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POPULATION STATUS OF PTEROPUS TONGANUS IN TONGA

BY

GILBERT S. GRANT

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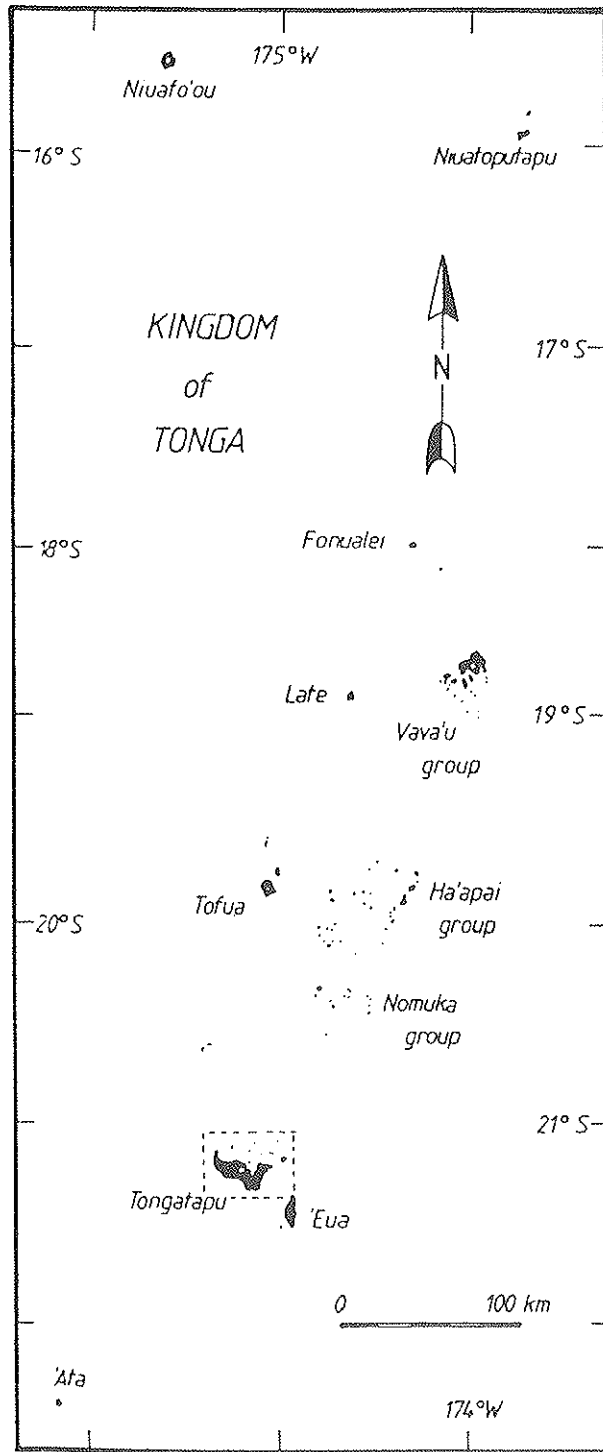


Figure 1. Map illustrating the major islands and island groups in the Kingdom of Tonga.

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ABSTRACT

Flying foxes (*Pteropus* spp.) are important pollinators and seed dispersers in many island ecosystems. Populations of flying foxes have declined markedly on most islands in the South Pacific since the 1940's. One potential conservation strategy is to reintroduce bats on islands where they historically occurred. In this manner, the risk of species extinction due to local catastrophic events can be reduced. Ideally the source population for such reintroductions must be robust. One such population might be in the Kingdom of Tonga, where flying foxes have been protected by local custom for a long time. However, virtually nothing has been published on the numbers, locations, and reproductive biology of *Pteropus tonganus* in Tonga. I therefore censused flying fox populations on as many islands as possible from 28 June to 26 July 1995. I found seven major roosts containing a total of 3,582 bats on Tongatapu, one roost with 30 bats in the Ha'apai group, and 27 roosts with a total of 5,925 bats on 14 islands within the Vava'u group. Thus, the flying fox population in Tonga seems robust and dispersed on many islands and is therefore a valuable potential source population.

