Elias, D. J., and M. W. Fall. 1988. The rodent problem in Latin America. Pages 13-28 in I. Prakash, ed. Rodent Pest Management. CRC Press, Boca Raton, Fla.

REF 1988-026

Chapter 2

THE RODENT PROBLEM IN LATIN AMERICA

Donald J. Elias and Michael W. Fall

TABLE OF CONTENTS

I. Introduction 14

II. The Neotropical Region 14

III. Rodents as Pests in Latin America 16
- A. Disease 16
- B. Postharvest Food Loss 18
- C. Agriculture 19
  - 1. Sugar Cane 19
  - 2. Cereal Crops 19
  - 3. Oil Crops 21
  - 4. Horticultural Crops 21
  - 5. Forest, Forage, Fiber, and Other Crops 22

IV. Discussion 23

References 24

I. INTRODUCTION

The collective term "Latin America" generally refers to those countries of North and South America (including the Caribbean Islands) that speak a language derived from Latin. The most frequent usage is restricted to Spanish- or Portuguese-speaking countries, but French-speaking French Guiana, the French West Indies, and Haiti may also be included. Though it would seem improbable, a natural zoogeographic region encompasses essentially the same area.[101] The Neotropical Region is South and Central America and the lowlands of Mexico. Some authors include the West Indies, Galapagos, and Falklands, even though the fauna of these island groups is not representative of a major continental pattern.[26,29,55,65] For purposes of this discussion, we exclude the island groups; references to that part of Mexico which pertains to the Nearctic zoogeographic region have been included.

This report summarizes a review of ecological, zoological, agricultural, and other literature relevant to rodents as pests in Latin America. Searches were conducted in the following computerized data bases: (1) AGRICOLA (U.S. Department of Agriculture), 1970-Nov. 1984; (2) BIOSIS (Biosciences Information Services), 1977-Feb. 1985; and (3) Wildlife Review (U.S. Fish and Wildlife Service), 1974-Oct. 1985. The Food and Agriculture Organization/World Health Organization (FAO/WHO) bibliographies on rodent pest biology and control for the periods 1950-59, 1960-69, and 1970-74,[40,41,115] and Kaukeinen's bibliography[64] on vertebrate pest biology and control for 1984 were searched manually. Other sources searched include Recent Literature in Mammalogy (American Society of Mammalogists), and conference proceedings that included the Vertebrate Pest Control Conferences, 1 through 11, the Noveno Congreso Latinoamericano de Zoologia: Zoologia Economica y Vertebrados como Plagas de la Agricultura,[34] and the Conference on the Organization and Practice of Vertebrate Pest Control.[30] Numerous books, some unpublished materials, information provided by colleagues, and personal experience have contributed to our discussion. Scientific nomenclature and taxonomic classification follow *Mammal Species of the World.*[57]

Much material addressing rodent pest problems in Latin America was, undoubtedly, missed; other information was unavailable to us and, in many cases, the available work has been insufficient for us to do any more than note the occurrence of rodent problems. Thus, we do not contend that this review is a comprehensive treatment of the subject; on the contrary, we submit that it is an initial look at a complex problem that merits more intense scrutiny.

II. THE NEOTROPICAL REGION

This zoogeographical area is, without a doubt, the most varied and diverse.[29,65] Many salient features contribute to the ecological diversity of the region. The South American continent is 7200 km long and 4800 km at its greatest width, comprising a land area of some 18 million km.^{2} It is the only continental mass that extends so far toward the Antarctic. It is connected to North America by the narrow bridge of Central America, extending 2900 km from the Darien lowlands northwest to the Isthmus of Tehuantepec (Figure 1).[97] Of the six major faunal regions, the Neotropical Region is one of two classified as barrier-limited.[26] After Australia, South America is the most isolated continent.[29,102] Two-thirds of it is vast plains rising no more than 300 m above sea level; this feature is contrasted with a colossal mountain range unrivaled in length and exceeded in height only by the Himalayas of Asia. Numerous rivers drain the land, including the Amazon — world's largest in terms of volume and area of its watershed.

