mature cells, and so a greater shift left. The sedimentation test is of no diagnostic importance, but gives an indication of the activity of certain diseases. For instance, in known tuberculosis or rheumatic fever sedimentation tests aid in deciding when the patients may be allowed more activity. Hematocrite determinations on the blood when taken in conjunction with the blood count give the volume of the erythrocytes and the degree of hydration of the blood.

SUMMARY

Many of the variations from the normal hæmatology of infants and children have been illustrated. It is hoped that this discussion will assist the clinician in interpreting laboratory findings.

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VECTORS OF RELAPSING FEVER IN RELATION TO AN OUTBREAK OF THE DISEASE IN BRITISH COLUMBIA

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A MOST interesting outbreak of relapsing fever occurring in the Kootenay district of British Columbia has recently been recorded by Palmer and Crawford.[16] While this constitutes the first record of the disease in Canada, it has been known for some time in various parts of the United States and has a very wide distribution in other parts of the world, particularly in tropical and sub-tropical regions. The most severe form is found in Africa and India, where the disease is of very common occurrence. In Europe and North America it is usually much milder in form, although serious epidemics have sometimes developed during and following European wars. Various workers have described a number of spirochætes as being responsible for relapsing fevers, but some of the highest authorities, including Wenyon, consider that they are strains of a single species, *Spirochæta* (*Treponema,* etc.) *recurrentis* Lebert. The American form has been discussed by many authors as *Sp. novyi.*

The spirochætes are transmitted by several blood-sucking arthropods, and it is with the insect and tick vectors that we are especially concerned in these notes. In the European epidemics, human lice, and particularly the body louse, *Pediculus humanus corporis* de Geer, are known to be the main transmitting agents and occasional outbreaks in North America have been traced to this source. Bedbugs, *Cimex lectularius* L., have been incriminated, but are generally considered to be of slight importance as vectors. The most important of the transmitting agents are undoubtedly various species of Argasine ticks of the genus *Ornithodorus.* The genus consists of some 13 species and of these at least 7 have been cited as vectors of relapsing fever in widespread areas in Africa, Asia and the Americas. Furthermore, certain species, such as the African hut tick, *Ornithodorus moubata* Murray, have been proved by Dutton and Todd[7] to be infective for life, sometimes as long as three years, and by Möllers (1907) to be capable of passing on the organism through the ova for at least three generations. In general, these ticks resemble bedbugs in their habits, feeding nocturnally, and (in the later stages) for only short periods of less than an hour, instead of becoming attached for days, as

do the members of the family Ixodidæ. In the day time they hide away in cracks and crevices. The larvæ of American forms remain attached to their hosts for several days while becoming replete. Species known to occur in the south-western United States are *Ornithodorus talaje* Guérin-Men., *O. turicata* Duges, *O. coriaceus* Koch and *O. megnini* Duges. The first two have been implicated as vectors of relapsing fever by Bates, Dunn[2] and others. Nothing is known of *coriaceus* as a vector, and *megnini,* the spinose ear tick of cattle, may be dismissed in this respect, because of its very different life history and habits, although Doflein (1911) has indicated that it is capable of such a rôle. All of these species occur in California and *talaje* and *turicata* have been recorded from Texas and the latter also from Arizona (Banks[1]).

Palmer and Crawford (*loc. cit.*) advance the hypothesis that the vector involved in the British Columbia outbreak of relapsing fever is the common "wood tick", *Dermacentor andersoni* Stiles. They state that, "It is our belief that in the cases which are now reported the wood tick has been the vector. It is confidently expected that more cases will appear this year, and we hope that, if such should happen to be the case, it will be possible definitely to prove or disprove this theory."

One of the major projects of the Dominion Entomological Laboratory at Kamloops, B.C., for several years has been a survey of the tick fauna of British Columbia, and much information has been accumulated as to the period of activity of various species of ticks. This information forces the writer to a different conclusion from that arrived at by Palmer and Crawford, since the time of onset of the cases cited is quite at variance with the period of adult activity of *D. andersoni,* and practically eliminates this tick as a possible vector in these particular cases. It should be noted that the incubation period of the disease is short and usually not over a week. In the six case histories given, the illness commenced on June 30, July 27, August 11, August 14, 1932, July 22, 1931 and August 13, 1930.