INTRODUCTION

In addition to the cultural significance of flying foxes to the Polynesian people, these bats play an important role as pollinators of flowers and in dispersing seeds of native rainforest trees (Cox et al., 1992; Banack, 1995). In the Old World tropical forests, at least 289 plant species rely on large populations of flying foxes for pollination and seed dispersal. These plants produce some 448 economically valuable products for humans (Fujita and Tuttle, 1991). Island floras have a high degree of endemism and flying foxes have been hypothesized to be strong interactors on South Pacific islands where they serve as the principal pollinators and seed dispersers. The extinction of flying fox populations on Pacific islands may ultimately lead to plant extinctions (Cox et al., 1991).

On many islands in Micronesia, Melanesia, and Polynesia, flying foxes are still hunted for food (Graham, 1992 and references therein) primarily at the subsistence level.

¹Department of Biological Sciences, University of North Carolina, Wilmington, NC 28403

²Present address: Department of Math and Science, Coastal Carolina Community College, Jacksonville, NC 28546

However, in some areas of Micronesia bats are harvested commercially (Stinson et al., 1992).

On Tonga, flying foxes (*Pteropus tonganus*) are considered the property of the King and can only be harvested by royalty. Consequently, the bat population is protected from human exploitation. This is in marked contrast to declining flying fox populations elsewhere in Polynesia and Micronesia (Graham, 1992). Despite the presence of an easily accessible roost which has become a tourist attraction in the village of Kolovai on Tongatapu, Kingdom of Tonga, little information about the numbers of bats present and their behavior has been published.

Local flying fox populations are vulnerable to hurricanes, overhunting, habitat loss, and deforestation (Craig et al., 1994; Miller and Wilson, 1997). Should a *P. tonganus* population become extinct on Niue or American Samoa, for example, the apparently healthy population on Tonga might serve as a source for reintroductions. Maintaining viable populations on many islands may be an effective conservation strategy for small populations of flying foxes on oceanic islands. Repopulating islands that historically supported bat populations reduces the risk of species extinction due to a single catastrophic event.

Ideally, the source population must be robust. I located roosts and censused flying foxes on 16 of the 171 total islands (697 km²) in Tonga (see Fig.1) from 28 June to 26 July 1995. Only about 36 of these islands are inhabited by humans.

MATERIALS AND METHODS

I located daytime roosts on Tongatapu (28 June-18 July 1995) by driving or walking all roads and trails, observing evening dispersal flights of bats, and conversations with locals. In the Ha'apai group (18-20 July 1995), I travelled the backroads on Lifuka and Foa Islands and also positioned myself in the evening at the north end of Foa Island so that I might witness interisland movements between Foa and Nukunamo Island. In the Vava'u group (20-26 July 1995) I hiked up to the summit of Mt. Talau, searched for roosts on the main island of Uta Vava'u, and travelled by boat to offshore islands.

I recorded the locations of daytime roosts on maps, counted the numbers of bats, identified the tree species used by bats, and determined the reproductive status (attached babies, mating vocalizations) where possible. At roost sites I used direct counting of all bats seen as my estimate of the number present. This technique underestimates the total number of bats present because in trees with dense foliage (*Mangifera indica* and *Ficus* spp.) many non-flying bats are not detected. Most of the roosts at coastal sites were located on ridges or slopes. I measured the compass orientation of these roosts where possible to determine if sites chosen by the bats offered thermal and/or convective advantages or disadvantages.

