Pan American Health Organization

PAHO/ACMR 15/2
Original: English

FIFTEENTH MEETING OF THE
ADVISORY COMMITTEE ON MEDICAL RESEARCH

Brasília, D.F., Brazil
14-17 June 1976

RABIES AND MONGOOSE ECOLOGY IN GRENADA

CONTENTS

RABIES AND MONGOOSE ECOLOGY IN GRENADA*

INTRODUCTION:

This paper gives a synopsis of part of an investigation into mongoose rabies undertaken by the author in Grenada between 1968 and 1975. This work was done in co-operation with the Grenada Ministry of Health, and especially the Public Health Department.

Rabies was first suspected in Grenada in the late nineteen-forties; because of the known involvement of vampire bats in rabies epizootics in Trinidad (Hurst and Pawan, 1931 and 1932), bat rabies was suspected but neither evidence of this nor the presence of the vampire, Desmodus, could be found. The first laboratory confirmed case of rabies in a cow was reported in 1952, and in the following year a cow known to have been bitten by a mongoose (Herpestes auropunctatus) died of rabies. Tierkel et al. (1952) reported the first major outbreak of mongoose rabies in the Western Hemisphere from Puerto Rico in 1950, it was this knowledge that led to the incrimination of the mongoose on Grenada as a carrier. The appearance of rabies on Grenada in livestock was brought to the attention of the Pan American Sanitary Bureau who sent Dr. Malaga-Alba with a small team of specialists to investigate and advise on the problem. Their report, dated 16 August, 1955, found 6 cases of rabies in cattle since November 1952, no rabies in bats, and no other wildlife except the mongoose associated with the disease till then. The report recommended a control programme (Malaga-Alba, 1955). The first laboratory confirmation of rabies in a dog was in 1955, and that of rabies in a mongoose in early 1956, when an animal was killed after it had bitten a person.

The first rabies control programme, under Dr. Malaga-Alba, commenced in early 1956 and a preliminary report on this was made by the Veterinary

*Prepared by Dr. C. O. R. Everard, Medical Research Council, External Scientific Staff, Caribbean Epidemiology Centre, Port of Spain, Trinidad, West Indies.

Officer (Cocozza, 1956) in June of that year. Mongoose poisoning and dog vaccination were put into effect and it was adjudged that 10,000 mongooses had been poisoned. The accidental poisoning of dogs put this part of the programme into disrepute, causing it to be suspended (Murray, 1968). Although vaccination of dogs was undertaken on a voluntary basis the whole programme was gradually discontinued. In 1959, a bounty system was introduced with 25 cents being offered for each mongoose.

The death of 3 people from rabies in the years 1962-1963 and an increase in the number of cases of animal rabies prompted reappraisal of the situation by the Government of Grenada and PAHO which led to a second control programme in 1965. This programme followed a sequence of events similar to those of 1956 and is reported in some detail by Presnall (1965), Taylor (1965), and Presnall (1966). During 1966, 1967 and early 1968, the programme was continued, but little change was noted in the population indices of mongooses. The past, present and future status of rabies control programmes was evaluated in Grenada during February 1968 by a team of three PAHO consultants (Sikes, et al., 1968). Their major conclusions were success in controlling the disease in humans and dogs, but no substantial reduction in the number of mongooses. An enhanced programme was undertaken in 1968 and this was reviewed by Presnall (1969).

The increase in the number of people receiving antirabies prophylaxis during 1970 as a consequence of bites, and the death of a child in November of that year, prompted a further reappraisal of the rabies control programme early in the next year (Winkler, 1971). A major dog vaccination programme was conducted by the Grenada Government in 1971. Dr. S.N. Watson, Pan American Health Organization (PAHO) Veterinary Advisor, was appointed in late 1972, and he organized and implemented with the assistance of the Grenada Government and PAHO an effective mongoose poisoning campaign plus livestock and domestic animal vaccination programmes. Unfortunately, this work was terminated abruptly in early 1974 because of insurmountable logistic difficulties in Grenada at that time. Dr. Dave Dreesen took over the portfolio of PAHO Veterinary Advisor to Grenada in late 1975.

The need for an ecological study of the mongoose had long been felt, and in early 1969 proposals were put forward for such a study on Grenada. A small laboratory was built at St. George's in Grenada during that year, and

by 1970 routine examination of trapped mongooses for rabies and ecological data was being undertaken under the aegis of the Ministry of Health - Public Health Department, Grenada, and the United Kingdom Medical Research Council (MRC).

