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# EPIDEMIOLOGICAL CHARACTERISTICS OF SMALLPOX OUTBREAKS IN TWO SMALL BRAZILIAN VILLAGES

by

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## INTRODUCTION

The Brazilian Smallpox Eradication Programme - Campanha de Erradicacao da Variola (CEV) - was created in August 1966, and given the technical and operational responsibility to eradicate smallpox in Brazil. Field training and organization of the systematic vaccination programme was the principal activity of CEV through mid-1968. At this time increasingly greater emphasis was put on surveillance activities and epidemic investigation. In early 1969, Smallpox Surveillance Units were established in the States of Minas Gerais, Bahia and Parana. Their responsibilities included the investigation of reported cases, outbreak control, and the further development and extension of the reporting network.

Largely as a result of the Smallpox Surveillance Unit activities in Minas Gerais, 1402 cases of smallpox were notified in that State in 1969. This compares to an annual average of only 387 cases for the previous eight-year period (1961-68). Although many outbreaks were investigated by the Surveillance Unit during 1969, two outbreaks in small villages of approximately the same size (Campo Alegre and Pirapitinga) were of particular interest in documenting the epidemiological pattern of spread of smallpox in Brazilian villages.

In both instances, the outbreak was discovered through investigation of other reported cases. Although a total of 134 cases of smallpox occurred during the two outbreaks, none had been notified through the established reporting system. In Campo Alegre (272 inhabitants), the outbreak, which terminated spontaneously, was traced back over a period of nine months. In Pirapitinga (243 inhabitants), cases of smallpox had occurred over a three-month period before vaccination in the community halted the epidemic.

The first case(s) in both villages were travellers who had brought the disease from elsewhere.

## BACKGROUND

Both Campo Alegre (Municipio of Santos Dumont) and Pirapitinga (Municipio of Caputira) are located in the Zona da Mata (Forest Zone) of the State of Minas Gerais. This zone is situated on the south-central interior plateau region of Brazil which is separated from the narrow, humid coastal plains by a mountain range. On the plateau, the rolling plains vary from 300 to 1000 metres in elevation. There are two distinct seasons. The summer, or wet season, is characterized by heavy rainfall from October through February of each year. The

winter, or dry season, runs from May through August. Principal crops in the area are corn, coffee, oranges, beans, rice, and sugar cane as well as dairy products.

The village of Campo Alegre is 10 km from the county seat (population - 40 000) of the municipio (county) of Santos Dumont. Santos Dumont lies on the Rio de Janeiro-Belo Horizonte highway approximately halfway (235 km) between the two cities.

The village of Pirapitinga is 6 km from the county seat (population - 8000) of the municipio of Caputira and approximately 300 km due east from Belo Horizonte, the State Capital. The straight line distance between Santos Dumont and Caputira is approximately 200 km, but about 425 km over the most travelled highways. Although the epidemic investigation showed similar findings in both outbreaks, the two outbreaks were independent and not associated with each other.

## METHODS

During the week ending 13 September 1969, 10 cases of smallpox were reported to the Smallpox Surveillance Unit of the Minas Gerais State Health Department from the Municipio of Santos Dumont. These cases had occurred on a small farm 5 km from the county seat. Upon investigation, the source of these cases plus six additional cases found in the area, was traced to the nearby village of Campo Alegre. In Campo Alegre, the investigative team was told of a smallpox outbreak that had been going on for months but had apparently ended. Since no cases had been previously reported from this area, every household in the village was visited to determine the size and extent of the outbreak. There were 71 houses of which 11 were vacant. Interviews were completed in the other 60 households with a total of 272 residents.

In August, the Smallpox Surveillance Unit had detected a similar situation in the village of Pirapitinga through the cross-notification of a case of smallpox from the State of Guanabara (Rio de Janeiro). This imported case had arrived in Guanabara already ill following contact with smallpox patients in Pirapitinga. Since no smallpox had been reported from this area, the Surveillance Unit immediately launched an investigation which revealed a sizeable outbreak that was still in progress. Suitable control measures were taken and the 75 households in the village were visited to document the extent of the outbreak. Of the 75 households, 59 were occupied and interviews were completed on all but three whose occupants were three adult males. There were 240 inhabitants found in the other 56 households.