The region's environmental diversity results from climatic extremes. The area of highest rainfall in the Western Hemisphere, the world's driest desert, hot humid regions, mild areas

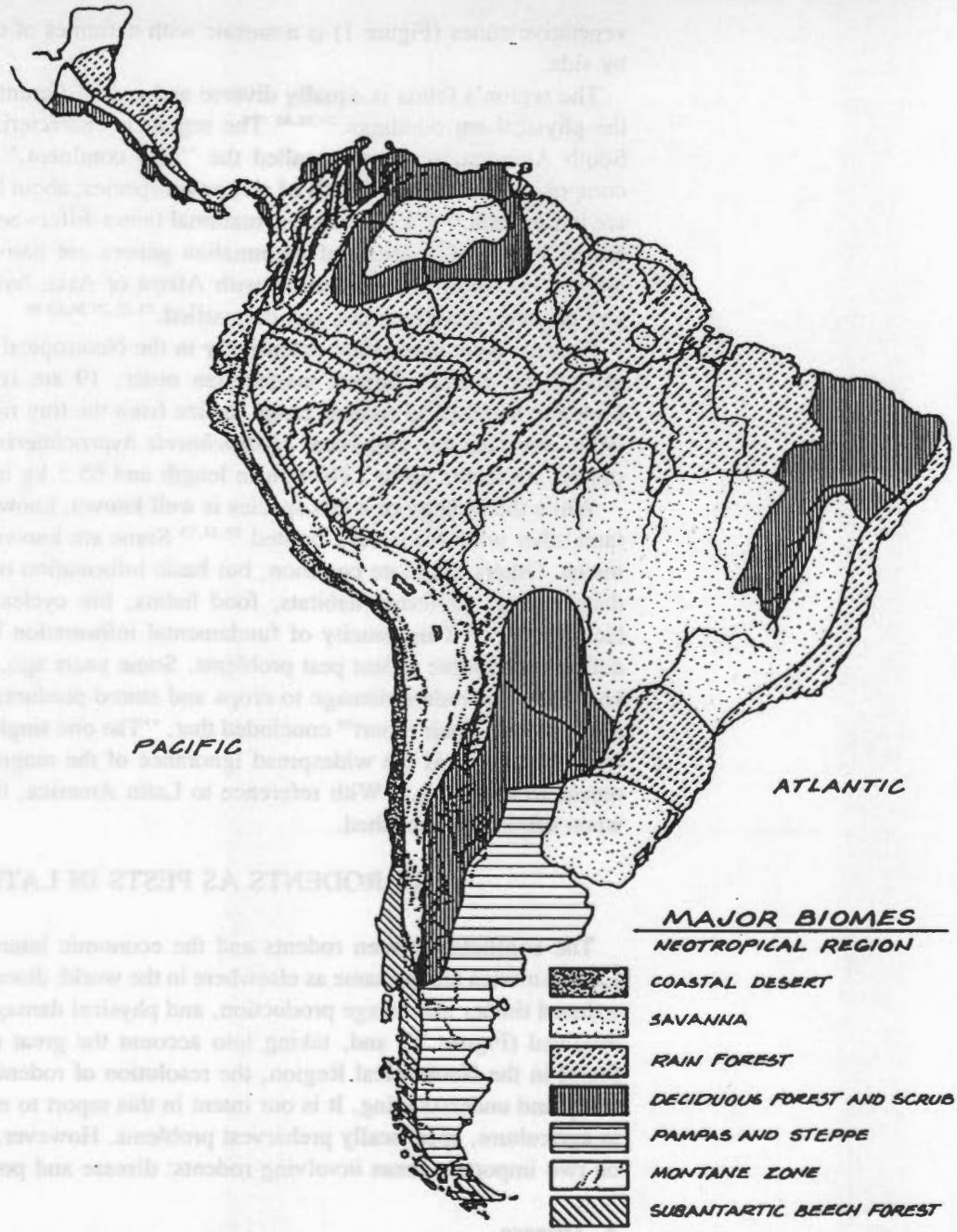

FIGURE 1. Distribution of the major floristic provinces of the Neotropical Region, illustrating the pronounced habitat diversity within the area. The associated fauna, including the rodents, is equally diverse. The multitude of ecological conditions, the variety of rodent species, and a lack of fundamental knowledge about their interactions with man has retarded progress in defining and resolving rodent pest problems. (Adapted from Dorst, J., *South America and Central America, A Natural History*, Random House, New York, 1967.)

with mediterranean climates, and vast cold regions are among the climatic variations found in the neotropics. The variety of the physical environment is reflected by the vegetation. Humid areas are covered by rain forests, that of the Amazon Basin being the most extensive forest on earth. Other vegetative types include treeless grasslands, deciduous tropical forests and scrublands, luxuriant temperate forests, the high, dry, bleak *puna* of the central Andes, and high, humid *paramos* of the northern Andes. Thus, the map of the region's major

vegetative zones (Figure 1) is a mosaic with extremes of climate and vegetation found side by side.

