The Risks of an Accidental Introduction and/or Transfer of Plague: Conditions prevalent in the East African Ports of Tanga and Mombasa

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SUMMARY

Rodents were trapped at Tanga and Mombasa seaports. Bacteriological, bio- logical and serological tests were performed on the captured animals. 22.6% of the rodents caught at Tanga had significant antibody levels for plague. Only 1.9% of the rodents trapped at Mombasa seaport were serologically positive for the disease. The above findings were discussed in the light of the presently applied anti rodents and antiplague measures and the conclusion was reached that the disease could be carried through the East African seaports. A stricter adherence to the International Health Regulations by the Shipping Companies would be desirable

INTRODUCTION

Plague is primarily a zoonosis in which man becomes accidentally involved. Several species of fleas have been shown to be efficient vectors of the disease (Hirst, 1923; Pollitzer, 1954; Msangi, 1975), transmitting it in sylvatic rodent population without affecting man. The disease remains enzootic in tolerant/resistant rodent species until such factors as the changed virulence of Yersinia pestis (aetiological agent of plague), the increase in susceptible rodent populations or creation of favourable ambient climatic/ecological conditions induce epizootics. During such epizootics semi-domestic rodents bring the disease into domestic surroundings, Alternatively the disease may be acquired by direct contagion. Plague may also appear in human populations through importation of infected materials (Spurrier 1907; Hirst, 1923; Wilcocks, 1944).

Since the first plague pandemic of Justinian time (542 A.D.), it has been observed that seaports play major role in the spread of the disease from one country to another (Pollitzer, 1954). The second plague pandemic of 14th Century (commonly known as Black Death) is believed to have originated from Central Asia and spread into Europe as rapidly as the transport of those days permitted. After the second pandemic, autochthonous plague ceased to exist in Europe and many parts of Asia but occasional outbreaks due to importation of the infection continued to occur. Thus even though France had become free from the disease by 1668, an epidemic, believed to have been due to importation from Syria took place at Marseilles in 1720 (Gibbon, quoted by Pollitzer, 1954).

In North Africa, plague reappeared in 1899 at the port of Alexandria (Egypt) due to its probable importation from South East Asia (Pollitzer, 1954), In East Africa too, the disease is thought to have been introduced from Central Asia by land and sea routes (Msangi, 1975), Mombasa experienced an outbreak of plague in 1697 through its alleged importation from Arabia (Roberts, 1935). In 1905, an outbreak of the disease in Zanzibar (Tanzania) was traced to be due to contaminated cargo of rice brought by "S.S. Sultan" on her voyage from Bombay to Durban (Spurrier, 1907).
In South Africa plague was first registered in ports around 1899 and was thought to be imported on ships with rats from Latin America and Far East (Varshavsky, Kozakevich & Lavrovsky, 1975). Also cases of imported plague during recent times give a clear indication of the existing

possibility of exporting this disease from one country to another. Thus in 1970 there was an imported case of bubonic plague in France and in June 1973 a similar case occured in U.S.A. (Akiev, 1975).

There has been a steady reduction in plague morbidity and since June 1958 plague cases have not been registered in any seaport of the world (Akiev, 1974). Due to this, the Public Health Workers do often lower their guard, a fact which can result in unexpected and undesirable consequences. Outbreaks of bubonic plague in countries where it was not registered for a long time evidence the danger of renewed epidemics (Akiev, 1974). Moreover the ever increasing transportation of goods and the frequency with which people travel between countries and continents has increased the risk of harmful insect vectors and rodents getting transported from one country to another. With the introduction of supersonic air transportation, the rate and speed by which the disease could be spread internationally has been increased tremendously.

Along with epidemiological survey of plague, the prevention of possible importation of the disease from other countries is very vital (WHO, 1972; Akiev, 1975). Preventive measures can only be applied successfully if the extent of present situation is known. This study is the first of a series of investigations to be carried out in several East African ports in order to assess the risk of accidental transmission of the disease to or from East Africa and hence the necessity of involving such ports in control campaigns.

MATERIAL AND METHODS

Location of the ports studied

Investigations were conducted at Tanga (Tanzania) and Mombasa (Kenya) seaports. Tanga port is situated on the western shores of Tanga Bay in Latitude 5^0 04'S and Longitude 39^0 08'E (approx.). It is a well sheltered, natural harbour and is linked with railway line to Dar es Salaam, Western and Northern Tanzania including Kigoma, Mwanza, Kilimanjaro and Arusha regions. The average annual traffic of sea vessels at Tanga port is about 350 cargo ships. Main export commodities are coffee beans, tea, cardamons, timber, wattle extract, pyrethrum, sisal, cocoa beans and soya beans while the imports are general cargo, machinery spares, cornmeal, wheat, tallow, chemicals, auto spares, match splint, fertilizer, jute gunnies and bulgar wheat. Annual capacity of handling dry cargo is 750,000 tons.

