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BIRD MALARIA

By Blanche A. Pedley

Early voyagers to the Hawaiian Islands found native birds plentiful. By the eighteen nineties their number had greatly decreased and some of the species were extinct or nearly so. It is interesting to note that this rapid decrease in bird population took place shortly after the introduction of the mosquito, a vector in the life cycle of bird malaria. Mosquitoes were unknown in Hawaii prior to 1823. There are three known "biting" mosquitoes in the Islands - the night mosquito, Culex quinoquefasciatus; the forest day mosquito, Aedes albopictus; and the Aedes aegypti. All three of these are known to be susceptible to infection with bird malaria. The first of these to arrive in Hawaii was the night mosquito and for several years was the only one. It is known that this mosquito appeared on Maui shortly after the "good ship Wellington" had put in to Lahaina from San Blas, Mexico, in 1826. Coming ashore for water, the sailors had doubtless rinsed out their water casks, and any wrigglers which had been breeding in them found themselves a new home.

Although no study of bird malaria has been made in Hawaii, it was found in pigeons in Honolulu in 1938 and two species were found in introduced birds in the Hawaii National Park in 1941. It has also been reported in California quail on Hawaii.

Avian plasmodia have been reported from many parts of the world, and have been found wherever the blood of birds has been carefully searched. Undoubtedly bird malaria occurs in every part of the world where birds and mosquitoes are found, except possibly in the far North. New hosts, as well as new species, would probably result from surveys made in areas that have not as yet been studied.

Malaria is known to occur more frequently in the passerine birds (perching songbirds) than in any other group. Sparrows have been heavily infected in most regions. Pigeons, doves, geese, ducks, turkeys and chickens are rarely infected in nature although malaria parasites are occasionally found in all of them.

Several genera and species of mosquitoes (Culex, Aedes, Anopheles and Theobaldia) are responsible for the transmission of malaria in birds, but it is quite probable that these are not equally distributed throughout the world.

It is fortunate that Danilewsky (1885) discovered plasmodia in birds so soon after Lavarn (1880) had discovered the organism causing human malaria. Research had reached the point where little more could be learned by direct observations on the parasites of human malaria and so the early studies of the plasmodia of birds were made in the effort to discover facts that could be directly applied to human malaria. The first important contribution to the study of bird malaria was the work of MacCallum (1897 and 1898) on the fertilization of the female gamete, followed by Ross's (1898) discovery of the mosquitoe transmission of malaria through the use of birds as experimental hosts. Roehl's (1926) discovery of plasmochin and Kikuth's (1932) work on atebrin

introduced two synthetic malaricidal drugs which have been widely used in the treatment of human malaria. These drugs were first tested on the plasmodia of birds.

Canaries have become the standard experimental host. Java sparrows, doves, pigeons, ducks and chickens have also been used in recent years as hosts for certain species of avian plasmodia. The transfer of parasites from an infected bird to a non-infected bird can be made by mosquitoes or by direct blood inoculation.

Malaria parasites in birds have been classified under approximately forty different species names. Of these, twelve show characteristics which are constant enough, in the opinion of most workers, to separate them from other species. The remaining species have either been reported only once, or have not been shown to be distinctly different from one of the "good" species. These twelve species are (1) P. cathemerium, (2) P. circumflexum, (3) P. elongatum, (4) P. gallinaceum, (5) P. hexamarium, (6) P. lophurae, (7) P. nucleophilum, (8) P. oti, (9) P. polare, (10) P. relictum, (11) P. rouxi and (12) P. vaughani.

The different species of avian plasmodia differ greatly in their degree of host-parasite specificity. P. relictum and P. cathemerium, for example, have been found in nature in many species of wild birds, and are readily transferred to the canary. These two species might then be considered as exhibiting loose host-parasite specificity. P. vaughani and P. polare, on the other hand, seem to exhibit a rigid host-parasite specificity, the former being found in nature only in robins and the latter in cliff swallows, although both have been inoculable to canaries. Various intermediate degrees of host-parasite specificity exist in other species.

The life cycle of avian plasmodia in the vertebrate and invertebrate host is similar to that of the human malaria parasites and is described by Hewitt (1940).