METHODS:

Rabies:

Between 1965 and March 1968 all material for rabies examination from Grenada was sent to either the Bat Control Unit, Ministry of Agriculture, Trinidad, or the Trinidad Regional Virus Laboratory (TRVL) now known as the Caribbean Epidemiology Centre (CAREC). Brain material was tested by direct fluorescent antibody (FA) microscopy, and in addition, brain or brain pooled with salivary gland was tested by mouse inoculation (MI) within 48 hours of arrival in Trinidad (Jonkers, et al., 1969). With the help of PAHO, Grenada set up its own rabies diagnostic facilities in 1968 using direct FA assay, and a technician was trained at both the Center for Disease Control (CDC) and TRVL to carry out routine diagnosis and surveillance. Under the joint Grenada Government/MRC/PAHO programme, trapped mongooses and bats; mongooses which attacked humans, domestic animals or livestock without provocation; and suspect livestock and domestic animals; were examined for rabies. The detailed procedure used in the FA test is given by Dean and Abelseth (1973) while that for the MI test is given by Koprowski (1973).

Tests for the presence of rabies serum neutralizing antibody (RSNA) from Grenadian mongooses, and the determination of titres, were undertaken initially at CDC. Details of the procedure and calculation of the LD50 end point are given by Atanasiu (1966), while information on the preparation of rabies reagents is given by Chappell et al., (1972). This test has been replaced at CDC by the much quicker and cheaper rapid fluorescent focus inhibition test (RFFIT) (Smith, Yager and Baer, 1973), which is now also performed at CAREC.

Ecology:

On Grenada, mongooses were caught alive in locally-made wooden box traps which measured 7.5 by 6 by 18 inches. Normally, 1 or 2 teams of 5 or

more trappers, each with 10 to 40 traps, were sent out 5 days a week throughout the year to catch mongooses in a variety of localities. These animals were killed at the laboratory either by ether or by the injection, in or near the spine, of 5 mg of succinyl choline chloride in 0.5 ml of water. Blood from these immobilized animals was taken by cardiac puncture prior to death and screened for haemoparasites, Leptospira antibody, and RSNA. The sex, maturity, weight and external measurements were recorded from all mongooses collected, and the fur was combed for ectoparasites. Stomach, rectum and portions of the intestine were examined for helminths, and the viscera were checked for gross signs of disease. In females, lactation, the presence and position of uterine scars, and the number and weight of embryos were noted. For males, testicular weight was recorded and fresh seminal smears from the testes and epididymis were examined for motile sperms. The brain was removed and processed for rabies diagnosis.

The population densities of mongooses at several localities on Grenada were studied by the capture-mark-release-and re-capture technique on selected grid trapping areas and estimated according to the Schumacher-Eschmeyer procedure (Davis, 1963; Seber, 1973). The range of mongoose movement within a grid was calculated by the exclusive and inclusive boundary strip methods considered by Stickel (1954). Mongooses were marked within the trap prior to release with Size 1, Monel Metal 4-1005 ear-tags (National Band & Tag Co.) numbered in sequence and clipped directly into the ear. The date, trap number, ear-tag number, sex and adult or juvenile status were recorded for both new captures and re-captures before an animal was released.

RESULTS:

Rabies:

The numbers of livestock reported rabid during the eight year period 1968 to 1975 are recorded in Table I. The observed range in the number of bovines recorded rabid per year during this period is 2 to 13, mean 6.5 SE± 3.58 x 2.37 (calculated range, 0 to 15.0), while the observed range in the numbers of all livestock recorded rabid per year in the same period is 6 to 30, mean 12.1 SE± 7.77 x 2.37 (calculated range 0 to 30.5). The incubation period of rabies in goats and sheep bitten by mongooses on Grenada has varied from 20 to 40 days. Clinical symptoms of the disease in livestock

were usually observed at least 5 days before death. One goat known to have been bitten by a rabid mongoose survived the incident and developed RSNA.

