RODENTS OF THE PHILIPPINE CROPLANDS[1]

KYLE R. BARBEHENN, JESUS P. SUMANGIL,
and JUSTINIANO L. LIBAY[2]

Rats have caused serious crop losses in the Philippines for many years. However, the taxonomic identity of the common pest species has been a source of confusion and only limited data on the nationwide distribution of real and potential pest species have been available. To help fill this gap in our knowledge, field collections of rodents were made throughout the Philippines from January, 1969 through May, 1971, with major efforts aimed at areas of lowland rice and other agricutural situations. The major pest species are *Rattus rattus mindanensis, R. argentiventer, R. exulans,* and *R. norvegicus.* All four species have been observed to inhabit rice fields apparently as self-sustaning populations, but usually only one species predominates in any particular situation. Little is known of the competitive relationships among Philippine rats, but such interactions are presumed to be very important in determining the relative abundance and distribution of certain species. New distribution records are reported — the most noteworthy being the occurrence of *R. latidens, R.* (*Tryphomys*) *adustus R. argentiventer* and *Chrotomys whiteheadi* in the lowlands of Luzon Destruction of major forest habitats will probably hasten the extinction of some rarer rodent species and increase the area occupied by the high densities of pest species.

INTRODUCTION

For at least as long as man has attempted to cultivate crops in the Philippines, rats have competed for a share of the produce. Devastating plagues of rats have produced emergency situations in recent year (Clark, 1958; Crucillo et al. 1954) and, as the Philippines aims at self-sufficiency in food production, rodents continue to take their tithe. In designing defenses against such enemies, it is axiomatic that one must recognize their identity and habits. Although most of the losses have apparently been caused by two or three species of rats, no extensive

[1] General Contribution No. 1038.

[2] Biologists, Rodent Research Center, College, Laguna. Present Address of K. R. Barbehenn: Center for the Biology of Natural Systems, Washington University, St. Louis, Missouri, U.S.A.

survey has been conducted previously to determine just which of the many species of Philippine rodents are associated with damage to crops. In addition to this, the taxonomy of the rats in the Philippines has been a source of confusion to workers in the field. The most recent general work on Philippine mammals (Taylor, 1934) is seriously out of date. Several of the species listed have since been reduced to synonymy and others should probably be. The survey of 1946-47 as reported by Sanborn (1952) was limited to a few areas of Mindanao, Northern Luzon, and the Palawan region. Most museum collectors have concentrated their efforts in the high mountain forests, leaving the lowlands superficially worked. The present study was undertaken to help remedy the apparent deficiencies and to provide firm ground for research in rodent control methods.

The specimens (nearly 2000) providing the basis for most of this report were collected by the authors, working together and separately, most intensively from January through June, 1969. The results have largely substantiated and extended many of the earlier conclusions by Sumangil and Rosell (1966) on the kind of rats and their habitats. We have updated the taxonomy and provided voucher specimens for future reference. Our work has been aided substantially by personal communications from Drs. David H. Johnson, Joe T. Marshall, Jr., and Guy G. Musser. Throughout the text we will acknowledge their contributions by the initials DHJ, JTM and GGM, respectively.

MATERIALS AND METHODS

Collecting was done by using snap-traps, live-traps, and poison, by blanketing (herding animals by removing vegetation), excavating burrows and in a few cases by spotting animals at night with a light and catching them by hand. Special emphasis was placed on surveying lowland ricefields, at all stages of growth or disuse, and their adjoining habitats. Other habitats such as buildings and forest not adjacent to cultivated areas were trapped when time permitted. The records do not provide estimates of relative species abundance in any particular area, but are adequate for general conclusions. A series of voucher specimens was preserved from each area; most of these have been deposited at the U.S. National Museum (USNM Nos. 348528-349200) where they were compared with the collections of earlier workers. A list of the numbers of specimens caught at each locality is available from the authors on request.

Species Accounts

The following account considers the taxonomy, identification, geographical distribution, habitats, and economic importance of each species. Some preliminary comments, however, are necessary:

Taxonomy. The taxonomic status of several Philippine rodents requires a rigorous review. Several named forms are known only by the type specimen(s), and some of these will certainly be reduced to synonymy when subjected to a critical study. We have listed what seems to be the most acceptable name for each taxon, generally following either Ellerman (1949) or later authors. Those synonyms that are likely to cause confusion in the Philippines are indicated and the taxonomic problem is briefly discussed where necessary. We have introduced no formal changes in nomenclature, but have noted where these might be desirable.

Identification. Among the varied fauna of the Philippines are several species of rodents so distinctive that they can be identified with certainty by anyone having either a reasonable picture or a museum skin for comparison. Among the "typical rats" are some that can be identified rather easily by anyone with sufficient interest. A few rats, however, have long been a challenge even to experienced field and museum workers. Most of these animals belong to the *Rattus rattus* group, of which and at least six species are known from the Philippines.

We have not presented a key to the rats primarily because there are no single, reliable external characters to distinguish species. The only way to learn rat identification is to work with a large series of each species, using several characters in combination until one has a "feel" for each taxon and its range of variability from weaning to adulthood. The notes given under each species plus those given by other workers (Harrison, 1966; Medway, 1965, 1969) will be helpful. With careful work, one can soon learn to identify most of the individuals likely to be encountered in croplands and houses of the Philippines.

Distribution. Hundreds of islands in the Philippines have never been visited by collectors and even the major islands have been inadequately surveyed. Continued efforts will doubtless reveal interesting and unexpected patterns of distribution in both natural habitats and those distributed by man.

Habitats. Rodents are highly mobile; some individuals of any species make dispersal movements that may be either innate or a consequence of over-population, or both. Disturbance by man in clearing forests may some-

times precipitate long range movements. Thus individuals of any speci may be taken occasionally in any habitat.

Many of the common Philippine rodents are versatile and capable o occupying a variety of habitats. Their relative abundance in a specif location varies with time and may be influenced by other species of roden and by man's activities. Thus, we cannot predict either number or habit with precision; preconceived notions based on experience in a few are may not apply under new circumstances. We have indicated the gener patterns observed in our studies, but the relationships between habit and abundance for each species require extensive study before they ca be understood.

Economic relationships. Our initial survey were directed primaril toward lowland rice areas because of the substantial crop losses due t rodents. The variety of rodent species in the Philippines provides a poter tial reservoir of additional pests. If limiting conditions changed or i competing species were removed, species that currently pose no economi problem might become a cause for concern. We have commented, whe ever possible, on damage of any sort or degree caused by Philippine rodent We should note, also, that the ultimate destruction of most primar forests in the Philippines will probably destroy several species of rodent The extinction of these forms will by no means reduce the rat problem since the disturbed habitats will probably produce an even greater numbe of those species we know to be serious pests.