Sporozoites present in the salivary glands of certain species of mosquitoes are injected into the blood of the bird while the insects are biting. The first parasite found in the red blood cells of the vertebrate host is the small trophozoite. This enlarges within the red cell and may eventually become either a segmenter or a gametocyte, the former representing the asexual division stage, and the latter the sexual stage, which undergoes further development in the mosquito. The division products of each segmenter are known as merozoite. These escape from the red blood cell and penetrate new ones; the asexual cycle is then repeated. The haemoglobin within the red cells is apparently digested and by-products, in the form of pigment granules, are deposited within the parasite. The asexual cycle varies in length in the different species of plasmodia from twelve to forty-eight hours. The gametocytes are of two types, male (microgametocytes) and female (macrogametocytes). After a mosquito ingests blood containing gametocytes, further development takes place. Each male gametocyte produces six to eight flagellated bodies (male gametes) in the stomach of the mosquito, and the female gametocyte undergoes a maturation process to become a female gamete. Fertilization is accomplished by the fusion of one male gamete with a female, and the resulting zygote becomes an elongated ookinette capable of progressive movement. Ookinettes penetrate the stomach walls of the mosquito and come to rest just beneath the outer envelope of the stomach where they form spherical oocysts within which large numbers of minute, elongate cells called sporozoites develop. These eventually escape into the body cavity of the mosquito and may find their way to the salivary glands. Upon biting, the mosquito injects some of the sporozoites into the vertebrate host and the asexual cycle begins. The sexual cycle within the mosquito host requires seven to ten days.

Infection in the mosquito depends upon the ingestion of an adequate number of male and female gametocytes and probably only occurs at the peak of gametocyte production in the bird when infection is at its crisis.

That sporozoites produce infection when introduced into a bird by the bite of a mosquito is without question. What happens next in the life cycle is not fully understood.

Three different types of exoerythrocytic parasites have been associated with certain species of bird malaria and attempts to separate them from the more familiar life cycle of plasmodia in the red cells have been unsuccessful. This leads workers to believe that they represent a stage in the asexual development of at least certain species of plasmodia but this has not been definitely determined (Hewitt, 1940).

Schaudinn (1902) seems to have been the only worker to have observed the penetration of the red cells by sporozoites, but his work has been doubted by most malariologists. Missiroli (1933, 1934, 1937, 1938) has observed nuclear divisions in sporozoite and their reproduction into a number of small parasites soon after inoculation into birds. He believes that what has been called a sporozoite is really a sporocyst. Raffaele (1937) found that blood samples taken from canaries which had received intravenous inoculation with massive doses of sporozoites (P. relictum) are not infective to new canaries for many hours after inoculation whereas samples taken after direct blood transfers were infective sooner. His conclusion was that sporozoites did not immediately penetrate the red cells. He also found exoerythrocytic parasites present and believes these parasites resulted from the penetration of sporozoite into reticulo - endothelial cells. This is not conclusive, however, since exoerthrocytic parasites may also be present after direct blood transfer and may be independent of sporozoites.

Studies since 1940 have probably explained the mystery of why exoerythrocytic schizogony is not associated with all species of plasmodia and whether or not it is a part of the asexual cycle in bird malaria.

Birds infected with bird malaria show the following symptoms: a moderate rise in temperature; loss of appetite; apathy; ruffled plumage; convulsions, and loss of weight. These symptoms occur at the time of sporulation of the parasite. Symptoms subside in from four to six days, parasites disappear from the blood, and the bird once more appears normal. Malaria in birds runs a chronic course and parasites may remain in the body of the bird for several years before complete recovery. As in human malaria, the recurrence of parasites in the blood after recovery from the primary attack is characteristic of certain species.

Chronically infected birds cannot be successfully inoculated with the same species but may or may not be with others, depending upon the species involved. Completely recovered birds can be reinfected. Studies that have been made indicate that antibodies of some kind exist in the blood serum of birds infected with some strains of plasmodia and that inoculation with large enough doses of immune serum can be effective in producing immunity. Attempts to demonstrate vaccination against malaria have met with variable success.

Avian and human malaria respond similarly to antimalarial drugs. It is not surprising, therefore, that new chemicals and compounds devised for the treatment of many human ills usually find their way into the blood stream of malaria-infected canaries in the hope that one of them will prove to be a true malaria specific.

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A PROPOSAL TO CREATE CERTAIN NATURAL PROTECTED AREAS ON STATE-OWNED LAND IN THE STATE OF HAWAII

Written by E.J. Britten, for the Co-ordinating Council for Conservation, and submitted to the 1961 Legislature.

One of Hawaii's greatest assets is her natural beauty--beauty of mountain, forest and ocean. The natural beauty of the Islands is one of the chief attractions to visitors. It is therefore one of the great economic assets of the Islands. Unlike many other assets, the beautiful and natural setting of the forests, the mountain and the sea can be enjoyed by all without loss since it is only seen and is not taken away. It can be enjoyed from a distance and therefore wild and inaccessible areas can be enjoyed by many people without having to enter them.

