

PLAGUE IN THE AMERICAS: AN HISTORICAL AND QUASI-EPIDEMIOLOGICAL SURVEY*

PLAGUE IN ECUADOR, *Cont.*

In addition to the Indian practice of raising guinea pigs for food, keeping them in the dwelling, and the dangerous habit of eating animals found dead, the mountain dwellers of Ecuador have two other customs which have been found of importance in plague epidemiology: that of crowding together for several days at wakes, as in Bolivia and Peru; and that of killing vermin (lice and fleas) with the teeth—believed to be the cause of the tonsillar form of plague.^{32, 33}

Rats and mice.—(See also Table 4.) According to Eskey, the rat population of Guayaquil is usually about 75–80 percent *norvegicus*, 15–20% *rattus*; and 5 to 10% *alexandrinus*. In the sierra towns, *alexandrinus* predominates, though *rattus* is nearly as common; *norvegicus* is greatly reduced.³⁴ (Ambato, March–Dec., 3,664 rats, 27.7% *norvegicus*; 37.6% *alexandrinus*; 34.6% *rattus*; Latacunga, which had no plague, Jan.–Dec., 6,567 rats, 6.4% *norvegicus*; 93.5% *rattus* and *alexandrinus*.³⁵) With the intensification of the antiplague campaign in Guayaquil (trapping and poisoning), the percentage of *norvegicus* dropped, and Eskey has stated that when the *rattus* group (including *alexandrinus*) of rats exceeds the *norvegicus* in a community where the latter usually predominates, the rat population has been so reduced that plague will probably disappear; or at least “the backbone of the disease has been broken.”³⁶ As already noted, the Casunga valley (Loja) rats were mainly *norvegicus* and *alexandrinus*.

There is a reddish brown wild rat in Ecuador which does not seem to invade buildings. No fleas have been found on it. At Guamote, three rats apparently a hybrid between the wild rat and *alexandrinus* were found, also without fleas.³⁷

Other animals.—Epizootics among domestic guinea pigs (*cuyes*, *cobayos*) in

* See General Review.

³² Eskey was apparently one of the first to emphasize the importance of *velorios* or death wakes in the spread of plague (*Pub. Health Rep.*, Sept. 5, 1930, p. 2083), although Suárez (“*Algunas observaciones, etc.*,” 1927, pp. 10, 11) had mentioned instances of contact of persons with the sick or with the clothing of sick persons, the abundance of fleas, and evidences of interhuman contagion. These observations have been confirmed by a number of others. (See General Review, Note 60.)

³³ Eskey seems also to have been one of the first to connect *angina pestosa* (tonsillar plague) with the habit of killing vermin with the teeth. (*Supra*, p. 2082.) The practice itself is old indeed: Edward Whymper (“*Travels Amongst the Great Andes of the Equator*,” London, 1892, p. 98) reported the custom among Indians at Latacunga and said that according to the historians, the habit was established before the Spanish Conquest. Espinosa Tamayo (L., “*Contribution à l'étude de la Géographie Médicale et des conditions hygiéniques de la République de l'Equateur*,” 1917, p. 37) mentioned seeing the practice among Coastal Indians as well.

³⁴ *Pub. Health Rep.*, Sept. 5, 1930, p. 2088. But Suárez in 1927 said that *alexandrinus* was the most numerous on the coast and *norvegicus* in the Sierras, although the most prevalent rodent in the Sierras was the mouse. These statements, as he himself observed, were merely preliminary and based on only a few figures. (“*Algunas observaciones, etc.*,” 1927, p. 13.)

³⁵ Eskey, *Pub. Health Rep.*, Sept. 12, p. 2177, Table 6.

³⁶ *Ibid.*, p. 2171. Of 168,663 rats and mice classified in Guayaquil in 1939, 64% were *musculus*, 25% *norvegicus*, 7% *rattus* and 3% *alexandrinus*; in 1940, of 120,385, the proportions were 54%, 33%, 7%, and 4% respectively. Disregarding mice, of the 115,561 rats examined in the two years, 71% were *norvegicus*, 17% *rattus*, and 10% *alexandrinus*. (Report of the Chief of the National Antiplague Service to the Pan American Sanitary Bureau, Jan. 27, 1941.)

³⁷ *Ibid.*, Sept. 5, p. 2089.

connection with Chimborazo and Loja outbreaks have already been mentioned, as have the finding of plague in wild rabbits and of epizootics among them in Chimborazo. Long has observed that the Loja natives refer to the "wild" rats there (*alexandrinus* and *norvegicus*) as *comadreja* (weasel), a circumstance which may have misled investigators relying on oral testimony, into thinking there were no rats.³⁸ Sáenz Vera reported plague-like epizootics in monkeys in the Alamor area, Loja, noting that the monkeys could come in contact with sick or dead rats when they went to the springs or rivers to drink.³⁹ Some persons declared they had seen monkeys playing with such animals. He regarded the circumstance (for which there is as yet no laboratory confirmation) as merely a possible indication of susceptibility in monkeys, and emphasized the fact that the most severely affected areas are those in which there are no monkeys (Catacocha, Céllica, Amaluza), but in which there is an overwhelming number of rats.