In both villages, information was obtained on all household members including age, sex, history of previous smallpox (prior to January 1969), history of smallpox illness during the current year, and vaccination history.

Variola virus was isolated by the Instituto Adolfo Lutz in São Paulo, from specimens obtained from two cases in Pirapitinga. In Campo Alegre, the last case had occurred 15 days before the epidemic investigation and no specimens were collected.

## DEFINITIONS

In addition to epidemiologic data, laboratory tests have demonstrated that variola minor has been the only form of variola present in Brazil in recent years.[1,2,3] Over the last ten-year period (1960-69), the smallpox case-fatality ratio in Brazil has varied from 0.5 to 2.6 per cent. and has been below 1.0 per cent. in 3 of the last four years.[4] In the Campo Alegre outbreak, there was one death among the 74 cases - a case-fertility ratio of 1.4 per cent. In pirapitinga, there were no deaths among the 60 cases. Therefore, the terms variola minor and smallpox will be used interchangeably in this report.

A vaccinated person is defined in this report as an individual who has a vaccination scar as evidence of successful vaccination. Surveillance data in Brazil has shown that variola minor seldomly occurs in successfully vaccinated individuals.[4,5]

For this reason, residents of the villages have been classified as "susceptible" (no previous history of smallpox or successful vaccination) or "non susceptible": the non-susceptible population may be further sub-grouped by history of previous smallpox or successful vaccination. All of the 60 cases in Pirapitinga occurred among susceptible individuals. In Campo Alegre, one of the 74 cases occurred in a young girl successfully vaccinated in 1964.

RESULTS

The Campo Alegre Epidemic

The village survey, which was performed on 10 October 1969, documented 74 cases of smallpox which dated back to late December 1968. The actual dates of onset for all of the cases occurring prior to July were difficult to identify. However, it was possible to identify the dates of onset to within a two-week period in all cases.

The 74 cases are shown in Fig.1 by month of onset. The first two cases, an elderly couple without children, had moved to Campo Alegre in mid-December from the Municipio of Bomfin (125 km north of Campo Alegre). At the end of December, both experienced fever followed three days later by rash. The existence of smallpox in Bomfin during this period was later confirmed by local health authorities.

Subsequent spread occurred first in the home of another elderly couple, both of whom had already suffered smallpox in 1945. However, their five-year old grandson, who lived with them, experienced smallpox in early February. The outbreak later spread throughout the village reaching a peak in May and affecting 24 of the 60 occupied households by the end of September. The last known case had the onset of rash on 25 September, 15 days prior to the village survey. No other active cases could be found as the epidemic appeared to have terminated spontaneously. Nonetheless, all residents of the village were vaccinated or revaccinated.

The Pirapitinga Epidemic

During the second week of June 1969, a family visiting Pirapitinga, from the Municipio of Inhapim (128 km away) included an adult female with an illness described as smallpox. Within three weeks, cases had occurred in four other households and by 23 August, 11 weeks later, 20 of the 56 households in the village had at least one case of smallpox. The residents of the village were all vaccinated on 21 August and by the end of August, eight additional cases had occurred, all of whom had been vaccinated after exposure but before the onset of illness.

The non-resident family, which included the patient that introduced smallpox into the village, left Pirapitinga following her recovery. This case was excluded for subsequent tabulation. The outbreak of smallpox in Inhapim had been investigated previously and has been reported.[6]

In both villages, households with smallpox were not noticeably clustered but distributed throughout the locality.

Attack rates by age-group and susceptibility

As seen in table 1A-B, there is an inverse relationship between age-group and susceptibility. In Pirapitinga, 95 per cent. of the children under 15 years of age were considered susceptible at the start of the outbreak and, in Campo Alegre, 71 per cent.

Of the 90 residents in Pirapitinga considered non-susceptible, 28 had been successfully vaccinated and 62 reported having previously been ill with smallpox. The last known epidemic in the village was reported to have occurred in 1949 and 49 of the 62 residents who had previously suffered smallpox had their illness during or prior to the 1949 outbreak. The remaining 13 persons all experienced smallpox before moving to Pirapitinga. Thus, smallpox had been absent in the village for a period of 20 years accounting for the almost virgin population under 15 years of age.

