

PSYCHE.

THE DISTRIBUTION OF THE NEW ENGLAND LOCUSTS.

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The Acridiidae, short-horned grasshoppers or true locusts, are a family of insects of especial value for the study of geographical distribution, "life zones," and kindred topics,—probably more valuable than any other group of insects, and perhaps as important as the birds; they are, in consequence, deserving of more attention from biological surveys than they have yet received.

The reasons for ascribing to them so great value in connection with this subject are as follows:—They are terrestrial (as distinguished from aquatic) in all stages of their existence. They are almost universally distributed—with the exception of dense forests—from desert to jungle, from sea-side to mountain-top, from the arctic zone to the equator. They are conspicuous in size and habits—being from one-half inch to four inches in length, one inch to nine inches in expanse, diurnal, active and alert, flying or leaping freely when approached, often adorned with striking colors or producing loud sounds either in flight or at rest. They are voracious, their food being general in

character rather than special, a question of quantity rather than quality. They are numerous in individuals, whether local or widespread occurring in sufficient numbers to make it possible with reasonable effort to procure series sufficiently large to permit of critical study. They require a relatively small amount of care and delicacy of handling, making it possible to devote a proportionally large amount of time during field-work to the securing of material rather than to its preparation. Finally, while the majority are winged and active in habit they are, with few exceptions, relatively stationary during life, for not only is the range of individuals comparatively restricted but the same is true also of the range of a species in a given locality, which seems to be dependent less upon the presence or absence of particular food-plants than upon physical conditions often of extremely local character, such as the quality of the soil, exposure, drainage, humidity, etc. So true is this last statement that in a region where the locust fauna is fairly well-known, *e. g.*, New England, given

a field of any particular character it is possible to predict with a high degree of certainty what species of locusts will be found therein.

This susceptibility to local physical conditions is a very important attribute of the group in this connection. Most cultivated crops and many wild plants are equally susceptible to the same conditions, — a fact especially noticeable in parts of California where exposure to sea-wind or direct sun-rays produces a marked difference in the amount and character of the vegetation on contiguous hill-slopes, and also in parts of New England, where fields a few acres in extent are seldom homogeneous in character.

Now, the successful cultivation of crops by the individual agriculturist is dependent on the factor here involved: a close adaptation of a particular species or variety to its environment, — the environment being constituted by conditions, as has been said, often extremely local in character. For this reason it seems probable that close study of the distribution of this group of animals would prove of exceptional value in delimiting the smaller details of life zones, especially in the more valuable narrow extensions of such areas, whose importance has been indicated by Dr. Merriam.

It is perhaps worth while to point out in this connection that species belonging to a southern zone and adapted to a sandy soil may find their northern limit considerably higher up, both latitudinally and vertically, than other spe-

cies equally characteristic of the same zone but restricted to a damp and heavy soil. More rarely the reverse arrangement would occur. Consequently, that the final limit of a given zone would vary according to the species selected to delimit it and the adaptation of these species to the physical conditions of the locality in question.

So much by way of preface and in regard to details. It remains to be seen whether the distribution of the group is of value in determining the broader features of life zones. For this purpose let us turn our attention to a district sufficiently well-known to allow a comparison to be made. Such a district we have in New England, whose locust-fauna, with the exception of northern and eastern Maine and western Vermont, is as well known as that of any part of the Union of equal extent and whose faunal areas also have been the subject of study. While it is true that a great deal remains to be done in working out the details there is sufficient available to enable a close approximation to the truth to be secured.

Geographically considered the locusts of New England fall into three groups: — 1st, species believed to be distributed over practically the entire district; 2nd, species known to be distributed over but a part of the district; 3rd, species whose distribution — either from local character or positive rarity — is insufficiently known. Of these groups the first is of interest in showing the relation of New England to the rest of the country; the third may be ignored for the present;

to the second we must look for the division of the district into faunal areas. If we include Long Island as a part of New England, which we may reasonably do, we have actual record of 48 species from this district. Of these 19 belong to the first group, 3 to the third, and 26 to the second.