Fleas.—(See also Tables 5 and 6.) Rat-flea studies were begun in Ecuador in December, 1926, in keeping with recommendations of the first Pan American Conference of Directors of Health (Washington, September, 1926).⁴⁰ Studies in 1926-27 showed a *cheopis* index of 6.0 in winter and 1.6 in summer in Guayaquil, with an average of 2.77; in Ambato the index varied with dryness and temperature, and was 0.71 in 1927. In September, 1929, Surgeon C. R. Eskey of the U. S. Public Health Service, acting as Epidemiologist of the Pan American Sanitary Bureau, and in cooperation with the Ecuadorian authorities, began a detailed study of the flea infestation of rodents in Guayaquil, the work lasting until March 31, 1930. During this time only three species of fleas were found in Guayaquil: *X. cheopis* (99.3% of 29,269 fleas from 5,105 rats), *Ct. felis* (0.6%); and *P. irritans* (0.02%); the *cheopis* index was 5.6 and the flea index 5.7.⁴¹ During the same period 841 *cheopis* were found on 3,733 *mus musculus*. The *cheopis* index was found to be quite variable, fluctuating from day to day depending on the place where rats were caught, their size, sex, and species. During the plague season the monthly index was: Nov., 8.00; Dec., 7.59; Jan., 4.73; Feb., 7.02; Mar., 5.97; average, 6.76. Outdoor rats had a low *cheopis* index, too low for the continued transmission of plague, so that indoor rats would seem to be the reservoir.⁴²

³⁸ Letter to Pan Amer. San. Bureau, April 8, 1935.

³⁹ *Bol. Of. San. Pan.*, Jul. 1940, p. 665.

⁴⁰ Resolution 29, recommending study and classification of fleas; and 32, appointing a Commission to study antiplague measures in New York and make recommendations. The Commission recommended to all the Pan American countries (1) daily catching of rats and other rodents for at least one full year; (2) examination and classification of such, and their parasites; (3) reporting of this information; (4) specimens of each species of flea to be submitted to a selected Expert so that classifications would be uniform; (5) other rodents than rats, and their parasites, to be examined when possible, especially if domesticated. The members of the Commission included Assistant Surgeon General Samuel B. Grubbs, U.S.P.H.S., Dr. Lucas Sierra, Director of Health of Chile, and Dr. Pablo A. Suárez, Director of Health of Ecuador. ("Actas" of the Conference, *Bol. Of. San. Pan.*, Mar. 1927, pp. 292, 294.) Ecuador was the first country to undertake these studies, beginning work in December, 1926. The first Ecuadorian report on fleas appeared in the *Bol. Of. San. Pan.*, May 1927, p. 437, and contained data for Alausí, Quito, Latacunga and Ambato, for January, 1927. Among the observations made by Suárez in connection with *cheopis* were: it is found only on rats and mice, not on guinea pigs, man, or other animals; it is found both where plague is and where it is not; and plague is found both with and without *cheopis*; where *cheopis* exists, epidemics tend to be periodic; where it is not, they have been occasional, transitory, localized, and of human incidence and propagation; when *cheopis* is over 6 per rat constantly, plague is endemic; where less, occasional. It was not found in rodents where the temperature was less than 14 C (57.2 F.) (Suárez, "Algunas observaciones, etc.," pp. 14, 15.) Some of Eskey's findings were different (see text).

⁴¹ In a period of nine days the *cheopis* index was more than doubled by a change in the procedure of securing fleas. Instead of the old method of drowning the rat, cyanide gas was used, and the rats were then combed for fleas and also struck a number of times in order to loosen up the fleas and knock them off. In a comparison study, drowning and searching gave a flea index of 2.21; cyanide and combing, 2.44; and cyanide, "knocking" and combing, 7.02. (Eskey: *Pub. Health Rep.*, Sept. 5, 1930, p. 2101.) The indices given above are based on the use of the new method, which was followed for the survey.

⁴² As mentioned in the General Review, the change in the season of the greatest number of human plague cases in Guayaquil from the last months of the dry season to January, February and March of the

Other observations in regard to *cheopis* included: finding of the species at altitudes of over 9,000 feet but not in sufficient numbers to cause plague epidemics; the highest altitude at which it was implicated in plague was 8,554 feet (Alausí) although plague has occurred at over 10,000 feet; it is the only rat flea found in the lowlands and up to 4,000 feet; constant importation is probably necessary in the higher altitudes to maintain it in sufficient numbers to cause plague; the dampness of the rainy season is the chief factor reducing the *cheopis* index in Guayaquil, although not affecting rats on second stories of buildings; high temperatures cause *cheopis* to leave its host, but at least in Guayaquil do not kill the flea; under normal conditions the *cheopis* index usually shows about 40% of females; poisoning causes an increase in the total *cheopis* index and in the percent of female *cheopis*, which may be used as an indication of poison efficiency;⁴³ the nature of the rat's harbor is more important than the place where it is caught, in determining the number of *cheopis*; and the *cheopis* index varies in proportion to the number of rats when the rats are harboring inside buildings.