The number of dogs considered rabid by clinical assessment and/or laboratory testing during the period 1955 to 1964 was 78, while the number of rabid cats was only 3 (Everard, et al., 1972). Cases of rabies in dogs and cats between 1965 and 1975 are recorded in Table II. The total numbers of cases between 1952 (when records were first kept) and 1975 were 110 and 15 for dogs and cats, respectively. There is no significant difference in the numbers of rabid dogs recorded in each of the years between 1965 and 1975. This suggests the partial effectiveness of the dog vaccination programmes during this period despite the probable increase in the dog population. However, considering the period 1952 to 1975, the difference in the annual numbers of rabid dogs is significant ($p<0.01$). There were 6.8 rabid dogs per year between 1955 and 1967 (88/13) and 2.8 per year between 1968 and 1975 (22/8), indicating the reduction of dog rabies in recent years after vaccination. The calculated range in the number of rabid dogs during the recent period 1968 and 1975 is SE± 2.38 x 2.37 (range, 0 to 8.0). The mean number of cases of dog rabies per year between 1955 and 1975 is 5.2 (110/21).

The dog vaccination programmes are recorded in Table III. Besides these major campaigns, 1371 and 3598 dogs were vaccinated in 1967 and 1969, respectively, and approximately 200 were vaccinated privately in 1971. In 1972, 531 dogs were vaccinated. These had been too young or had missed vaccination in the previous years. During 1973, approximately 1500 farm animals, including cattle and equines, were vaccinated against rabies. In 1975, 242 sheep, 213 goats, 93 cows, 33 donkeys, 9 horses and 90 cats (= 680) were vaccinated.

The total number of rabid mongooses recorded on Grenada between 1952 and 1967 was 142 (Everard, et al., 1972). The results of tests on samples of trapped and suspect attacking mongooses sent to TRVL between 1965 and March 1968, are reported by Jonkers, et al., (1969). Briefly, 2 of 75 (2.7%), 8 of 191 (4.2%) and 12 of 262 (4.6%) trapped mongooses were diagnosed rabid in the years 1965, 1966 and 1967, respectively. Cases of mongoose rabies during the period 1968 to 1975 are shown by category in Table IV. The total number of rabid mongooses found so far on Grenada is 142 + 472 = 614. There

is a highly significant difference ($p<0.001$) between the numbers of rabid mongooses (all categories) in each year during the eight-year period 1968 to 1975. The recorded range is 40 to 107, mean 59.00 SE± 21.87 x 2.37 (calculated range 7.2 to 110.8). Of more importance is the fact that there is a highly significant difference ($p<0.001$) when comparing the ratios (positive animals to the number trapped) for each of the eight years (Table IV). This suggests a natural fluctuation of wildlife rabies occurring in the mongoose population, which is reflected in the drop from 3.7% trapped rabid mongooses in 1968 to 0.5% in 1970, and the subsequent build-up to 3.5% in 1971 with the corresponding more gradual decline to 0.5% by 1975. Mongoose rabies occurs throughout the island.

In addition to mongooses, 4 other cases of wildlife rabies have been documented from Grenada (Everard, 1975); these include: the Molossus bat which bit a woman in 1961; what must almost certainly be a spurious report of a rabid opossum, Didelphis, attacking in 1969; and two cases of bat rabies in 1974, one of which was confirmed in the laboratory from an Artibeus bat. All cases of rabies reported in Grenada between 1968 and 1975 are recorded in Table V.

Rabies serum neutralizing antibody at a titre >1:5 was found in 498 of 1675 (29.7%) mongooses tested between 1971 and 1974. The lowest and highest proportions of mongooses from selected localities with observed antibody were 9.1% (3 of 33) in northern Grenada where transmission is known to be low, and 54.5% on the central west coast. 7.1% of a sample of 127 mongooses had a titre >1:1000; the highest titre recorded was 1:5900 (Everard, et al., 1974).

The isolation of rabies virus from a frugivorous bat, Artibeus jamaicensis, in 1974 led to the investigation of 233 additional bat specimens, but none were found to be rabies positive. RSNA studies, however, showed that antibody was present in 29 of 352 (8.2%) bats involving the following six species: Anoura geoffroyi, Artibeus jamaicensis, Artibeus cinereus, Glossophaga longirostris, Molossus molossus (formerly M. major) and Sturnira lilium. The highest proportion of antibody was found in 17 of 42 (40.5%) A. jamaicensis from a single locality on the west coast of Grenada.