The region's fauna is equally diverse and is as different from other areas of the world as the physical surroundings.[29,55,65] The region is characterized by many indigenous groups. South America, sometimes called the "bird continent," has the richest of all avifaunas comprising at least one-fourth of all known species; about half of the 67 families represented are indigenous.[26,29] Likewise, the mammal fauna differs notably from other zoogeographical areas; 89.5% of neotropical mammalian genera are native.[55] There are few ungulates or hooved mammals in comparison with Africa or Asia; however, other groups like the bats and primates are numerous and diversified.[21,22,29,56,65,66]

Rodents have diversified extensively in the Neotropical Region. Of the 35 families comprising the world's largest mammalian order, 19 are represented in Latin America.[24,57] Endemic neotropical rodents range in size from the tiny rice rat, *Neacomys spinosus*, to the large, semi-aquatic capybara, *Hydrochaeris hydrochaeris*.[113] The latter, the largest living rodent, measures up to 1340 mm in length and 65.5 kg in weight.[80]

While the biology of a few species is well known, knowledge of most neotropical rodents (and other wildlife) is very limited.[29,71,73] Some are known only from single museum specimens. Others are more common, but basic information on their geographic and altitudinal distributions, preferred habitats, food habits, life cycles, and taxonomic relationships is lacking.[71,73,113] This paucity of fundamental information bears directly upon our ability to define and resolve rodent pest problems. Some years ago, Hopf et al.[58] studied the existing knowledge of rodent damage to crops and stored products in tropical and subtropical areas of the world. Their report[58] concluded that, "The one single fact which emerges most clearly from the survey is the widespread ignorance of the magnitude of the rodent problem, and means to control it." With reference to Latin America, this statement is as valid today as when originally published.

III. RODENTS AS PESTS IN LATIN AMERICA

The conflicts between rodents and the economic interests or well-being of mankind in Latin America are the same as elsewhere in the world: disease transmission, food destruction, reduced timber and forage production, and physical damage. Certainly, different species are involved (Figure 2), and, taking into account the great diversity of ecological conditions found in the Neotropical Region, the resolution of rodent pest problems will require much study and understanding. It is our intent in this report to emphasize the problems of rodents in agriculture, specifically preharvest problems. However, we would be remiss not to touch on two important areas involving rodents: disease and postharvest food loss.

A. Disease

Rodents serve as reservoirs for numerous diseases or parasites that are transmissible to man and domestic animals.[2,6,8,27,44,45,71,114] They may also affect human or animal health by limiting food availability thus contributing to malnourishment.[8,51,71,84,86] It is beyond our purpose and scope to review these disease relationships in detail; it will suffice to discuss a few of the significant problems in Latin America.

The most common disease association is that of plague, the "black death" of 14th century Europe. Plague is not just a disease of history. Between 1958 and 1979 human plague occurred in 30 countries.[6] It is endemic in four Latin America countries (Bolivia, Brazil, Ecuador, and Peru) and has occurred periodically in Colombia and Venezuela.[6,7] Nearly 5000 human cases of plague were reported from South America between 1960 and 1969. Seventeen indigenous neotropical rodent genera (50 species) have been proved or strongly implicated as carriers of plague.[2,6,7,48,71]