The second group — those distributed over but a part of New England — falls naturally into two divisions, a boreal

and an austral. The former, consisting of several species of boreal character, extends from the north over varying portions of the district; the latter, austral in character, extends similarly from the south over varying portions. These two divisions overlap each other widely, a consequence due in part to the general north and south trend of the more important physical features, — mountain chains, river valleys and sea-coast, — with its consequent effect on temperatures, but chiefly to other causes, particularly that of specific adaptability, as will be shown.

The northern division contains six species. The first of these, *Podisma glacialis*, is of a truly boreal and sub-alpine character, and is found more or less commonly in the vicinity of tree-line on the higher mountains of New England (Ktaadn, 1, White Mts., 8, Ascutney, 15, Greylock, 26, 3000 to 4500 ft.) and at a lower level in northern Maine (Jackman, 2).

Closely related to it in distribution and associated with it in several of the same stations is *Melanoplus mancus*, which seems, however, to be able to

withstand a higher temperature. This species has been found on Mt. Desert Id., 4, the White Mts., 1, Ascutney Mt., 15, and occurs, probably in an outlying colony, as far south as southern Connecticut, 34. This southward extension of its range is probably due to the influence of the ice-age.

These two species are apterous or sub-apterous and in consequence of their boreal character, are markedly discontinuous in distribution, except, possibly, in the extreme north. The remaining four are winged, in consequence are able to range more widely and occur, in the adult stage at least, on the alpine summits of the White Mts. as well as at lower levels.

Two of them prefer moist situations and apparently have much the same distribution. These are *Mecostethus gracilis* (Norway, Me., 6, White Mts., 8, and Jaffrey, 11, N. H., northern Vermont, 12, 13, Greylock Mt., 26, Mass.) and *Melanoplus extremus* (Hudson, 3, and Norway, 6, Me., White Mts., 8, Jackson, 9, and No. Conway, 10, N. H., Ascutney Mt., 15, Woodstock, 14, and northern Vermont, 12, 13, Mt. Greylock, 26, and Winchendon, 22, Mass). The first of these is met by its congener, *lineatus*, which takes its place in southern New England.

The remaining two boreal species extend even further to the south, reaching northern Connecticut. These are *Circotettix verruculatus* and *Camnula pellucida*. The former frequents rocky ground and is met (or overlapped) at

Canaan, Ct., 38, by *Spharagemon saxatile*, a species having precisely similar habits which covers the southern part of New England. *C. verruculatus* occurs at Palmer, 24, Mass., and is recorded from Cambridge, 17, but seems not to be found there now, while *saxatile* is plentiful. *C. pellucida* reaches So. Kent, 39, in western and Thompson, 33, in northeastern Connecticut on high hills, outposts of the highlands of western and central Massachusetts.

So much for boreal species. Passing to the austral we find a group of three, *Tryxalis brevicornis*, *Clinocephalus elegans*, *Orphula olivacea*, occurring in swamps and salt-marshes in the vicinity of New York (Ravenswood, L. I., 42, Stamford, 40, and Greenwich, 41, Ct.) but perhaps extending further to the northeast. A fourth, *Schistocerca americana*, is found not infrequently about New York, and has been taken once near Boston. This is, however, an insect of exceptionally powerful flight and strong migratory tendency and is entirely adventitious in New England.