Only 4 humans have died of rabies on Grenada as far as is known, 3 in

the period 1962-1963 (2 of which were from dog bites and 1 from a cat bite) and 1 in 1970 from an unknown source of exposure (Everard, et al., 1972). Post-exposure antirabies treatment in humans averaged 22.8 cases per year (range 5 to 45), observed range SE± 11.48 x 2.37 = 0 to 50.0) during the period 1968-1975; no records of treatment are available prior to 1968. The contacts of the cases requiring treatment are recorded in Table VI. Bites from attacking mongooses precipitated 56.0% of all treatments. The average number of mongoose bites per year is 12.8, observed range 5 to 22 (calculated range 12.8 ±SE 5.55 x 2.37 = 0 to 25.9). Two incidents fairly typical of mongooses attacking unprovoked are as follows: 24.11.73 - Clozier, St. John's, Miss D.M., age 22, was taking clothes from the line in the yard of her farm when she suddenly felt a bite on the right side of her right foot. She was not able to kill the attacking mongoose and ran into the house for protection, from where she observed the animal frantically attacking a Tannia bush. The mongoose escaped. 26.1.74 - Maran, St. John's, at 7 p.m. a distraught 1-year old child was found inside the house with a mongoose attached to her nose. The animal was killed and the child taken to hospital where she was given first aid and antirabies treatment. The mongoose was found to be rabid on examination at the laboratory.

Ecology:

Mongooses are found throughout Grenada, from the dry scrub zones of the south-west and north-east, to the high mountain forest. Although prefering a dry habitat they are encountered at altitudes over 2000' with 160" of rainfall per annum.

Grid trapping results from six sample localities are shown in Table VII and indicate population estimates from 1.3 to 4.2 (range 1.0 to 5.1) animals per acre. 50.7% of 375 marked mongooses were recaptured on the grid areas. Mongooses may utilize an area of approximately 21 acres and travel 0.4 linear miles (2,112 feet) per day, though the average daily movement may not exceed 0.2 linear miles (1,056 feet). The maximum linear movement recorded on Grenada was 1.3 miles, though on Hawaii, Tomich (1969) records 5.0 and 4.8 miles maximum movement for a male and female respectively.

Pregnant female mongooses were found in Grenada during all months of the year but with a considerable drop in numbers in November and December.

Three distinct breeding peaks were evident in the first 10 months of the year, particularly in February/March, May/June, and August/September (Fig. I). The gestation period is seven weeks. The data suggest that there must be at least 2 litters a year, and maybe even three in some cases, depending perhaps on age, time of birth, and time of onset of the first breeding season. 1-5 embryos may be found developing at the same time. Examination of 283 pregnant females showed that 11.3%, 61.8%, 23.7%, 2.8% and 0.3% had 1, 2, 3, 4 and 5 embryos respectively developing at the same time. The average litter size was 2.19. The young are haired at birth, weigh between 22 and 36 grams, and have advanced incisors which assist with suckling. The milk dentition is complete 30 days after birth, but the eyes open between day 17-20. The full complement of permanent teeth is present 22 weeks after birth. Weaning is probably complete between 6-7 weeks after birth and the young become independent of the mother between 10 and 12 weeks of age when males and females should weigh about 300 and 250 grams, respectively. The average weight of a mature male mongoose is 660 grams, observed range 313 to 982, while that of non-pregnant females is 434 grams. The overall sex ratio obtained from trapped mongooses was 1:2.5 (female to male) or 28.8% female. However, ratios of 1:1.2 and 1:7.0 have also been obtained in some areas.

The mongoose is a diurnal omnivorous carnivore and can adapt to many different foods depending upon availability. It is probably capable of attacking and eating most small animals, and the bulk of its diet in Grenada is thought to consist of Orthopteran insects and arachnids, supplemented with amphibia, lizards, small snakes, ground-nesting birds and eggs, small rodents, molluscs and crustaceans. The results of other aspects of the ecological investigation are given in Everard (1975).

GENERAL DISCUSSION AND CONCLUSIONS:

Just over a century has elapsed since the mongoose was established in the Caribbean, and from a handful of animals originally imported to Jamaica in 1872 has grown a population which in places rivals the black rat in pest status. After some initial success at rodent control in sugarcane (the main economic cash crop of the islands until recent times), the mongoose itself came to be considered an unmitigated pest. Mongoose trapping for bounty was instigated by several Caribbean Governments, and considerable effort and

finance were expended. For example, between 1927 and 1930 £3,558 was paid for 142,324 mongooses killed on Trinidad. The decreasing importance of sugarcane on many of the islands led to the neglect of mongoose control campaigns, but with the incrimination of Herpestes auropunctatus as a vector of rabies on Puerto Rico in 1950, reassessment of its status was necessary, especially as mongoose-transmitted rabies was later found to occur on Cuba, the Dominican Republic and Grenada. Thus the present day major issues involving the mongoose are not its failure to control rodents or its sporadic nuisance value, but its status as a known and potential carrier of rabies and leptospirosis, the consequences of which are already being felt on some of the Caribbean islands.