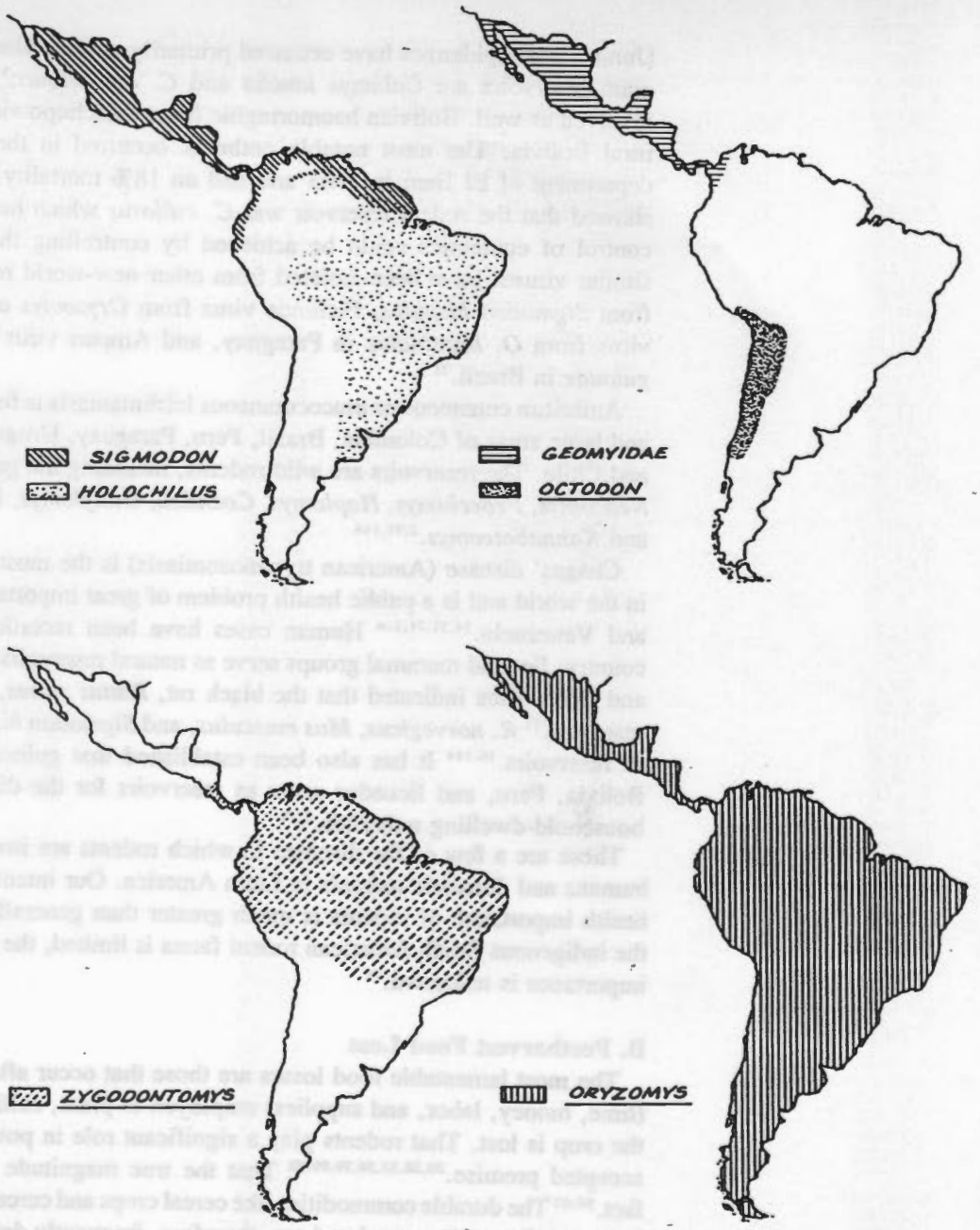

FIGURE 2. Approximate distributions of major rodent groups damaging agriculture in Latin America that are based on reports in technical literature. The cosmopolitan *Rattus* and *Mus* are major problem species throughout the region; their distribution is worldwide. *Octodon* is illustrative of several rodent groups that are not widely distributed but which have had a significant impact on a specific segment of the agricultural economy within their range. Existence of several such groups requires that rodent damage problems be examined within the context of ecological and environmental parameters.

Venezuelan encephalitis, also known as Venezuelan equine encephalitis, is a serious disease of equines and man. It is found in northern South America, Central America, and Mexico.[51] Epidemics appeared in Venezuela in 1962 and Colombia in 1967. The disease is maintained in nature by a rodent-mosquito cycle.[2,51,71]

The South American haemorrhagic fevers are associated with rodents which serve as reservoirs and probable transmitters of these diseases.[51,71,100] Argentine haemorrhagic fever

(Junin virus) epidemics have occurred primarily among wheat- and corn-field workers. The main reservoirs are *Calomys laucha* and *C. musculinus*;[51] other rodent species may be involved as well. Bolivian haemorraghic fever (Machupo virus) caused similar infections in rural Bolivia. The most notable outbreak occurred in the San Joaquin township in the department of El Beni in 1963 and had an 18% mortality rate.[71] Epidemiological studies showed that the rodent reservoir was *C. callosus* which had become commensal, and that control of epidemics could be achieved by controlling these rodents.[44,71] A complex of similar viruses have been isolated from other new-world rodents including Tamiami virus from *Sigmodon hispidus*, Pichinde virus from *Oryzomys albigularis* in Colombia, Parana virus from *O. buccinatus* in Paraguay, and Ampari virus from *O. capito* and *Neacomys guianae* in Brazil.[71]

American cutaneous or mucocutaneous leishmaniasis is found in much of Central America and large areas of Colombia, Brazil, Peru, Paraguay, Uruguay, Bolivia, and into Argentina and Chile. The reservoirs are wild rodents, including the genera *Oryzomys, Zygodontomys, Neacomys, Proechimys, Hoplomys, Coendou, Ototylomys, Heteromys, Dasyprocta, Agouti*, and *Kannabateomys*.[2,71,114]

Chagas' disease (American trypanosomiasis) is the most important cause of myocarditis in the world and is a public health problem of great importance in Brazil, Argentina, Chile, and Venezuela.[14,51,71,114] Human cases have been recorded from every South American country. Several mammal groups serve as natural reservoirs; evidence from Brazil, Panama, and Costa Rica indicated that the black rat, *Rattus rattus*, was the main intra-domiciliary reservoir.[71] *R. norvegicus, Mus musculus*, and *Sigmodon hispidus* have also been implicated as reservoirs.[16,114] It has also been established that guinea pigs (*Cavia*) kept for food in Bolivia, Peru, and Ecuador serve as reservoirs for the disease transmitted to humans by household-dwelling reduviids.[2,71]