The season of activity of adult *D. andersoni,* during which attachment to man occurs, is rather well defined in the dry belt of British Columbia and is restricted to the first warm weather of the spring, and on, for a period seldom exceeding two and a half months. It usually commences in the last week of March, reaches a peak in April and recedes in May. The peak of activity in 1932 occurred about April 15 and the season was a normal one. During investigations extending over five years we have only on very rare occasions found adults of this species attached after the end of May. In Montana, according to Cooley,[3] the season may extend to the end of June. The last dates of attachment in our British Columbia records are: 1930, June 29, North Thompson Valley; 1931, July 14, South Okanagan; 1932, June 5, Eagle Valley; 1933, June 24, Nicola. The 1930, '31 and '32 records were from fairly high elevations. It should be stressed that these records are exceptional, being long after the main tick season was over. If *andersoni* was the vector, we should expect the disease to occur during or shortly following the main period of tick activity in April and May, but certainly not in July and August as in the case histories cited.

No other species of tick commonly attacking man are known to be plentiful in the Kootenay district, and Palmer and Crawford state that they have been able "with practical certainty to rule out the louse and bedbug as vectors". It would therefore seem to us to be extremely likely that one of the *Ornithodorus* vectors has become established in the district, rather than that a native species can be involved. There is much to support this possibility. With one recent exception,* only Argasine ticks have so far been incriminated definitely as vectors, and none of the Ixodidæ has been involved. Certain species of *Ornithodorus* are known to have become established far north of their normal range. The spinose ear tick of cattle, *Ornithodorus megnini* Duges, is particularly apt to be transported long distances, since, unlike other species of the genus, it remains attached to the host for very long periods. The main range of *megnini* in North America, according to Hooker, Bishopp and Wood,[11] is Mexico and the lower tier of the south-western United States, and sparsely to Oregon in the north, and from northern California east to Colorado. Like the other species of *Ornithodorus,* it is essentially a southern tick and yet it has become established and has adapted itself to conditions at least as

* Dr. R. R. Parker has brought to our attention Sergent's paper,[19] in which the dog tick, *Rhipicephalus sanguineus,* proved to be the vector in a case of relapsing fever in Algeria.

far north as Alberta. Hadwen[8] records it as having been taken at Lethbridge in October, 1912, and mentions that it was observed by veterinary inspectors some years before that. (See also Hewitt[10]). Professor E. H. Strickland, of the University of Alberta, has sent us specimens taken from jack rabbits at the same locality on December 22, 1931. Dr. R. A. Cooley (*loc. cit.* p. 19) indicates that this tick has been established in Montana for at least sixteen years. Dr. R. R. Parker,[17] of the U. S. Public Health Service tick laboratory, Hamilton, Montana, informs us that he has recently taken *O. turicata* at a mountain camp near Moscow, Idaho, and Dr. R. Matheson[12] has recorded a most interesting occurrence of *O. talaje* in north-eastern America. He states,[13] "Though this species is restricted to the tropical and sub-tropical regions, the author (1931) recorded a typical house infestation in western New York. Here the species has maintained itself for at least four years. Other tropical species may become established, temporarily at least, in our homes and act as agents in transmitting disease."

In the New York case, furniture appears to have been the vehicle for the ticks and doubtless personal effects, such as bed rolls, camping kit, etc., brought in by fishermen and other tourists from the south might be the means of introducing such species as *O. talaje* and *O. turicata* into British Columbia. Migratory birds would seem to us to be another source, and interesting examples of this possibility have been noted. Tick specimens, collected by Mr. A. R. Cummings from a golden-crowned sparrow, *Zonotrichia coronata,* at Vancouver, B.C., on May 2, 1932, and sent to Prof. George Spencer, who forwarded them to the writer for identification, proved to be the fowl tick, *Argas persicus* Oken. The main range of this species in North America (ref. 11, p. 48) is in Mexico and through the southern tier of the United States from California to Florida. The larval stage is the only one in which the tick remains for any length of time on the host, the period of engorgement being from five to six days, but occasionally as long as ten days. This would seem to give ample opportunity for infested migratory birds moving north to transport the ticks long distances. While the fowl tick is mainly known as a serious pest of poultry, it is also sometimes very annoying to man, and has even been cited as a transmitter of relapsing fever (Doflein, 1911), although this has been questioned by Nuttall[14] and his associates. It will be noted that this species and most of the Ornithodori have many habits and characteristics in common.

