

this century, perhaps brought in by migrant tribes or remaining active in isolated spots.

According to the reports reaching the World Health Organization (20), Abyssinia had 2,860 cases in 1950. The number of annually reported instances increased to 7,499 in 1953 and 8,760 in 1959, with a low of 2,760 in 1961. The number increased to 5,971 in 1964 and came to 3,729 in 1968. All provinces are infected at present (1969-1970) and the number of reported cases has not been below 2,760 in any year between 1950 and 1968.

The Sudan had less than 100 cases per year until 1953, then very few until 1967 when 70 instances were reported, and 1,948 in 1968. This has to be considered a veritable epidemic. All five provinces of the Sudan are now infected.

Developments in the Chad followed the opposite path. A few hundred cases were reported in 1950 and 1951, less than 100 in 1952 and 1953, very few in 1959, then none. Fig. 27 shows the fluctuations in the number of cases reported to the World Health Organization on a logarithmic scale. It has to be remembered that only louse-borne but not tick-borne cases are reported according to the International Sanitary Regulations now in force (379).

The great number of cases in Ethiopia and the Sudan deserve further attention.

Bryceson *et al.* (127) pointed out that the Abyssinian highlands are cold, principally during the local winter (June-September), where agent, vector, and susceptible host coincide. There are numerous susceptible seasonal laborers and job-seekers coming to Addis Ababa and its environs. Historically, the war between the Mahdists and Christians on the Ethiopian Plateau in the 1880's is of interest. Few of the defeated Mahdists moved away but there was an exodus for religious reasons to Chad in 1894. Chad is on the pilgrimage path from West Africa to Mecca, as well as on the trade route from North Africa. When the followers of Rabih Zuhair were defeated in 1900, they moved probably along the latter trail to Fezzan, Algeria, and Tunisia (127). According to these authors relapsing fever was first diagnosed in the Adua and Axum outbreaks in 1918. Italian physicians in Ethiopia and British troops faced the disease during the war (646). Ethiopian out-

breaks have been recorded by several writers (156, 607, 608, 661, 664, 736), as well as the export of the disease to Kenya (296) and its movement from and to the Sudan (411). Sparrow (664) and Bryceson *et al.* (127) consider Ethiopia a highly important epidemic focus, with about 1,000 cases and 5% mortality per year in Addis Ababa. Relapsing fever in Ethiopia is at home also in the South-West Highlands especially among seasonal coffee bean pickers, along the railroad from the Red Sea Coast, and in the lowlands of Jijiga, where the tick-borne form is also present.

Whereas *B. hispanica*, an Eastasian tick, followed the route of the Moslem Conquest to the West, *B. recurrentis*, probably of African origin, spread by war and migration to all parts of the world except Australia, New Zealand, and Polynesia. Tick-borne borreliæ have become louse-adapted in the laboratory but have not mutated into the epidemic strain. Lice do not transmit borreliæ to their progeny by the transovarian (hereditary) route, which is contrary to most *Borrelia*-bearing ticks. Each vector-louse has to be infested individually, and less than 20% of the lice fed on patients are able to transmit the disease. The presence of infected man or some other, hitherto unknown reservoir appears to be a *conditio sine qua non* for the maintenance of relapsing fever caused by the epidemic strain, *B. recurrentis*, or else tick-borne borreliæ mutate into a louse-borne type by a hitherto undiscovered mechanism. The continuity of louse-borne relapsing fever, demonstrated by Bryceson *et al.* (127), certainly speaks in favor of contiguous and continuous man-to-man transmission, while *O. moubata* and lice feeding on the same persons in Africa yet offer food for thought and consideration along another course.

Endemic Relapsing Fever

Endemic relapsing fever is tick-borne. Its ecology coincides with that of *Ornithodoros* species carrying human pathogenic borreliæ. The occurrence of this type of relapsing fever also depends on the frequency of contact between man and arthropod. Man and *Ornithodoros* meet according to the life habits of the species involved. *O. moubata*, dwelling in huts inhabited by man, will have a greater and more frequent opportunity to feed on him and transfer bor-

reliae to man than will *O. parkeri*, which avoids human abodes. Man may, however, invade the habitats of the tick as a temporary visitor (hunter, vacationer, soldier, and so forth), or as a permanent resident when new lands are opened for cultivation and new roads are built.