RESULTS

I found seven major roosts (Figs. 2 and 3) totalling 3,582 P. tonganus on the island of Tongatapu (Fig.4; Table 1). The largest roost was along either side of the main road in the adjacent villages of Kolovai and Ha'avakatolo. I counted 1,355 bats in 28 trees (Table 1) at this roost. In the Ha'apai group, I saw a few bats on Lifuka and Foa Islands and saw one bat fly from Nukunamo Island to Foa at dusk on 19 July. I found one small roost of 30 bats on Lifuka Island. In the Vava'u group, I counted 5,925 bats in 27 roosts located on 14 islands (Table 1).

All roosts on the low-lying island of Tongatapu were inland. The single roost on the low-lying Lifuka Island was also inland. However, most roost sites on the elevated islands in the Vava'u group were coastal and most faced the west ($277^{\circ} \pm 35$ SD, $n = 26$) (Fig. 5, Table 1).

I determined the tree species utilized for day roosts by 3,492 P. tonganus at several roosts, primarily on Tongatapu and Lifuka. Most (87.6 %) of the bats roosted in Casuarina sp., Mangifera indica, and Eucalyptus sp. (Table 2).

I observed interisland movements of flying foxes in all three island groups. Four bats flew over the village of Kolonga on Tongatapu towards 'Eue'iki (6 km) on 10 July 1995 (Fig. 4). Fifteen bats flew over Ha'atala and the Christianity Landing Point on the west end of Tongatapu towards the offshore islet of 'Atata (8 km) on 11 July 1995. Two or three bats arrived at dusk on Fafa' Island (6 km) from Tongatapu on 27 July 1995. In Ha'apai, I witnessed one bat fly from Nukunamo Island to Foa Island (0.5 km) on 19 July 1995. In the Vava'u group (Fig. 5), at dusk on 22 July 1995 I saw bats flying between Oto, Luakapa and Kapa Islands (1-2 km).

I saw harems, babies, and copulations in 5 of 7 roosts on Tongatapu (Pea, Kolovai, Fatai, Ha'ateiho, and Tofoa) and in 5 of 26 roosts in the Vava'u group (Ofu, Mafana, Makave #2, Tauta, A'a #2). However, the observation distance and unstable boat platform in Vava'u made it difficult to detect evidence of breeding in most of these roosts.

I heard bats on Tongatapu at night while they were feeding in a Hernandia sonora tree. On Fafa' Island, off Tongatapu, I watched one bat lick nectar from flowers of three coconut palms (Cocos nucifera) at dusk on 27 July 1995. On Lifuka Island in the Ha'apai group I heard bats squabbling at night in a Terminalia catappa tree and 30 - 40 partially chewed fruit were seen on the ground the next morning. Five of these clearly had bat claw and tooth marks. On Vava'u, I heard bats at night in Ceiba pentandra trees that were in flower at the time.

DISCUSSION

The population of flying foxes in Tonga seems robust. A minimum of 9,500 Pteropus tonganus were counted in known roosts, and roost counts in most instances were probably an underestimate of the total number of bats in the roosts. Invariably, many

additional bats were not detected due to the dense foilage in some roost trees, particularly mangos (*Mangifera indica*). In my experience, evening dispersal counts from roosts frequently revealed additional bats. On many occasions roost exit counts on American Samoa were twice as high as daytime counts. On Tongatapu, an evening dispersal count at Kolovai (1,413 bats) was similar to the daytime count (1,355 bats). However, I could see only a portion of exiting bats and my field of view narrowed considerably as total darkness approached. More than 2,000 bats were probably using the Kolovai-Ha'avakatolo roost.