Rattus rattus mindanensis Mearns

Taxonomy. Although originally described as a distinct species, thi taxon is generally considered as a subspecies of *R. rattus* (Ellerman an Morrison-Scott, 1966). This convention seems acceptable until new evi dence proves otherwise.

Identification. Since this is the most common species of *Rattus* in th Philippines, it is a useful standard against which to compare other specie It is a medium-sized rat, with adults averaging 180 g (range:100-250g) The tail is usually longer than the head and body and is uniformly black o dark brown. Scalation of the tail is variable and is of little obvious us for identifying individuals. The hind foot of adults averages 38 mm including the claw, but the range is from 34 to 42 mm, overlapping thos in many other species of rats. Plantar pads are well developed and hav

fine lamellations which resemble fingerprints (JTM). As noted by all previous workers, the pelage color is variable, ranging from greyish brown to reddish chestnut dorsally and usually blending gradually into a paler venter which is even more variable—from creamy white to dirty grey, often with a wash of buff of variable intensity. In occasional specimens, the venter is creamy white throughout and may be sharply demarcated from the dorsal pelage. The venters of museum skins may acquire a yellowish color from incomplete cleaning of fat. Animals from higher elevations tend to have a softer pelage, a situation also noted by Dr. Godofredo Alcasid (personal communication). However, equally soft pelages can be found in the lowlands, and the situation may be further confused by the softer pelage of subadult animals. In this taxon, as in most other murids, the pelage of juveniles is much softer than that of adults and one must exercise great care in identifying such animals. The ears average 21 mm, measured from the notch, with a range of 19 to 23 mm.

R. r. mindanensis typically has two pairs of pectoral mammae and three pairs inguinally, with the anterior pair of inguinals actually being abdominal. Conventionally, the mammary formula is written 2 +3 = 10. A source of confusion, however, is that "twinning" in the posterior pair of pectoral mammae occurs occasionally. Presumably this is a developmental anomaly. Twinning is usually recognized by the asymmetry of the posterior pair and their close association with the middle pair; two and one-half pairs of pectoral mammae also occur. In species where three pairs of pectoral mammae is the typical number, the mammae are usually uniformly and symmetrically spaced.

Distribution. This endemic subspecies might be presumed to occur on virtually every island in the Philippines. There are, however, two apparent gaps in the available records. Balabac and Busuanga Islands. Sanborn (1952) reports specimens of *R. r. mindanensis* from Palawan (22), Culion (1), and Cuyo (7) Islands but, although other species are listed from Balabac and Busuanga, *R. r. mindanensis* is not. The USNM has a series of 53 rats from Balabac and 32 from Busuanga but *R. rattus* is not present in either collection. These gaps, if they are real, are curious, but they may be due to a tendency to preserve only "interesting" material. Distribution of the *R. r. mindanensis* from our collections is indicated in Figure 1.

Habitat. This species is found in a variety of habitats throughout the Philippines. Sanborn (1962) states, "It was found from the seacoast to

over 6,000 feet in Luzon and Mindanao." Sumangil and D.S. Rabor collected them at about 8,000 feet on Mt. Canlaon, Negros Oriental in 1950; and it seems unlikely that there are altitudinal restrictions on its distribution. This is a sharp contrast to the situation in Malaya (Harrison, 1966) where a near relative, *R. r. diardi,* is restricted to the immediate vicinity of human habitation.

Economic Relationships. In Luzon and in the Visayas, *R. r. mindanensis* is by far the most serious pest in lowland and upland ricefields and gardens. In parts of Mindanao, this species may be relatively rare in fields, presumably due to competition with *R. argentiventer.* In such cases, it generally damages only backyard gardens, tree crops, household effects, and stored foods. In Mindoro, a similar situation generally exists. In Palawan, *R. rattus* did not seem to be a serious pest in ricefields even though it was common locally. The Palawan *R. rattus* belongs to *R. r. diardi* (GGM).

R. rattus rattus Linnaeus

Taxonomy. This is the nominate form of the genus and species. This group of European-type house rats has been transported widely by man; the names *R. r. frugivorous* and *R. r. alexandrinus* are synonyms (Johnson, 1962). If *R. r. mindanensis* differed only at the subspecific level, we would not expect isolating mechanisms to exist between the two forms and the characters of introduced *R. r. rattus* should be swamped by the high gene frequencies of *R. r. mindanensis.*

Identification. In body form, the typical *R. r. rattus* differs from *R. r. mindanensis* in having a more conspicuous ear and a relatively longer tail. The pelage occurs in three "color phases", the genetics of which has been determined in Hawaii by Tomich and Kami (1966). The black or melanistic phase is obvious enough and is likely to be confused only with the melanistic Norway rat in the Philippines. Taylor (1934) apparently made this error (DHJ) and some workers are still confused. The agouti/white (*frugivorous*) and agouti/grey (*alexandrine*) phase can be distinguished from *R. r. mindanensis* only with difficulty and uncertainty. A large series of specimens of certain identification is a prerequisite for making comparison; identifications should be verified by major museums.

Distribution. This rat has been transported around the world by ships and may be present in any port city. USNM specimens that appear to be

typical *R. rattus* are from Manila (1913, USNM No. 200389), Sangley Point (1945, Nos. 287404-287409), and Subic Bay (1945, No. 279613), all in Luzon. Hollister (1913) reported this rat from Iloilo, Panay. Whether permanent colonies of this race occur in the Philippines is unknown, but a large collection from Manila and other port areas should prove of interest.

Habitats. Judging from its performance elsewhere (Tomich, 1969) this rat could successfully occupy a great variety of Philippine habitats if there were no competing species. A successful invasion, however, seems impossible.

Economic relationships. Ecological barriers seem to preclude the possibility that *R. r. rattus* can become a problem in agricultural areas.

Rattus tiomanicus Miller

Taxonomy. This rat was considered to be a subspecies of *R. rattus* for many years but the fact that three "subspecies" of *R. rattus* (*R. r. diardi, R. r. jalorensis,* and *R. r. argentiventer*) coexist in adjacent habitats in Malaya has led to the conclusion that each is a distinct species (DHJ; Harrison, 1966). *R. jalorensis* is inappropriate as specific name since this taxon is considered to be conspecific with *R. tiomanicus* Miller and *tiomanicus* has priority (Medway, 1965).

Identification. R. tiomanicus is somewhat smaller than *R. r. mindanensis* in all dimensions. Our series of eight adults (USNM Nos. 348629-348636) average 82 g in weight, 31 mm for the hind foot, and 18 mm for the ear; thus, they occupy the area of non-overlap between *R. r. mindanensis* and *R. exulans.* The tail is relatively shorter than that of the latter two (species). Our series has a soft, dark brown to nearly black dorsal pelage, sharply demarcated from the white (with a grey wash) belly. Sanborn (1952:120) referring to his collections, states, "These specimens agree in color with series from Kuala Lumpur" and the same is true for specimens collected by Rabor (see below). Our series, however, lies outside the range of color found in Selangor (Lim Boo-Liat, personal communication). Considering the observed variability on Palawan, it seems doubtful that they should be designated as subspecies *jalorensis.* The mammae are 2 + 3 = 10.