These are a few of the diseases in which rodents are involved in affecting the health of humans and domestic animals in Latin America. Our intent is to emphasize that the public health importance of rodents is much greater than generally realized. Since knowledge of the indigenous South American rodent fauna is limited, the full extent of their public health importance is unknown.[71]

B. Postharvest Food Loss

The most lamentable food losses are those that occur after harvest; the entire investment (time, money, labor, and supplies) employed to plant, cultivate, protect, harvest, and store the crop is lost. That rodents play a significant role in postharvest food losses is a widely accepted premise.[20,28,53,58,79,89,92] That the true magnitude of the problem is unknown, is fact.[58,62] The durable commodities like cereal crops and cereal products are the most important in terms of quantity stored and are, therefore, frequently damaged by rodents.[58,79] However, other produce such as potatoes, fruits, and beans are also stored and subject to rodent damage.[58] The extent of losses in postharvest situations is unknown because there are no practical methods for obtaining loss estimates.[19,47,53,62,79,92] Several rodent groups have been implicated as pests of stored products in Latin America; the most important ones are, undoubtedly, the cosmopolitan murids, *Rattus* and *Mus*. Others named included *Oryzomys, Calomys, Akodon, Heteromys, Peromyscus, Ototylomys, Eligmodontia, Neotoma*, and *Proechimys*.[36,58,113]

Much concern about postharvest food losses in Latin America has been expressed. The United Nations Food and Agricultural Organization's Regional Office for Latin America and the Carribean (FAO/RLAC) and the Centro Nacional de Treinamento en Armazenagem (CENTREINAR) in Vicosa, Brazil, have sponsored two Latin American seminars on postharvest losses; rodent problems were included as a major topic in each.[19,32,37] FAO/RLAC has published a collection of booklets on various postharvest grain management technologies and procedures; one of these was on rodent damage and control.[36]

C. Agriculture

The development of Latin American agroecosystems covers a broad spectrum — from slash-and-burn plots, to small, multi-crop subsistence farms, to large, monoculture plantations. Although more than one-third of Latin America's population is engaged in agriculture, many parts of South America and almost all of Central America are considered to be diet-deficient areas.[21,42] There are many contributing reasons; among them are food losses to rodents. That rodents are pests of some notoriety in this part of the world is not a recent phenomenon. Depictions on Incan and pre-Incan pottery in museums in Lima, Peru, show rodents feeding on ears of corn; in the agricultural calendar of the Inca, protection of crops from rodents and other vertebrate pests was specified along with cultivation, harvest, and storage.[48,86,87]

Rodents, and other animals, become pests only because they somehow come into conflict with man; it is generally a direct result of man's activities that these conflicts arise. For example, efforts to increase agricultural production in Latin America have involved environmental changes which appear to influence the types and degree of man/rodent conflicts. A principal means for countries to increase agricultural production has been to bring new lands under cultivation by clearing forest, scrub, or marsh areas for agriculture. The newly available food sources and the disappearance of natural predators often benefit rodent populations. Other efforts to increase food production have included introduction of exotic species, improvement of native crop varieties, more intensive management practices, expansion of grazing areas for livestock, and irrigation schemes. Such activities inevitably result in radical modification of environments, beneficial to some forms of wildlife and detrimental to others.[33,39,42,72,74,81,110] The resultant changes in rodent populations may be dramatic or subtle, and the importance of any group of rodents to man's interests may change in a significant way.[27,39,50,71,77,99]

We have focused this review on the most important crops — arbitrarily defined as those produced in more than half of the 21 Latin American countries. Virtually all of these crops are subject to rodent damage; we found at least one reference to rodent damage for all but two (cabbage and peppers) of the crops listed (Table 1). The specific crop for which we found the most references to rodent damage was sugar cane. This was not surprising since Latin America is the world's leading producer of sugar cane.[42] We found numerous references to rodent damage in cereal crops; most dealt with rodent problems in rice, but maize and wheat were specified in many papers. Rodent problems in root and tuber crops, especially cassava; oil crops, especially coconut; cacao; and bananas were also discussed in a number of papers. Finally, references to rodent damage in forest and forage crops were relatively more numerous than those dealing with other major crops.

