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SOME FACTORS AFFECTING THE DISTRIBUTION OF AND VARIATION IN NORTH AMERICAN ECTOPARASITES

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THE distribution of the groups of higher vertebrate animals and their variation and speciation in Nearctic North America have long been subjects for fruitful research. Associated with these higher vertebrates are host-infesting ectoparasites of several groups, the distribution of which is dependent to a greater or less degree upon the distribution of their hosts. Their distribution, therefore, offers a problem somewhat more complex than that of their free-living hosts.

Dr. Karl Jordan (1929) has presented a most excellent paper on the problems of distribution, variability and variation in North American fleas. He found that there were 131 described species in America north of Mexico. This number probably represents at least two thirds of all those that exist in this territory.

The outstanding fact in regard to the relationship of distribution to variation is that the latter, as expressed in numbers of genera and species, is far more pronounced in the western part of the continent than in the eastern part. Dr. Jordan gives the key to the situation in the following words: "Among the 31 species so far found in the Eastern States there are 17 which also occur in the West or at least are there represented by special subspecies, leaving 14 which are restricted to the East, but probably extend on to the Central plains, at least in the North. Some of these 14 are purely Northern forms, being only known from New England and the neighboring States; others are of wider southward distribution. In the Western area, on the other hand, the number of indigenous species confined to the West, but partly de-

scending eastward into the foothills, is 90, more than six times as many as in the Eastern States."

Dr. Jordan has discussed various factors which may have brought about this paucity of genera and species in the eastern part of the continent as compared with the western part. Among these are mentioned the fact that apparently but little collecting has been done in the southeastern part of the United States and also that the summer climate of the low levels of the East is adverse to fleas in general. Yet the chief reason for the differences in the diversity of the flea faunas of the East and West is attributed to glaciation. He states: "In the glacial period life was practically destroyed in the Northern Atlantic States, whereas in the Pacific half of the continent glaciation was less complete, so that life could persist in many cases. This, no doubt, accounts to a large extent for the greater abundance of species in the West."

The present writer, having collected and studied ectoparasites from nearly all sections of the United States, has long noted this greater diversity of the fauna in the West. It is not at all confined to fleas but appears to be more pronounced in this group than in the host-infesting mites, the biting lice, or the sucking lice. Yet in the ticks, a group in which much of the time of the individual parasite is spent detached from its hosts, there is a condition paralleling that found in the fleas. Thus in the genus *Dermacentor,* a genus particularly well represented in North America in comparison with the other continents, there are present in the western part of the United States nine species, while in the eastern part there are only three and only one of these is abundant.

The present writer would attribute the greater diversity of the flea and tick faunas of the West, first, to the presence of natural barriers in the form of high mountain ranges, and secondly, to the diversity of climate. Along the northern border of the United States there are

three closely related species of *Dermacentor,* so closely related in fact that they were at first confused with one another. One of these, *D. occidentalis* Neumann, is found only west of the Cascade Mountains; another, *D. andersoni* Stiles, is found only between the Cascades and the plains; and the third, *D. variabilis* Say, is found only east of the arid plains, except for an isolated area along the Pacific slope of southern Oregon and California. That this distribution is brought about chiefly on account of natural barriers and different climatic zones is strongly indicated. The Rocky Mountain spotted fever tick, *Dermacentor andersoni* Stiles, originally was confined to the area between the Rocky Mountains on the east and the Cascade and Sierra Ranges on the west; but since the introduction of domestic animals it has spread considerably to the eastward but has never crossed the plains. There can be but little doubt that large numbers of *D. andersoni* have been carried into the plains and to the eastward in the past, and also that large numbers of *D. variabilis* have been carried into all regions of the West. Consider the number of these ticks that must have been taken into the West by the pioneers with their horses and cattle to say nothing of their dogs. It is stated that at times some of the roads to the western states were clogged with hundreds or thousands of these immigrants and their domestic animals. Yet with these ideal conditions for the spread of the eastern *Dermacentor,* it does not seem to have obtained a foothold in the West except along the southern part of the Pacific slope.