Mombasa port, which is situated in Latitude 4^0 40'S and Longitude 39^0 40'E, comprises of two harbours. Mombasa old harbour is on the east side of the Mombasa island while Kilindini harbour is on the south-west of the island. The former harbour is only used by dhows, small coasting vessels and cement carrying vessels. Both harbours are well sheltered by natural formation of coast and by outlaying reefs. They are linked by a railway line into the hinterland as far as Taveta and Tanzania in south-east, Magadi in south, Nanyuki in north, Kitale, Kisumu, Eldoret and Uganda in the West. The average annual traffic at Mombasa port is about 1700 cargo and passenger ships. Main export commodities are raw cotton, raw coffee, tea, sugar, sisal, cassava, copra, ivory, pyrethrum, timber and tyres while the imports are general cargo, machinery spares, automobiles, auto spares, petroleum, fancy goods, rice and wheat. Annual capacity of handling dry cargo is 2.1 million tons.

Trapping

Three types of traps were used: box, Chauvancy and spring door (Kilonzo, 1976). Live trapping of rodents was carried out for 12 days in the month of March 1976 and for 13 days in July 1976 at Tanga and Mombasa ports respectively. The trapping covered export and import sheds,

workshops, offices, stores, open grass compounds and cargo ships at the harbours. The traps were baited with either oats, dry fish, cashewnuts or fruits. They were set before noon and checked early in the morning the following day. The trapped rodents were anaesthetised with ether, identified and recorded. All the flea ectoparasites were removed and preserved in 70% alcohol.

Laboratory Techniques

Cardiac blood was taken from each of the captured animals in an equal volume of normal saline containing a trace of sodium azide (1:80,000). The blood was allowed to clot at room temperature (about 29°C) in order to separate serum which was then preserved at +4°c for plague serology. The rodents were examined post mortem and impression smears of heart, spleen, liver, lungs, axillary and inguinal lymph nodes were made. Bits of these organs were removed and preserved in Broquet's solution (Baltazard et al., 1956) at 4°C. The impression smears were fixed with ether:methanol (1:1) for at least 60 minutes and stained with 2% methylene blue for bipolarity. The flea ectoparasites were processed using the techniques of Scott and Borom (not dated). The rodent organs were pooled into groups each made up of organs of up to five animals of the same species and locality.

Each of such pools was macerated in 2 to 3 ml of sterile nutrient broth. A total of 1 ml of each macerate was inoculated into two experimental albino mice (0.5 ml each) subcutaneously. 2 to 3 drops of the same macerate was also inoculated percutaneously on two more mice of the same type. The inoculated animals were examined daily and any external signs of the disease were noted. All the animals which died during incubation peri- od (14 days) were examined and pathological manifestations (e.g. lymphadenitis, congestion of spleen, oedema, hepatomegaly etc.) noted. All the surviving mice at the end of the incubation period were killed and the autopsy on them performed.

Impression smears of their organs were prepared, fixed and stained as mentioned earlier. Organs from each group were aseptically macerated as before and the mace- rates were separately inoculated on Deoxycholate Citrate Agar plates which were then incubated at 28°C for up to 48 hours. Suspicious colonies which consisted of bipolar (methylene blue stain), Gram negative coccobacilli were subcultured in beef heart infusion broth. The inoculated broth was incubated at 37°C for 48 hours. Bacteriophage, colour differentiating medium, sugar fermentation, urea, methyl-red, Voges-Proskauer, indole, Kligler's iron agar and motility tests were performed with organisms from the broth medium, using standard techniques (Cowan, 1974; Hahmanyar & Cavanaugh, 1976).

Rodent sera were sent to the WHO Plague Reference Centre in Stavropol - USSR for Indirect haemagglutination and Antigen-neutralisation tests for detection of plague antibodies.

RESULTS

A total of 53 rodents were trapped from the Tanga port area and none from the ships. Of these, 22 were *Rattus rattus*, 22 were *Rattus norvegicus*, 7 were *Mus musculus* and 2 were *Praomys natalensis* (table 1). The relative abundance of rodent calculated according to the formula of Bahmanyar & Cavanaugh (1976), was 11.3%. 30 fleas of which 29 were identified as *Xenopsylla cheopis* and 1 as *Xenopsylla brasiliensis* were collected from the trapped rodents.