1. Sugar Cane

Sugar cane is produced in every Latin American country except Chile. Of the total area devoted to this crop in the world, 44% is in Latin America which produces 47% of the world total.[42] Twenty-two rodent genera were named as pests of sugar cane in Latin America; the most frequently mentioned groups were *Holochilus*, *Sigmodon*, *Rattus*, and several genera of the Geomyidae. The geomyids and *Sigmodon* were the major pests in Mexico, Central America, and part of Colombia.[1,16,23,38,45,49,50,58,69,95,103-105] *Holochilus* was of primary importance in South America, particularly in Venezuela, the Guianas, and Brazil.[3,4,9-11,54,58,68,75,76,84,88,107,108] Other genera that were named in a number of reports include *Peromyscus*, *Zygodontomys*, *Oryzomys*, and *Reithrodontomys*.[1,11,52,58,63,76,113]

2. Cereal Crops

Rice is produced in each of the 21 Latin American countries. Among the developing market economies of the world, Latin American rice production is second only to the Far

Table 1
REPORTS OF RODENT DAMAGE TO MAJOR CROPS IN 21 LATIN AMERICAN COUNTRIES

	No. producing countries*	No. of rodent damage references
Cereals		
Rice	21	28
Maize	20	19
Sorghum	15	4
Wheat	12	10
Roots and tubers		
Potato	17	7
Cassava	17	11
Sweet potato	11	5
Pulses		
Dry beans	17	3
Dry peas	11	2
Soybeans	11	1
Vegetables and melons		
Tomato	19	2
Cabbage	15	—
Dry onion	15	3
Watermelon	13	4
Cantalope	12	2
Pepper	11	—
Grapes		
Grapes	11	4
Sugar crops		
Sugarcane	20	33
Fruits		
Oranges	19	3
Banana	17	9
Pineapple	16	6
Avocado	15	3
Mango	14	2
Plantain	14	4
Papaya	11	2
Lemon/lime	11	1
Tobacco crops		
Tobacco	17	2
Fiber crops		
Cotton	14	7
Oil crops		
Cottonseed	14	7
Coconuts	14	11
Groundnuts	13	1
Coffee, cacao, tea		
Coffee	15	6
Cacao	11	10
Forest crops*	21	9
Forage*	21	9
Other or unspecified*	—	35

* Data from Food and Agriculture Organization, *Production Yearbook 1983*, FAO Statistics Series No. 55, Food and Agriculture Organization of the United Nations, Rome, 1984. Entries added by these authors are indicated by an asterisk.*

East[42] We found reports implicating 22 different rodent genera as pests in rice fields, but certain ones were evidently more important than others based on frequency of reference. These were *Holochilus*, *Sigmodon*, *Oryzomys*, *Zygodontomys*, and *Rattus*.[3,15,17,33,38,58,61,67,68-70,106,108,110,113,116,117,119]

Maize is probably the most important cereal grain in Latin America, and, according to FAO,[42] is produced in 20 of the 21 countries considered here; no production statistics were reported for Surinam. Latin American maize production is second only to that of North America and first among the developing market economies of the world.[42] More than 20 rodent genera were mentioned as problems in the literature we examined. Again, a few groups were reported with sufficient frequency to indicate them as the more important pests of this crop. The pocket gophers (family Geomyidae) were apparently the principal rodent pest of maize throughout their range.[35,58,87,103-105,113] *Sigmodon*, *Oryzomys*, *Akodon*, and *Rattus* were other rodent groups that appeared as important pests of maize in Latin America.[1,5,36,38,48,58,68,83,93,113]

Wheat is produced in 13 Latin American countries; major producers reported were Argentina, Brazil, Chile, and Uruguay.[42] Fewer rodent genera were implicated as pests in this crop; 12 were named in the literature reviewed, with only a few citations each. This was likely due to several factors. Wheat is produced in a much more restricted area than sugar cane, rice, or maize, and production areas are more temperate with relatively fewer kinds of rodents. *Oryzomys*, *Octodon*, *Rattus*, *Akodon*, *Phyllotis*, and *Mus* appear to be the principal rodent pests of wheat.[5,35,46,54,58,74,93,106]

3. Oil Crops

Major oil crops in Latin America are coconut, cottonseed, and groundnuts.[42] Oil palm has been introduced into several areas including Venezuela, Colombia,[96] Brazil, and Peru.[58] Reports of damage to young palms in newly established plantations in Brazil and Peru did not identify the rodents.[58] In Colombia, *Proechimys* caused similar damage.[111] Coconuts are produced in 15 Latin American countries; Mexico is the leading producer with Brazil, Venezuela, Ecuador, and Colombia following.[42] Rodent damage can be a limiting factor to the coconut industry. For example, rodent damage as high as 77% occurred in one coconut producing area of Colombia.[31] This high damage resulted in a problem of serious economic consequence to the local community and closure of a coconut processing plant. Of eight genera implicated in the reports we examined, those most frequently named as pests of oil crops were *Rattus* and *Sigmodon*.[1,31,35,38,58,63,106,109,112,113] Most reports on cotton did not distinguish between fiber and oilseed production and are summarized under "Forest, Forage, Fiber, and Other Crops."