Contrary to the experience of Suárez, who found *cheopis* only on rats and mice, Eskey reports the finding of 25 *cheopis* among the fleas of 16 guinea pigs from Huigra and vicinity (index 1.5); and the finding of 2 *cheopis* on a larger number of guinea pigs in Alausí. Many guinea pigs have no fleas at all.

Ceratophyllus londinensis was found on both rats and mice at altitudes of over 8,000 feet, but not on rats below 4,000 feet; the degree of infestation is low and it is not believed to play much of a role, if any, in plague.⁴⁴ The same may be said of *Leptopsylla*, found on rats and mice in all the mountain towns except Huigra and Riobamba.

With regard to other rodent fleas, *Rhopalopsylla cavicola* is found on the guinea pig, especially those reared in houses; those in outdoor pens are often free of fleas. It is occasionally found on tame rabbits and on rats and mice (Guamote, 1 *Rh. cavicola* among 3 rats; Quito, 2 among 62 rats; Ambato, 1 among 14 rats and 2 among 170 mice; Riobamba, 1 on 1 rat and 8 on 5 mice; Latacunga, 2 on 7 rats.) Plague transmission experiments and attempts to cause it to bite man were unsuccessful, although not regarded as conclusive.⁴⁵ *Hectopsylla suarez*, found on guinea pigs at high altitudes (Guamote, Riobamba, Nisac) is not numerous enough to be of consequence and is not found in the areas of greatest plague incidence.⁴⁶ One was found on a Quito rat.

Ctenocephalus felis and *canis* are occasionally found on rats, but are not considered plague vectors.⁴⁷

The human flea, *P. irritans*, characterized by Eskey as "one of the pests of Ecuador,"⁴⁸ is found everywhere, both in the coast and mountains; it infests the blankets and ponchos of the natives; it is common on rats in the mountains, not so common on guinea pigs (8 *P. irritans* in fleas from over 100 guinea pigs); it is the only flea found on clothing. It is believed to be the chief transmitting factor in the causation of plague in the localities in Ecuador in which no *cheopis* are found; it is even probable that some of the cases in Guayaquil are due to it.⁴⁷

rainy season, following 1916, was attributed to the circumstance that outdoor rats, with their low *cheopis* index, were probably less exposed to plague than were indoor rats; and that the infection spreads slowly among the non-immune indoor rats every year (younger rats) until the onset of the rains, when many outdoor rats are forced to seek shelter inside and the rodent plague rate consequently increases considerably, with a consequent rise in the number of human cases. (Eskey, *Ibid.*, pp. 2078, 2197.) When plague was reintroduced into Guayaquil in 1935 after a four-year absence (1930), the severity of the epidemic was considered as probably due to a loss of immunity by the rats. The disease was much more acute in them in 1935 than in 1929-30; and latent or inapparent cases, very common in the early period, were not seen in 1935. (Report of Dr. John D. Long.)

⁴³ Eskey, *Ibid.*, Sept. 5, p. 2115.

⁴⁴ This is probably the flea originally identified by earlier writers as *C. fasciatus*.

⁴⁵ Eskey, *Ibid.*, p. 2094.

⁴⁶ *Ibid.*

⁴⁷ *Ibid.*, p. 2095.

⁴⁸ *Ibid.*

Eskey has further observed that either *P. irritans* or the louse, both of which are killed by biting them, is the cause of *angina pestosa*, and that *viruela pestosa* (vesicular plague) is also probably caused by another agent than *cheopis*, else it would be more common in other localities—and this agent may well be *P. irritans*.⁴⁷

Lice.—Lice may be responsible for some cases of *angina pestosa*, according to Eskey, but there is no evidence that they act as vectors under normal conditions. Both *P. corporis* and *P. capitis* are found among mountain Indians; the former is not found in Guayaquil.⁴⁸

Seasonal incidence.—In Guayaquil the number of cases of plague generally began to increase in September. Prior to 1916 the yearly epidemic reached its highest point during October–December, or the last of the dry season; but since then the greatest number of cases have been during January–March. (See Note 42.) Over the whole period, 1908–1939, however, the highest incidence of plague was in December; the lowest, in June. In the mountain areas, as already noted, most of the outbreaks were during January to June, although cases have occurred during the rest of the year as well.