If no attempt were made to control the mongoose on Grenada, it could be expected that a continuous threshold of wildlife rabies would be maintained, with observable fluctuations within certain limits. Using data on trapped mongooses between 1968 and 1975 (152 positive/9345 examined in eight years), the confidence limits for the mean of 1.6% per year would give a range of 0 to 5.0% (99.9% limits) of the mongoose population rabid. It is sometimes useful to provide finite numbers, though it should be remembered that these are largely conjectural. Grenada has an area of approximately 120 square miles or 76,800 acres. Trapping data indicate that 1.3 to 4.2 (mean 2.6) mongooses may be utilizing an acre of land, so that the island-wide population may approximate to nearly 200,000 mongooses and probably not fewer than 76,800 (1 per acre). Estimating further, not less than 9.1% of 76,800 (6,988 mongooses) would have RSNA, though this figure must be much higher as these are minimal values. Using the lowest annual percentage figure of 0.5% (Table IV) and 1 animal per acre, not less than 384 mongooses would be rabid in any one year. If the mean figure of 2.6 mongooses per acre were used with the mean percentage of 1.6 rabid animals, then the estimated numbers of diseased and immune animals would be considerably higher.

Viewed against the total mongoose population, the trapping of a few thousand animals per year can only be regarded as a negligible control measure. Ineffectual control campaigns succeed only in reducing populations to a level which encourages a rapid build-up to the original density. Since there is also a possibility that the presence of rabies, and conceivably that of leptospirosis, in the mongoose population achieves this effect naturally, mongoose numbers on Grenada are more likely to fluctuate than to maintain a constant level. The aim of control programmes, as yet unattained, has been

to reduce the population density to a level at which contact between rabid and susceptible mongooses is so rare that transmission of the disease becomes unlikely. This objective can be achieved only with a continuous and thorough poisoning campaign in all areas over a number of years. However, because poisoning will indiscriminately remove both immune and susceptible animals, there is a strong possibility that drastic population reduction will result in the eventual build-up of a succeeding non-immune population. Efficient poisoning may therefore be defeating its own objective in rabies control, and this is particularly pertinent on Grenada where up to 54.5% of local mongoose populations are known to have RSNA.

The eradication of the mongoose on any major Caribbean Island and the elimination of rabies on Grenada in the near future are highly unlikely eventualities. Herpestes will probably never be eradicated by the efforts of man, nor will its numbers be substantially reduced by the trapping efforts of rural communities. In Grenada, the vaccination of domestic animals and livestock, the elimination of stray dogs, the implementation of effective poisoning or wildlife vaccination programmes, and routine surveillance, are of paramount importance. The fact that rabies is now present on only a few Caribbean Islands is no guarantee that other islands will remain unaffected indefinitely. Also, the presence of rabies on Trinidad without mongoose involvement is no surety that mongoose populations on other islands will remain unaffected should the disease be introduced. Government Health Departments would be well advised to implement stringent regulations prohibiting the importation of all animals which may introduce rabies to their uninfected mongoose populations.

ACKNOWLEDGMENTS:

The studies and observations on which this paper is based were conducted with the support and under the auspices of the Medical Research Council and Overseas Development Administration, both of the United Kingdom Government, the Government of Grenada, the Governments of Trinidad and Tobago, Jamaica, Guyana and the Eastern Caribbean Territories, the United States Department of Health, Education and Welfare, and the Pan American Health Organization. The author wishes to acknowledge the considerable assistance provided by the Trinidad Regional Virus Laboratory/Caribbean Epidemiology Centre, and especially by Dr. Jack Price and Malcolm W. Race; Dr. George M. Baer of the Center for Disease Control, Lawrenceville, Georgia; Mr. P.K. Gilbert of the Public Health Department, Grenada; and the senior laboratory technicians at these establishments.

REFERENCES:

ATANASIU, P. 1966. Quantitative assay and potency test of antirabies serum, p. 167-172. In: Laboratory techniques in rabies. World Health Organization, Geneva, Monograph Series No. 23, 178pp.

CHAPPELL, W.A., BUCCA, M.A., WHILE, L.A., and GAMBLE, W.C. 1972. Rabies reagents, p. 51-56. In: Production manual of viral, rikettsial, chlamydial and mycoplasmal reagents (5th edition). U.S. Dept. of Health, Education and Welfare, Center for Disease Control, Atlanta.