Additional colonies of bats were reported on other islands within the Ha'apai group by locals and crews of sailing vessels. Reported roosts on Hunga, Fofoa, and Umuna Islands in the Vava'u group could not be verified due to time constraints and inclement weather. Some steep cliff-side colonies also probably exist on the west side of the main island of Uta Vava'u and on the wooded islands of Fonua'one'one, Luaafuleheu, Luahiapo, Lua ui vaha, Fua'amotu, and Fatumanga in southern Vava'u group. Gill (1987) reported seeing roosting bats in trees on 'Eua Island and Rinke (1987) observed bats on Kalau Island (south of 'Eua Island). Rinke et al. (1992) found a large colony on the northwest forested slope and a smaller one in the south on the island of 'Eue'iki (6 km offshore of Tongatapu Island). Rinke (1991) reported flying foxes on Late Island and found colonies on all of the small islands in the crater lake of Niuafou'ou Island. Thus, the flying fox population in Tonga is sizeable and is distributed on many islands from 'Eua and Kalau in the south to Niuafou'ou in the far north.

I feel confident that I found all of the significant colonies on the island of Tongatapu. Interestingly, several natives remarked that the bat roosts on Tongatapu have spread eastward from Kolovai to the remainder of the island during the last twenty years. Although a roost was reputed to be in a cocoa (*Theobroma cacao*) plantation near Fatumu on the east side of Tongatapu, I could find no bats there. One resident reported that the farmers had chased the bats away to minimize damage to crops in the area. According to residents, the roost in Tofoa was much larger in the recent past. A large mango tree that formerly housed many bats recently had been cut down. The nearby colonies of Fatai, Pea, Liahona, and Ha'ateiho may have absorbed some of the Tofoa bats.

Human predation and disturbance does not appear to be a problem in Tonga. Bats were very tolerant of people walking under roost trees (in some instances bats were only 5 m overhead) and loud noises (horns, car doors slamming shut) caused minimal disturbance. Roost site locations are consequently more stable in time and frequently occurred within villages on Tongatapu. In the Vava'u group, however, most roosts are located on west-facing ridges of islands. The prevailing winds are southeasterly and may be strong enough on occasion to cause the bats to choose locations with less wind. On a very windy day on Tongatapu, all bachelor males and most harem males and females abandoned exposed sites. When the winds subsided the following day, most bats returned to the formerly-occupied sites.

Fewer tree species were utilized as roost sites by *P. tonganus* in Tonga than in American Samoa. This might be an artifact of the highly modified vegetative cover on Tongatapu and my inability to identify most roost trees in Vava'u from a distant and unstable boat observation platform. Very little native vegetation remains on the relatively flat island of Tongatapu.

I witnessed interisland movements of flying foxes over relatively short distances (up to 8 km) in Tonga. Gill (1987) cited Rinke (1987) for observations of evening flights of bats from Kalau Island to 'Eua Island. However, Rinke (1987) reported bats on Kalau but did not present data on interisland flights. Rinke et al. (1992) reported flights between 'Eue'iki Island and Tongatapu Island. Locals reported seeing flights between 'Eua and Tongatapu Islands (20 km). Despite positioning myself in the evening to witness these latter flights, I did not observe any. *P. mariannus* is known to make longer flights between Guam and Rota, and perhaps other islands in the Marianas, in response to human disturbance (Wiles and Glass, 1990). Interisland flights in Tonga appear to be for foraging. The presence of *P. tonganus* on most large islands in Tonga and on many islands between Papua New Guinea and the Cook Islands (Miller and Wilson, 1997) suggests interisland flights have occurred frequently in the past.

Most species of flying foxes in Australia appear to have mating/nursery camps (roosts) separate from non-reproductive camps (Nelson, 1965). *P. tonganus* probably breeds year-round in Tonga as it clearly does in American Samoa. Volant young, non-volant young of all sizes, and mating vocalizations were heard in numerous colonies in Tonga (both on Tongatapu and Vava'u) suggesting that camps or roosts in Tonga are multi-purpose.

Flowers and fruit consumed on Tonga are similar to items utilized in American Samoa (Banack, 1995) and elsewhere (Wiles and Fujita, 1992). Few remains of food taken by bats under the roost trees were found. Numerous chickens and pigs foraged under bat roosts on Tongatapu and probably removed items shortly after they fell to the ground.

