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Rat Predation on Bonin Petrel Eggs on Midway Atoll.—Rats (*Rattus* spp.) are native to few oceanic islands and where introduced have generally caused extensive damage to the vegetation and avifauna. Introduction of rats to Sand and Eastern Islands, Midway Atoll (28°13′N, 177°23′W), in the Leeward Islands of the Hawaiian Archipelago occurred in 1943 with the buildup of military activities (Alsatt 1945). Insular tameness due to the historical lack of predators renders many species vulnerable to predation by rats. Rats have been very successful on islands and are extremely difficult to exterminate once established. A vigorous rodent control program during and prior to 1970 (Howell 1978a,b; T. R. Howell and G. A. Bartholomew, pers. comm.) by the U.S. Navy on Midway Atoll reduced the impact of rats on birds' eggs. During our stay on Midway Atoll during the springs of 1980 and 1981 we noted high roof rat (*Rattus rattus*) populations on both Eastern and Sand Islands and intense predation on the eggs of Bonin Petrels (*Pterodroma hypoleuca*). Predation by the Polynesian rat (*R. exulans*) on eggs, young, and/or adult albatrosses, petrels, shearwaters, tropicbirds, frigatebirds, and terns on nearby Kure Atoll has already been documented (Robbins 1966, Kepler 1967, Fleet 1972, Woodward 1972).

Materials and methods.—Bonin Petrels excavate burrows .6 to 3 m long; at the end of each burrow is an enlarged chamber containing a well-lined nest. A single white egg weighing ca. 39 g is laid. To quantify egg predation we dug vertical shafts 15–20 cm in diameter to the nest chamber which was .3 to 1.3 m vertically below the surface. The shafts were covered with plywood. The two main study areas chosen on Sand Island were a colony of 654 nest burrows south of the Chapel (hereafter designated the chapel colony), and a colony of 225 nest burrows north and east of the Cannon School (hereafter designated the school colony). Egg neglect (adult not present) and orientation in the nest chamber with respect to the long axis of the tunnel were recorded. The shaft covers were lifted and the orientation was noted without disturbing the incubating bird.

Results.—In 1980, 26 eggs were monitored periodically in the chapel colony during the course of incubation. Of these, 25 were eaten by rats and one hatched. Of 21 eggs monitored periodically in the school colony, 19 hatched and 2 were broken by incubating petrels. In addition, 94 other partially eaten eggs were found scattered on the ground in the chapel colony. Some eggs were consumed by rats inside the burrows (partially eaten eggs were found in the nest chamber), thus evidence that predation had occurred was not always available on the surface of the ground. Only one egg in the chapel colony of 654 burrows is known to have hatched in 1980. In 1981, 130 partially eaten petrel eggs were found in the chapel colony. These two colonies are about 100 m apart and separated by a narrow paved road.

Rats were frequently seen in both colonies at night. Rat traps were set in the chapel colony almost every night from 31 January to 29 February 1980. We caught 16 rats inside the chapel colony (area = 2548 m^2) during 269 trap nights (number of traps set × number of nights). Traps were set inside the school colony (area = 1766 m^2) from 1–11 March 1980. We caught 7 rats during 130 trap nights. Thus the numbers of rats caught per trap night are similar in the two colonies.

Egg neglect occurs regularly in some of the smaller procellariiform birds (Boersma and Wheelwright 1979), and this would clearly facilitate predation of the eggs by rats. Ninety-one nests were checked daily for 12 days during incubation for evidence of egg neglect. Three eggs were neglected (average neglect = 3.3 days). Since eggs are rarely neglected, most eggs must be taken while the petrel is in the nest chamber. Incubating Bonin Petrels orient predominately with the tail toward the tunnel entrance (210 of 289 observations, n = 25 pairs).

Egg predation by rats on Midway Atoll was not restricted to Bonin Petrels at the chapel colony. Scores of partially eaten petrel eggs were found at many other colonies on Sand Island. A rat was photographed eating the contents of a deserted Black-footed Albatross (*Diomedea nigripes*) egg. Three albatross eggs equipped for use as silica gel-filled eggshell hygrometers (Rahn et al. 1977) were eaten by rats. Rat incisor indentations were seen in the plastic fittings and epoxy. Many White Tern (*Gygis alba*) eggs under study disappeared from their "nests." We suspect rat predation. We observed rats, at night, several meters above the ground in ironwood (*Casuarina equisetifolia*) trees in which both White Terns and Black Noddies (*Anous tenuirostris*) nest.