COCOZZA, J. 1956. Report on the rabies problem. Unpublished Document, Ministry of Health, Grenada.

DAVIS, D.E. 1963. Estimating the numbers of game populations, p. 89-118. In: Wildlife investigational techniques (Mosby, H.S., ed), The Wildlife Society, Washington, D.C. 20016, 419pp.

DEAN, D.J., and ABELSETH, M.K. 1973. The fluorescent antibody test, p. 73-84. In: Laboratory techniques in rabies (Eds. Kaplan, M.M., and Koproswki, H.), World Health Organization, Geneva, Monograph Series No. 23, 367pp.

EVERARD, C.O.R., MURRAY, D., and GILBERT, P.K. 1972. Rabies in Grenada. Trans. R. Soc. trop. Med. Hyg., 66: 878-888.

EVERARD, C.O.R., BAER, G.M., and JAMES, A. 1974. Epidemiology of mongoose rabies in Grenada. J. Wildl. Dis., 10: 190-196.

EVERARD, C.O.R. 1975. The ecology of the mongoose, Herpestes auropunctatus, in Grenada and Trinidad, with special reference to its importance as a vector of disease. Ph.D. Thesis, University of London, 288pp.

HURST, E.W., and PAWAN, J.L. 1931. An outbreak of rabies in Trinidad. Lancet, 2: 622-628.

HURST, E.W., and PAWAN, J.L. 1932. A further account of the Trinidad outbreak of acute rabies myelitis: histology of the experimental disease. J. Path. Bact., 35: 301-321.

JONKERS, A.H., ALEXIS, F., and LOREGNARD, R. 1969. Mongoose rabies in Grenada. West Indian Med. J., 18: 167-170.

KOPROWSKI, H. 1973. The mouse inoculation test, p. 85-93. In: Laboratory techniques in rabies (Eds. Kaplan, M.M., and Koprowski, H.), World Health Organization, Geneva, Monograph Series No. 23, 367pp.

MALAGA-ALBA, A. 1955. Report and recommendations for control of rabies in Grenada. Unpublished Document, Ministry of Health, Grenada.

MURRAY, D. 1968. Rabies in Grenada; its epidemiology and control, and a discussion on some more recent advances in forms of treatment. Unpublished Thesis for Diploma in Tropical Public Health, London School of Hygiene and Tropical Medicine, London. 48pp.

PRESNALL, C.C. 1965. Control of rabies among mongooses in Grenada, W.I. Unpublished Document, PAHO, AMRO-0701, Washington, D.C.

PRESNALL, C.C. 1966. First year progress report, Grenada rabies control programme. Unpublished Document, PAHO, Washington, D.C.

PRESNALL, C.C. 1969. Rabid mongoose control, Grenada, W.I. January 6th to April 6th, 1969. Unpublished Document (cyclostyled) PAHO, Washington, D.C. 12 + 2pp.

SEBER, G.A.F. 1973. The estimation of animal abundance and related parameters. Charles Griffin, London, 506pp.

SIKES, R.K., MALAGA-ALBA, A., and PRESNALL C.C. 1968. Grenada rabies control programme. Unpublished Document, PAHO, Washington, D.C.

SMITH, J.S., YAGER, P.A., and BAER, G.M. 1973. A rapid reproducible test for determining rabies neutralizing antibody. Bull. Wld. Hlth. Org., 48: 535-541.

STICKEL, L.F. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mammal., 35: 1-15.

TAYLOR, K.D. 1965. The rat and mongoose problem in Grenada. Internal Report - Infestation Control Division, Ministry of Agric., Food and Fisheries, London.

TIERKEL, E.S., ARBONA, G., RIVERA, A., and DE JUAN, A. 1952. Mongoose rabies in Puerto Rico. Publ. Hlth. Rep., Wash., 67: 274-278.

TOMICH, P.Q. 1969. Movement patterns of the mongoose in Hawaii. J. Wildl. Mgmt., 33: 576-584.

WINKLER, W.G. 1971. Evaluation of rabies control programme in Grenada (3-18 February, 1971). Unpublished Document, PAHO, Washington, D.C.

TABLE 1. LIVESTOCK REPORTED RABID ON GRENADA BETWEEN 1968 AND 1975.

