

Mary Vanu Trent
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ENVIRONMENTAL IMPACT STUDY ON THE TERRESTRIAL FAUNA AND FLORA OF TINIAN WITH RESPECT TO THE PROPOSED ESTABLISHMENT OF A U.S. MILITARY BASE ON THAT ISLAND

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INTRODUCTION

In accordance with various dispatches between the High Commissioner of the Trust Territory and the Commander-in-Chief of the Pacific Air Force in November and December 1973, and January 1974, the writer undertook a study of Tinian as indicated in the title above. The writer and his assistant, Takesi Suzuki, from the Conservation Section of the Trust Territory Biology Laboratory on Koror, in the Palau Islands, spent from January 18 to 25 on Tinian making on-the-spot observations. The writer also spent one day in Honolulu conferring with and getting information on the proposed military base on Tinian from Mr. Edward Lau, sanitary engineer, and Mr. Jonathan Kajiwara, entomologist. Both of these men are U.S. Air Force employees associated with the Tinian project. The writer also spent three days on Saipan gathering information on Tinian from Trust Territory Headquarters files including literature, aerial photographs and maps. Additional literature, particularly with reference to scientific publications on the fauna and flora of Tinian, was consulted from the files and library available at the Trust Territory Biology Laboratory on Koror. In addition to this review of existing literature and the on-the-spot investigation, the writer is well acquainted with the general biology of Tinian from several past trips to Tinian during the time he has worked as a biologist for the government of the Trust Territory (1949 to present).

PHYSICAL SETTING

Tinian is located in the Western Pacific Ocean at about 15 degrees North latitude and 145 degrees and 37 minutes West longitude. It is one of the Mariana Islands, a group of islands which sit atop a volcanic ridge running north and south from Guam in the south to Uracas in the north. The nearest islands are Saipan to the north (3 mi.) and Agiguan to the southwest (5 mi.). Guam, the largest island in the Marianas is 100 miles south-southwest. The larger continental island groups of Japan, Ryukyus, Philippines and New Guinea are all from 1000 to 1500 miles from Tinian in a western arc from north to south. The basic pyroclastic structure of Saipan, Tinian, Agiguan, Rota and northern Guam are overlain with marine deposited limestone from past periods of submergence. The soils of Tinian are mostly derived from decomposed limestone with

accumulated organic matter. Of the forty one square miles of land surface on Tinian about one square mile is composed of decomposed pyroclastic rock and soils, and through erosion some of these soils have been deposited onto adjacent limestone rock and soils. The land of Tinian is mostly flat or rolling with seaward cliffs and some internal ridges. The highest altitude on the island is 552 feet above sea level.

The climate of the island is typical of oceanic islands in this part of the western Pacific with northeast trade winds blowing most of the year, temperatures between 70 to 90 degrees Fahrenheit and an annual rainfall of around 80 inches. Occasional typhoons and rare droughts are further climatic features.

The geographical location, climate, geology and geological history of Tinian are all very basic determinate factors for the past and present evolution and existence of the terrestrial fauna and flora of Tinian. Of somewhat less importance, but still a significant factor, has been the changes in the fauna and flora brought about on the island by human occupation and use of the island.

ECOLOGICAL HISTORY

Assuming that the Mariana Islands have had no sea level contact with the continent of Asia or its large adjacent islands (at least since the last submergence), it must be postulated that the basic fauna and flora of Tinian had to reach Tinian by overwater means. These means would be by flying (birds, bats and insects) or airborne by storms, hitch hikers on or in birds or bats (insects, seeds) or plants and animals that reached Tinian from other areas as drifters on floating logs or other debris. This is borne out by the fact that most of the fauna and flora of Tinian is related to other islands in Micronesia and the continental islands off Asia including the Philippines, Indonesia and New Guinea. With the advent of aboriginal man on Tinian, undoubtedly other of the present fauna and flora now on Tinian accompanied the first and later aboriginal settlers. Within historical times human traffic with Tinian by ships and planes has further increased the fauna and flora of Tinian from many other parts of the world including the New World.

There are no accurate records of the human population of Tinian when the island was first seen by western explorers (in the 1500s), nor are there accounts of the fauna and flora or general ecology of the island at that time. It can be fairly well assumed that the island was heavily forested except in those immediate areas of human occupation. The early Chamorros did not practice agriculture extensively except for tree crops and taro. Areas for growing

most kinds of taro are and were very limited on Tinian. During the next two centuries through warfare, disease and forced emigration Tinian became depopulated and would have reverted to its original forested state except that the Spanish had introduced cattle, which became wild during the times the island was uninhabited. The feeding activities of the wild cattle, and perhaps wild goats and pigs, in the absence of human control and use, no doubt accounts for the comments of Commodore Anson, who visited the island in 1742, stating that the island was parklike rather than heavily covered with forests. Tinian was occupied on and off during the long Spanish administration but was never seriously exploited agriculturally or otherwise except for raising cattle and possibly other domesticated animals. The short (1899-1914) German Administration of the Mariana Islands probably had little or no effect on the ecology of Tinian beyond the changes already occasioned during the Spanish administration.