Distribution. The Hoogstraal expedition (Sanborn 1952) failed to take this rat on the mainland of Palawan but did secure several from Arena

Island (Aborlan Municipality) and from Busuanga. Dr. D. S. Rabor has subsequently deposited three specimens of *R. tiomanicus* from the Brooks Point area and one from Bo. Malabuson, Roxas in the USNM and our own collecting also confirms the presence of this species on Palawan proper.

Habitats. In Malaysia, this species is found primarily in tree plantations, scrub, and disturbed lowland forest. Our specimens were brought in by local farmers who claimed they were from rice fields and gardens.

Economic relationships. In Malaysia, *R. tiomanicus* is a serious pest in oil palm plantations. It seems to be of minor importance locally in the Palawan area.

Rattus argentiventer Robinson and Kloss

Taxonomy. This rat has caused particular nomenclatorial problems among field workers in the Philippines. Kellogg's (1945) description of a new subspecies (*R. r. umbriventer*) from Mindoro was made without reference to *R. argentiventer*, and the synonym was later recognized (DHJ). As indicated above, *R. argentiventer* is specifically a distinct species rather than a subspecies of *R. rattus; R. r. brevicaudata* is a synonym (Chasen, 1940) still used by some workers in Indonesia. Musser (in press) has recently reviewed the entire problem.

Identification. In the field, this rat is most likely to be confused with *R. r. mindanensis* and with *R. adustus*. Typically, the dorsal pelage of both *R. argentiventer* and *R. adustus* has a "salt-and-pepper" effect; the black guard hair mix with the lighter colored hair rather than blending with them as in a typical *R. r. mindanensis*. *R. argentiventer* tends to be yellowish, while *R. r. mindanensis* is reddish or chestnut, but the dorsal pelage alone is unreliable for identification. *R. argentiventer* usually has a tuft of orange hair at the anterior base of each ear; this is especially conspicuous in immature animals. In *R. r. mindanensis* this tuft is either absent or rendered inconspicuous by its similarity to the surrounding pelage. Ventrally, *R. argentiventer* is variable but typically has "silver" pelage. The belly color is usually broken by a band of darker hair across the chest, and a dark gular patch is common. *R. r. mindanensis* may have various amounts of white ventrally, but this is usually a soft, creamy white, not closely resembling the color in *R. argentiventer*. The tail is relatively shorter than the head and body length and the ears and feet of *R. argentiventer* average smaller than those of *R. r. mindanensis*, but there is extensive overlap in all measurements and proportions.

One of the best characters is found in the pads on the soles of the hind feet. Those of *R. argentiventer* are generally smaller and only slightly raised above the surrounding surface. The lamellae on the plantar pads are very weakly developed in contrast to those of *R. r. mindanensis* (JTM). Musser (in press) provides greater detail. These and other character differences are presumably associated with the original habitats—grassland for *R. argentiventer* and forest for *R. r. mindanensis*. Comparisons with *R. adustus* are presented below.

Mammae are 3 + 3 = 12, not 2 + 3 = 10, as reported by Kellog (1945). This mammary formula is shared by *R. norvegicus* and *R. nitidus* in the Philippines.

Distribution. *R. argentiventer* provides one of the most interesting problems of zoogeography in the Philippines. The first known specimen was rediscovered in the British Museum (Natural History) by Dr. Musser in 1970. The specimen (BMNH 95.5.7.8) was collected from Mindoro in 1894, and had remained unidentified. Specimens collected from Mindoro in 1945 provided the basis for Kellog's (1945) description of *R. r. umbriventer* and represent the first series of *R. argentiventer* we know of from the Philippines. Schwarz and Schwarz (1967) reported an early specimen from Panay (USNM No. 262263), but this specimen is not *R. argentiventer.*

The first collections of *R. argentiventer* from Mindanao (deposited at the USNM) were made by Sumangil and Rosell at Cotabato in 1955. The species is shown by our collections to be present throughout the lowlands (Fig. 1). Although the Hoogstraal expedition collected in the lowlands of Davao and Cotabato in 1946 (Hoogstraal, 1951), they did not report *R. argentiventer* (Sanborn 1952). It is quite possible that the geographic distribution in Mindanao was formerly quite restricted but that the recent development of roads, destruction of forests, and creation of almost continuous belts of kogonal (*Imperata cylindrica*) grassland have erased any possibilities for reconstructing the earlier distribution.

The history of the outbreaks of rats in Mindanao argues against a very recent introduction. Irruptions occurred almost simultaneously in Central Cotabato (1953) and Davao del Sur (1954)—about 75 miles apart and separated by mountainous terrains. It seems most unlikely that this rat could have been introduced simultaneously to both areas and, if the port of entry was at either Davao or Cotabato, a lag of several (possibly 10) years would have been expected between the irruptions. (See Elton, 1959 for

description of typical patterns of invasion.) The facts cannot be known with certainty, but one hypothesis is that small populations of *R. argentiventer* existed at several widespread localities in Mindanao prior to 1950. These isolated populations may have been introduced by man at various times or may reflect the species' dispersal via land bridges connecting the Philippines to Borneo.

On June 17, 1971, two young adult *R. argentiventer* were taken on the electric fence at the International Rice Research Institute, Laguna, Luzon. Despite examination of hundreds specimen from this area both before and since then, the species has not been collected again. It thus seems as rare as *R. latidens and Chrotomys whiteheadi* as discussed in the species accounts. This record from Luzon suggests that *R. argentiventer* may be present in other islands in numbers too low to detect by simple trapping surveys.

Habitats. Wherever *R. argentiventer* is known to occur in Southeast Asia it is essentially a grassland species, as it is in the Philippines. It is found almost exclusively in habitats that have been highly disturbed by man, such as wasteland and rice paddies. Thus Harrison and Traub (1950) considered it as an introduced species in Malaysia and Musser (in press) indicates that man has transported *R. argentiventer* to Sulawesi (Celebes) and some other areas where it now occurs. We do not know where *R. argentiventer* evolved since "natural" grasslands are not common anywhere in the region, usually except in small patches of volcanic slopes and around lakes. Possibly the situation was different at various times during the Pleistocene.