The remaining species inhabit a much larger portion of the district. *Schistocerca alutacea* is common in swamps in southern Connecticut and reaches Martha's Vineyard, 30. *Melanoplus scudderi* is found in western (So. Kent, 39), southern (New Haven 37), and southeastern (Deep River, 34) Connecticut, and is reported from

Springfield, Mass., 25.* *Dichromorpha viridis* is common in all quarters of Connecticut, 33, 36, 38, 40, and at Amherst, 23, Mass., and is reported from New Hampshire which it probably reaches in the Connecticut valley. It is found at Wickford, 31, R. I., and probably throughout most of the State but is absent from the vicinity of Wellesley, 20, and Boston, 16. *Paroxya floridana*, common in southern Connecticut, reaches Boston, 18, and Cambridge, 17. *Scirtetica marmorata* is found in southern Connecticut, 36, on Martha's Vineyard, 30, and at Provincetown, 29, Mass. *Schistocerca rubiginosa* is found in northeastern Connecticut, 33, at Provincetown, 29, Dedham, 28, and Wellesley, 20, Mass. *Orphula maculipennis*, also common in northeastern Connecticut, is found along the coast at least as far as Lynn, 21, Mass., but for some reason is practically absent from the vicinity of Wellesley, 20. *Paratettix cucullatus* occurs in extreme northwestern, 38, southern, 37, and northeastern, 33, Connecticut and has been reported from the vicinity of Boston. *Arphia xanthoptera*, *Spharagemon saxatile*, and *Sph. collare scudderi* cover much or all of Connecticut, a large part of central Massachusetts, are common about Boston, and probably extend considerably farther to the north and east, probably reaching southwestern

* The reported occurrence of this species in Brunswick,

Me. (Scudder, Rev. *Melanopli*, p. 214) is erroneous, the specimen proving to be another species — *Melanoplus dawsoni*, not previously known to occur in New England.

Maine. *Pseudopomala brachyptera*, *Mecostethus lineatus*, *Melanoplus minor*, and *Orphula aequalis* extend even farther north, in most cases at least to Woodstock, 14, Vt., Jaffrey, 11, and No. Conway, 10, N. H., Fryeburg, 5, and Norway, 6, Me. The sole remaining species is noteworthy as illustrating in a high degree the peculiar susceptibility of many of the group to physiographical conditions, and its distribution may rightly be said to be almost as much physiographical as climatal. This is *Trimerotropis maritima*, the sea-side locust, which is restricted to the sandy sea-beaches of the coast from York, 7, Me., southward. The only exception known to me is that of a small colony at North Haven, 36, Ct., on the sandy plains of the old sea-floor, now a few miles inland but only a few feet above tidewater.

Examining the positive evidence given above in connection with the faunal and climatal map of New England in Scudder's Butterflies of the Northeastern States we find a remarkable conformity in the distribution of the locusts with the courses of the mean annual isotherms, a conformity most striking in the western, more inland, part of their courses. Compare, for instance, the southward extension into Massachusetts of the ranges of *Mecostethus gracilis* and *Melanoplus extremus* with the line of 44° , of *Circotettix verruculatus* and *Camnula pellucida* into Connecticut with the line of 46° ; the northward range of *Mecostethus lineatus*, *Melanoplus minor*, and

Orphula aequalis to that of 42° , of *Dichromorpha viridis* to the western part of 46° , of *Melanoplus scudderi* to the western part of 48° .

The distribution of the locusts is distinctly closer in agreement with the annual means than with the winter means; perhaps a little closer with them, on the whole, than with the faunal zones drawn from the distribution of the butterflies. I greatly regret to have been unable to compare it with the summer means or with lines based on the laws given by Dr. Merriam, viz.—that northward distribution is governed by the sum of positive temperatures for the entire season of growth and reproduction, and the southward distribution by the mean temperature of a brief period during the hottest part of the year.

Of course discrepancies occur. These are probably due, in part, to insufficient data, but may be due to other agencies, such as, *e. g.*, some unknown factor, or the difference between the annual mean temperatures and the factors stated above or to the possible conflict of these two factors between themselves, resulting in unconformable limits of two adjoining zones, distinguished by the overlapping or absence of characteristic species in certain sections.