LIVESTOCK ANIMAL	TOTAL	RANGE PER YEAR	PERCENTAGE
BOVINE	52	2 - 13	53.6
SHEEP	12	0 - 4	12.4
GOAT	17	0 - 8	17.5
PIG	7	0 - 3	7.2
HORSE/DONKEY/MULE	8	0 - 5	8.2
UNKNOWN	1	-	1.0
TOTAL:	97		

TABLE 11. CLINICAL AND LABORATORY CONFIRMED CASES OF RABIES IN DOGS AND CATS BETWEEN 1965 AND 1975.

	YEAR											TOTAL
	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	
DOG	6	3	1	7	2	5	4	1	2	0	1	32
CAT	-	-	-	-	3	4	1	1	2	1	0	12
TOTAL	6	3	1	7	5	9	5	2	4	1	1	44

TABLE 111. DOG IMMUNIZATION ON GRENADA BETWEEN 1965 AND 1975.

YEAR	NO. OF DOGS VACCINATED	ESTIMATED TOTAL POPULATION
1965	8,963	11,000
1968	8,087	-
1971	11,184	16,000
1973	7,350	35,000
1975	1,001	-

TABLE IV. MONGOOSE RABIES ON GRENADA BETWEEN 1968 AND 1975.

CATEGORY	YEAR 1968	1969	1970	1971	1972	1973	1974	1975	TOTAL	MEAN
TRAPPED MONGOOSES EXAMINED	705	1019	1727	1742	1404	780	828	1140	9345	1168.1
TRAPPED MONGOOSES POSITIVE	26	11	9	61	28	6	5	6	152	19.0
PERCENTAGE POSITIVE	3.7	1.1	0.5	3.5	2.0	0.8	0.6	0.5		1.6
SUSPECT ATTACKING MONGOOSES	34	29	31	45	29	63	39	45	315	39.4
OTHER MONGOOSES	1	0	2	1	1	0	0	0	5	-
TOTAL	61	40	42	107	58	69	44	51	472	59.0

TABLE V. ALL CASES OF RABIES REPORTED ON GRENADA BETWEEN 1968 AND 1975.

ANIMAL/HUMAN	NUMBER	PERCENTAGE		MEAN PER YEAR	
HUMAN	1	0.2	(0.2)	0.1	(0.1)
MONGOOSE	472	77.8		59.0	
OPOSSUM	1	0.2	(78.3)	0.1	
BAT	2	0.3		0.3	
DOG	22	3.6	(5.6)	2.8	(4.3)
CAT	12	2.0		1.5	
BOVINE	52	8.6		6.5	
SHEEP	12	2.0		1.5	
GOAT	17	2.8	(15.8)	2.1	(12.0)
PIG	7	1.2		0.9	
HORSE/DONKEY/MULE	8	1.3		1.0	
UNKNOWN	1	0.2	(0.2)	0.1	(0.1)
TOTAL:	607	-		75.9	

TABLE VI. ANTIRABIES TREATMENT IN HUMANS ON GRENADA FROM 1968 - 1975.

CONTACTS	NUMBER	PERCENTAGE	MEAN
HUMANS	3	1.7	0.4
MONGOOSES	102	56.0	12.8
DOGS	37	20.3	4.6
CATS	14	7.7	1.8
BOVINES	10	5.5	1.3
GOAT	1	0.6	0.1
DONKEY	2	1.1	0.3
RAT	1	0.6	0.1
BAT	1	0.6	0.1
UNKNOWN	11	6.0	1.4
TOTAL/MEAN	182	-	22.8

TABLE VII. MONGOOSE POPULATION ESTIMATES ON THE GRENADA GRIDS CALCULATED BY THE SCHUMACHER-ESCHMEYER PROCEDURE.

GRID	GRID ACREAGE AND HABITAT	NUMBER OF MONGOOSES MARKED AND RELEASED	NUMBER OF RECAPTURES	POPULATION ESTIMATE	POPULATION ESTIMATE PER ACRE	POPULATION RANGE PER ACRE FROM STANDARD ERROR
MT. HARTMAN GRID A	16.5 DRY ZONE SCRUB AND WOODLAND	80	88	96.1	4.2	3.3 - 5.1
MT. HARTMAN GRID B	74.4 DRY ZONE SCRUB AND WOODLAND	84	101	97.5	1.3	1.0 - 1.6
ANNANDALE GRID C	18.6 FOREST AND COCOA	60	65	67.8	2.4	2.0 - 2.9
LES AVOCATS GRID D	18.6 FOREST RESERVE AND NATURAL FOREST	41	55	43.7	1.6	1.1 - 2.1
GRAND ETANG GRID E	18.6 RAIN FOREST AND PALM BRAKE	47	51	52.8	1.9	1.6 - 2.2
PIEDMONT/FLORIDA GRID F	12.4 COCOA, SAVANNAH AND RAIN FOREST	63	44	83.6	4.0	3.1 - 4.9