Kinds of plague.—The most common form of plague in Ecuador has been bubonic, the usual location for the bubo being the thigh or groin,⁴⁹ although it is said that axillary buboes are very frequently seen, especially in the mountains.⁵⁰ Pneumonic plague has been important in the mountains (see below). Two rare forms not often seen elsewhere have been observed in Ecuador over many years: *angina pestosa* (plague sore throat) and *viruela pestosa* (plague smallpox). The former is a tonsillar type of plague which may be either primary or secondary; the secondary involvement is likely to have arisen from a submaxillary bubo, and is less dangerous because the patient has probably received serum treatment. The primary form begins like an ordinary angina, with pain, chill, high fever, headache, nausea, and prostration, and is often not diagnosed until too late for effective treatment. Secondary buboes may appear in the neck.⁵¹ It is believed that this form is caused by killing vermin with the teeth. (See Characteristics of Mountain Plague.) In 1912–15 there were 8 cases of *angina pestosa* with a 63% mortality, among 1630 cases (0.4%).⁵² *Viruela pestosa*, described by Larrea about 1913, is characterized by an eruption like that of smallpox or chickenpox, which appears on the sixth or seventh day of illness, after an apparent improvement. Martínez Vinueza estimated the mortality at about 92%.⁵³ Among 1630 cases in Pareja's

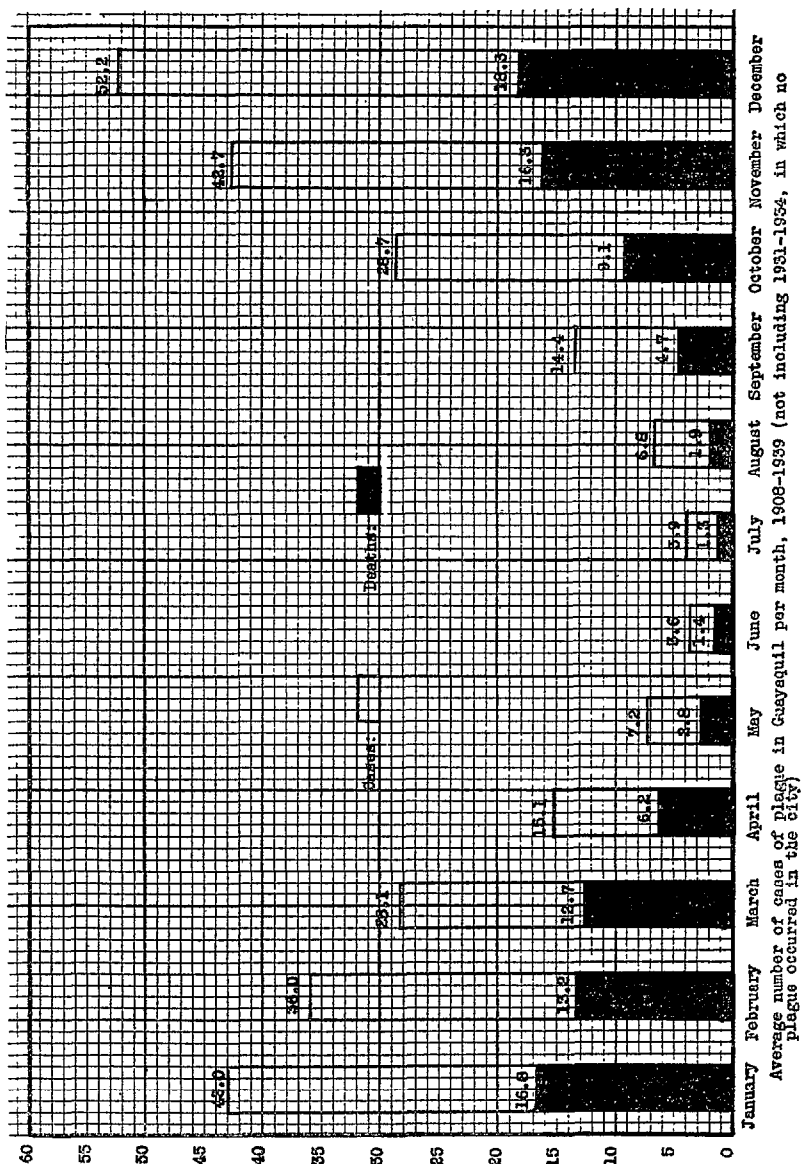
⁴⁹ An analysis of cases treated in the Guayaquil plague hospital from 1912 through the first half of 1915 revealed that of 1,620 cases, 58% had buboes in the thigh or groin (34% crural), 17% had axillary buboes, and 14% cervical. Those with buboes of the left axilla suffered the highest mortality (52%) followed by inguinocrural (48%) and cervical (39%). Pareja, Wenceslao: Algunos datos sobre la peste bubónica en Guayaquil, "Actas y Trabajos," I. Cong. Méd. Ecuatoriano, 1915, Tomo I, p. 398.

⁵⁰ Eskey, *supra*, Sept. 5, p. 2081.

⁵¹ Martínez Vinueza, J. J.: Peste eruptiva (viruela pestosa) y angina pestosa, *Bol. Of. San. Pan.*, Oct. 1930, p. 1189.

⁵² Pareja, *supra*.