Some of our recent observations are biased by the fact that much of the collecting was done during the dry season. Populations that build up during the wet season probably disperse when the rice is harvested. We trapped several *R. argentiventer* well inside a buri palm (*Corypha elata*) grove near Mamburao. Mindoro Occidental, where there was no herbaceous ground vegetation and one in the rafters of a house set on stilts in a barrio (USNM No. 348532). These would seem to be typical habitats, and we can only speculate as to whether *R. argentiventer* could occupy them permanently in the absence of competition from other species of rats. Certainly, the versatility of the species adapting to unusual habitats was demonstrated. We also took several in a sparsely vegetated, overgrazed, sandy floodplain near San Augustine, Mindoro. Sumangil has observed that

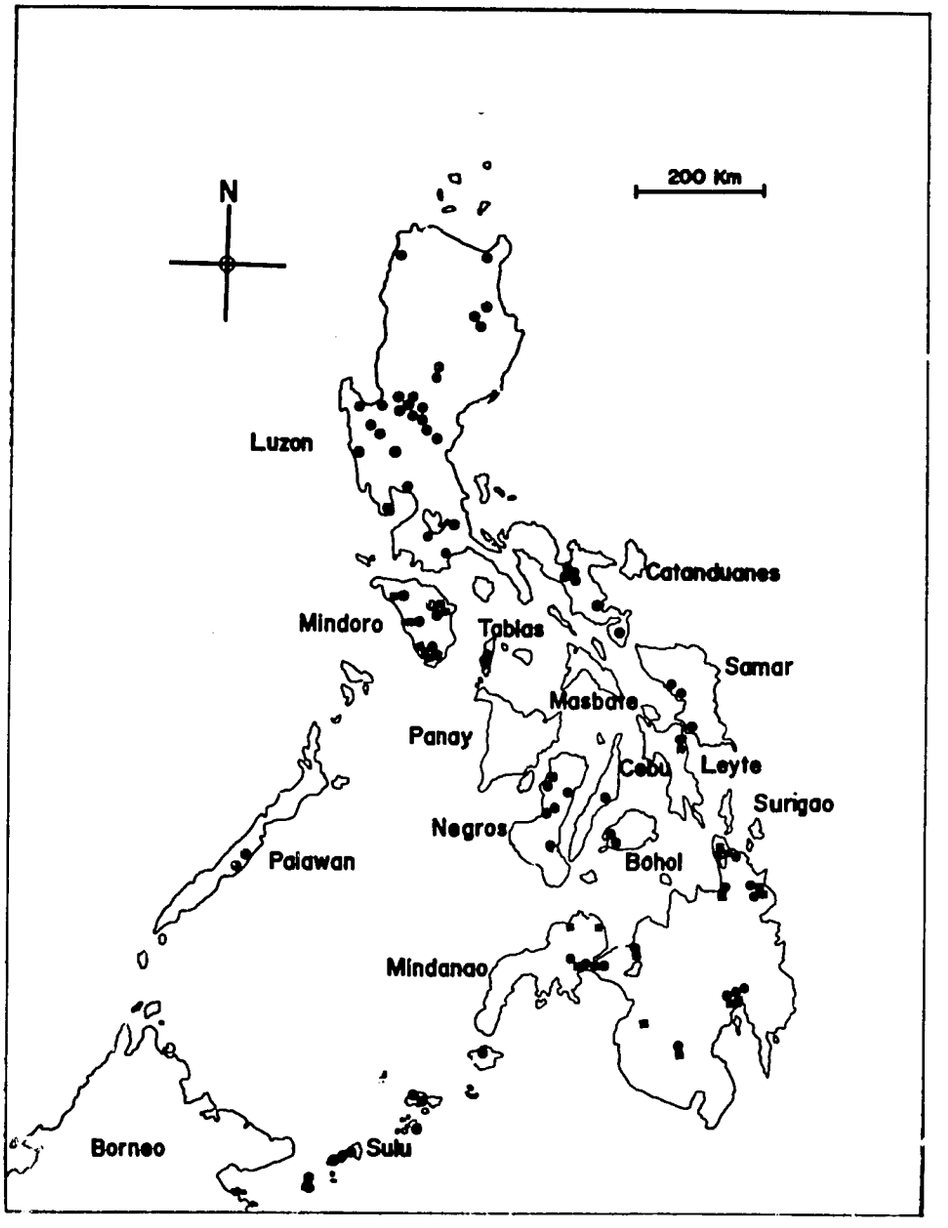

Figure 1. Distribution of *Rattus rattus mindanensis* (black circles) and *Rattus argentiventer* (black squares) in the Philippines, showing collection areas visited from February, 1969 to December, 1971.

the habitats of *R. argentiventer* and *R. r. mindanensis* show much less overlap during the wet season in Cotabato.

Since *R. argentiventer* is known to have been present in Mindoro for at least 80 years it seems probable, that many accidental introductions to Luzon and other islands have occured. The real question, then, is why the species has become well-established on only two islands. Since suitable habitats seem to be abundant, the likely explanation lies in the competitive relationships among the species. The mechanisms of competition are poorly understood and may be influenced by a variety of factors and interactions (Barbehenn, 1969[a]). Although general observations on Mindoro and Mindanao indicate that *R. r. mindanensis* is often absent from the favorite habitat of R. *argentiventer* many exceptions have been observed. For example at the Sablayan Penal Colony in Mindoro Occidental on March 1969, traps set in various habitats took 39 *R. r. mindanensis* and five *R. exulans*. Six *R. argentiventer* were taken in the same area by digging out burrows. Collections at other rural localities during the same week produced 21 *R. r. mindanensis*, 12 *R. exulans*, and 56 *R. argentiventer*. In similar collections from Sablayan, made during October, 1958, Sumangil and Menguito (1958) found 85% of the specimens were *R. r. mindanensis*, the rest being approximately half *R. exulans* and half *R. argentiventer*.

The composition of these collections spaced over ten years does not provide an adequate basis for determining the stability of the small mammal community. It suggests, however, that long term, directional change is not occurring. The area of suitable habitat for *R. argentiventer* at the Sablayan Penal Colony is relatively small and is surrounded by forested hills. We can only speculate that the abundance of habitat which favors *R. r. mindanensis* over *R. argentiventer* has somehow prevented the latter species from establishing dominance in the field areas. Competitive relationships not only influence relative abundance but also behavioral characteristics. Behavior, in turn, alters the probability of trapping some small mammal species in mixed communities (Barbehenn, 1969[b]).

It is possible that the irruptions of *R. argentiventer* in Mindoro and Mindanao were associated with the sudden creation of extensive habitat by deforestation and that this tipped the competitive balance between *R. r. mindanensis* and *R. argentiventer*. That such a situation has not developed on other islands could have been due to circumstantial relationships between the timing of the deforestation and the presence of pre-existing populations and habitats for *R. argentiventer*. Ricklefs and Cox (1972) cite several examples of bird species which were known to exist on certain

islands for many years before they suddenly became abundant and widespread. Reasons for the lag in population growth are unknown. Future observations may provide further insight into the fascinating, but complex patterns of competitive relationships and these, in turn, may lead to a better strategy for managing habitats and pest populations.

Economic relationships. Certainly *R. argentiventer* is by far the most destructive pest to grain crops before harvest in Mindoro and Mindanao. Historically, its depredations have occured in plaque-like proportions causing nearly total crop failure in many areas.