In summary, the population of *P. tonganus* in Tonga seemed robust and dispersed over many islands between 'Eua-Tongatapu in the south and Niuafu'ou in the north. This seems likely the result of the protection afforded to these "sacred" animals by the King of Tonga. The King and citizens of Tonga are to be commended for their attitude toward flying foxes.

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Table 1
 Flying Fox Roost Locations, Composition, Number of Trees Utilized, and Compass
 Orientation(Coastal Roosts) in the Kingdom of Tonga

Location	No. of Bats	No. of Trees	Compass Orientation (°)
Tongatapu Island			
Kolovai-Ha'avakatola	1,355	28	-
Tofoa	158	5	-
Ha'ateiho-Golf Course	549	3	-
Nuku'alofa	30	1	-
Matafanua-Liahona	75	many	-
Pea	400	several	-
Fatai	1,015	50	-
Ha'apai Group			
Lifuka	30	2	-
Vava'u Group			
Pangaimotu-Utelei	200	?	270
Pangaimotu-Utungake	40	3-4	270
Pangaimotu-Maungai Pt.	60	several	270
Afo Island	25	?	340
Ofu Island	110	?	260
Manafa (Mafana) Island	350	?	330
Uta Vava'u-Makave #1	650	?	180
Uta Vava'u-Makave #2	600	?	270
Uta Vava'u-Makave #3	30	?	290
Uta Vava'u-Mt. Talau #1	6	?	280
Uta Vava'u-Mt. Talau #2	4	?	270
Tauta Island	40	?	330
'Eueiki Island	30	?	200
'Euekafa Island	40	?	270
Kapa Island-Mt. Teisina	1,200	?	260
Kapa Island-Muifaitunga	100	?	290
A'a Island #1	50	?	270
A'a Island #2	250	?	290
Kitu Island	300	?	250
Nua Papu Island #1	700	?	310
Nua Papu Island #2	2	?	310
Nua Papu Island #3	85	?	300
Nua Papu Island #4	30	?	280

Table 1 (continued)

Nua Papu Island #5	3	?	270
'aka'eitu (Vaka'eitu) #1	120	?	260
'aka'eitu (Vaka'eitu) #2	600	?	280
Luakapa Island	300	?	?

Table 2
Tree Species Utilized as Roost Sites by Pteropus tonganus in Tonga

Tree Species	No. of bats Roosting in Trees	Percent of Total Bats	No. of Trees	Bats/Tree
<u>Casuarina</u> sp.	1581	45.3	26	60.8
<u>Mangifera indica</u>	792	22.7	8	99.0
<u>Eucalyptus</u> sp.	684	19.6	31	22.1
<u>Ficus</u> sp.	149	4.3	3	49.7
<u>Cocos nucifera</u>	147	4.2	12	12.3
<u>Pisonia grandis</u>	50	1.4	1	50.0
<u>Terminalia catappa</u>	50	1.4	1	50.0
<u>Erythrina</u> sp.	26	0.7	1	26.0
<u>Ceiba pentandra</u>	8	0.2	1	8.0
<u>Cananga odorata</u>	5	0.1	1	5.0
Total	3492	99.9	85	

Figure 4. Location of the seven major *Pteropus tonganus* roosts on Tongatapu, Kingdom of Tonga (1 = Kolovai-Ha'avakatolo, 2 = Matafanua-Liahona, 3 = Fatai, 4 = Pea, 5 = Ha'ateiho-Golf Course, 6 = Tofoa, 7 = Nuku'alofa). Direction of evening interisland feeding flights by bats are indicated by arrows to offshore islands (A = 'Atata, B = Fafa', C = 'Eue'iki).