The native plants, birds, insects and other forms of native life represent kinds of life which in large part are found nowhere else in the world. Over ninety percent of the native plants do not occur anywhere in the world but Hawaii. Some plants are found only on one Island. The native flora and fauna of Hawaii represent a treasure house of living things; one of the most amazing assemblages of natural living things in the world. We have, for example, more kinds of ferns in Hawaii than in all the rest of the United States. Many of the living things of Hawaii are famous throughout the scientific world. The story of the development of a group of birds, the Hawaiian honey creepers, is better known to men of science in many distant countries of the world than it is to our own people in Hawaii.

Since man has complete control over the life and death of these natural objects, it is his duty to protect them. If man does not protect these living things, the eyes of the world and of future generations will look upon us with rage and anger--for once a kind of living thing is lost, it is gone forever and no miracle of science can bring it back.

With the rapid change of wild lands to urban areas, the native home of the plants and birds is made smaller and smaller. We must save certain typical areas on each island as native habitats. To this end it is proposed that "natural protected areas" be created on State land for the preservation of certain forms of native life.

It has been thought that a number of kinds of Hawaiian birds have become extinct during the last fifty years. With the discovery by Dr. Frank Richardson and John Bowles in the summer of 1960 that the Hawaiian "O'o" is still alive as well as other rare species, hope is renewed that other rare birds may still be alive in wild and secluded areas of the forests. It is therefore incumbent upon us to preserve the native homes of these birds--not only for the birds, but also for the plants that they live among, which also are rare.

Many different forces pose a threat to these natural sanctuaries. It is important therefore to set certain areas aside as natural protected areas where these rare plants, birds, and other forms may live in a relatively undisturbed condition--not only for their own sakes, but so future generations of man may enjoy and study them.

The following are proposed natural protected areas: Mt. Kaala Wilderness and Sanctuary Area, Oahu; Eke Crater Protected Area, Maui; Okokui-Wailau Protected Area, Molokai; Alakai Swamp Wilderness Area, Kauai.

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MIDWAY ISLANDS

Ruth Rockafellow shares with us the following exerpts from a letter written by Lieut. Commander Edward Wilson, USN, Retired, describing a trip to Midway, taken with Chandler Robbins.

... Several years before, Chan had worked with Midway gooneys, so that on my first trip our mission was to determine if $110,000.00 by his recommendation was well spent when leveling and black-topping an established nesting area for half a mile along the runway and widening the same 600 feet to 750 feet from runway centerline. For answer, we counted birds soaring over the runways at all hours and in all kinds of wind and weather, for comparison with earlier records. These were made from 10 different stations and we rode bicycles (because they are the only legal method of transportation there) for unending miles it seemed. Birds over runways dropped 67%.

To accommodate birds displaced from ancestral nesting sites on Midway, some work was done on neighboring Kure Atoll in 1959 (I believe), westernmost of the Hawaiian Chain and 55 miles toward Japan. On my first trip, but one banded bird from Midway was found there and ten months later on my second trip four banded birds, whereas we might have expected hundreds. A Loran station for trans Pacific air travel had meantime been established there together with operating personnel and airstrip with some consequent competition for the island's birds. However, the birds appeared to have appropriated some ground wire areas for nesting. So man doesn't appear too successful in changing the homing and nesting instincts of these birds.

On that second trip, we found something like 40 of the first 100 Laysan albatrosses banded in 1938 and now 29 years old or more.

Birdbanding never appealed much to me, but on that first trip with occasional help we banded 10,000 birds, mostly half grown gooneys on nests (on ground). And so of necessity, I suppose, I have improved as a bander. During the second visit with grown birds exchanging incubating duty every 2 or 3 weeks over a nine week period, only 8,900 bands were used, for mature birds require greater time and effort. Hatching began 2 weeks before we left and was sixty percent complete as we left.

As in any sea bird rookery, bird totals are usually large and species numbers relatively small. Chan and I made a Christmas bird count with 19 species and 47,964 birds. How many of the following birds do you know: Black-footed Albatross, Laysan Albatross, Bonin Island Petrel, Red-tailed Tropic (Bosun's) Bird, Blue-faced Booby, Red-footed Booby, Great Frigatebird, Pintail Duck, Pacific Golden Plover, Ruddy Turnstone, Bristle-thighed Curlew, Wandering Tattler, Sanderling, Common Noddy, Hawaiian Noddy, Fairy Tern, Rock Dove, Short-eared Owl, Canary.