As on most Pacific Oceanic islands the aboriginal inhabitants can probably be credited with adding rats and dogs to the original fauna and the common Pacific island food plants such as breadfruit, coconut, taro and a few other food plants. During the Spanish contact and administration cattle, swine, cats, goats, horses, poultry and additional rat species were introduced to the islands and in some cases became feral and established in the wild. Also during this long Spanish period many new plant species were introduced both intentionally and accidentally from other parts of the world. It was probably during this time that the now dominant plant on the island, Leucaena leucocephala (formerly known as Leucaena glauca) became established on Tinian. This is a new world shrub or small tree but it may have come to the Mariana Islands by way of the Philippines.

The Japanese occupied Tinian from 1914 until 1944. This was the period of the most drastic ecological changes on Tinian. Except for the two swamp area (Lake Hagoi and Marpo Swamp) and the essentially soilless forested rocky ridges and cliffs, the Japanese established sugar cane plantations over the whole of the islands, and also except for those areas occupied by villages, sugar refineries, dock areas and truck gardens to feed the sugar cane workers. During this period of time the population on Tinian (20,000 by 1941) was almost entirely Japanese, Korean and Okinawan. This intensive sugar cane agriculture necessitated the destruction of most of the remaining native forests and ecological associations except on the aforementioned ridges and cliffs. Cattle grazing during Spanish times and sugar cane cultivation during Japanese time no doubt exterminated many species of native plants and some species of the native original fauna.

With the advent of World War II additional ecological disturbances were visited on Tinian. The Japanese moved in troops and fortified parts of the island. The Americans invaded the island in 1944 after causing considerable destruction to the Japanese installations and some of the landscape through bombing and naval gun fire. After the island was captured the Americans then moved onto the island in force with eventually over 100,000 troops and built docks, barracks, airfields, roads, quarries and other structures on many parts of Tinian. The bulldozing, quarrying and laying of concrete and asphalt permanently (ie. for a hundred years or more) destroyed parts of Tinian.

At the end of the war the American military departed Tinian and nature started to heal the scars of centuries of abuse, the greater part of them occasioned by the sugar cane cultivation and the Second World War. The abandoned sugar cane fields and war disturbed areas did not revert to the original Tinian vegetation. For the most part the island became overgrown with the introduced Leucaena leucocephala (Tangentangen in Chamorro) and other weedy plants. Tangentangen is an aggressive plant which has long seed viability and grows well in the disturbed limestone soils of Tinian. Although considered by most people as a weed, it is a nitrogen producing legume and in time will stabilize and rebuild disturbed limestone soils, eventually (probably hundreds of years) allowing a normal plant succession back to some semblance of the original plant cover of the island.

Under the U.S. administration Tinian remained essentially vacant until 1948 when some 400 Chamorros who had been living on Yap during Japanese times were moved to Tinian and established permanent homes there. This Chamorro population has now increased to about 800. These new residents of Tinian took up truck farming as their basic economic activity and have continued to do so until the present. They are farming only a small part of the available acreage on the island. During the early 1960s an outside organization, the Micronesian Development Corporation (MDC) leased eventually around 10,000 acres of land on the eastern parts of the island for a cattle ranch. The tangentangen and other scrub growth that had come up after the second world war were mostly cleared and pasture grasses planted. However, in some of these areas the tangentangen was only cut and allowed to sprout and regrow at a low level as it is a good cattle feed. The grain milo was also planted on some of the acreage to serve as cattle food during extensive dry seasons when the grasses are not adequate for the cattle.

This return to extensive cattle grazing (several thousand head) has again realtered the ecology and the fauna and flora on part of Tinian. In addition, the Chamorros are increasingly acquiring

and grazing cattle on parts of the island not leased by MDC.

In spite of these changes in the use of Tinian since the second world war, most of the island is still covered with the tangentangen which grew up on the disturbed soils from the Japanese times and the war.

THE PRESENT SITUATION WITH REGARDS TO THE FLORA

The foregoing ecological history of Tinian gives a broad picture of the present state of the flora of the island of Tinian. However, specific categories will be discussed below.

Level Lands and Slopes

This category comprises approximately nine tenths of the island. Small parts of it are under commercial and home truck gardening. The crops being grown are melons, tomatoes, bell peppers, chinese cabbage, eggplant, green onions, radishes, taro, pineapple, okra, beans, cucumbers, cassava and bananas. In addition some tree crops are grown for home consumption including citrus, breadfruit, mango, coconut, soursop and eugenias. The MDC acreage (10,000) is mostly in pasture grasses, milo and cut tangentangen which the cattle keep cropped. Windbreak and shade trees have been left in the pasture areas and these include Casuarina equisetifolia (Polynesian ironwood), Delonix regia (flame tree), Acacia confusa (Formosan koa), Morinda citrifolia and Ceiba pentandra (cotton tree). These same trees occur throughout most of the rest of the level lands and slopes in small numbers. The rest of the level lands and slopes not in pasture, not in the village, and not in cultivation is covered with almost solid stands of tangentangen. This means most of the land on the island.

Wetlands

There is one lake in the northern part of the island (Lake Hagoi) and one swamp in the south central part of the island (Marpo Swamp). Lake Hagoi with its surrounding marshy area is about a half a mile long and a fifth of a mile wide. The entire border of the lake to a width of about thirty yards is thickly grown with the tall cane Phragmites karka. In the open parts of the lake clumps of sedges are common. Behind the cane on the dry edges of the lake are clumps of a large thorny bamboo (not Bambusa vulgaris). Marpo Swamp covers about the same

area as Lake Hagoi but is very different in vegetation. On the relatively dry edges of the swamp grow clumps of common bamboo (Bambusa vulgaris), Pithecellobium dulce and breadfruit. The total swamp area itself is entirely grown over with a thick almost impenetrable tangle of Hibiscus tiliaceus trees. There is no open water in the swamp, only small pools under the Hibiscus.