⁵³ *Supra*.



study, 57 were *viruela pestosa*, only 5 of which recovered (91% mortality).⁵⁴ As to other types of plague, a few instances of gastrointestinal, ocular, and meningeal complications have been reported.⁵⁵

⁵⁴ *Supra*.

⁵⁵ Pareja, *supra*. Of 1680 cases, 9 had ocular complications, and 5 of these cases died (one succumbed to meningeal plague after leaving the hospital apparently cured). Treatment by protection from light, use of atropine sulfate, etc., at the suggestion of Dr. Ortega, brought good results in ocular involvement. Two gastro-intestinal plague cases were reported, one revealing ulcerations of the small intestine, covered with pseudo-membranes containing plague bacilli, at autopsy. There were two instances of localization in the mammary gland (bacteriologically demonstrated), another of an indurated phlegmon on the leg and one of a similar induration at the level of the fourth intercostal space, both containing plague bacilli

Pneumonic plague.—Sáenz Vera⁵⁶ has estimated that from 1908 through early 1940 approximately 237 cases, 233 deaths (98% mortality) of pneumonic plague have occurred in Ecuador. Such cases have been rare along the coast (43 out of some 8,000, or 0.5%), and fairly common in the mountains (194 out of some 874 recorded cases in Chimborazo from 1913 to date, or 22.19%). The tendency toward pneumonic plague in these regions he considers as probably due to: first, the altitude and the low temperature, favoring pulmonary involvement; and second, the pneumogenic tendency of sylvatic plague. Another factor is the custom of eating animals found dead, which may set up a septicemia with rapid pulmonary localization, so that in some instances it is difficult to recognize the original case in an outbreak as a secondary complication of bubonic or septicemic plague.⁵⁷ Despite the complete lack of hygiene, the living in close contact with all kinds of animals (pigs, guinea pigs, rabbits), the heavy infestation with lice and fleas, and the crowding together on occasion, which characterize the rather numerous Indian population, the plague morbidity, both pneumonic and bubonic, has been low in the Ecuadorian mountains, and the disease is really more endemic than epidemic. It may be, according to Sáenz Vera, that the climate is not favorable to the development of the maximum virulence of the plague organism, and he observes that the enormous epizootics found in other parts of the world are not seen in the Ecuadorian mountains, except in the Loja valley, which is warmer and has a climate more like that of the coast. Another factor reducing the spread of pneumonic outbreaks may have been the rapid action of the health service in isolating not only cases, but all contacts as well.

Plague mortality in Ecuador.—In Guayaquil, where all cases received serum if discovered in time, the plague mortality until recent years was unusually low: from 1908 to 1930 it was 38.9%, ranging from 29 to 45.2%.⁵⁸ From 1935 to 1939 the mortality rate was 54%. The determination of mortality rates for the mountains is more difficult, due to the much greater probability of cases going undiscovered, but in general they are said to be fairly low. Reports from Loja outbreaks since 1929 range from 51 to 74%; in Chimborazo, from 39% to 51%. In the Quilloag, Cañar outbreak, May, 1933, the mortality was 90.4%.⁵⁹ Many of these cases were pneumonic.

Vaccination and serum-therapy.—Vaccination has been used in Ecuador mainly for the immunization of persons in a limited area

⁵⁶ Sáenz Vera, C.: "Breves observaciones sobre neumonía pestosa en el Ecuador," 1940; also *Bol. Of. San. Pan.*, Jan. 1941, p. 11. See also Murdock's report on pneumonic plague in Ecuador in 1939, *Pub. Health Rep.*, Nov. 22, 1940, p. 2172.

⁵⁷ In connection with the Riobamba outbreak of pneumonic plague in 1939, a commission from the School of Medicine, University of Quito, studied the possibility of human carriers, and found bacilli, apparently those of plague, in the throats of healthy persons who had been in contact with pneumonic plague cases. (*Bol. Of. San. Pan.*, Nov. 1939, p. 1072.) Sáenz Vera was unable to confirm these findings either in Loja or in Chimborazo, but the examinations are to continue for a time.

⁵⁸ Miño, and Eskey, *supra*.

⁵⁹ *Bol. Of. San. Pan.*, May 1931, p. 571; Mar. 1932, p. 229; Jan. 1934, p. 1; Feb. 1935, p. 109, Ecuadorian health reports.

threatened by a plague outbreak—as for instance, the inhabitants of small Indian villages.⁶⁰ The value of serum-therapy has long been recognized. The observations of Martínez Vinuesa and Lloyd have already been mentioned (see General Review), both stressing the importance of using fresh serum and using it early. Pareja reported that mortality rose from 23% in cases treated the first day to 45% in those treated on or after the fourth day; the use of collargol in addition to serum improved results (28.9% in 739 cases treated with serum and collargol; 48.7% in 812 cases treated without collargol).⁶¹ Lloyd has also recalled several instances of plague in pregnant women who were successfully treated with serum and who did not abort or miscarry.⁶² He says that according to the records, 6,213 cases of plague, with 2,346 deaths (a mortality of 37.36%) were treated in the plague hospital of Guayaquil from Jan. 1, 1909, to Dec. 31, 1923, and that 90% of these patients must have received serum, although not always early enough. The mortality for 1908 when at least 200 out of 588 patients did not receive serum (it was unavailable) was 46.6%.⁶³