On a 2 day banding trip to neighboring Kure Atoll (Ocean Island) Chan chose before dawn operations to insure using up 2000 bands allotted. So at 6:10 a.m. (dark) I located a large nesting Black-footed Albatross (classification assigned me) asleep with head under wing. He fought throughout as I set the band in the dark using the sense of touch only. To prevent his beak slashing me, I tossed him away smartly. He then attacked me in the rear so that I didn't sit down for over a week without knowing I had been had.

To save time and leg-work counting and identifying birds, I try to know and imitate all bird calls and do the characteristic gooney bird dance. On taking another big Black-foot off the nest about half a mile farther on, a newly-hatched chick faintly cried: "eeu eeu; eeu eeu; eeu eeu", and so I discovered the meaning of the adult bird's call, similar thereto, as it faced the egg or baby chick and settled over the nest usually after banding. Baby talk! Thereafter to divert the old bird from counterattack to incubating I called baby fashion and was frequently answered as the bird again settled.

Numbered bird bands come 100 to the circular string. Once while using up partial strings left over from earlier operations on non-nesting birds, I commenced stalking to save energy, while offering to (imitating) dance with them. One bird, I'm sure, stalked off, saying, "What's this guy trying to do?" Another, I feel equally certain gave me to understand, "Let's watch this guy, his imitation isn't too bad." After banding that pair, I next tried retreating a step backward instead of moving up and had the glorious result of having a bird come forward and nuzzle my pant leg as

it might another bird before dancing. Shamefacedly, I acknowledge that I banded it too though I had the impulse to let it go. ...

Both Chan and I brought back colored slides and some movie footage. Sorry we do not live closer together for then I should like to show them. ...

9-1-1961.

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FIELD TRIPS:

Audubon Society Trip to Popoia Island, Saturday, August 26, 1961.

Eighteen members of the Society met on the beach at Kailua for the annual trip out to Popoia to observe the Wedge-tailed Shearwaters at close range. The weather was warm and bright with a fairly strong tradewind blowing.

Once on the island, the group split up into several small parties each going separate ways. The Shearwaters were nesting everywhere, in burrows, coral holes, and even in some instances on the bare ground in the bushes.

Very few eggs were found, most having been hatched several weeks before judging by the size of the young birds. The small Shearwaters were covered in various shades of sooty grey down. The adult birds were all missing except in the case of the few very recent young arrivals.

The Ruddy Turnstones were very abundant, three flocks were continually being put to wing by the wandering Society members. The birds all rose at the same time giving sharp cries of alarm as they flew from one area to another. Now and again, a Wandering Tattler would join the Turnstones alarmed by the other bird calls. We were also fortunate in seeing a few Golden Plover.

As the light began to fail, the Shearwaters glided in from the open sea in ever increasing numbers. At one point, a Frigatebird flying over decided to attack a Wedge-tailed Shearwater returning to the island and gave our members a thrill to see this scavenger attempt to gain a free meal from the Shearwater.

One highlight of the trip was the young Bulwer's Petrel, completely feathered except for a downy head, which we found still in its nesting burrow in the coral.

Our only disappointment was that the boat came to take us back before the Shearwaters began their recital of moans and groans.

W. Michael Ord

For Members of Pacific Science Congress, Wednesday, August 30, 1961.

On Wednesday, August 30, our Society, led by Dr. H. McClure Johnson, conducted a tour for 75 scientists attending the Pacific Science Congress to Ulupau Head to observe the Booby colony there.

The outbound route was via Kuliouou and Waimanalo. A short stop was made at Kuliouou Beach Park to see the Hawaiian Stilt. Plover, Wandering Tattler and Sanderling were also seen. Another stop was made opposite Rabbit Island (Manana), where our guests were told about the large number of Terns and Shearwaters that nest there and also about the White (Fairy) Terns recently discovered near Hanauma Bay by Michael Ord.

At the U.S.M.C. Air Station, Kaneohe, we were well received by Captain Morrissey and Sergeant Sheehan, who conducted us to Ulupau Head. Firing on the range had been suspended for two hours especially for our visit. Cameras had to be checked at the gate but the Marine Corps supplied each member of the party with three 8x10 black and white photographs, one of Moku Manu, one of a kiawe tree with nests and birds and a particularly excellent one of a well-grown young bird. Colored negatives were also supplied us and Dr. Johnson arranged for transparencies to be made by a Waikiki photo shop for those who desired them.

As this is the end of the nesting season there were very few young birds left on nests but there was a large number of them in the dark plumage stage. The air was full of flying Boobies with the usual occasional Frigatebird.