Strand

The rather meager beach strand areas contain typical Pacific strand vegetation including coconut palm, Hernandia, Ochrosia, Messerschmidia, Scaevola, Triumphetta, Pandanus, Casuarina, Wedelia, Sophora, Thespesia and Ipomea pescaprae.

Limestone Ridges and Cliffs

Although these areas make up less than ten percent of the land area of Tinian, it is here that most of the original indigenous plants and trees still survive. This writer is not well acquainted with this vegetation but the following were noted: Cynometra, Premna, Elaeocarpus, Ficus, Pisonia, Pandanus, Eugenia and Bikkia.

Weeds

The weeds on Tinian are probably all introduced (accidentally or intentionally) plants and occur in great abundance in the village, on all cultivated or recently abandoned land, along roads and airstrips and in pasture lands.

The weeds observed include Jatropha gossypifolia, Momordica charantia, Stachytarpheta, Crotalaria, Mimosa, Cassia alata, Cassia toro, Cassia occidentalis, Ipomea spp. and wild papaya. The wild papaya is significant as being a prime host for the Oriental fruit fly (Dacus dorsalis), a serious pest which has been completely eradicated from Tinian and the rest of the Mariana Islands. Its presence would enhance the reestablishment of the fruit fly if adequate quarantine against it is not exercised. The same is true of Momordica which is a prime host of the melon fly (Dacus curcurbitae), another serious pest which has been eradicated from all of the Mariana Islands except Guam.

Ferns, Fungi, Algae, Mosses and Lichens

These lower forms of plant life are abundant in all parts of the island.

THE PRESENT SITUATION WITH REGARDS TO THE FAUNA

Most of the original fauna of Tinian probably still remains with the possible exception of two or three bird species and an unknown number of insect species that were restricted in their food habits to some of the tree and plant species that are no doubt extinct now. Listed below are various categories of the fauna and their observed or presumed present status.

Insects

Insects were notably abundant only in the village, on cultivated plants, on weeds and around cattle. They seemed to be in negligible numbers in the beach strand areas, the limestone ridge and cliff forests and in the two small wetland areas. Cultivated crops in Tinian are plagued with a score or more bothersome to serious insect pests including citrus swallowtails, cucumber beetles, serpentine leaf miners, corn ear worms, Asiatic corn borers, French bean flies, tomato worms, Philippine ladybeetles, cabbage loopers, coconut scales and many others. All of these are accidentally introduced pests. Some of these are under tolerable to good control by previously introduced biological controls (parasitic and predaceous insects). Some of the pests on commercial truck crops must at times be brought under control by the use of insecticides if the crops are to be saved or profitably harvested. As mentioned above, two of Tinians previously most serious pests, the Oriental fruit fly and the melon fly have been completely eradicated by the sterile fly and male annihilation methods.

Some insects bothersome or harmful to humans were observed. House flies (probably both Musca sorbens and Musca domestica) were common in the village and in cattle areas. Filth flies (sarcophagids and bottle flies) were not particularly abundant except where toads or snails had been run over on the roads and around garbage cans. Mosquitoes were not noticed at all and larval mosquitoes were noticed only along the edges of Lake Hagoi and in discarded cans and bottles. Anopheles subpictus is known from Tinian and, as an anopheline mosquito, must be a suspected malaria carrier. However, it apparently prefers to bite cattle to humans and no cases of malaria transmission by this mosquito are known. Other species of mosquitoes are known from Tinian that are potential transmitters of encephalitis or filariasis.

Several species of termites were noted, both ground nesting and dry wood species. They are a problem in some poorly constructed buildings. Ants of several species were noted including household pests, plant pests and stinging ants. They were not overly abundant and are a minor problem. Two species of sphecid wasps which build paper nests in shrubbery and around homes as well as in the tangentangen were noticed. One of them Rhopalidia marginata, can give a serious and sometimes fatal sting, particularly if a person is allergic and is stung by several wasp at one time. These can be controlled by burning out or spraying the paper nests whenever found. Both of these wasps are accidental introductions to Tinian. Honey bees were observed but not common. Within homes on Tinian the large cockroach Periplaneta americana was abundant or scarce depending on how clean the home was kept. Other species of cockroaches were seen in the forests and scrublands. Fleas and lice of several species are known from humans and other warm blooded animals on Tinian. Dragonflies of several different species were abundant on and around Lake Hagoi and Marpo Swamp.

Other Terrestrial Invertebrates

Two species of centipedes were observed including one very large one which can give a very painful bite which can make a person ill for several days. Two small species of millipedes were seen. One small scorpion was seen. The sting of this scorpion is inconsequential even if it manages to pierce the skin. Sowbugs were abundant. The common dog tick was seen on several dogs and the cattle tick is a continuing problem with cattle owners and requires chemical treatment for adequate control. Red spider mites are pests on some truck and fruit crops. Angle worms were abundant in rich soil, particularly around the edges and in Marpo Swamp.

Spiders of a dozen or more species were observed. The dangerous spiders of the genus Latrodectus (Black Widow), found elsewhere in the Marianas, were not found even though likely habitats were searched.