As nearly as we can judge, however, from the data at hand, these limits are conformable in the case of the New England locusts except in eastern Massachusetts, where, also, the principal discrepancy with the isotherms is found, consisting in the absence from the

neighborhood of Boston and Wellesley, at least, of the austral species *Melanoplus scudderi* and *Dichromorpha viridis*, and the boreal species *Circotettix verruculatus* and *Camnula pellucida*. *

Notwithstanding discrepancies, to whatever agency due, it is clear that the distribution of locusts in New England is primarily and distinctly climatal in character, although strongly influenced by physiography and its attendant conditions.

The division of the district into faunal zones is apparently less distinct, but we may confidently recognize three,—first, a boreal or Canadian, closely following the restricted limits of that zone as laid down on Scudder's map, but even a little more restricted. †

This zone is characterised by the absence of the austral species and the

presence of the boreal, of which *Podisma glacialis* is the most characteristic. Its limits are most sharply marked in the White Mt. region in the vicinity of No. Conway. It covers the tops of the higher mountains in Massachusetts, Vermont, New Hampshire and Maine, a part of northern Vermont and New Hampshire, and the larger portion of northern Maine.

Second, an austral, upper austral, or Carolinian zone, characterized by the absence of typically boreal species and the presence of distinctly austral ones. This covers a large part of Connecticut, reaches Massachusetts in the Connecticut valley, and extends also into the southeastern part of that State.

Third, a transition or Alleghanian zone covering the territory not included by the other two and characterized by the overlapping of boreal and austral species. The line of demarcation between the transition and austral zones is most distinct in Connecticut, closely following the isotherm of 48°; it is less distinct in Massachusetts though probably all of the area southeast of this line in that state should be included in the Carolinian zone. *

* This is particularly interesting from the fact that both of the austral species are nearly or quite flightless,—*scudderi* entirely so, *viridis* except for a long-winged form of small numerical percentage,—and are usually plentiful in localities where they occur. Possibly they are to be regarded as recent invaders which have not yet reached their ultimate extension in New England. Of interest in this connection is the fact that while *viridis* at least is common in Rhode Island, both species are absent from Block Id. 32, and Martha's Vineyard, 30, where other flightless species are found (on the former: *Nomotettix cristatus*; on the latter: *Nom. cristatus*, *Pseudopomala brachyptera*, *Chloealtis conspersa*, *Melanoplus fasciatus*), all of them having a much more extensive northward range. Both *scudderi* and *viridis*, I am informed, are found on Long Id., a fact probably due to its proximity to shore. Otherwise, the island-fauna essentially agrees, so far as known, with that of the adjacent mainland, but it has been very little studied.

† It is possible that the passing of the winter in the egg stage in the ground may permit of a more general northward range of austral species among locusts than in some other groups.

* In support of this view there may be adduced the absence from the country around Wellesley and Boston of the two boreal species *C. verruculatus* and *C. pellucida*, which have the greatest southward range, and the presence of the austral species *Paroxya floridana*, *Hesperotettix brevipennis*, *Orphula maculipennis*, and *Schistocerca rubiginosa*. Here also the sassafras, chestnut, hickory nuts, and hazel nuts are plentiful, even the tupelo is common, and peaches, while not fully reliable, are in certain places, under careful management, an important crop. In view of these facts it would seem that this section should be regarded as an extension of the upper austral, carrying a dilute Carolinian fauna.

This area, however, is a broad one of complex topography and has been but little studied except near Boston and Wellesley and on parts of Cape Cod.

While the larger part of the area of New England thus lies in the transition zone, the locusts inhabiting it are very largely austral in character.

Turning to the extra-limital distribution of the New England species we find strong conformation of the conclusions drawn from their intra-limital distribution, the two being closely parallel in character, each species having, with rare exception, the same zonal range extra-limittally as intra-limittally.

This isothermal or zonal distribution is very striking in a tabular arrangement where we find that by far the larger number of the species are distributed more or less widely over the upper austral and transition zones, chiefly in their eastern—Carolinian and Alleghanian—areas, a fact that would seem to indicate that the transition is essentially a part of the upper austral. A small number extend into three zones—the two above-mentioned and either the boreal or the lower austral, and a few cases occur of presence in four and of restriction to one.