At Tanga seaport, *R. rattus* and *R. norvegicus* were the only rodent species which harboured fleas and their flea indices were 3.5 and 2 respectively (table 1). Impression smears of the rodents did not reveal presence of bipolar organisms. Biological and bacteriological analyses

of the rodent organs were negative for plague. From the 53 rodents captured at Tanga, 12(22.6%) had specific antibodies for plague as detected by indirect heamagglutination test and/or antigen neutralisation test. Of the seropositive animals, 8 were *R. rattus*, 3 were *R. norvegicus* and 1 was *P. natalensis*. Their antibody titres ranged from a minimum of 1:40 to a maximum of 1:1280 (table 2).

Table 1. No. of fleas and infested flea indices of rodents trapped at Tanga seaport.

Rodent Species	No. of rodents caught	No. of rodents infested	No. of *X. cheopis*	No. of *X. brasiliensis*	Total No. of fleas	Infested flea index
R. rattus	22	4	14	-	14	3.5
R. norvegicus	22	8	15	1	16	2
M. musculus	7	-	-	-	-	-
P. natalensis	2	-	-	-	-	-
Total	53	12	29	1	30	2.5

98 rodents were trapped from the Kilindini harbour area and none from the Mombasa Old harbour. A total of 3 rodents were captured from 2 ships which were alongside the quay at the Kilindini harbour. Majority of the trapped rodents were *R. rattus* (63), the rest comprising of several species as shown in table 3. 212 fleas of which 211 were identified as *X. cheopis* and 1 as *X. brasiliensis* were collected from these rodents. All the rodent species harboured fleas except *M. musculus*. The infested flea indices of these rodents are shown in table 3. The relative abundance of rodents at Kilindini harbour was 13.4%. Of the rodents caught on the ships, 2 were *M. musculus* and 1 was *R. rattus*. None of these carried any fleas. Impression smears of the rodents did not reveal presence of bipolar organisms. Biological and bacteriological analyses of the rodent organs were not performed. From the 101 rodents trapped at Mombasa seaport, 2(1.98%) were seropositive for plague i.e. a *R. rattus* with an antibody titre of 1:160 and a *R. nervegicus* with an antibody titre of 1:80 (table 2).

DISCUSSION

a) Rodents in the East African ports

Presence of rodents in the surveyed harbours can be attributed to many factors. Most of the sheds at the ports were not rodent proof. Several rodent burrows were found in and around the sheds. Open grass compounds used for dumping broken wooden crates, tarpaulins and metal parts, partly covered by grass, provided an ideal nest-

Table 2. Results of serological analysis of rodent sera.

Area of study	No. of rodents	Rodent species	Titre of Serological tests IHA	AgN
Tanga seaport	8	*R.rattus*	-*	1:80
			1:160	1:160
			1:80	-
			1:80	1:80
			1:160	-
			1:640	1:1280
			1:80	-
			1:640	-
	3	*R.norvegicus*	1:40	1:40
			1:60	-
			1:80	1:80
	1	*P.natalensis*	-	1:80
Mombasa seaport	1	*R.rattus*	1:160	-
	1	*R.norvegicus*	1:80	-

-* not done due to insufficient serum.

Table 3. No of fleas and infested flea indices of rodents trapped at Mombasa seaport.

Rodent species	No. of rodents caught	No. of rodents infested	No. of *X.cheopis*	No. of *X. brasiliensis*	Total No of fleas	Infested flea index
R.rattus	64	36	184	-	184	5.1
R.norvegicus	9	5	13	-	13	2.6
P.natalensis	7	3	9	1	10	3.3
M.musculus	7	-	-	-	-	-
Otomys sp. *	11	1	1	-	1	1
Acomys sp. *	3	1	4	-	4	4
Total	101	46	211	1	212	4.6

* await indentification up to species level.

ing area for field rodents. The generous scattering of grains and other edible commodities seemed to support large population of rodents. At the time of survey, rodent control measures were not being taken by the Tanga port authorities. The Mombasa port authorities controlled the rodents both by application of rodenticides and by killing the rodents with break-neck traps. The failure to capture any animals from the Mombasa Old harbour is probably attributable to the regular and liberal use of rodenticides and to the fact that the relatively small area of the harbour made such rodent control easy and successful.