No land crabs were seen but their burrows were numerous in some parts of the island - including fresh burrows. Hermit crabs were abundant in the beach areas. One coconut crab was seen. They were once abundant on Tinian on the beach areas and limestone cliff and ridge forests. However, local informants state that in recent years they have been intensively hunted for shipment and sale to Guam and Saipan and so are now quite scarce. Many coconut crab traps (made from opened coconuts) were observed in the cliff and ridge forests.

The Giant African Snail (Achatina fulica) was introduced into Tinian in the 1930s and soon became a serious pest as an omnivorous plant feeder, particularly on young truck crops and ornamental plants. The snails killed on highways, and airstrips and those dying for other causes became breeding sites for countless filth flies, and the intact shells of other dead snails became mosquito breeding sites. In 1955 the east African carnivorous snail Gonaxis kibweziensis was introduced to Tinian and a few years later another carnivorous snail, Euglandina rosae, was introduced from Florida. Both of these snails were introduced to prey on the Giant African snail and hopefully bring it under control. The writer found both of these carnivorous snails well established on all parts of Tinian and Giant African snail populations only a fraction of what they were in the 1950s. The great reduction in Giant African snails was also verified by questioning old time residents of Tinian. Although other factors have probably also been responsible for this great reduction in the pest snail, the carnivorous snails are probably the most important. The Giant African snail is still a nuisance pest in some situations on Tinian, though compared with the 1950s there has been a vast improvement.

There are about a dozen other species of small to minute land snails on Tinian, mostly assumed to be indigenous. They are general organic matter scavengers or tree leaf fungus feeders. None are plant pests and in general should be considered beneficial or at least as a part of the balanced environment of the island. One species of introduced slug is present on Tinian. It is a plant feeder, but its damage to economic plants is very minor and usually goes unnoticed. This slug is preyed upon by the West Indian toad (Bufo marinus) which predation may be keeping the slug under good economic control.

In addition to all the other invertebrates mentioned above, there is a vast world of microscopic and semi-microscopic fauna on Tinian. The animals in this fauna include many species of protozoa, nematodes, flatworms, rotifers, predaceous mites and other minute arthropods. This minute fauna is vitally important to the overall ecology of the environment. Many of these elements are engaged in the ultimate breakdown of organic matter to keep the cycle of energy and nutrients going. Some are parasitic on other organisms and some serve as food for larger elements of the fauna. At least one, a plant feeding nematode, is a fairly serious pest on Tinian. This nematode, which is assumed to be introduced feeds on the roots of certain of the truck crops grown on Tinian and sometimes requires control measures.

Amphibians and Reptiles

No snakes were seen. The small blind burrowing snake Typhlops brahminus should be on Tinian, as it is on most of the other high islands of Micronesia. The blue tailed skink is common on all parts of the island as is a golden brown ground skink. Geckoes of one species only were seen - and only in houses. The large (up to five feet) monitor lizard (Varanus indicus) was seen on several occasions and must be presumed to be common. The local people abhor it, both for its appearance and because it destroys a certain number of domestic chickens at times. It probably also destroys as many of the native and introduced birds that it can get to, including nestlings and eggs. On the other hand it is a known rodent predator and may exert some control over the rat population on the island. The West Indian or Marine Toad, Bufo marinus, is fairly common on Tinian, especially around water sources. The tadpoles of this toad were seen in abundance in both Lake Hagoi and Marpo Swamp. Although this toad secretes a strong poison from its neck glands, it is harmless if not handled. It is a voracious insect feeder and so probably generally beneficial.

Mammals

Domestic animals known to be on Tinian are horses, cattle, goats, dogs, cats and swine. There is reported to be at least one flock of wild goats on the island and several feral cats were seen by the writer. Two were shot. The wild goats, if not controlled or eradicated, will multiply and cause serious damage to some areas of Tinian as they are doing now on the island of Agiguan. The remaining original forests on the ridges and cliffs could particularly suffer from wild goat browsing. The feral cats are a menace to the bird life of the island and should be killed whenever possible. No wild dogs were seen or reported. Neither were wild pigs seen or reported.

The Marianas fruit bat (Pteropus mariannus) was not seen but was reported to still be on the island though declining rapidly. Again the reason for the decline is the intensive hunting of the bats for export to Guam and Sainan markets. One of the bat hunters reported that one of the favorite foods of the bats on Tinian is the fruit of the kapok or cotton tree. Wild papaya and fruits of some of the indigenous limestone forest trees on the ridges and cliffs no doubt also serve as fruit bat food on Tinian.

The Oriental musk shrew (Suncus murinus) was observed once in the writer's hotel. This small mouse-sized mammal may only recently have gotten to Tinian. It was accidentally introduced to Guam in the early 1950s and has since spread to Saipan and Truk. It likes to live in and around human habitations and is considered a nuisance for this reason as well as its aggressiveness and resemblance to rodents. Its principal food is insects though it will occasionally get into stored food supplies.

The house mouse has been reported from Tinian but was not seen by the writer. Rats of two species have been reported from Tinian - Roof rat (Rattus rattus) and Polynesian rat (Rattus exulans). A third rat, the Norwegian Rat (Rattus norvegicus) may also have become established on Tinian. The writer saw three rats on Tinian crossing roads in the day time but none were collected. The rats seen, by size and coloration, were probably roof rats. Rats sometimes cause serious damage to crops of watermelon and cantelope and are household pests in the village. Many prematurely fallen coconuts seen around the island were noted to have been chewed into by rats. Rats are one of the hardest of pests to control, and require a continuous control program to obtain any kind of success. So-called rat eradication programs are a waste of time.