Residents of Campo Alegre denied the existence of smallpox in the village within the past 10 years. Of those who had suffered a previous illness, the most recent was in the year 1959.

The overall attack rate was 25 and 27 per cent. respectively, in the two villages. Among susceptible residents in Pirapitinga, 40 per cent. had contracted smallpox in the 11-week period following introduction of the disease. All 60 cases occurred among the susceptible population. In Campo Alegre over an 11-month period of time 59 per cent. of the susceptibles had contracted smallpox. Only one of the 74 cases occurred in an individual considered non-susceptible (a six-year old girl vaccinated in 1964).

Table 2A-B presents attack rates for susceptibles by age-group for all households with at least one case of smallpox. In Pirapitinga, the overall attack rate in children under 15 years of age (73.1 per cent.) was 3.7 times the overall attack rate in adults (19.6 per cent.) However, when corrected for susceptibility, there is little difference in attack rates through 30 years of age. Sixty per cent. of the susceptible residents in the 20 households affected had contracted smallpox in an 11-week period of time.

In Campo Alegre, where the epidemic appears to have terminated 15 days prior to the vaccination of the village, 79 per cent. of susceptibles in affected households had contracted smallpox. The overall attack rate was almost four times higher among children less than 15 years of age as compared to the adult age-groups. When attack rates are calculated on the basis of susceptibles only, there is a only a slight difference between those under and over 15 years of age.

A tabulation of attack rates based on the nature of acquired immunity and susceptibility of the 144 residents in the 24 households with smallpox is shown in Table 3.

Characteristics of households with and without smallpox

In both villages there was a substantially greater proportion of susceptibles in the households with at least one case of smallpox as compared to households without smallpox (Table 4A-B).

In Campo Alegre, 46 per cent. of the villagers were considered susceptible prior to the epidemic. However, almost two-thirds of the residents in the households subsequently afflicted were susceptible as compared to only 25 per cent. of residents in the remaining households in the village. Substantial differences are noted in all but the pre-school age-group.

In Pirapitinga, a greater proportion of suceptibles is seen only in the 5-14 and 15-29 year age-groups and these differences are not as distinct as those seen in Campo Alegre.

A summary of household characteristics is shown in Table 5. In both villages, there is a remarkable similarity in household composition. There were six persons per household in those with at least one case of smallpox. In the households not affected, the average number of persons is only 3.2 and 3.6, respectively. With respect to children in the households, these differences are even greater. There were almost 3.5 children under 15 years of age per affected household. The corresponding number for other households was only 1.0 and 1.4, respectively. In addition, over half of the residents in affected households were under 15 years of age as compared to approximately one-third in the non-affected households.

DISCUSSION

Both Pirapitinga and Campo Alegre are not on the main routes of communication or transportation but could not be considered isolated communities. Still, there is good evidence that these villages had been free of smallpox for 20 and 10 years, respectively, and a large proportion of the population in both localities, especially those under 15 years of age, had never been vaccinated. Once smallpox was introduced from outside the village, epidemics could be expected.

In Campo Alegre, the outbreak persisted for a period of eight months and 59 per cent. of the 124 susceptibles living in the village contracted smallpox. The village and environs were vaccinated at the time of investigation but it is probable that the outbreak had already terminated spontaneously.

In Pirapitinga, almost two-thirds of the 240 residents and all but five of the 104 children under 15 years of age were susceptible when smallpox was introduced into the village, Within 11 weeks, the outbreak had involved 40 per cent. of the susceptible population at which time it was controlled by vaccination.

Both villages are small and there is daily interchange between most of the community members. There was no marked geographic localization of cases in either village. The affected households had a greater proportion of susceptibles, were more crowded and had more children.

In Pirapitinga, the primary or co-primary case in 14 of the 20 households affected, were of school age. Once smallpox was introduced into a given household, most subsequent cases appeared to have contracted smallpox from other family members rather than from cases in other households. Angulo[7] made a similar observation in an outbreak of variola minor in São Paulo, Brazil as well as Henderson[8] in a village outbreak of variola major in Dahomey.

The overall attack rates and attack rates among susceptibles, in both villages, are very similar to those reported in a hamlet of 203 persons in Nigeria[9]. In that hamlet, the outbreak was also triggered by an imported case and involved 62 cases over a period of 15 weeks. The respective total and susceptible attack rates were 30.3 and 52.1 per cent.