Variation and speciation have, in fact, taken plaee to a much greater degree in the western part of North America in groups other than ectoparasites. For example Howell (1929) finds that in the chipmunks (*Tamias* and *Eutamias*) there is but one species with five races in the eastern part of the continent; while there are sixteen species representing sixty races in the western part. Then there is that classical example of the song sparrow.

According to recent authorities there are no less than thirty-three races, or subspecies, of this common North American bird. Yet of this large number only four races are found east of the Rocky Mountains; while California alone has ten resident races. Chapman (1920) and others attribute this condition of affairs, and doubtless correctly, to the presence of barriers in the West and to the great diversity of climate, which in turn is dependent largely upon these barriers.

The apparently uneven and unusual way in which the flea, *Pulex irritans* Linnaeus, has distributed itself in the United States has been mentioned by Howard (1896) and Jordan (1929). However, the distribution of this species has not been ascertained with sufficient accuracy in the past. The unusual thing about its distribution has to do rather with its sparseness in certain large areas than its absence in them. Yet certain areas exist in which repeated search for this flea has failed to reveal its presence. In order to get a more complete and up-to-date picture of the distribution of this species, there are here given in tabular form all locality records, based upon specimens determined by specialists, that are in the files of the United States National Museum and of the United States Bureau of Entomology, particularly in the Bureau's Division of Insects Affecting Man and Animals.

AUTHENTIC RECORDS OF THE OCCURRENCE OF *Pulex irritans* LINNAEUS IN THE UNITED STATES

Arizona: Madera Canyon, Santa Rita Mountains, June 19, 1898; Omaha, July 28, 1928; Phoenix, May 10, 1930.

Arkansas: Imboden, 1928; Georgetown, April 27, 1921.

California: Lakeside; Alameda County; Carbon Canyon, Puente Hills, January 23, 1926; San Diego, December, 1896; Azusa, July 23, 1894; Redwood Creek, Humboldt County, June 17, 1903; San Francisco, October, 1907; Humboldt County, December 1, 1927.

Colorado: Larimer County, November 15, 1926.

District of Columbia: Washington, June 25, 1909 (by W. L. McAtee).

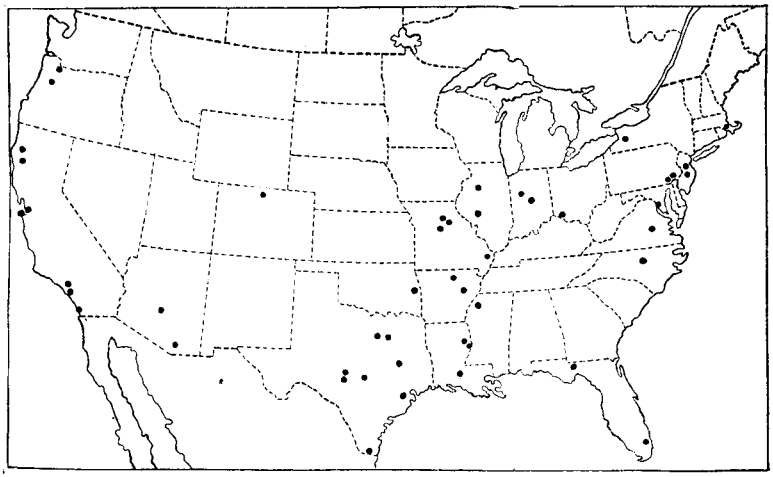
Florida: Little River, November 30, 1912, and December 20, 1913; Quincy, June 7, 1915.

Illinois: Elmwood, July 2, 1914; Winchester, 1921; Kempsville, April 28, 1921.