The Marianas Deer (Rusa marianna) was introduced to Tinian in the early 1960s from Saipan and Rota (six animals). In spite of hunting in recent years these have increased spectacularly and may number between one and two hundred on the island now. They are regularly hunted, which is good, because otherwise they would become a serious pest both to agriculture on the island and highly detrimental to the remaining indigenous vegetation of the island.

Birds

Twenty seven species of birds have been previously reported in the scientific literature as occurring on Tinian. Of these the writer saw fifteen species and collected eleven species. In addition, three species of birds not previously reported from the island were seen by the writer. The previously reported birds are as follows:

Reef Heron (Demigretta sacra)*+
Chinese Least Bittern (Ixobrychus sinensis)*+
Black-crowned Night Heron (Nycticorax nycticorax)
Marianas Mallard (Anas oustalevi)*
Garganey Teal (Anas querquedula)

Widgeon (Anas penelope)
 Shoveller (Anas clypeata)
 Tufted Duck (Aythya fuligula)
 Micronesian Megapode (Megapodius laperouse)*
 Gallinule (Gallinula chloropus)*+
 Common Coot (Fulica atra)+
 Pacific Golden Plover (Pluvialis dominica)+
 Amer. Wandering Tattler (Heteroscelus incanus)
 White Tern (Gygis alba)*+
 Blue Rock Pigeon (Columba livia)*
 Marianas Fruit Dove (Ptilinopus roseicapillus)*+
 Philippines Turtle Dove (Streptopelia bitorquata)*+
 White-throated Ground Dove (Gallinula xanthonura)*+
 Short-eared Owl (Asio flammeus)
 Edible Nest Swiftlet (Collocalia inexpectata)*
 White-collared Kingfisher (Halcyon chloris)*+
 Eastern Barn Swallow (Hirundo rustica)
 Rufous-fronted Fantail (Rhipidura rufifrons)*+
 Tinian Monarch (Monarcha takatsukasae)*+
 Micronesian Starling (Aplonis opacus)*+
 Cardinal Honey-eater (Myzomela cardinalis)*+
 Bridled White-eye (Zosterops conspicillata)*+

*Resident - all others are migratory, casual or accidental
 +Seen
 =Collected

The Chinese Least Bittern, White Tern, Philippine Turtle Dove, White-collared Kingfisher, Rufous-fronted Fantail, Tinian Monarch, Micronesian Starling and Bridled White-eye were common all over the island. The Golden Plover is also abundant but is restricted to beaches, roadways, open fields and airplane runways. Over fifty Golden Plovers were seen in one plowed field avidly searching for insects and insect larvae exposed by the plowing. In addition to the previously reported birds on the above list the writer saw three other species of birds. These are: a Whimbrel, which is a migratory curlew; a Pintail Duck, also migratory, over Lake Hagoi; and, several European Tree Sparrows, which species is now apparently established and resident in the village of San Jose.

The Tinian Monarch is an interesting case. It is on the world's list of endangered species, as well it might be, because it is found no where else except on the island of Tinian. An ornithologist who reported on the birds of Tinian in 1945 stated that there were no more than forty or fifty Tinian Monarchs left. This writer's observations were that the birds were in the thousands. Without fail,

anywhere on the island that the writer stopped, that had bushy cover or trees, the birds were always to be found. This includes in the tangentangen areas, native forests, strand areas and even close to and in the village. This discrepancy between the numbers of the birds on the island in 1945 and at present can no doubt be accounted for because of the great change in the ecology of the island since 1945. In other words most of the sugar cane land and military disturbed land has reverted to wild brush and trees and the monarch has been able to readily adapt to and increase in this environment. At any rate it is good news for ornithologists. No doubt most of the other resident birds of Tinian were also at a low ebb in 1945.

The Philippine Turtle Dove is an introduced bird which was brought to Tinian (or flew to Tinian from introduction on Saipan, Rota or Guam) by the Spaniard possibly one to two hundred years ago. It is more than normally abundant. One admiral is reported to have shot more than seventy of these doves in one day on Tinian recently. The doves are probably so abundant now because of the large amount of milo that is being grown on the island as cattle feed. The doves are in fact a pest and destroy a considerable amount of the milo by feeding on the milo grains and breaking the stalks down. The hunting of these birds, which are excellent food, should be continued, if not encouraged.

Other birds are not doing so well on Tinian. The Marianas Fruit Dove is quite rare. Two specimens were seen and perhaps two or three more heard. Since they have a very distinctive call which can be heard for long distances, and since the writer was on all parts of Tinian from which a call could be heard, it is assumed that this bird is at a very low population level. Basically this can be accounted for because the dove is mostly restricted in its feeding preferences and habitat preferences to the small amount of original forest left on Tinian. Furthermore, hunters out after the Philippine Turtle Dove will also shoot the Marianas Fruit Dove if seen. This dove has not been able to adapt to the drastic environmental changes on Tinian since the original forests were cleared off. The White-throated Ground Dove is also rare, though it has probably made a somewhat better adaptation to the changing environment and may now be feeding extensively on the wild papaya. This dove too is shot if seen by hunters after the turtle dove. The turtle dove has not usurped the environments of, nor is it in competition

with the two native doves. It occupies a different ecological niche and prefers different foods and more open country. The Gallinule is restricted to the Marpo Swamp and Lake Hagoi and the areas immediately surrounding them. They may be surviving well there but only in very small numbers and if either of these wetland areas are tampered with or destroyed by filling or poisoning, the Gallinule will probably not survive on Tinian.