Tick-borne relapsing fever is usually at home within the 24°C summer isotherm (471). *Ornithodoros* do not live in the monsoon and rain forests. They occur in semi-desert areas, but man seldom goes there. In colder climates these arthropods are active only during the warm season, but all year around in the tropics. The feeding time of the nymphs and adult ticks usually coincides with the period when relapsing fever is most frequent. In the Kashmir, however, ticks breed during the winter, but relapsing fever is most frequent in the summer (394) when man more often invades the habitats of ticks.

Lice have to be crushed to transfer *Borrelia*. They die as a result of such an injury and thus can infect only one person. However, ticks do not have to be damaged to transfer the borreliae they carry. A single *Ornithodoros* may infect a different person or animal at each feeding. Adult ticks usually transfer borreliae through their coxal fluid, which is excreted during or after feeding. Some ticks, especially young specimens and developmental forms, may transmit borreliae with their bite. Since ticks do not move far from their burrows, they infect only man and animals that enter their limited area. Some *Ornithodoros*, as *O. moubata*, seldom move farther than about 20 meters under their own power. However, they can be carried by man or animals to new locations and may originate new endemic foci but not epidemics.

At present, the best known foci of tick-borne relapsing fever are in Northwest and West Iran (591), in the desert-steppe regions of Central Asia (564), in Azerbeidjan principally on the Aspheron Peninsula (39, 585), in Soviet Georgia (746), Southwest Turkestan (586), Turkmenia (566), Kazakhstan (651), Uzbekistan (657), along the Southwest Littoral of the Mediterranean (686), in the Arab countries (36), Israel (253), Kenya, Tanzania, and Uganda (303), South Africa (556), the Kashmir (600), in the Western part of the United States (69, 740), especially in Oklahoma (274), Kansas (183), Texas (195, 722), Oregon (218,

283, 356), and California (70, 652).^{*} Only scattered cases have been reported in the United States with the exception of an incident involving a small scout troop which visited a cave infested with *O. turicata* in Kansas (U.S. Communicable Diseases Center report). Several other occurrences of tick-borne relapsing fever were discussed in the chapter on *Ornithodoros* and the borreliae carried by them.

Reports from South America are meager. Marinkelle and Grose (474) isolated an unidentified *Borrelia* species from a bat (*Natalus tumidirostris*) in the large Macaregue cave near San Gil, in Colombia. This indicates that borreliosis is still present in that country. Vigors Earle (705) reported tick-borne relapsing fever in Ecuador, Colombia, and Venezuela.

An interesting summary of the relationship of the types of human habitations to the tick population was published by Walton (715). In regions where ticks are not infested in large numbers, the infection may be smoldering. An example is Madagascar, where *B. duttoni* is maintained by transovarian passage in relatively few individual *O. moubata* (189, 517). In Panama, the proportion of *Borrelia*-infested ticks may not have changed recently, but since canvas cots are replacing the old board or bamboo beds the ticks have been deprived of their hiding places, which has resulted in a lower infection rate in man (182).

As stated, soldiers, hunters, laborers, and tourists entering tick-infested areas are frequent victims of relapsing fever (137, 182). Local inhabitants of endemic areas may have acquired a certain degree of immunity during childhood (73). Therefore, it is principally the newcomer who becomes ill in such regions (705). This was the case in Cyprus during World War II where tick-borne *Borrelia* infestations were discovered also in local miners (291, 738). Tick-borne relapsing fever appeared in 41 soldiers entering native huts in Transvaal (492), in troops and travelers moving along tick-infested roads in Madagascar (189, 430), in the caravanserais of Iran (245, 739), and in the mountains of California where hunters and vacationers had used abandoned huts often infested with ticks (729). An episode of tick-borne relapsing fever

^{*}Thompson *et al.* (J.A.M.A., 210:1045, 1969) recently called attention to tick-borne relapsing fever also in the State of Washington.