The koa haole bushes, in which the Boobies nest, are in a sad state, evidently due to prolonged drought in this small area. Two or three small patches have been burned, leaving bare spots. The few kiawe trees, also used by the birds, are in fair condition. No doubt good rains would bring the koa haole back to life.

The return trip was made via the Pali, with a stop at the Reservoir along the old road, where a solitary Gallinule, plus two or three Coot, were seen.

Other members of our Society who accompanied the group were Mr. and Mrs. Ernest G. Holt, Mr. Michael Ord and myself.

Al Labrecque

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FIELD NOTES:

From W. Michael Ord.

Date	Place	Species
7/22/61	Hanauma Bay	Mockingbird, White-tailed Tropic-bird.
7/23/61	Hanauma Bay	White and Red-tailed Tropic-bird.
7/29/61	Makapuu Light House . . .	Wandering Tattler, 3 Ruddy Turnstone, 3 Golden Plover.
8/5/61	Popoia	14 Turnstone (Summer Residents)
8/6/61	Chinaman's Hat Island . .	4 Red-tailed Tropic-birds.
8/20/61	Daylight trip around Oahu*	
	Kahua Ranch Area to . .	14 Golden Plover, 20+ Cattle Egret, 3 Gallinules,
	West Loch	5 Stilt, 5 Coot, Wanderling Tattler, 2 Night Herons.
	Wheeler Air Force Base. .	1 Skylark, 10 Golden Plover, 6 Ricebirds
	Kuapa Pond	46 Golden Plover, 18 Ruddy Turnstone, 3 Night Herons,
		2 Stilt, 10 Sanderling, 14 Wandering Tattler.
	Kaelepulu Pond	150+ Ruddy Turnstone, 50 Golden Plover, 100 Coot,
		2 Wandering Tattler.

*Golden Plover, Turnstone--95% of these were in almost full breeding plumage. Very tired, and in the case of 150+ turnstones possibly today's arrivals.

Bristle-thighed Curlew at Kuapa Pond.

On Monday Morning, September 4th 1961, my wife and I were driving around Kuapa Pond, stopping every now and again to observe the shorebirds feeding on the mud flats and in the small pools. The Golden Plovers were everywhere, some flying up in front of the car with shrill cries of alarm and in turn causing the feeding birds to disperse to a safer place. On one of these occasions, we noticed a much larger bird fly up from the mud flats and fly in the direction from which we had just come. It landed on the gravel road about 40 yards from the main entrance into the Kuapa Pond area.

As the bird flew, I recognised that it was a curlew but couldn't be sure of the specie until I made a closer observation. Going back, slowly, I was able to get within 30 yards of the curlew--my being between the bird and the sun gave the perfect light conditions. The rusty chestnut rump and tail feathers with their black bands made identification of a Bristle-thighed Curlew very easy. The bill was approximately $3\frac{1}{2}$ inches in length with a buffish marking on the lower mandible. Trying to get closer, I frightened the bird and it took off across the pond giving its very pleasing call "curleeee, curleeee." I later managed to drive within 20 feet of the curlew as it fed on the makai side of the pond where it remained until I left the area.

On Tuesday Evening, September 5th, a Semipalmated Plover was observed at close

quarters feeding with the Sanderlings in a lagoon to the right of the road dividing Kuapa Pond. The Curlew was not seen by the writer on this occasion.

W. Michael Ord

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NEW MEMBERS: We extend a hearty welcome to the following new members:

Gerald B. Burtnett, 4302 Kahala Ave., Honolulu 15, Hawaii
H. Meyer, Box 444, Kailua-Kona, Hawaii
W. Michael Ord, 1540-C Thurston Ave., Honolulu 14, Hawaii
Noah K. Pekelo, Jr., P.O. Box 155, Kaunakakai, Molokai

We apologize for misspelling the name of two of our new members--Quentin and Michael Tomich.

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THANKS to Mrs. Mildred Mench, who has given us some slides of mainland birds to add to our collection of bird slides.

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OCTOBER ACTIVITIES:

FIELD TRIP: AL LABRECQUE WILL LEAD (Phone: 983-104)

October 8 - To Hanauma Bay and Kauapa Pond, in hope of seeing the Fairy Terns.. We are sure of seeing fairly recently arrived shore birds. Meet at the Library of Hawaii at 8:00 a.m.

MEETINGS: BOARD - October 9, at 3653 Tantalus Drive, at 7:30 p.m. Members are always welcome.

GENERAL - October 16, at the Honolulu Aquarium Auditorium at 7:30 p.m. Mr. William Ward will show pictures of Hawaiian birds, synchronized with his recordings of their calls and songs.

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