It is seen that in Campo Alegre, a village of less than 300 inhabitants, variola minor persisted for a period of eight months. Secondary attack rates observed in the households affected are similar to those reported in village outbreaks in West Pakistan[10] but are somewhat lower than those reported in the small village outbreak in Dahomey[8] which was due to variola major (see below):

| Immunity status | Campo Alegre | | | | Secondary attack rates (%) | | |
|---|---|---|---|---|---|---|---|
| | No. in household | Primary or co-primary cases | Secondary contacts | Secondary cases | Campo Alegre | West Pakistan | Dahomey |
| History of smallpox | 33 | 0 | 33 | 0 | 0.0 | 0.0 | - |
| Vaccination scar | 19 | 0 | 19 | 1 | 5.3 | 4.3 | 15.4 |
| No vaccination scar | 92 | 30 | 62 | 43 | 69.4 | 65.7 | 77.8 |

If not for adequate control measures, the outbreak in Pirapitinga would have undoubtedly continued for a considerably longer period. In 11 weeks, 40 per cent. of the susceptibles in the village had contracted variola minor. In affected households, the secondary attack rate was 53 per cent. less than that seen in Campo Alegre, where the outbreak evolved over a longer period of time uninterrupted by control measures.

That outbreaks of variola minor can persist for long periods of time in "out-of-the-way" but not isolated communities is well documented here. The occurrence of disease may or may not have been known to local health authorities but it certainly was not reported.

TABLE 1A. VARIOLA MINOR IN PIRAPITINGA MUNICIPIO OF CAPUTIRA - MINAS GERAIS JUNE 22 - AUGUST 30, 1969

| Age Group | Population | | | | No. of cases | | Attack rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | Total | Non-Susc* | Susc. | % Susc. | Non-Susc* | Susc. | Total | Susc. |
| 0 - 4 | 33 | 0 | 33 | 100.0 | 0 | 13 | 39.4 | 39.4 |
| 5 - 14 | 71 | 5 | 66 | 93.0 | 0 | 36 | 50.7 | 54.5 |
| 15 - 29 | 53 | 25 | 28 | 52.8 | 0 | 10 | 18.9 | 35.7 |
| 30+ | 83 | 60 | 23 | 27.7 | 0 | 1 | 1.2 | 4.3 |
| TOTAL | 240 | 90 | 150 | 62.5 | 0 | 60 | 25.0 | 40.0 |

TABLE 1B. VARIOLA MINOR IN CAMPO ALEGRE MUNICIPIO OF SANTOS DUMONT - MINAS GERAIS DECEMBER 1968 - OCTOBER 1969

| Age Group | Population | | | | No. of cases | | Attack rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | Total | Non-Susc* | Susc. | % Susc. | Non-Susc* | Susc. | Total | Susc. |
| 0 - 4 | 33 | 2 | 31 | 93.9 | 0 | 16 | 48.5 | 51.6 |
| 5 - 14 | 95 | 34 | 61 | 64.2 | 1 | 44 | 47.4 | 72.1 |
| 15 - 29 | 46 | 30 | 16 | 34.8 | 0 | 7 | 15.2 | 43.7 |
| 30+ | 98 | 82 | 16 | 16.3 | 0 | 6 | 6.1 | 37.5 |
| TOTAL | 272 | 148 | 124 | 45.6 | 1 | 73 | 27.2 | 58.9 |

*Persons with vaccination scar or history of smallpox

TABLE 2. SMALLPOX ATTACK RATES BY AGE GROUP AND SUSCEPTIBILITY IN HOUSEHOLDS WITH AT LEAST ONE CASE

A. PIRAPITINGA (20 HOUSEHOLDS)

| Age group | No. of residents | | No. of cases | Attack rate (%) | |
|---|---|---|---|---|---|
| | Total | Susc. | | Total | Susc. |
| 0 - 4 | 17 | 17 | 13 | 76.5 | 76.5 |
| 5 - 14 | 50 | 50 | 36 | 72.0 | 72.0 |
| 15 - 29 | 24 | 16 | 10 | 41.7 | 62.5 |
| 30+ | 32 | 9 | 1 | 3.2 | 11.1 |
| TOTAL | 123 | 92 | 60 | 44.7 | 59.8 |