The Marianas Mallard is another of the vary rare birds of the world being found only on the few bodies of fresh water existing in the Marianas Islands. On Tinian this means only Lake Hagoi. There is no open water at Marpo Swamp. This duck probably migrates up and down the Marianas chain depending on food supplies available and the amount of hunting or disturbance pressures they will tolerate. The duck is not presently protected by game laws and could easily be reduced to extinction through hunting or destruction of open bodies of fresh water in the Marianas. The creation of the Fena River Dam Lake on Guam, and the prohibition of hunting ducks on that lake by the Navy, could save this species. The writer did not see the duck on Lake Susupe on Saipan before proceeding to Tinian. One duck flying at a distance over Lake Hagoi appeared to be a Marianas Mallard, but the distance was too great for accurate identification of this undistinctive patterned duck. The writer spent half a day splashing around through the bulrushes of Lake Hagoi and could hear ducks quacking all around, but could not get a clear enough view of open water to see the ducks responsible. They could have been Marianas Mallards or some migratory ducks from Asia or both.

The Black-crowned Night Heron, Garganey Teal, Widgeon, Shoveller, Tufted Duck, Amer. Wandering Tattler, Pacific Golden Plover, Short-eared Owl and Eastern Barn Swallow are all migratory birds from Asia and their fate on Tinian would not greatly affect the species involved. However, it would be nice to think that the people living on Tinian would welcome these interesting visitors. There are no doubt quite a few other migratory birds that pass through Tinian which have not yet been recorded - particularly among the shore birds such as sandpipers, plovers, dotterels, turnstones, stints, curlews, etc.

The writer observed the European Tree Sparrow (Passer montanus) in San Jose village. This bird has been established on Guam for about twenty years and has now flown to or somehow been transported to Tinian. This is not a good introduction as the Tree Sparrow acts

and lives very much like the English or House Sparrow which is such a nuisance in urban and farm areas around the world. The tree sparrow is aggressive and will drive out some of the more beautiful and interesting native song birds in the areas it occupies. It is also a bird disease carrier.

The Micronesian Megapode is indicated on the list above as a resident bird. It has been presumed by ornithologists that this bird (or rather the Marianas subspecies - there is another subspecies in Palau) has been extinct on all the Mariana Islands from Guam to Saipan for fifty to one hundred years. It is still known to exist in very small numbers on some of the Mariana Islands north of Saipan. The Micronesian Megapode is a chicken sized bird with big feet that scratches together a huge mound of soil and compost (sometimes six feet high and fifteen feet across) and deposits its eggs in the mound. The eggs are incubated not by the parents but by the heat of the decaying compost within the mound. The writer was greatly elated when told by a reliable informant that two of these birds had been seen only two weeks before his arrival on Tinian. This was a surprise but not too great a surprise because the writer had seen magapodes on Agiguan Island just south of Tinian in 1955. Several local informants, on questioning, accurately described the bird including its big feet, crest on head and mound building activities. In addition they knew the correct Chamorro name for the bird - "Sasengay". This information came too late for the writer to mount any adequate search for the bird or its telltale incubation mounds but he is convinced that a sufficient search will reveal that the Marianas Megapode is still resident on Tinian after this long period of presumed extinction.

THE ASSUMED IMPACT ON THE FAUNA AND FLORA OF TINIAN BY THE PROPOSED MILITARY BASE

Now that the physical setting, the ecological history and the present status of the fauna and flora of Tinian has been described, the crux of the matter is to attempt to judge the impact on the fauna and flora of the building and operation of the proposed military base and the ecological changes that it will effect. Although the writer has some information on the proposed structures, highways, airfields, etc. that are planned, he does not know precisely where they will be located on the approximately two thirds of the island of Tinian that the military proposes to lease and use. Nor does he have more than a vague idea of the number of personnel, both military and civilian, that will be involved both during the construction

phase of the project and after the base is down to a routine operation. These facts are ultimately essential in making a reasonable impact statement. An attempt will be made, however, in any case.

Impact on the Flora

If the military could confine their construction work and ultimate operations to the previously highly disturbed lands used by the U.S. military at the end of world war II primarily, and then secondarily to the previous sugar cane lands now grown up in tangentangen, little or no adverse effect on the flora of Tinian will result. This would imply that construction and other soil and flora destructive activities be kept away from the original forests still extant on the ridges and cliffs, kept away from Lake Hagoi and if possible from the good agricultural soils presently in use, even though that use would cease during the time a military base is operating on Tinian. If it is found on subsequent investigation that there exist any individual specimens or general area of very rare plants or trees, then any such area should be exempted from any disturbance.