Control.—Plague control in Guayaquil and in the railroad and low-land towns has meant incessant war against the rat, with an outbreak or invasion of the disease the penalty for any attempted armistice. While the necessity of rat-proofing has been recognized by those conducting the campaigns, the tremendous nature of the task of building the rat out of Guayaquil has baffled all comers,⁶⁴ and most of the work

⁶⁰ However, in Guayaquil in 1908, about 16 per cent of the population of Guayaquil (some 12,000 persons in all) were inoculated with Haffkine's prophylactic, with or without a previous injection of serum, and ignoring cases which developed before inoculation began, the uninoculated furnished 1 case for about 230 persons, the inoculated, 1 for every 750, and ignoring the 4 who developed plague immediately following inoculation, the proportion was about 1 per every 1,000 for the latter group. "Observations of Dr. Lloyd," An. Rep. Surg. Gen. Pub. Health and Marine Hosp. Service, Fiscal Year 1908, p. 145.)

⁶¹ Pareja, *supra*. He also compared the results of using serum intravenously (41.9% mortality in 114 cases), subcutaneously (48.2% mortality in 986 cases) and a combination of both methods (28.8% mortality in 450 cases).

⁶² Lloyd, B. J.: *Jour. Amer. Med. Assoc.*, Sept. 5, 1925, p. 729. Pareja reported a mortality of 48% in 29 pregnant women (from 3 to 9 months pregnant); 80% of those who recovered did so without aborting. Though not stated, it is probable that these cases received serum treatment. He further concluded that in cases of plague in pregnant women, abortion was most apt to occur in the early months, and in about 24% of cases; but that the general prognosis was worst during the most advanced stages. (Pareja, *supra*, p. 411.)

⁶³ Lloyd, *supra*.

⁶⁴ The favorable conditions for rats offered by Guayaquil have already been described. (See Notes 8 and 9.) Lloyd, a consistent advocate of rat-proofing for many years, once remarked that "the most efficient and at the same time the most economic rat-proofing campaign that could be conducted against plague is one that begins from twenty-five to fifty years prior to the advent of the disease," inasmuch as it is relatively inexpensive to construct buildings in a fairly rat-proof fashion, but very expensive to rat-proof them once they are built. (*Jour. Amer. Med. Assoc.*, Sept. 5, 1925, p. 729.) Guayaquil had unfortunately been built in a far from rat-proof manner. Before 1922, attempts at renovation were made in houses where plague cases had occurred, although these efforts to put in cement floors, do away with double walls, and so on, met with much resistance. (Dirección de Sanidad Pública: "Cartilla Sanitaria No. 1," p. 8. The anonymous author of this pamphlet characterized the work as "trench warfare," with the number of rat harbors being reduced "redoubt by redoubt." "*Es la guerra de trincheras: hoy que ir ganando reducto por reducto la habitación de las ratas.*") He also made the interesting observation that during the intense campaign against yellow fever in 1919, when all water tanks in houses were covered, but no particular anti-rat measures were being taken, there was a notable decrease in human plague, from 279 cases the year before to 66 in 1919,—a decrease he attributed to a diminished number of deaths of rats inside houses, since they had then to go to the river or ditches for water, and died there rather than in houses.

has been rat extermination. However, regulations requiring a permit from the sanitary department before the construction of new buildings, have been in force for a number of years⁶⁴ and the measure is bearing fruit. Progress has also been made in general sanitation and garbage disposal.⁶⁵

Trapping and poisoning to reduce the rat population of Guayaquil were begun by Doctor B. J. Lloyd, who was made Acting Director of Health when plague first appeared, and they have been used with varying degrees of intensity ever since. In 1929-30, under the direction of J. D. Long, the Ecuadorian Anti-Plague Service intensified trapping activities and began a series of systematic poisonings.⁶⁶ Poison and bait were mixed and put up in little paper packages or "torpedoes" of a type previously devised by Cajas of the Guayaquil plague service. The most effective mixture was believed to be dried codfish, corn meal and arsenic; powdered cheese was also a good bait.⁶⁷ During a seven months' campaign the only domestic animals killed were a few cats (less than 10) attracted by the fish. The number of rats decreased enormously—in April, 1930 nearly 5 times as many traps were in use as a year before, and fewer rats were caught. The percentage of *rattus* and *alexandrinus* increased from 16 to 55, and it was estimated that the *norvegicus* population had been reduced 75 percent and others 50 percent. Both human and rat plague disappeared from Guayaquil in 1930. It was hoped that reinfection would be prevented by fumigation of all freight trains from the interior at Bucay, but negligence permitted unfumigated cars to slip through, and it is considered practically certain that the epidemic which began in 1935 was due to a reintroduction of the disease on this account. Thorough cleaning up of plague foci, including disinfection, destruction of rat harbors, fumigation of burrows, removal of food and distribution of poison, in the focus and the surrounding eight blocks, daily trapping and examination of rats throughout the city, and so on appear to have again resulted in the eradication of plague in the city.⁶⁸