Indiana: Frankfort, April 29, 1914; Greenwood, June 19, 1922; locality (?), May, 1928.
Louisiana: Port Barrie, April 26, about 1915; Tallulah, May, 1918; Mound, June 17, 1918; locality (?), May, 1928.
Massachusetts: Fall River, August 16, 1921.
Michigan: Locality (?), 1921.
Mississippi: Dundee, April 12–15, 1921.
Missouri: Gilliam, August, 1914; Mexico, April 11, 1921; Atlanta, June 21, 1921; Charleston, July 1, 1921; locality (?), May, 1928.
Nebraska: Locality (?), fall, 1926.
New Jersey: New Brunswick, September 18, 1916; Browns Mills, May 5, 1916.
New York: Springville, November 7, 1921.
North Carolina: West Raleigh, April 8, 1915.
Ohio: Cincinnati, June 28, 1915; locality (?), June, 1923.
Oklahoma: Wister, July 8, 1904.
Oregon: Portland, 1903; Albany, June 20, 1915; locality (?), October 23, 1928.
Pennsylvania: Oxford, June, 1912; Chadd's Ford, April, 1921.
Texas: Brownsville, May 7 and 18, 1904, July 6 and 9, 1904, and July 5, 1895; locality (?), February 10 and 20, 1897; Dallas, September 1, 1915 (questionable identification), May 27, 1905, April 1, 1907, May 4, October 16, October 18, and November 21, 1917, and June 14, 1918; Concan, December 7, 1917; Uvalde, May 31, 1918; College Station, June 3, 1918; San Antonio, summer, 1919; Sandy Point, April 17, 1920; Ft. Worth, April, 1927.
Virginia: South Richmond, July 6, 1917.
Wyoming: Locality (?), November 27, 1927.

In addition to these seventy-one records which come from twenty-three states and the District of Columbia, there are many others that are not based upon specimens determined by specialists. These other records are from the same general areas as are covered by the valid ones. Doubtless most of them refer also to *Pulex irritans* Linnaeus.

If we mark on a map the definite locality records, we get a distribution as indicated on the accompanying map. Each dot represents a known locality record. In some instances definite records were obtained for certain states but not for a locality in the state. These have not been marked on the map. Thus there is a record for the state of Michigan, another for Nebraska, and also one for Wyoming, but, since the locality is not known in



Map of the United States showing the distribution of *Pulex irritans* Linnaeus, as indicated by the records (based upon specimens) in the United States National Museum and the United States Bureau of Entomology.

each of these cases, the records could not be given on the map.

Three large areas are to be noted on the map from which we have no records or but very few of them. First, there is that large area between the Rocky Mountains on the east and the Sierra and Cascade Ranges on the west. This area includes the Basin States of Idaho, Nevada and Utah and much of the surrounding territory. Then there is the Great Plains area adjacent eastward of the Rocky Mountains. Finally, there is the southern coastal plain section of the South Atlantic States. Can the absence of records or scantiness of the same in this southern coastal plain section be attributed to lack of search for this flea, or to a probability that it is not being reported by entomologists in this as in the other three areas mentioned? There has been much collecting of ectoparasites in the Basin States area and also in the southern coastal plain section of the South Atlantic States. In fact from these areas both the Bureau of Entomology and the National Museum have an abun-

dance of records of other ectoparasites, including many flea species. In the Great Plains area but very little collecting has been done, and since this area is so sparsely settled one would not expect many reports from the inhabitants.

The absence of records from the Southern Appalachian section is probably due to the lack of collecting. At any rate, for the present, this section should be left out of consideration, as our knowledge of its ectoparasitic fauna is too limited. Dr. Jordan (1929) predicts that *Pulex irritans* will be found to occur in this section.

Since coming to Washington in 1919 the writer has been repeatedly reminded of Dr. Howard's (1902) statement that the fleas sent in for identification from the eastern cities are not *Pulex irritans* Linnaeus but either the cat flea or the dog flea. Not only has the present writer never received in all the eleven years of his connection with the Federal Bureau of Entomology a single specimen of *Pulex irritans* from the big cities of the East, but in his extended field work over a period of several years in the eastern parts of the states of Maryland, Virginia and North Carolina he has never taken a specimen of *Pulex irritans.*

About Washington, D. C., fleas are abundant but, as Dr. Jordan has noted, the number of species is not large. In the low swampy lands of eastern Virginia and North Carolina a month's survey work on ectoparasites by the writer and Charles East during the height of the flea season (July, 1928) revealed only four flea individuals. Two of these were *Echidnophaga gallinacea* Westwood on a rat, one was a species of *Ceratophyllus* on a rat, and the other was on a rat but escaped before being determined. Thus the absence of *Pulex irritans* in this section is attributed to adverse conditions that affect fleas in general. This does not hold in the least, however, as far as the District of Columbia is concerned, for the fleas are abundant in and about Washington. Thus out of thir-

teen specimens of one of our most common mammals, the white-footed mouse, *Peromyscus leucopus,* taken near Washington, eight were found to be infested with fleas; while out of eighteen specimens taken in the low swampy districts of eastern Virginia and North Carolina not a single one had as much as a single flea.