4. Horticultural Crops

Root crops are important dietary staples in Latin America as they are elsewhere in the world.[59] Potatoes and cassava are each produced in 17 Latin American countries and sweet potatoes in 11.[42] The literature reviewed implicated 19 rodent genera as pests; of these, the more important were *Oryzomys*, *Phyllotis*, and the geomyids.[5,35,48,54,58,63,94,103-105]

Pulse crops are produced to some extent in all Latin American countries although production data for French Guiana were unavailable.[42] Brazil and Mexico were the largest producers.[42] Although pulses are an important source of dietary protein in much of Latin America, few reports of rodent damage to these crops were encountered; *Rattus* reportedly caused damage to beans in Brazil,[58] and *Pappogeomys* was said to do considerable damage to bean fields in Mexico.[113]

Vegetables and melons are produced in all countries of Latin America; specific crops and production varied considerably among the different countries but Brazil and Mexico were the leading producers.[42] Relatively little information on rodent damage to these crops was

encountered. *Rattus, Sigmodon, Oryzomys, Holochilus, Phyllotis, Punomys, Andinomys, Orthogeomys, Hydrochaeris*, and *Agouti* were among the rodent genera named as causing damage to vegetable and melon crops.[1,4,5,35,38,76] The general nature of these reports was anecdotal and serious rodent problems are likely very localized in nature except in periods of high rodent populations or "ratadas".[38,48,60,71,82,108]

Latin America is a major producer of fruits, being the leading world producer of some including bananas, oranges, avocados, mangos, and papayas.[42] Damage to fruits was attributed to 18 genera of rodents in the literature examined. Geomyid rodents were noted as causing significant damage to bananas.[35,58,103-105,113] Bananas have become the most economically influential plant in Central America[63] and are of major importance as an export crop in numerous countries of tropical America. Bananas, avocados, and mangos were noted as preferred foods of pacas (*Agouti*) and agoutis (*Dasyprocta*) in South America.[13,113] Our review also indicated that pineapple was highly susceptible to rodent damage. Total losses of pineapple crops to *Punomys* and *Oryzomys* were reported in Peru.[5] *Holochilus* and *Sigmodon* damaged pineapple in Venezuela,[4,68] and *Sigmodon* was a pest of this crop in Nicaragua[12] and Mexico.[1,58] Cultivated *tuna*, the edible fruit of the prickly pear cactus, was extensively damaged by *Octodon* in Peru and Chile.[46,83,118] Fruit trees, particularly citrus and apple, were often girdled by a variety of rodents including *Oryzomys*[48] and *Sigmodon*.[98]

Grapes are produced in 11 Latin American nations; they are exported by Chile. Wine production is an important industry in several countries including Chile, Argentina, Uruguay, and Peru. Rodents implicated as vineyard pests included *Oryzomys* and *Octodon*.[46,48,83,118]

Although coffee is of African origin and is grown in practically every tropical country, coffee production is greatest in the Western Hemisphere.[59] Coffee is grown in 15 Latin American countries and is an important export crop for most of them; Brazil and Colombia were the world's leading producers.[42] Rodent groups reported to damage coffee included *Punomys, Oryzomys, Orthogeomys*, and *Rattus*.[5,36,58,87,106,113] In the Central American countries, pocket gophers (family Geomyidae) damaged root systems, often killing the entire plant. Coffee seedlings may also be destroyed by these rodents.

Cacao, in contrast to coffee, is indigenous to the American tropics, but Africa is the leading producer.[59] Brazil and Ecuador were major producers among the 11 Latin American countries where it is grown.[42] Several rodent groups were mentioned as significant pests in Latin American cacao plantations. For example, squirrels (*Sciurus*) damaged cacao fruits in Costa Rica,[63] and reports from Colombia[69,110] and Peru[5] named *Sciurus* and *Rattus*. Several rodent groups reportedly caused damage in Brazilian plantations including *Nectomys, Rattus, Thomasomys, Rhipidomys*, and *Akodon*.[25] Other reports cited *Sigmodon, Holochilus, Peromyscus, Punomys*, and *Oryzomys*.[5,93,94]

Although tobacco is a major crop and is produced in 17 Latin American countries, we found only two references to rodent damage;[1,58] both were from Mexico, but the rodent species was not named.