Rattus nitidus Hodgson

Taxonomy. A large series collected by the Hoogstraal expedition on Mount Data, Luzon, were considered by Sanborn (1952) to be *R. benguetensis* Hollister. D. H. Johnson identified the Hoogstraal specimens as *R. nitidus* and GGM concurs. The status of *R. benguetensis* remains uncertain. Some relatively soft-furred specimens we collected near Baguio are variations of *R. r. mindanensis.*

Identification. R. nitidus is superficially similar to *mindanensis* but the available series from Mt. Data is more uniform than any comparable number of *R. r. mindanensis.* The dorsal fur is shorter, denser, softer, and darker than in *R. r. mindanensis,* and the belly is a uniform grey. The tail is relatively short. The feet are pearly white and the plantar pads are lamellate (JTM). The mammary formula is 3 + 3 =12.

Distribution. This species in the Philippines is known to us only by those collected on Mt. Data.

Habitat. Sanborn (1952) reports the specimens as taken in rice and camote (sweet potato) fields at elevations from 5,300 to 6,500 feet. Rabor (1955) finds the species, together with *R. exulans* and *R. r. mindanensis,* the "worst enemies of the farmers" in the Mt. Data area.

Rattus norvegicus Berkenhaut

Taxonomy. Sometimes incorrectly referred to as *R. norvegicus* Erxleben. Schwarz and Schwarz (1967) consider *R. magnirostris* Mearns to be synonymous.

Identification. This is the largest of the common commensal rats; adults weigh from 200 to 500 g and the hind foot usually exceeds 40 mm. It is most readily distinguished from *R. r. mindanensis* by the relatively

small ears and the shorter, heavier tail. The undersurface of the tail is usually paler, especially at the base. The feet are usually all white and the plantar pads are relatively smooth. The belly is a uniform grey. Melanistic individuals are relatively common in the Philippines. The mammary formula is 3 + 3 = 122. The dorsal fur is longer and coarser than that of *R. nitidus*.

Distribution. This species has been reported from most of the major islands in the Philippines, especially in port areas, but it also occurs in land. Our most recent specimens have come from Tarlac, but Sumangil has seen Norways with apparent increasing frequency in the barrios of Nueva Ecija, Pampanga, Bulacan and Laguna. This is a marked contrast to the situation in Malaysia (Harrison, 1966). Norways occur in the port cities but have never been taken in Kuala Lumpur—a mere 20 miles inland. Accidental transport by humans may have aided the distribution on Luzon, but more potent barriers to invasion must exist in some tropical areas.

Habitat. This rat is primarily a commensal species, being closely associated with areas of human habitation and other buildings. Our Tarlac specimens came from a rather remote barrio of Mayantoc (Pitongbayog); three individuals were trapped in irrigated ricefields at least 100 meters from the nearest house, but a close association with human habitation seems to be the rule. There is no obvious reason why this species is not more common, especialy in irrigated areas. During our initial visit to Cebu, Norways were the only species trapped in ricefields; however, *R. r. mindanensis* was collected in abundance on a subsequent visit. Medway (1965: 123) reports Norways from rice paddies in the Kudat District, Sabah, Malaysia.

Economic relationships. This species is a pest found locally on stored foods and household effects and is a potential problem in ricefields, especially near houses. Norway rats are a major pest in the canefields of Hawaii (Hilton, 1968).

Rattus exulans Peale

Taxonomy. Most of the several "species" in the *Ephippium-concolor* group listed by Taylon (1934) are now considered subspecies of *R. exulans;* some are no longer considered distinct even at that level (Sanborn, 1952). The various subspecies are best distinguished by geographical location.

Identification. This is the smallest of the "typical" rats in the Philippines. The hind foot averages 27 mm and rarely, if ever, reaches a length of 30 mm. Plantar pads are well developed and lamellate (JTM). Coloration of the pelage is variable and not highly distinctive. The dorsum is frequently quite spiny, but this character shows great individual variation and is of little use for identification when the spines are absent. The mammary formula is 2 + 2 = 8.

Distribution. *R. exulans* may well occur on every island in the Philippines, although the records are obviously incomplete. It is probably the most successful island colonizer of any rodent species.

Habitats. Over its wide geographic range, *R. exulans* is one of the most ubiquitous of all rodent species; its local behavior and distribution seems limited only by interactions with other species. In the Philippines, there are apparently no limits to its latitudinal distribution but its local abundance is highly variable. A few *R. exulans* were collected in clearings planted with camote at an elevation of about 2,250 m (7,380 ft) near the plateau of Mt. Data but were common at lower elevations (Rabor, 1955). On Luzon and Mindoro, it is common in gardens and on the periphery of ricefields but is generally not abundant inside ricefields. On Mindanao, it seems to be rare in the lowlands, even in kogon (*Imperata cylindrica*) and talahib (*Saccharum spontaneum*) fields. While this situation may be related to competition with *R. argentiventer*, which usually dominates such habitats, it is interesting to note that these two species are common associates in the lalang (*Imperata cylindrica*) fields of Malaysia (Harrison, 1966). General impressions from various regions suggested that this little rat is not partial to areas subject to frequent flooding and standing water, such as a ricefield or marsh. It was therefore a considerable surprise to find *R. exulans* burrowing extensively in the paddy dikes at Narra, a new colony in Palawan. There the rats had been identified as "mice", but we took no *Mus*. We also found these small rats very abundant in weedy field near Puerto Princesa and in a lowland forest near Narra. Trapping in the latter area was conducted at least 600 meters from the forest edge, virtually eliminating the possibility that we were observing an "overflow" from the harvested ricefields. By checking traps in the evening and again in the morning, we averaged nearly one rat per trap set—53 *R. exulans* and one *R. panglima*. This was an exceptionally high catch for a humid tropical forest. Rats in lowland rice are not considered to be a serious, chronic problem in Palawan, so it is possible that periods of damage are associated with short-lived irruptions. Sanborn (1952) however, reported

the composition of the rats examined in Palawan as over 70% *R. exulans* suggesting that these species might be typically abundant, invading ricefields only in exceptional years. F.N. Swink (personal communication) also found *R. exulans* to be the predominant species in the ricefields of Palawan. A Bureau of Plant Industry museum collection of rats obtained from Palawan ricefields in 1955 were all *R. exulans*.

Economic relationships. As suggested above, this rat is generally of minor importance, but has the capacity to become a major pest. Rabor (1955) finds *R. exulans,* together with *R. r. mindanensis* and *R. nitidus* the principal species destroying rice before harvest in Mt. Data.

Rattus everetti Gunther

Taxonomy. Sanborn (1952) has placed *R. tagulavensis* Mearns and *R. albigularis* Mearns in the synonymy of *R. everetti* Gunther.