Out of the 24 ships in which trapping was done, masters of 10 ships (41.6%) failed to produce either valid Derating Certificates or Derating Exemption Certificates. Moreover they confessed that rodent control measures were not being taken in their ships. Absence of such measures can partly explain the infestation of some ships with rats. Measures taken to control rodents in the remaining ships varied. Some used "Warfarin", others preferred to use wheat baits containing acute poisons, while still others were using trapping methods.

b) Transmission of disease by Rodents

In the past many authors have indicated that *R. rattus* and *P. natalensis* play a key role in the causation of human plague epidemics in East Africa (Davis, 1953; Msangi, 1975). The observations that 9(10.4%) of *R. rattus* and 1(11.1%) of *P. natalensis* caught during these studies contained specific, plague antibodies and that the two species had comparatively high flea indices (table 1 & 3) partly support such reports. *R. norvegicus* which is mostly found along the East African Coast (Davis, Heisch, McNeill and Meyer, 1968) has not been incriminated for plague transmission in the area though it has been found to be involved in the transmission of the disease in China, India, Burma, Khmer Republic and South Viet-Nam (Bytchenko, 1976). Some workers claim that *R. norvegicus* is a less important host of plague than *R. rattus* - which partly explains disappearance of Black Death from West Europe (Pollitzer, 1954). Whatever the case may be, the fact that *R. norvegicus* was found to be infested with the same species of efficient flea vectors (*X. cheopis*) as *R. rattus* and that 4 (13%) of the captured *R. norvegicus* were seropositive for plague indicate the signficance of this rodent as a possible plague reservoir in the urban areas of East African coast. All the 14 rodents of genera *Otomys* (11) and *Acomys* (3), captured from Kilindini harbour, lacked antibodies for plague. This however, does not rule out their possible importance in plague tramsission as these rodents harboured efficient flea vector *X. cheopis*. Moreover in Kenya, members of these genera were found to be seropositive for plague (Davis *et al.*, 1968).

c) The port and its inland

The disease has not been known to be endemic in Tanga region nor has there been any recorded case of plague in the past. However, Tanga is linked by railway and roads to several regions including Kilimanjaro and Arusha, both of which have endemic foci of sylvatic plague. The 22.6% positivity in the rodents collected from Tanga seaport might have been due to importation of the disease through infected fleas and/or rodents brought by railway or land-routes from such endemic areas.

d) The past outbreaks of plague in the East African ports

In 1697 Mombasa had an outbreak of plague which lasted for 33 months (Roberts, 1935). After that, sporadic cases of the disease continued to occur in the years 1912, during the first World War, 1928, 1930 and 1941. In 1920 there was even an epidemic of the disease (Davis *et al.*, 1968). Since 1941 cases of plague have not been registered in Mombasa but a serological survey of rodents, carried out in 1966 by Davis and his colleagues (1968), revealed that the infection still continued there. Detection of plague specific antibodies in 2 rodents, caught from Mombasa port during these studies, indicates that the infection still persists there.

e) The port facilities

Since Tanga port does not have deep water berth facilities large, ocean vessels have to be anchored in the sea, away from the quay. This would make rodent transfer from the shore to the ship or vice versa quite difficult. This can partly explain the absence of rats in ships examined at this port. However, personal communication with the harbour workers indicated that rodents could be carried with goods transferred through barges from ships to the shore or vice versa.

Most of the ships calling at Mombasa port (especially Kilindini harbour) can be accommodated alongside the quay. This would normally facilitate rodent transfer except that all the ships examined at the port were found to have ratguards on their mooring ropes, thus making it impossible for the rodents to get onto or out of the ships along such ropes. Presence of rodents in some of the ships checked can however be ascribed to their transfer during and through the loading and unloading of goods.

f) The role of ships in the spreading of plague

The possibility that some of the rodents caught in ships and in port areas had been imported from some other places where the ships had anchored previously cannot be avoided. In fact it was learned that ports in U.S.A., Indonesia and Indo-China had plenty of rats (McCaffery, Abarquez and Ek van Usk, 1976 - personal communication). This was thought to be attributed to the fact that the wooden sheds in most of U.S.A. ports as well as export commodities like wheat (U.S.A.) and copra (U.S.A., Indonesia and Indo-China) encouraged large rodent populations. It is to be noted that plague is endemic in all the above countries and hence the possibility that ships from such countries could be contaminated with plague-infected materials cannot be overlooked.

Article 54 of the International Health Regulations of 1971, administered by the World Health Organization, requires every ship to be permanently kept in a rodent and plague vector free condition or if not, be periodically derated (WHO, 1972). These studies revealed that this regulation was not followed strictly. On disussing the issue with Captains and/or Chief Mates of all the ships it was felt that due to heavy expenses incurred and the time lost in derating ships, masters of ships were reluctant to carry out such operations unless the port health authorities took stringent measures to ships without valid Derating Certificates or Derating Exemption Certificates. The lack of such certificates on 10 ships indicated the relaxed attitude of port health authorities.

In conclusion it is felt that the above attitude of the authorities concerned together with lack of control measures on rodent and flea populations could provide ample opportunities of an accidental transfer of plague into or out of East Africa. This is supported by the findings that 26% of Rodents caught in Tanga and 1.9% of those caught in Mombasa had a significant antibody level for plague. A stricter adherence to the International Health Regulations by the Shipping Companies would be desirable.

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