With the eradication of plague from Guayaquil, the disease soon disappeared or was eradicated from the other lowland towns.⁶⁹ Periodic deratization of all towns along the railway line in Chimborazo and down to Eloy Alfaro station, and fumigation of railway cars are the measures

Rodent plague, he said, quite possibly did not decrease. P. 7.) Eskey has noted that rats actually living in houses harbored many more fleas than those living out-of-doors, and that even though outside rats might gain access to a rat-proofed house, they would be less of a menace (because of their low flea index) than rats which lived and bred there: he considered this another argument in favor of rat-proofing.

⁶⁵ Report of Dr. John R. Murdock.

⁶⁶ Eskey, *supra*, Sept. 12, p. 2162.

⁶⁷ Barium carbonate must be used in larger quantities than arsenic, but Eskey suggests its use the first time a city is poisoned, because it is less dangerous; after the inhabitants are used to the idea of poison being distributed, arsenic should be substituted. . . . Other baits tried were flour, corn meal, oil of peppermint, cinnamon, cloves, and anise; only oil of anise seemed to attract rats. To cover Guayaquil, 100,000 population, four times, 1,030 lbs. barium carbonate, 500 lbs. arsenic, 3,600 corn meal, 2,300 flour, and 340 reams of wrapping paper were used. The poisoning was begun at one end of the city and traps were placed at the other end, for evidences of migration, but there was no indication of any such movement. Thereafter the system was to place poison from the outside of an area toward the center.

⁶⁸ Report of Dr. John R. Murdock. He observes that the resistance and objection on the part of the citizens to the placing of rat poison and traps around houses, which was considerable when the measures were first introduced, have to a great extent been overcome, and telephone calls are received daily informing the health department of the presence of rats in buildings, homes, or yards.

⁶⁹ Eskey said that Guayaquil "is the source of all the plague epidemics in the central part of Ecuador and the disease would disappear if not for the endemic center in Guayaquil." (*Supra.*, Sept. 5, 1930, p. 2113.) There seems to have been no permanent reservoir in any of the towns.

employed to prevent reinfection. A base laboratory was organized in Alausí in April, 1940, to serve as a center of operations.⁷⁰

In the mountain towns rats are trapped and poisoned, and construction is supervised.⁷¹ Attempts have been made to induce the Indians to hold their wakes in a special building.⁷²

Ecuador has long been the scene of encouraging examples of international cooperation in public health, and especially in plague control. Her earliest campaign was under the direction of Dr. B. J. Lloyd of the United States Public Health Service, who was engaged in work against yellow fever in cooperation with the Ecuadorian authorities, and who was appointed by the Ecuadorian government to take charge of antiplague activities.

Pan American cooperation.—More far-reaching still was the program instituted in 1929, when Ecuador agreed to cooperate with the Pan American Sanitary Bureau in a campaign against plague, and Dr. J. D. Long and Epidemiologist C. R. Eskey began their epidemiological and eradication work, which was afterwards extended to other countries under Dr. Long's direction.

In 1930 the authorities of Peru and Ecuador agreed to the joint combat of plague in their respective frontier provinces of Ayabaca and Loja.⁷³ In 1932, Dr. Benjamin Mostajo of Peru came to Guayaquil to observe plague control work, as a Temporary Traveling Representative of the Pan American Sanitary Bureau, and in April of that year, Dr. Carlos A. Miño, of Ecuador, under a similar commission, went to Peru with Drs. Long and Mostajo on an inspection of the work there.⁷⁴ The visit of the Peruvian Technical Assistant, A. Ramos Díaz to Loja in 1935, where he made a survey with Dr. J. Selim Rodríguez⁷⁵ and was able to find rats and plague-infected rats in that Province, has already been mentioned. Other representatives of the Pan American Sanitary Bureau who have cooperated in Ecuadorian plague work include Drs. John R. Murdock, Anthony Donovan and Henry Hanson, of the U. S. Public Health Service.

Research.—Ecuadorian research might be said to have been chiefly in the fields of epidemiology and control. Beginning with the rat-flea studies undertaken by Suárez in 1926 in fulfillment of the recommendations of the Plague Committee of the First Pan American Conference of Directors of Health,⁷⁶ continuing through the painstaking and comprehensive surveys made by Eskey in 1929-30, the investigation of the possibility of "carriers" made by Suárez and others;⁷⁷ the pneumonic plague studies and the surveys in Loja and Chimborazo carried out by Sáenz Vera, the epidemiological contributions of this country have been an interesting and valuable addition to plague history. The

⁷⁰ Izquieta Pérez, L.: La Sanidad en el Ecuador, *Bol. Of. San. Pan.*, Jan. 1941, p. 8.