Discussion.—We can only speculate on how rats obtain petrel eggs while the birds are present in the nest chamber. Egg neglect rarely occurs, and thus a 180 g petrel (Fisher 1961, Grant et al. in press) must be displaced to remove the egg. Bonin Petrels defended their eggs vigorously from our hands. Their hooked beaks frequently tore our skin and caused bleeding. However, incubating petrels faced away from the tunnel entrance (the route of entry by rats) 73% of the time. We suspect that the rat would make tactile contact first with the distal tips of the primaries and rectrices, and that the startled petrel would turn around to face the rat and probably lose its egg to the rat while turning.

Chicks are generally unattended during the day and would be vulnerable to rat predation for at least several weeks. Chicks 10–15 days old offered little defense against our hands in the burrows. Three small chicks were known killed by rats.

Nest materials, eggs, and tunnels are impregnated with a strong odor (characteristic of procellariiform birds) that may attract rats. However, eggs were eaten by rats in the chapel colony but not in the school colony.

Nest density was twice as great at the chapel colony (one nest/3.9 m^2) as at the school colony (one nest/7.9 m^2). However, rat density (judging from the number of rats trapped per trap night) was the same in the two areas. We doubt if petrel nesting density *per se* significantly influenced predation in these two colonies. We suspect that successful petrel egg removal and eating is a learned behavior by some rats on Midway Atoll. This is suggested by its localized absence in the school colony and its widespread occurrence in the chapel colony and most other colonies on Sand Island. In addition, trapping of rats in the chapel colony seemed to have no impact on the rate of egg predation. We suspect that the few egg-eating rats were not visiting our traps. Rats were seen in deserted petrel burrows containing abandoned eggs in the school colony but these eggs were not eaten. Woodward (1972) suggested that a small group of Polynesian rats on Kure Atoll had learned to attack nesting albatrosses.

The impact of rat predation on Bonin Petrels on Midway Atoll is considerable. Petrels have been largely exterminated as successful breeders on Eastern Island where rat populations are denser. Rats are frequently seen foraging during the daylight hours on Eastern Island. Lawrence Pinter (pers. comm.) examined 6 freshly killed roof rats on Eastern Island on 20 March 1981. Numerous nicks and cuts around the nose and on the ears suggested intense intraspecific aggression, indicative of an extremely high rat population density. Successful nesting by Bonin Petrels on Sand Island was largely limited to the school colony in 1980 and 1981. Howell and Bartholomew (1961) considered the Bonin Petrel the most abundant nesting species on Midway. Ludwig et al. (1979) expressed alarm at the decline in numbers of nesting Bonin Petrels on Midway. They (p. 15) estimated that the 1979 population was one-third of that seen by them in 1963. The U.S. Navy maintained a vigorous rodent control program until at least 1970 (Howell 1978a,b), and an estimated 14,000 rats were killed by poisoning and trapping from January to April 1945 (Munro 1945). No young Bonin Petrels were known to have fledged on Kure Atoll between 1964 and 1968. A localized poisoning program using warfarin increased petrel hatching success there significantly (Woodward 1972). No control measures are currently being undertaken on Eastern Island and the present control measures on Sand Island are largely ineffective in reducing the rat population. Institution of a vigorous poisoning and trapping program on Midway Atoll is needed to prevent the extermination of the Bonin Petrel as a successful breeding species there.

Summary.—One Bonin Petrel colony was free of rat predation while others suffered nearly total predation. The continuous incubation, orientation of the incubating petrel with respect to the tunnel entrance, procellariiform odor, and learning are discussed in relation to rat predation. If the present rate of egg predation persists, the Bonin Petrel will soon be lost as a successful breeding species on Midway Atoll.

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On the Slit Pupil of the Black Skimmer (*Rynchops niger*).—The Black Skimmer is the only bird known to close the pupil into the form of a vertical slit. The slit pupil was first noted by Taczanowski (Proc. Zool. Soc. Lond., 1874:563) and was later discussed by Wetmore (Proc. Biol. Soc. Wash. 32:195, 1919) as follows: "The opening was reduced very little in its vertical length but narrowed greatly so that when contracted the opening was nearly as high as when expanded. When fully opened the upper and lower points of the pupillar aperture were marked by distinct angles so that even at this time the opening was not circular."