B. CAMPO ALEGRE (24 HOUSEHOLDS)

| Age group | No. of residents | | No. of cases | Attack rate (%) | |
|---|---|---|---|---|---|
| | Total | Susc. | | Total | Susc. |
| 0 - 4 | 23 | 23 | 16 | 69.6 | 69.6 |
| 5 - 14 | 56 | 48 | 45* | 80.3 | 91.7 |
| 15 - 29 | 23 | 11 | 7 | 30.4 | 63.6 |
| 30+ | 42 | 10 | 6 | 14.3 | 60.0 |
| TOTAL | 144 | 92 | 74* | 51.4 | 79.3 |

*Includes one case in a six-year old female successfully vaccinated in 1964

TABLE 3. VARIOLA MINOR - CAMPO ALEGRE
ATTACK RATES BY HISTORY OF SMALLPOX AND VACCINATION STATUS IN 24 HOUSEHOLDS WITH ONE OR MORE CASES PER HOUSEHOLD

| History of smallpox | Vaccination status | No. of persons | No. of cases | Attack rate (%) |
|---|---|---|---|---|
| Previous smallpox | Vaccinated | 0 | 0 | 0.0 |
| | Not vaccinated | 33 | 0 | 0.0 |
| No previous smallpox | Vaccinated | 19 | 1 | 5.3 |
| | Not vaccinated | 92 | 73 | 79.3 |
| TOTAL | | 144 | 74 | 51.4 |

TABLE 4. PERCENTAGE OF POPULATION SUSCEPTIBLE BY AGE GROUP IN HOUSEHOLDS WITH AND WITHOUT SMALLPOX

A. PIRAPITINGA

| Age group | Households with smallpox (20) | | | Households without smallpox (36) | | |
|---|---|---|---|---|---|---|
| | Pop. | Susc. | % Susc.(1) | Pop. | Susc. | % Susc.(2) |
| 0 - 4 | 17 | 17 | 100.0 | 16 | 16 | 100.0 |
| 5 - 14 | 50 | 50 | 100.0 | 21 | 16 | 76.2 |
| 15 - 29 | 24 | 16 | 66.7 | 29 | 12 | 41.4 |
| 30+ | 32 | 9 | 28.1 | 51 | 14 | 29.5 |
| TOTAL | 123 | 92 | 74.8 | 117 | 58 | 49.6 |

B. CAMPO ALEGRE

| Age group | Households with smallpox (20) | | | Households without smallpox (36) | | |
|---|---|---|---|---|---|---|
| | Pop. | Susc. | % Susc.(1) | Pop. | Susc. | % Susc.(2) |
| 0 - 4 | 23 | 23 | 100.0 | 10 | 8 | 80.0 |
| 5 - 14 | 56 | 48 | 85.7 | 39 | 13 | 33.3 |
| 15 - 29 | 23 | 11 | 47.8 | 23 | 5 | 21.7 |
| 30+ | 42 | 10 | 23.8 | 56 | 6 | 10.7 |
| TOTAL | 144 | 92 | 63.9 | 128 | 32 | 25.0 |

TABLE 5. CHARACTERISTICS OF HOUSEHOLDS WITH AND WITHOUT SMALLPOX PIRAPITINGA (P) AND CAMPO ALEGRE (CA)

| | (1) Households with smallpox | | (2) Households without smallpox | |
|---|---|---|---|---|
| | P | CA | P | CA |
| No. of residents | 123 | 144 | 117 | 128 |
| No. of households | 20 | 24 | 36 | 36 |
| Residents/households | 6.2 | 6.0 | 3.2 | 3.6 |
| No. of susceptibles | 92 | 92 | 58 | 32 |
| Susceptibles/residents | 74.8 | 63.9 | 49.6 | 25.0 |
| No. <15 years | 67 | 79 | 37 | 49 |
| < 15 years/household | 3.4 | 3.3 | 1.0 | 1.4 |
| < 15 years/residents (%) | 54.5 | 54.9 | 31.6 | 38.3 |