Identification. This is a large-sized (250-350 g) shaggy, grey rat with conspicuous ears (24-25 mm), a long tail, and large feet (about 46 mm). The distal third of the tail is usually much paler or whitish. This is shared with the "Bullimus" group of rats, but all of those are larger (hind foot over 50 mm) and with relatively shorter tails. The mammary formula is 2 + 2 =8.

Distribution. This species is generally known from Luzon and Mindanao but JTM has collected it on Lubang Island. *R. gala* of Mindoro is probably conspecific.

Habitat. R. everetti is generally considered to be a montane forest species, but several records are at variance with this generalization. We took one in shrubby, abandoned cropland at La Trinidad, Benguet; Libay trapped 20 in grassy embankment along a shallow stream at Clark AFB, Pampanga; and Sumangil has taken in the edges of forest clearings, three in a house, and one in a laboratory of the Bureau of Plant Industry at Buluan, Cotabato. Sanborn (1952) also reports *R. everetti* from lowlands of Mindanao. The Hoogstraal collections from Mt. Data include *R. everetti* trapped in "clearings close to densely vegetated gullies" at about 6,000 to 7,000 feet (Rabor, 1955).

Economic relationships. There is no evidence that this species is more than an occasional, minor problem, usually in patches of cultivation adjacent to montane forest.

Rattus latidens Sanborn

Taxonomy. This species was described from a single specimen from Mt. Data, Mountain Province, Luzon.

Identification. Superficially, *R. latidens* is similar to *R. r. mindanensis*, but is larger, with a hind foot of about 45 mm. The most prominent diagnostic character is the width of the incisors, which measure 5.3 mm at the tip in the type specimen. In a second specimen (collected by Dr. Lowell D. Uhler, USNM No. 357244), the width of the incisors is only 4.5 mm, but this is still conspicuously broader than that of any other rat from the Philippines. The second specimen has what appears to be an exceptionally well-developed mid-ventral gland — so conspicuous that the collectors assumed it to be the scar from a surgical incision! This character was not mentioned by Sanborn, perhaps because the type specimen was a female while the second is an adult male. Rabor (1955) however describes what appears to be similar observations of "well-pronounced naked and calloused area" whose size and thickness on the mid-abdominal region is related to the age of the animal and is often found among fully matured males in *Rattus* (*Bullimus*) *luzonicus*. The mammary formula in unknown.

Distribution. Known only from Mt. Data and Los Baños, Laguna. Luzon.

Habitats. The type was taken at an altitude of 7,500 feet in a "patch of heavily wooded area". The second specimen was collected from the electric fence at the International Rice Research Institute—an area of intensive rice cultivation at an elevation no higher than 200 feet! This rare species apparently may be found anywhere in Luzon.

Economic relationships. R. latidens is a species of considerable interest to taxonomist but not likely to present problems for agriculture.

Rattus adustus Miller

Taxonomy. Miller's genus, *Tryphomys* is now considered under the synonymy of *Rattus* (Ellerman, 1941; Sanborn, 1952). Our recent observations of the palatal mucosa and of the plantar pads suggest that this taxon merits subgeneric status.

Identification. Superficially, these rats most closely resemble *R. argentiventer,* since they have the "salt-and-pepper" dorsal pelage, short ears, short tail and small feet. They are most easily identified by the small,

weakly developed plantar pads which number the typical six, rather than the five indicated by Taylor (1934). The pads on the forefeet are highly reduced. The molars are noticeably broader than those of the commensal group, and the ridges of the palatal mucosa are unique among Philippine rodents that have been examined. The mammary formula is 2 + 3= 10.

Distribution. *R. adustus* was previously known only from Mt. Data. Dr. Lowell Uhler trapped one at the base of Mt. Makiling, Laguna, Luzon and Libay collected another specimen at Mud Springs on Mt. Makiling. We also have added two localities in the Province of Tarlac, Luzon.

Habitats. *R. adustus* is presumed to be a montane forest species. Specimens collected by F.N. Swink and Sumangil (USNM Nos. 348530, 349043-5) plus one by Barbehenn and Libay (USNM No. 348531), have been taken in areas where lowland rice paddies predominated.

Economic relationships. *R. adustus* is currently of minor importance to agriculture but may have the potential to expand if released from pressure of competition with other species.

Rattus muelleri Jentink

Taxonomy. Sanborn (1952) erected two new taxa—*R. culionensis* from two specimens on Culion Island and *R. muelleri balabagensis* from one specimen on Mt. Balabag, Palawan. The USNM series of 31 *muelleri* from the Palawan area confirms Sanborn's opinion that these rats are lighter in coloration than those from Borneo and Malaysia. One specimen from Culion and three from Busuanga Island seem to blend into the remaining specimens. Whether *R. culionensis* merits specific recognition remains to be determined.

Identification. This large, shaggy rat is most likely to be confused with *R. norvegicus* and *R. everetti.* It differs from the first in having a tail generally longer than head and body from both in having the tail uniformly dark. The belly is near-white in contrast to the darker grey of the Norway. The mammary formula is 2 + 2 = 8.

Distribution. Specimens in the USNM are from Palawan, Balabac, Busuanga and Culion Islands.

Habitats. This is a rat of the lowland forest in Malaysia and is partial to swamps and stream banks (Harrison, 1966). The limits of its local distribution in the Philippines are unknown.

Economic relationships. We did not capture this species in croplands in Palawan. In Sabah, however, Lim Boo Liat (personal communication)

has found *R. muelleri* to be common in cacao plantations; it has been taken in ricefields as well.

Rattus panglima Robinson

Taxonomy. *Rattus palawanensis* Taylor is a synonym. Chasen and Kloss (1932) identify rats from the islands of North Borneo as *R. surifer panglima.* Medway (1955:128), utilizing pelage characters, considered the type of *R. panglima* Robinson as a subspecies of *R. rajah,* in agreement with Ellerman (1949:74). We believe that *R. panglima* Robinson should be retained as a distinct species until the complex situation is clarified by further study

Identification. This is a medium-sized grey rat with conspicuous ears. The dorsal pelage consists large of stiff spines. The belly is white and the tail is sharply bicolored throughout its length. It is not likely to be confused with any other rat in the Philippines. The mammary formula is 2 + 2 = 8.

Distribution. Specimens in the USNM come from Palawan, Balabac, and Busuanga Islands. It is also recorded from Culion (Sanborn, 1952).

Habitat. This is primarily a lowland forest rat but we took one specimen in a hillside garden where the vegetation was a sparse mixture of shrubs, grass and bananas.

Economic relationships. The species is not known to be a pest anywhere but may be expected occasionally in gardens of the Palawan region.

Mus musculus castaneus Waterhouse

Taxonomy. In recent revision, Marshall (in press) confirms the opinions of Taylor (1934) and Schwarz and Schwarz (1934) in recognizing that the Asian ochraceous-bellied-house mouse, *M. musculus castaneus,* is not *M. m. musculus* introduced from Europe. Marshall identifies all Philippine specimens available to him (not including ours, but including the holotype of *commissarius*) as belonging to this taxon.