Impact on the Fauna

The existing fauna on the island of Tinian will be least disturbed and endangered if the remaining relatively undisturbed habitats on the island can be bypassed in the process of the construction and operation of the military base. Again, as in the case with the flora, the preservation of habitats as such, rather than the individual species of fauna, is the best basic policy. The loss to the fauna of some of the already highly disturbed land and vegetation would be a minimal loss, and since most of the species living in this type of vegetation have already proven themselves highly adaptable, there may be no overall loss at all as far as the fauna is concerned if adequate landscaping is done after the construction phases of the project are finished. In the case of some individual species, however, there must be some special precautions taken. Lake Hagoi must be left intact and not filled, poisoned or oiled if any consideration is to be given to saving the Marianas Mallard and the Gallinule. Lake Hagoi is not only the sole refuge for the Marianas Mallard but also the only part of Tinian that can serve as a way station to migratory waterfowl. If the surmise that the Micronesian Megapode still survives on Tinian is true, then its minimum habitat must be delimited and set aside as undisturbed as possible.

The invertebrate fauna such as worms, spiders, mites, ticks and insects would be little affected in any way adverse to the ecology of the island. There could be some increase of pests insects on the ornamental and other plants used in the landscaping of the military area, but this need not be so if care is exercised to chose landscaping plants that are little or not at all affected by the pest insects which are presently on the island. The coconut crab will probably benefit by the operation of the military base since civilian hunting and commercial export of this animal will cease. Whatever collecting or hunting of this animal is done by military personnel for their own use probably would not affect their population adversely. This same situation will probably also obtain with regards to the fruit bat and it can be expected that the fruit bat populations will recover and flourish on the military base.

SOME GENERAL CONSIDERATIONS

In general, large military reservations, by their exclusive nature, become wildlife preserves and preserve fauna and flora which might otherwise be destroyed or badly harrassed by normal civilian development and use. This is self evident on Guam where the military reservations are the last stronghold of the indigenous fauna and flora of Guam. The writer is also well aware of this from experience in his home state of Washington and elsewhere in the United States. This premise assumes that the military administrators of these bases control the use and exploitation of the faunal and floral resources by military personnel - which is usually the case. Gross exceptions do occur and the following quote from "Birds of the World" by Oliver L. Austin, Jr. is a case in point: "Sentiment has also always been on the side of the cranes in Korea and Japan, where the birds have been rigorously protected for half a century and small stocks maintained on their wintering grounds. Unrestricted poaching by occupation personnel after World War II drove the cranes from several of these sanctuaries or reduced their numbers." On the island of Tinian, wildlife which prospers on the proposed military base will serve as a reservoir for replenishing these resources on the southern third of the island occupied by the civilian population.

It is not within the instructions to this writer to comment on the sociological and economic impact of the military base on Tinian. However, where sociological and economic impact also affects the fauna and flora it seems germane to discuss it here. The restriction of the civilian population of Tinian to the southern one third of the island portents that those land and resource use activities

that they have been carrying on all over the island will now be concentrated in that southern one third of the island. Furthermore, the anticipated influx of, first construction workers, and later civilian employees for the military base, will further intensify the land and resource use of the non-military land. A lot of this will be misuse and the fauna and flora of this area will probably suffer more than is presently the case. Of course, the Trust Territory government, the District Administration and the Tinian Municipality administration are all at liberty to devise laws and regulations to minimize land and resource misuse or over exploitation. Some such laws do exist at the present time. More are needed but neither existing or future resource laws will have much effect unless resources education and resource law enforcement procede together. Whether or not intensive agriculture will be carried on in the southern one third of the island after establishment of the military base, is open to question. There is still plenty of good agricultural land in the southern part of the island and markets for produce will continue in Guam and increase on Tinian with the military base there. However, when faced with the choice between a steady livable salary as a worker for the military, and the somewhat less certain but more profitable choice as a farmer, this writer feels that the agricultural pursuits will decline. On the surface of it, the fauna and flora of this area would profit by less exploitation of the land. However, the spectre of an Eleye-like situation developing on Tinian, in general bodes no good for either the fauna and flora or the human population.

The military organization and personnel on Tinian will be subject, as all other Trust Territory residents are, to existing Trust Territory laws relating to conservation (including regulations of the Trust Territory Environmental Protection Board), land use and plant and animal quarantine. Some provisions must be made to allow Trust Territory employees to check on the observance of these laws and regulations. Plant and animal quarantine is a particular point in case. Presumably, military, and possibly some civilian aircraft will be both scheduled and irregularly arriving from other parts of the Pacific and the world at the military airport on Tinian. It will be necessary that Trust Territory Agricultural Quarantine Inspectors clear these incoming aircraft with respect to our plant and animal quarantine laws. This is necessary not only to protect the island from new insect and animal disease and weed introductions, but also to prevent the importation of exotic plants and animals which on establishment on Tinian could become detrimental to the island. Military personnel flying in from exotic places are wont to quite innocently bring in parrots, monkeys, potted plants, and other oddities that are potentially harmful in a new area. The Trust Territory quarantine permit system is a means for preventing this, or for passing judgment ahead of time as to what can or cannot be imported into the Trust Territory. Military and civilian ships coming into Tinian must be subject to the same surveillance.