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FIG. 1
SMALLPOX CASES BY MONTH OF ONSET CAMPO ALEGRE (MG), BRAZIL
NOVEMBER 1968 - OCTOBER 1969

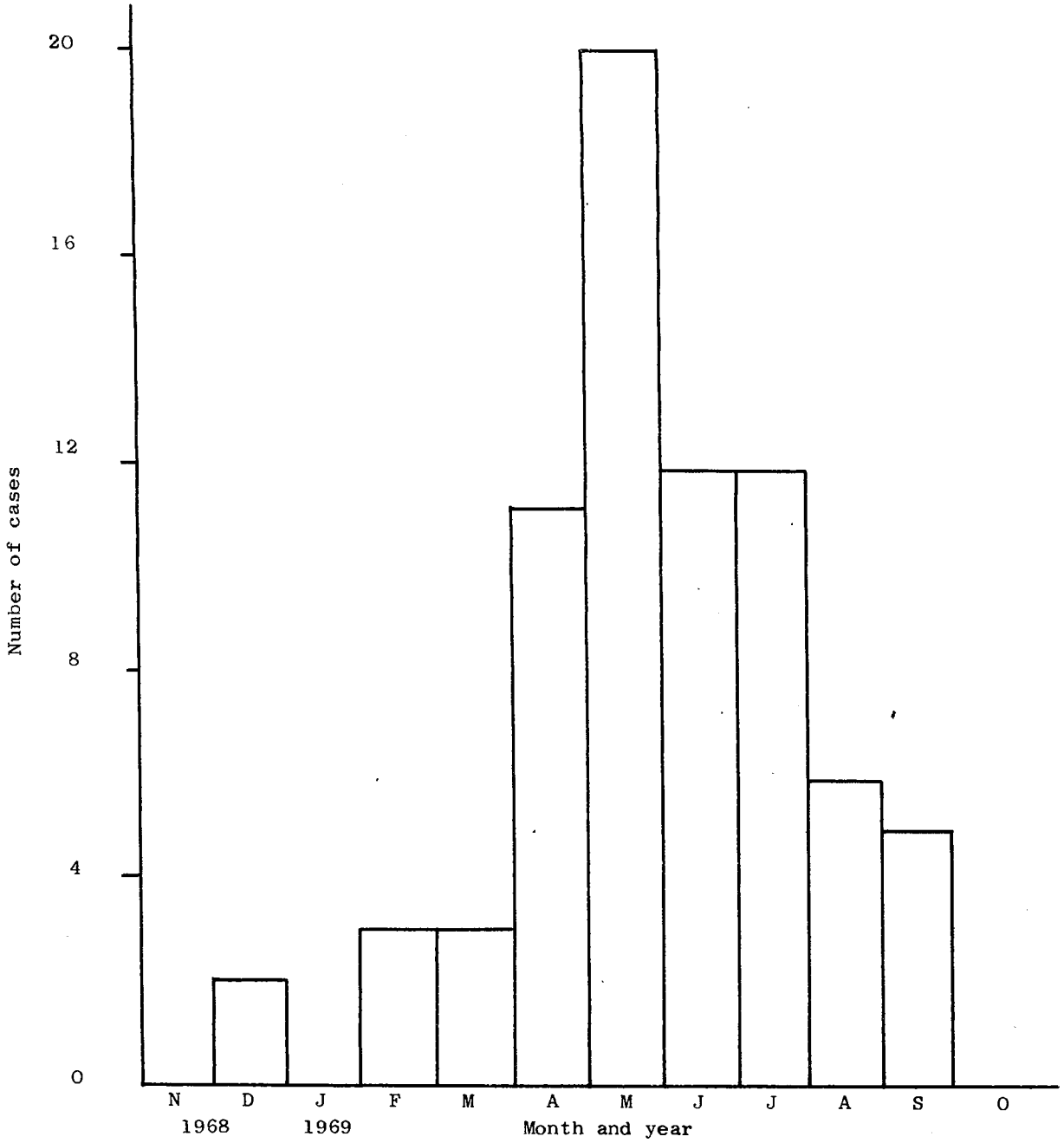

FIG. 2
SMALLPOX CASES BY WEEK OF ONSET PIRAPITINGA (MG), BRAZIL
JUNE - AUGUST 1969