Identification. This tiny (12 g) mouse is unlikely to be mistaken for any of the commensal rodents in the Philippines, except for juvenile *R. exulans.* The hind foot rarely exceeds 17 mm, and this measurement scarely overlaps with that of recently weaned *R. exulans.* Our small collection contained two with a mutant (JTM) coloration: darker and with

the tail coloration broken by a light band near the distal third. The mammary formula is 3 + 3 = 10.

Distribution. *Mus* probably occurs on most major islands but the records are incomplete. Sanborn (1952) did not record this species.

Habitat. Apparently closely associated with houses and other buildings. Sumangil has never seen mice in hundreds of field-blanketing operations. However, house mice are common residents of old fields in Guam quite remote from areas of human activity. Our mutants were taken at Tagum, Davao del Norte, in a woodpile beneath a house located in croplands. Presumably, the mice disperses through a variety of habitats, but are essentially unknown in forest areas.

Economic relationships. *Mus,* in the Philippines, is primarily a household pest, but may attack stored grains.

Chrotomys whiteheadi Thomas

Taxonomy. In addition to the nominate form, Kellog (1945) described the subspecies *mindorensis* from a single specimen taken in Mindoro.

Distribution. To the previously known provinces of Mountain, Benguet and Mindoro Occidental, we can now add Nueva Ecija, Tarlac, Pampanga and Laguna, all in Luzon. Taylor (1934) questioned an earlier report of *Chrotomys* from the forests of Tarlac, but our observations make the early record credible. Certainly the species can be found in the Bicol region.

Identification. This striped rat with a very short tail and protagnathous incisors cannot be mistaken for any other known Philippine rodent.

Habitat. Again we have a rodent that has long been considered as a montane forest species, although Sanborn (1952) reports them from camote fields above an elevation of 7,000 feet. The USNM has one specimen taken by Libay at Clark Air Force Base, Pampanga with habitat recorded as "bananas, grass, and tall tree areas close to swamp" and three specimens collected by Dr. Lowell Uhler from the electric fence at IRRI. Recently, Libay secured a specimen from ricefields in Nueva Ecija, F. N. Swink and associates took seven from ricefield irrigation ditches in San Miguel, Tarlac, and Sumangil took eleven at the edge and inside canefields at the same locality. Kellog's type specimens came from "foot hill grassland" at an estimated elevation of 200 feet, 3 miles SSE of San Jose (Central), Mindoro Occidental. We saw a mounted specimen at San Jose and another was reported; one came from the edge of town and one from nearby fields. Thus,

it seems likely that *Chrotomys* is a regular, but generally uncommon, resident of lowland areas.

Economic relationships. *Chrotomys* may possibly be a minor economic pest locally. In cage tests at Hda. Luisita, Tarlac, *Chrotomys* did not eat sugar cane. Rabor (1955) notes that all specimens collected in Data contained remains of earthworms.

Taxonomy. The Philippines is well known for its large and fascinating assemblage of indigenous murid rodents. Among those not previously discussed are two taxa that are considered by Ellerman (1949) to be in the genus *Rattus* but were formerly known as *Apomys* and *Bullimus*. Several other named species of *Rattus* are poorly known. The other genera of murids known from the Philippines include *Chiropodomys* (*Insulaemus* of Tailor), *Carpomys, Batomys, Phloeomys, Crateromys, Celaenomys, Rhynchomys, Crunomys, Mindanaomys, Limmomys,* and *Tarsomys.*

Identification. It is beyond the scope of this work to provide descriptions of the species of little or no known importance to agriculture. Virtually all of these rodents are so different from those described above that they should easily be recognized as such. Unusual rodents that are collected or found dead should be preserved by exposing the viscera and soaking the entire carcass in either 10% formalin solution or in 70% alcohol. Specimens, labeled with locality, date, collector, and any other notes should be sent to museums for identification.

Distribution. Except for *Chiropodomys,* which is a genus from the Bornean fauna and, in the Philippines, is found only in the Palawan region, these endemic genera are known primarily from Mindanao and Luzon.

Habitat. These rodents are known primarily as residents of montane forest. Sanborn (1952) described a new species of *Apomys* from the lowlands of Cotabato and JTM notes that *Apomys* has been taken at Clark AFB, Pampanga.

Economic relationships. The larger forms, as *Pholeomys,* have been used for food and fur, but the vast majority are known only for their importance to students of evolution, ecology, and zoogeography. As such, they and their vital habitat are worth preserving for posterity. Sanborn (1952) records that *R.* (*Bullimus*) *luzonicus* was collected in a camote field and *R.* (*Bullimus*) *bagobus* in an abaca plantation, a coffee plantation, and a vegetable patch. The relative number of such records, however, is indeed low in comparison with that of the commensal *Rattus* forms. The potential for economic damage by any of the above can be considered virtually non-existent.

DISCUSSION

In the preceding accounts, all taxa from *R. rattus mindanensis* through *R. exulans* are closely related and share several morphological characteristics which distinguish them from other members of the genus *Rattus* (Ellerman, 1949). It seems more than a coincidence that the major pest species are included in this group and su[illegible] commensalism suggests that man's modification of habitats through time may have been a factor in the evolution of the "*R. rattus*" group. However, the occurence of non-commensal rodents in agricultural lands can cause only very minor economic loss. It is man's modification of habita[illegible] which can have very adverse effects on the non-commensal rats. Taking a long look into the future, it seems worthwhile to consider the potential benefits of the non-commensal rodents.

Our immediate concern is either to prevent or reduce economic damage by rats but our ultimate concern must be to manage the landscape and its biota in ways which permit mankind to survive with dignity. The solution to the broader problem is not simple and it is beyond our present level of understanding to create an optimal design (see Elton, 1958). It may be anticipated, however, that one aspect of the design will include various patterns of land management that minimize the need for pesticides. There is no forseeable way to exterminate commensal rats except locally and temporarily, but it should be possible to promote relatively stable, low density populations which can be controlled directly when they do exceed the threshold of economic damage. Providing location-specific directions which satisfy current needs for expanding food production cannot be done confidently without extensive, long-term experimentation. Our data base is inadequate. We can, however, forsee the probability that a sound strategy for managing the landscape will take advantage of competitive interactions among the various rodent species. Available existing quantitative evidence (Barbehenn, 1969[a]) suggests that the total density of rats in non-agricultural land is inversely related to the number of species present. Agricultural operations greatly simplify the biota and reduce the diversity and stability of rodent populations. Converting forests into wastelands produces similar results—the degraded ecosystem ends to become the exclusive domain of commensal rats. The many species of non-commensal rodents constitute a valuable biotic resource which can help minimize future pest situations when we learn how to live compatibly with the rest of the ecosystem.