With the housing of several thousand military personnel on Tinian there are going to be some problems concerning household pests, nuisance pests and mosquitoes, whether they are of health significance or not. Good sanitary practice as far as house cleaning, sewage disposal, pet control solid waste disposal and litter control should take care of these potential problems without any threat to the fauna or flora. Where normal sanitary measures do not control any particular pest, then the use of chemical control or other measures may be necessary. Aerial spraying of insecticides should not be considered. Too many other forms of life besides the target species are affected including beneficial species of insects such as honey bees and insects parasitic or predaceous on pest insect species - including the very species that the control measures were devised for. Restricted ground applied mist spraying around homes and working areas is usually more effective and less expensive than aerial spraying or fogging. Litter control is particularly important in mosquito control to prevent mosquitoes from breeding in rainwater collected in such litter. This also brings up the question of possible excessive mosquito breeding in Lake Hagoi which has been earlier suggested as one of the most important fauna and flora habitats on Tinian which should not be disturbed. In the first place, housing and working area could be located far enough away from Lake Hagoi that any mosquitoes breeding there would not be bothersome. Even if mosquitoes are breeding in quantity in Lake Hagoi, this doesn't necessarily mean that they are disease carriers or that they will attack human beings sufficiently to need control. Light traps can pick up thousands of mosquitoes and bodies of water be teeming with their larvae, but if they do not bite human beings regularly this is of no consequence. Also, mosquito fish or other mosquito biological controls could be introduced into Lake Hagoi if necessary. In any case, every means possible should be taken to prevent the filling in, chemical poisoning or oiling of Lake Hagoi.

It is this writer's understanding that solid waste disposal on Tinian is to be handled in the military area by sanitary land fill rather than by ocean dumping. With the porous limestone subsurface of Tinian, care must be taken that solutions from this landfill or from waste oil or chemical disposal do not filter unchanged into the water lense which is the fresh water supply for Tinian. An examination of existing U.S. Geological Survey maps of Tinian could avoid this error. Soil depths on Tinian are not great and the scraping up of enough soil to keep a normal sanitary land fill going would probably be detrimental to the area involved. There are numerous old limestone quarries on Tinian. Perhaps one of these could be used for solid waste disposal even without a soil covering if far enough removed from human activities on Tinian. Sewage disposal on Tinian will presumably be through a secondary treatment plant with the effluent being disposed of into the sea. From the terrestrial point of view this is fine. It should be mentioned

here that the beaches on the eastern side of Tinian are a horrible mess as the result of untold quantities of cans, bottles, plastic containers, etc. being piled up on these beaches. This material is coming from the shoreside solid waste disposal areas on Saipan. Perhaps the Air Force, once established on Tinian, would be willing to bomb Saipan to force correction of this situation.

The establishment of recreational facilities on Tinian for the military personnel could be accomplished without any particular detriment to the fauna and flora providing that recreation does not include shooting up the island. Golf courses, tennis courts, swimming pools and development of the available sandy beach areas are cases in point.

This writer has no information on the effects of noise pollution from aircraft operation as it might affect the existing fauna of Tinian. The effects, if any, will be presumed to be minor. There are no large nesting colonies of sea birds on Tinian so no physical interference with aircraft operation from this source need be anticipated.

No particular mention has been made concerning the Micronesia Development Corporation's cattle ranch on Tinian. Most of this ranch is within the area to be taken over by the military. The corporation has other land holdings in southern Tinian which they will presumably develop and continue their operation, though on a smaller scale. The writer visited several of the MDC areas on Tinian and had a talk with the manager of the operation. It appears that a relatively efficient beneficial agricultural operation is being carried on with minimal disruption to the ecology of the island.

The idea that rare and endangered species of plants and animals should be saved is more than a general attitude towards aesthetics or something conceived by bird-watchers and people who like to go to sleep under trees. The idea that any living species is a part of a genetic gene bank on this earth that can never be replaced if the species becomes extinct, is a scientific principle which is difficult to explain to laymen. These gene banks are constantly being tapped for all sorts of beneficial scientific work in plant and animal breeding, development of disease resistant forms, and, in the case of plants, a part of the reservoir that can be explored for new medicines and other useful products.

Hopefully, the U.S. military, in taking over the use of a part of Tinian, will view its occupancy as a trusteeship of a part of Micronesia, which will someday be returned to the people in as good a shape, or better, than when they receive it. A concern for the fauna and flora of Tinian on the part of the military occupying Tinian will hope to ensure this premise.

The idea that military bases are subject to attack in time of war cannot be avoided, and such an attack or attacks on a military base on Tinian, particularly with nuclear weapons, would be nothing but bad for the fauna and flora of Tinian. The other side of this speculative coin is that if a U.S. military base on Tinian is conceived as military protection for Tinian, as well as the rest of Micronesia and the United States, then the protection of Tinian from foreign invasion and occupancy, and the possible excessive exploitation of the land and resources of Tinian by such an occupying power, as has happened in the past, then the lack of such military protection could be equally destructive to the ecology and existing fauna and flora of Tinian.

CONCLUSIONS

This writer, from his present knowledge of the fauna and flora of the island of Tinian, and the expected development and use of the island by the U.S. military, concludes that, although the ecology of the island will be somewhat changed, no overall deterioration of the fauna and flora of the island can be expected.

This environmental impact statement on the fauna and flora of Tinian and the possible effects of a military occupancy and use of the northern two thirds of the island can be considered preliminary only, and a further impact statement on the fauna and flora should be made at a later date when specifics of the constructions activities, construction locations, completed base operations, military population and imported civilian labor population are known.

Robert P. Owen

Robert P. Owen
Chief Conservationist
Trust Territory of the Pacific Islands
Biology Laboratory
Koror, Palau, Caroline Islands 96940

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