Perhaps one of the most interesting instances is that of an Ixodid tick, *Ixodes auritulus* Neumann, a species attacking birds, and originally known and described only from the most southerly tip of South America. Hadwen[9] recorded this tick from Queen Charlotte Islands, B.C., where it was taken on June 23, 1910, the hosts being the northern bald eagle, *Haliœetus leucocephalus alascanus* and the Queen Charlotte jay, *Cyanocitta stelleri carlottæ.* The specimens, a male, female and ten larvæ, were identified by Nuttall. (See also ref. 10, p. 227 and Nuttall[15]). This species has come to hand recently on several occasions during our present tick survey, and specimens in the collections at the Kamloops laboratory are from the song sparrow, *Melospiza melodia* (series of twenty-four nymphs taken at Victoria, B.C., July 25, 1932, by J. A. Munro); and from the sooty blue grouse, *Dendragopus obscurus fuliginosus* (one engorged female taken on Pender Island, B.C., by F. Kermode, in September, 1930; another female from S. Pender Island collected by A. R. Spalding on October 30, 1931; and a series of five females taken in the Gulf Islands, B.C., on September 27, 1932, by A. Bryan Williams). Mr. Kenneth Racey, through whose kindness we have secured many interesting tick records, has sent us two nymphs and an adult female from Oregon ruffed grouse, *Bonasa umbellus sabini,* taken at Tofino, V.I., on May 28, 1931. Philip[18] has recently recorded the taking of this species in Oregon on the house sparrow, *Passer domesticus,* this being the first record from the United States. It is evidently now well established in the coast district of British Columbia. Three of the hosts mentioned are resident birds with a very limited range of movement.

Most species of *Ornithodorus* do not appear to have very restrictive host preferences and doubtless also might be transported by migratory birds. Dunn[6] has shown in Panama that *O. talaje* has a remarkable diversity of hosts and will feed on human, mammalian, avian and reptilian blood. He found larvæ of both *O. talaje* and *O. venezuelensis* on chickens, and concluded that probably all domestic fowl may be accepted as hosts. Chicken roosts sometimes

become heavily infested with the former species. The larvæ remain attached for several days before becoming engorged, unlike the nymphs and adults, which feed rapidly after the manner of bedbugs.

Palmer and Crawford's six cases developed in private summer camps at three points along the Lower Arrow Lake. In our experience such cabins, usually utilized for only a short time in the summer for fishing and holiday purposes, almost invariably become the haunts of "pack-rats" (*Neotoma cinerea*). These rats are very plentiful in the less settled districts of the Kootenays, and as soon as a cabin is built they either make themselves at home under the floor or else nest in the proximity and have "the run of the house" by night. They almost invariably winter in vacant cabins, caves or crevices in rocky cliffs and in hollow trees. Their habits render them particularly liable to be important reservoirs of the spirochætes of relapsing fever, and also to act as suitable hosts for *Ornithodorus* ticks during the absence of human tenants. Chipmunks, mice and other rodents might also be factors. Dunn and Clark[5] have brought together considerable information on rats and a number of other mammals as reservoirs of spirochætes and as the possible source of human infections. The common brown rat, *Mus norvegicus,* is considered to be a particularly important disseminating agent in Panama. These authors state that, "Cases of relapsing fever have occurred from time to time in the United States. Several of these apparently acquired their infection while in isolated areas, which would indicate that naturally infected mammals may be concerned in the propagation and dissemination of the disease in the United States". Dunn[4] also, in discussing a house infestation by *O. talaje* in Panama, considered that rats were responsible for bringing in the ticks.

SUMMARY

An outbreak of relapsing fever recorded by Palmer and Crawford as the first occurring in Canada is discussed from the viewpoint of arthropod vectors. The common "wood tick", *Dermacentor andersoni* Stiles, suggested by the authors, is discarded as a possibility in the particular cases cited, since the period of adult activity of this species in British Columbia is from March to May, whereas the cases mainly occurred in late July and August, long after this tick has æstivated. Other native ticks commonly attacking man are unknown in this part of British Columbia, and the suggestion is advanced that one of the well-known Argasine vectors of the spirochæte, such as *Ornithodorus talaje* or *O. turicata,* may have been introduced from the south-western United States or Mexico. Possible means of such introductions and known instances elsewhere are given. *Argas persicus* is recorded from Canada for the first time and new hosts are recorded for *Ixodes auritulus.* Pack rats, *Neotoma cinera,* are discussed as possible factors in the disease, both as reservoirs for the spirochætes and as hosts maintaining the ticks when the summer camps are untenanted.

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