate bat populations occur in the island chain. These populations, if truly distinct, would be separated by a single large expanse of water acting as a barrier to movement between two islands. Such a barrier would have to occur somewhere between Saipan and Alamagan, the distributional limits thus far determined for the two subspecies. However, no exceptionally large distances occur between these islands. Excluding the small and somewhat out-of-the-way island of Farallon de Medinilla, the greatest separation between any two islands in this portion of the archipelago occurs between Saipan and Anatahan. As previously noted, there is good evidence that fruit bats fly between these two islands. The recognition of two subspecies of P. mariannus in the island chain may be incorrect, based on the hypothesis that bats are able to move between all islands, thereby facilitating gene flow throughout the archipelago. A reevaluation of the taxonomic status of P. m. paganensis should be conducted with a much larger sample of specimens, and may reveal this subspecies to be synonymous with P. m. mariannus. Yamashina's (1932) description of P. m. paganensis was determined from a sample of four animals.

To date, there have been no efforts to tag or mark P. mariannus in the Mariana Islands. Such studies would provide better information on the extent and frequency of movements between islands. If tagging is conducted to examine localized movements, investigators should monitor bat populations on neighboring islands for the presence of marked animals.

This research was supported by the U.S. Fish and Wildlife Service through the Federal Aid to Wildlife Restoration Programs for Guam and the Commonwealth of the Northern Mariana Islands, and the Endangered Species Conservation Program for Guam. M. E. Wheeler, D. T. Aldan, T. O. Lemke, E. M. Taisacan, J. D. Reichel, and T. K. Pratt assisted with data collection. The U.S. Air Force kindly allowed us access to their lands on Guam. P. J. Conry, M. J. McCoid, J. D. Reichel, R. D. Anderson, and K. T. Wilkens reviewed the manuscript.

LITERATURE CITED

Breadon, C. 1932. The occurrence of the flying-fox (Pteropus giganteus) in the Punjab. J. Bombay Nat. Hist. Soc. 35:670.

Ferrar, M. L. 1934. Daily flighting of flying foxes (Pteropus giganteus Brunn.). J. Bombay Nat. Hist. Soc. 37:214-215.

Fosberg, F. R. 1960. The vegetation of Micronesia. Bull. Amer. Mus. Nat. Hist. 119:1-75.

Hall, L. S. 1983. Black flying-fox. Pp. 280-281, in Complete book of Australian mammals (R. Strahan, ed.). Angus and Robertson Publishers, Sydney, 530 pp.

Kingdon, J. 1974. East African mammals. An atlas of evolution in Africa. Vol. 2A. Insectivores and bats. Univ. Chicago Press, Chicago, 341 pp.

Kuroda, N. 1940. A monograph of Japanese mammals, exclusive of Sirenia and Cetacea. Sanseido Co., Ltd., Tokyo.

Lim, B. L. 1966. Abundance and distribution of Malaysian bats in different ecological habitats. Federated Mus. J. 11:61-76.

McWilliam, A. N. 1985-1986. The feeding ecology of Pteropus in north-eastern New South Wales, Australia. Myotis 23-24:201-208.

Nelson, J. E. 1965. Movements of Australian flying foxes (Pteropodidae: Megachiroptera). Australian J. Zool. 13:53-73.

Nowak, R. M., and J. L. Paradiso. 1983. Walker's mammals of the world. Fourth ed. The Johns Hopkins Univ. Press, Baltimore, 1:1-568, 2:569-1362.

Perez, G. S. A. 1972. Observations of Guam bats. Micronesica 8:141-149.

Ratcliffe, F. 1932. Notes on the fruit bats (Pteropus spp.) of Australia. J. Anim. Ecol. 1:32-57.

Taylor, E. H. 1934. Philippine land mammals. Bur. Sci. Monogr. (Manila) 30:1-548.

Thomas, D. W. 1983. The annual migrations of three species of West African fruit bats (Chiroptera: Pteropodidae). Can. J. Zool. 61:2266-2272.

Walton, R., and B. J. Trowbridge. 1983. The use of radio-tracking in studying the foraging behaviour of the Indian flying fox (Pteropus giganteus). J. Zool. (Lond.) 201:575-579.

Wheeler, M. E. 1980. The status of the Marianas fruit bat on Saipan, Tinian, and Rota. 'Elepaio 40:109-113.

Wheeler, M. E., and C. F. Aguon. 1978. The current status and distribution of the Marianas fruit bat on Guam. Guam Div. Aquatic Wildl. Resources Tech. Rept. 1:1-29.

Wiles, G. J. 1987a. The status of fruit bats on Guam. Pacific Sci. 41:148-157.

-----. 1987b. Current research and future management of Marianas fruit bats (Chiroptera: Pteropodidae) on Guam. Australian Mammal. 10:93-95.

Wiles, G. J., T. O. Lemke, and N. H. Payne. 1989. Population estimates of fruit bats (Pteropus mariannus) in the Mariana Islands. Conserv. Biol. 3:66-76.

Yamashina, Y. 1932. New species of bats from the mandated south Pacific islands. Trans. Nat. Hist. Soc. Formosa 22(121):240-241 (in Japanese).