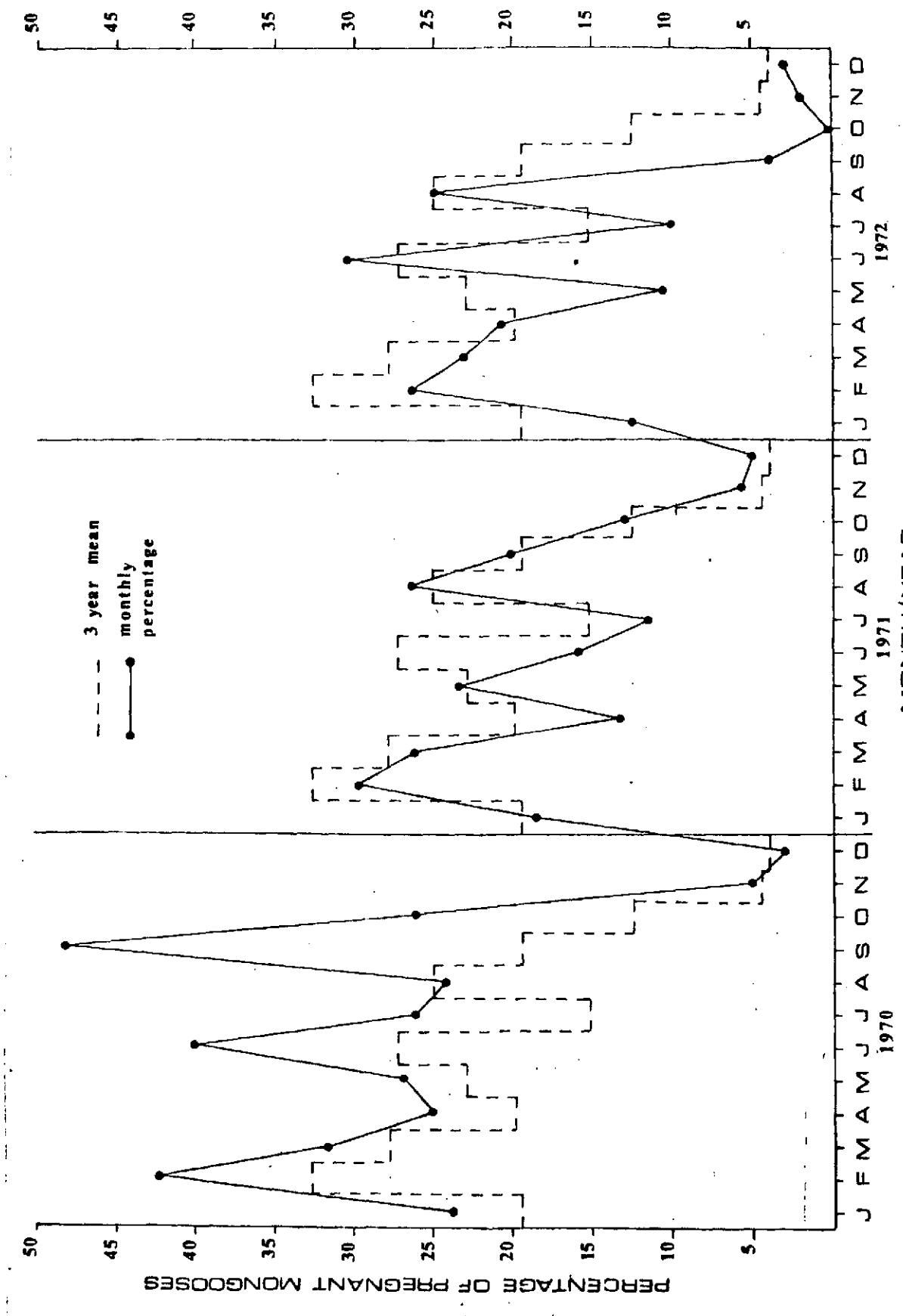

FIGURE 1. Breeding cycle of female mongooses over a three-year period in Grenada.