⁷¹ In Tungurahua, which has had no plague for many years, 5,093 rats were trapped and 4,492 examined in 1939, 525 guinea pigs were exterminated, 5 rounds of poisoning of rat burrows were made, and so on. (Martínez, Luis J.: "Informe Anual Delegado de Sanidad de la Provincia de Tungurahua, 1940, p. 8.)

⁷² Eskey, *supra.*, September 5, 1930, p. 2083.

⁷³ *Bol. Of. San. Pan.*, Oct. 1930, p. 1242.

⁷⁴ *Bol. Of. San. Pan.*, Aug. 1932, p. 821. Another Ecuadorian health officer who has had such an appointment is Dr. J. Illingworth Icaza. (*An. Rep. Director Pan Amer. San. Bur.*, 1935-36, p. 2.)

⁷⁵ *An. Rep.*, Director Pan Amer. San. Bur., 1937-38, p. 25.

⁷⁶ The visit of the members of the Commission to observe prevention methods in New York was another example of international cooperation. (See above.)

⁷⁷ As previously stated, Sáenz was unable to confirm these findings (Note 57).

paper package system of poisoning there devised has been adopted in other countries.⁷⁸

The lessons learned from the Ecuadorian campaigns have been of value to workers elsewhere. It may have been because of this apparently prevalent spirit of scientific curiosity⁷⁹ that Ecuador is one of the countries which has shown the least tendency to ever debate the question as to whether plague has appeared in a given locality—demonstrating an attitude of frankness and fair dealing which deserves full recognition.

PLAGUE IN ECUADOR^a 1908-1939

		Cases	Deaths
<i>Coastal Zone</i>			
Guayaquil.....	Feb. 1908-1939	7,921 ^b	2041 ^c
Province of Manabí.....	Dec. 1913-1937	337	107 ^c
Provinces Los Ríos, El Oro, and Guayas (excluding Guayaquil).....	1909-1939	416 ^d	?
<i>Central Zone</i>			
Province of Chimborazo.....	1909-Mar. 1940	1,335	469 ^e
Province of Tungurahua.....	1916-1929	187	
Province of León			
Guaitacama.....	1926	53	25
Guainailín.....	1929	15	8
<i>Southern Zone</i>			
Province of Loja.....	1921-Mar. 1940	1,411	?
Province of Cañar Sitio Quilloag ^f	1933	45	31
Total through March 1940.....		11,465	

⁷⁸ One advantage of the paper package is that it appears to be less tempting to children and domestic animals than most other forms of distributing poison.

⁷⁹ A tragic illustration of this scientific spirit is that of a young Ecuadorian medical student who, while vacationing in Columbe, heard of deaths among Indians on a near-by hacienda (in April, 1939), and went to investigate. Two patients had symptoms of pneumonia, and with the history of the Riobamba outbreak of pneumonic plague in mind, the student examined the lungs of the patients and made smears of the sputum for examination. He was said to have found the plague bacillus the following day. Two days later he became ill, dying on April 18 of pneumonic plague. In the Riobamba outbreak the first cases, originating in Tixan and Alausí, were diagnosed as pneumonia and typhoid fever. A total of 18 cases, 17 deaths of pneumonic plague occurred in Riobamba in January and February, 1939. Among the victims were 11 Sisters of Charity and a physician, Dr. Alfonso Villagomez, who had cared for the patients. Dr. Villagomez made the diagnosis of plague pneumonia after becoming suspicious of the disease and making sputum examinations, but until then no special precautions had been taken. (Murdock, J. R.: *Pub. Health Rep.*, Nov. 22, 1940; Suárez, P. A.: *Bol. Of. San. Pan.*, Nov. 1939, p. 1073.) Another martyr, in the line of duty, to plague in Ecuador, was health inspector Alvarado, who died of pneumonic plague in Loja in 1931. (*Bol. San.*, Ecuador, Apr.-Sept. 1932, p. 45.)

^a Miño's data 1908-1933 supplemented from Annual Reports.

^b Includes some cases from coast provinces treated in Guayaquil.

^c Deaths for 1936 not included. There were 64 cases in that year.

^d Including 17 cases in Zaruma, El Oro, 1939 (inland, possibly infected from Loja).

^e Deaths 1913-1939 from Suárez, plus later figures. He gives only 741 cases 1913-1939; Miño does not give deaths, for Chimborazo.

^f Probably infected from Chimborazo.

The figures for the Central and Southern Zones must be regarded as rather incomplete, since it is admitted that cases in remote districts are often not reported to the authorities unless the inhabitants become very much alarmed. In the period May 1939-March 1940, in addition to the cases included above, there were 151 suspected cases in Loja and 5 in Chimborazo. The data for Guayaquil are probably quite accurate, especially the number of deaths.