The scarcity of certain flea species in eastern Virginia and North Carolina may be attributed to the scarcity of their favored or normal hosts, but this explanation would not apply to the distribution of the majority of them. This section is very low and flat and most of it during some time of the year is flooded. The rainfall, however, both in total annual precipitation and in its seasonal distribution, is very nearly the same as at Washington, D. C. The surface water, however, does not drain off but accumulates in a soured mixture of peaty composition over much of the area. Experimentally such conditions have been approximated in the water treatment recommended by the Bureau of Entomology for the control of fleas, *i.e.,* the flooding of the infested soil with water, not once but several times, in order to destroy the flea larvae. Such treatments have proven effective against the human flea and dog and cat fleas.

What the writer has observed in regard to the paucity of fleas in his survey of ectoparasites of birds and mammals in the lowlands of eastern Virginia and North Carolina is in accord with the observations of Pearse in Africa. Pearse (1928) found that in Nigeria fleas were much more abundant in the section of that country where the climate was dry. He states: "Fleas flourish best on hosts which live in a dry climate and have a more or less permanent home, such as a burrow or a human habitation."

Although the moisture in the soil and the presence of surface water at frequent intervals on much of the area should account for most of the sparseness of the flea population in the section under consideration, yet there is also another factor to be considered. It is this: The

mammal population as a whole is inclined more to aquatic or semi-aquatic habits. In much of this section, instead of the cottontail rabbit, which avoids the water at all times, there is present the marsh rabbit, *Sylvilagus palustris palustris,* which is semi-aquatic, frequently taking to the water like a true water species.

Pulex irritans is a flea that thrives in association with man, although it may possibly not have man as its most favored host. It is frequently found on domestic animals, particularly pigs. Because of this close association with man and possibly with pigs also, but few of these fleas would be found in districts where human habitations are scarce. This would in part explain the absence or scarcity of *Pulex irritans* in the Great Basin and over the Great Plains. Excessive dryness would be particularly detrimental to the larvae of those species that normally infest nests of hosts that are built above the ground. This would not be true, however, of fleas on certain burrowing mammals, as they are known to thrive in desert conditions. Does *Pulex irritans* breed on any burrowing animal that occurs in our country? An answer to this question might help us understand better its distribution in the United States.

SUMMARY

1. Ectoparasites that spend a part of their life detached from their hosts are affected not only by most of the factors that determine the distribution of their hosts but by many others that affect them as independent arthropods during their free-living periods.

2. The much greater diversity of species and genera in the western part of North America appears to depend fundamentally upon the presence of natural barriers in the form of high mountain ranges and upon the diversity of climate which is largely determined by the presence of these mountain ranges.

3. The distribution in the northern part of the United States of three closely related ticks of the genus *Dermacentor* is discussed.

4. Records of the occurrence of *Pulex irritans* Linnaeus in the United States are published, and the peculiar distribution of this parasite of man is considered.

5. The presence or abundance of *Pulex irritans* Linnaeus in any region of the United States appears to depend in part upon the following:

(a) the proper moisture content in the soil and the absence of surface water on top of the soil during the period of its larval development,

(b) the absence of extremely low temperatures,

(c) the presence of human habitations,

(d) the presence of hosts other than man, these hosts for a particular region not being known at the present,

(e) the habits of all hosts (including man) in the region under consideration.

6. A study of the records of the occurrence and abundance of fleas in general and of *Pulex irritans* Linnaeus in particular would appear to indicate that the abundance of individuals is largely independent of the following factors;

(a) total annual precipitation,

(b) humidity during adult state.

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