Many of the endemic Philippine rodents are now rare and additional non-commensal forms are likely to become rare as the forests are cut. It is encouraging to note that at least some of the little known species (*R.*

latidens, R. adustus, Chrotomys) seem to be able to survive at lower elevations and in disturbed habitats. We are uncertain of the long-term stability of such populations. It may be that the extinction rate of lowland colonies is high and that their presence in such situations depend on constant replenishment from forest areas. The only way to assure the perpetuation of most of our native rodents (and many other forms of life unique to the Philippines) is to maintain several large areas of forest in an undistributed state. Large areas are likely to be more effective than are many small islands of forest on isolated mountain tops because the rate of extinction on isolated "islands" is predictably high (MacArthur and Wilson, 1967).

To conclude, no more than four of the many species of rodents in the Philippines can be considered as major pests of agriculture. Minor damage may be done locally by a few additional species, but the vast majority of non-commensal rodents are economically neutral and may even be beneficial by suppressing pest species through various forms of competition. The opportunity to preserve a resource that can help to promote stability in the human ecosystem is still available. Should habitat destruction proceed to the point of extinction for any species, the opportunity will be lost forever.

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LITERATURE CITED

BARBEHENN, K.R. 1969[a]. Host-parasite relationships and species diversity in mammals: an hypothesis. Biotropica 1:29-35.

———————. 1969[b]. Response of rodents and shrews to patterns of removal trapping. p. 247-252. In Indian rodent symposium. December 8-11, 1966. Calcutta, India.

CLARK, R.J. 1958. Report to the Government of the Philippines on the control of field rats in Mindanao. FAO Report No. 785, Rome. 22 p.

CHASEN, F.N. 1940. A handlist of Malaysian Mammals. Bull. Raffles Mus. 15:1-209.

———————, and C.B. KLOSS. 1932. Mammals of the lowlands and islands of North Borneo. Bull. Raffles Mus. 6:1-82. (1931).

CRUCILLO, C.V., F.Q. OTANES, and J.L. MORALES. 1954. What we're doing to control field rats in Cotabato, Philippines. Pest Control. 22(10):9-10, 12, 16, 74, 76; (11):10, 12, 14, 16.

ELLERMAN, J.R. 1941. The families and genera of living rodents. Vol. 2, Family Muridae. British Museum (Natural History), London, 690 p.

———————. 1949. Families and genera of living rodents. Vol. 3 Part I. British Museum (Natural History), London, 210 p.

———————, and T.C.S. Morrison-Scott. 1955. Supplement to Chasen (1940). A handlist of Malaysian mammals. British Mus. (Nat. Hist.), London. 66 p.

———————. 1966. Checklist of Paleartic and Indian mammals, 1758 to 1946. 2nd Ed. British Mus. (Nat. Hist.), London, 810 p.

ELTON, C. 1959. The ecology of invasions by animals and plants. John Willey & Sons. New York, 181 p.

HARRISON, J.L. 1962. Ecology of the forms of *Rattus rattus* in the Malay Peninsula. Proc. 9th. Pacific Sci. Congr. 19:19-24.

———————. 1966. An introduction to the mammals of Singapore and Malaya. Malayan Nature Soc., Singapore. 340 p.

———————, and R. TRAUB. 1950. Rodents and insectivores from Selangor, Malaya. Jour. Mam. 31:337-346.

HILTON, H.W. 1968. The rat problem in Hawaiian sugarcane. Proc. Asia-Pacific Interchange (East-West Center, Honolulu). p. 34-36.

HOLLISTER, N. 1913. A review of the Philippine land mammals in the U.S. National Museum. Proc. U.S. Nat. Mus. 46:299-341.

HOOGSTRAAL, H 1951. Philippine zoological expedition, 1946-1947; Narrative and itinerary. Fieldiana (Zoology) 33:1-86.

JOHNSON, D.H. 1962. Rodents and other Micronesian mammals collected. p. 21-38. *In* T.I. Storer (ed.) Pacific Island rat ecology Bernice P. Bishop Mus. Bull. 225. Honolulu.

KELLOGG, R. 1945. Two new Philippine rodents. Proc. Biol. Soc. Washington 58:121-124.

MACARTHUR, R.H., and E.O. WILSON. 1967. The theory of island biogeography. Princeton Univ. Press, Princeton, N.J. 203 p.

MARSHALL, J.T., JR. (In press). Preliminary key to Eurasian species of Mus. Amer. Mus. Novitates.

MEDWAY, LORD. 1965. Mammals of Borneo: field keys and annotated checklist. Jour. Malaysian Br. of the Royale Asiatic Soc. 36(3):1-193 (1963).

MEDWAY, LORD. 1969. The wild mammals of Malaya and offshore islands including Singapore. Oxford Univ. Press, London, 127 p.

MUSSER, G.G. (In press). Taxonomic association of *Rattus argentiventer* with *R. pesticulus* (Rodentia, Muridae) and the occurence of *R. argentiventer* on Celebes (Sulawesi) and New Guinea. Results of the Archbold Expeditions No. 98. Amer. Mus. Novitates.

RABOR, D. S. 1955. Notes on mammals and birds of the central northern Luzon highlands, Philippines. Part I: Notes on Mammals. The Silliman Jour. 2(3):193-218.

RICKLEFS, R.E., and G.W. COX. 1972. Taxon cycles and the West Indian avifauna. Amer. Natur. 106:195-219.

SANBORN, C.C. 1952. Philippine zoological expedition, 1946-1947; Mammals. Fieldiana (Zoology) 33:87-158.

SCHWARZ, E., and H.K. SCHWARZ. 1943. The wild and commensal stocks of the house mouse, Mus musculus Linnaeus. Jour. Mamm. 24:59-72.

————. 1967. A monograph of the *Rattus rattus* group. An Esc. Nac. Cienc. Biol. Mexico 14:79-178.

SUMANGIL, J.P., and M. MENGUITO. 1958. A survey and analysis of the Sablayan rat infestation with particular emphasis on the Sablayan Penal Colony problem. Unpub. report to the Director, Bur. of Plant Industry, Manila, 13 p.

————————, and N.C. ROSELL. Notes on the studies of Philippine species of field rats. Phil. Geogr. Jour. 10:11-17.

TAYLOR, E.H. 1934. Philippine land mammals. Bur. Sci. Monogr. (Manila) 30:1-548.

TOMICH, P.Q. 1969. Mammals in Hawaii; a synopsis and notational Bibliography, Bishop Mus. Press, Honolulu. 238 p.

————————, and H.T. KAMI. 1966. Coat color inheritance of the roof rat in Hawaii. Jour. Mamm. 47:423-431.

TOWNES, H., and J. MORALES. 1953. Control of field rats in the Philippines with special reference to Cotabato. Plant Industry Digest 16 (12):3-12.