5. *Forest, Forage, Fiber, and Other Crops*

Forests and woodlands cover about 45% of the land area in Latin America, ranging from about 4% in Uruguay to 96% in Surinam.[42] Most of these areas are natural forest; others are intensely managed plantations of exotic species. Forests and woodlands provide a variety of products from fuelwood to lumber and paper, and are of major economic importance. For example, forestry has become the second major industry in Chile.[90] Forestry, as an industry, is important in several Latin American countries;[18,78,91] reforestation, as a necessity, is important in many areas.[14,27,43,47]

Rodents were reported as impediments to successful reforestation in several countries.[18,58,78,91,95,106] In Chile, for example, *Octodon bridgesi* was described as the primary pest in reforested areas planted to *Pinus radiata*.[85] Recent studies estimated a 43% incidence

of damage and a tree mortality rate of 12.5% in young plantations.[91] Other rodents implicated in damage to Latin American forest crops include *Clyomys*, *Agouti*, *Coendou*, *Sciurus*, and the geomyids.[18,35,83,95,113]

Pasture or forage crops are also subject to damage by rodents. Damage may take many different forms. For example, it may occur as direct competition with livestock for available forage, as physical damage by burrowing rodents which is a hazard to livestock or contributes to soil erosion, or as destruction of forage either before or after harvest. Several different rodent groups were reported to cause such damage in Latin America. In Mexico and Central America, *Dipodomys*, the geomyids, especially *Orthogeomys*, and *Sigmodon* were reported to compete with cattle for forage and damage alfalfa crops and dairy pastures.[38,58,103,104,113] In Peru, four genera, *Oryzomys*, *Andinomys*, *Phyllotis*, and *Cavia*, were named as causing damage to natural grass pastures, and losses of 10 to 30% in alfalfa crops.[5,94] Destruction of rangeland by rodents was described as an important problem in Chile,[93] and rodents of the genera *Ctenomys* and *Lagostomus* were named as pests in pasture and forage in Argentina.[35,58]

A variety of fiber crops are grown in Latin America including flax, hemp, jute, sisal, and cotton. Cotton is, by far, the most important fiber crop, being produced in 14 countries.[42] This was the only fiber crop for which we found reports of rodent damage. Rodents implicated as pests in cotton were *Sigmodon*, *Oryzomys*, and *Holochilus*.[1,38,48,58,68,94]

Numerous reports which discussed rodent damage in Latin American countries did not specify the crop or crops damaged, and, all too often, did not identify the rodent species involved. The generic phrase "... rodents are an important problem in cultivated crops ..." was common in the literature. Considerable work remains to be done in defining rodent problems associated with minor crops and localized areas.

IV. DISCUSSION

The variety of rodent problems now identified in Latin America reflects substantial progress in defining the rodent species associated with major crop, disease, and postharvest problems. However, few field data have been gathered for the population ecology of most species, their behavior in man-modified environments is largely unknown, and virtually none of the problems caused in the region by rodents have been defined in economic terms.

Although most of the common rodenticides and other control materials are commercially available throughout the region, their use is largely restricted to problems involving the commensal rodent species that occur in cities, towns, and ports. Except for the few native rodent species ranging into North America, no toxicological data are available upon which to base commercial formulations for cropland use.

Numerous threatened and endangered species occur in Latin America, along with a great variety of rare fauna and flora; however, we know of no situation where questions of ecological impact have been examined in relation to rodent damage problems or control activities. The successful efforts made in many countries in recent years to develop ecologically-based crop damage control programs are, with very few exceptions, not evident in Latin America.

Clearly, new materials, techniques, and programs unique to the region will be required in some of the diverse agricultural situations where problem rodent species are encountered. We do not expect that existing rodent-damage-control technology could be adapted to deal adequately with all of the problems touched in this review — although adaptation is a starting point that should be pursued. The limits of adaptation apply to developments within the region as well. Materials and delivery systems that work well for the labor-intensive efforts on small farms will be of little practical help or economic benefit on the large mechanized farms that are common in parts of a Latin America — even when the same crops and rodent species are involved.

Long-term solutions to rodent problems in agriculture and public health will require increased emphasis on training in the public and private sectors and support for coordinated research efforts throughout the region. Initial research should examine existing and potential control materials and delivery systems for principal rodent groups causing crop damage in some of the major agroecosystems. The opportunity exists in Latin America, as in few other areas of the world, to approach this process with emphasis on the development of environmentally compatible techniques, supporting databases, and mitigation of impacts on indigenous fauna and flora.

The past decade of effort by Latin American scientists has produced a substantial increase in the knowledge of rodent problems in the region; nearly 70% of our citations were published in this period. However, most of this work deals with problem definition, serving principally to confirm what farmers already knew — that serious rodent problems occur in many parts of Latin America. We anticipate that the next decade will produce a start toward solving some of these problems in the interest of increased food production, improved human and animal health, and environmental protection.

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