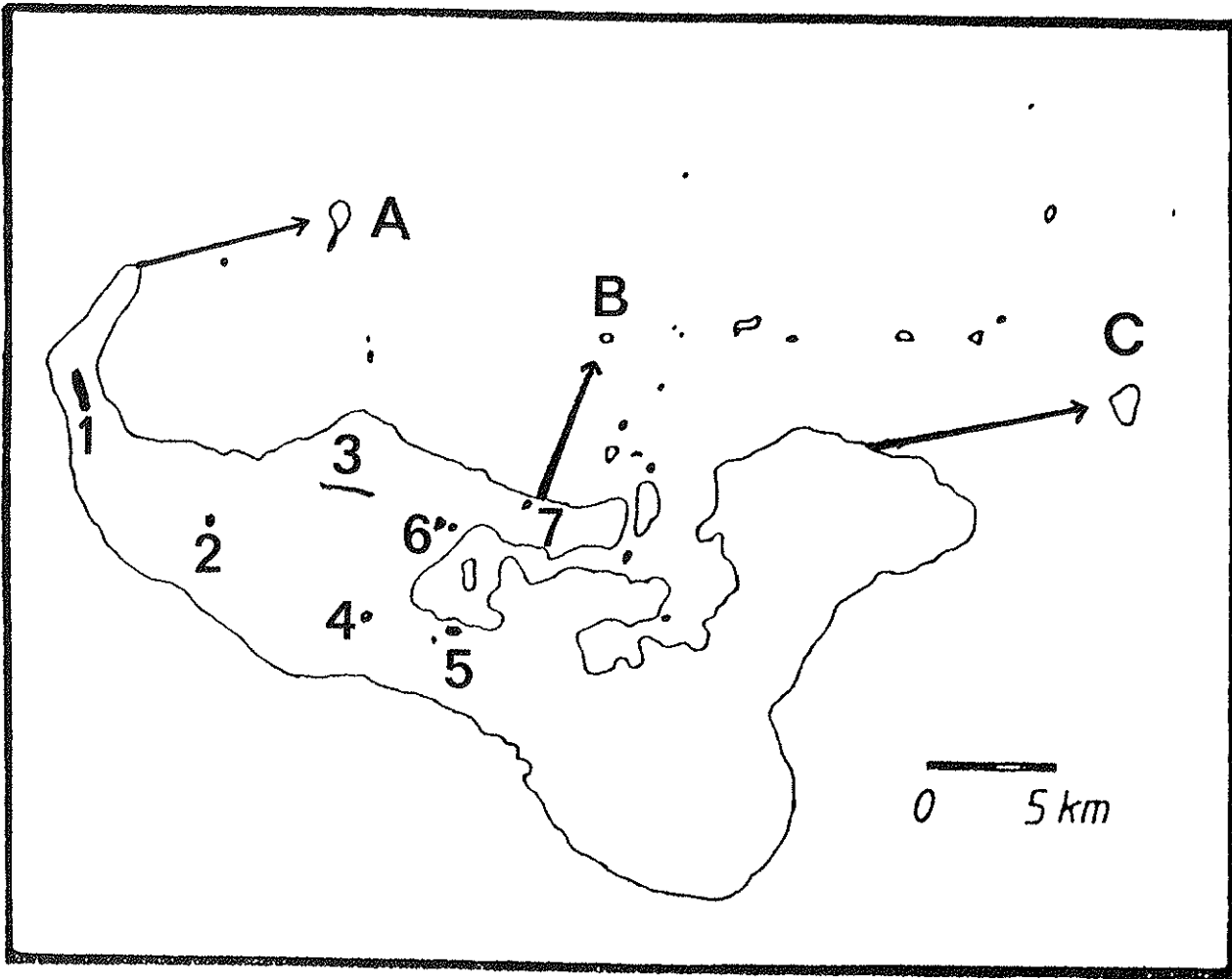




Figure 5. Locations (x) of *Pteropus tonganus* roosts in the Vava'u group, Kingdom of Tonga.



Figure 2. Pteropus tonganus in a roost on Tongatapu, Tonga.



Figure 3. Portion of a roost used by Pteropus tonganus in Kolovai, Tonga.