Owing to the lack in many cases of enough, and of sufficiently accurate and definite, data it is impossible to speak otherwise than in very general terms, nor would time and space permit a discussion of details. And while it is true that the family has been studied and collected most in the transition and upper austral zones and that we have

relatively few data from the boreal and lower austral zones it is believed that subsequent study will tend to confirm rather than disprove the statements made above.

The distribution of a few species is of more than ordinary interest. *Melanoplus atlanis* has a remarkably wide range, from Nova Scotia to Beaufort, N. C., Winnipeg, Alberta, and Washington to Orizaba, Mex.; *Mel. fasciatus* ranges from Labrador and Newfoundland to New Jersey, Michigan to Missouri, Alberta and Washington to Colorado; *Paroxya floridana* from Boston, Mass., and Michigan to the Gulf of Mexico; *Orphula olivacea* from Stamford, Ct., and the Bermuda Ids. to Darien and Venezuela; *Tryxalis brevicornis* from Long Island to Honduras, St. Domingo and Brazil. *Hesperotettix brevipennis* has been found at Walpole and Wellesley, Mass., in New Jersey and Georgia, while of its numerous congeners none approach nearer than the Great Plains. *Trimerotropis maritima* is found along the Atlantic coast from Maine to Florida and occurs in a slightly differing form on the shore of several of the Great Lakes, a fact explained by and tending to confirm the theory of the previous existence of a southern connection—by way of the Mohawk and Hudson valleys—of the Great Lake basin with the Atlantic seaboard in the vicinity of New York City, a connection believed to have been open during the close of the glacial period.

Brief mention only may be made of the seasonal distribution. As stated

elsewhere (Psyche, viii, 164), the great majority of species pass the winter in the egg stage, hatch in the spring, and attain maturity in summer or early fall, being, in consequence, most numerous in the adult stage in August and September. This is the case with all of the Tryxalinae and Acridiinae and most of the Oedipodinae. Of the latter, however, three species (*Arphia sulphurea*, *Chortophaga viridifasciata*, *Hippiscus tuberculatus*) hatch in midsummer, pass the winter as nymphs, and reach maturity in April or May, flying until midsummer or rarely until September; these are all hardy species and reach a high latitude. The Tettiginae form a marked exception to the other groups in passing the winter as adults, being most numerous in September, October, April and May, and rare in midsummer; most of these, also, extend throughout the district. Immediately on the coast development is delayed from three to ten days in spring and the season is considerably prolonged in the fall.

The study of distribution would be greatly aided by the publication of local lists giving exact locality and date of capture, with such biological notes in reference to environment as careful and continued observation will secure. Very much might be done by local collectors in this way and it is to be hoped that more attention will be paid this group than heretofore. The most effective method of adding to our knowledge of the subject would be by making a series of transections of the isotherms at the proper season over portions of

the district to be investigated. By this means an experienced collector could secure a large amount of valuable data with a minimum of effort.

Some of the problems that should be borne in mind in connection with future observations are: the extent to which distribution, either local or general, is influenced by other factors than climate or temperature, such as food-plants, the necessity of a particular kind of soil or other substance for oviposition or as nidus for the eggs (rotten wood, pithy stems, etc.); the relative abundance locally of winged and wingless species; the relative abundance and width of range from year to year of each species, to determine whether it tends to increase or decrease in numbers and extent of habitat, to supplant others or be supplanted, — particularly, in New England, to determine whether *M. scudderi* and *D. viridis* are or not extending their range, etc.

To sum up:—Locust distribution is primarily and very distinctly climatal in character, habitats varying specifically in range but closely paralleling the isotherms. In its details it is influenced to a very high degree by physiography and its attendant conditions, such as character of the soil, humidity, etc. In its broader features it is eminently characteristic of life zones and regions, agreeing well with those drawn from study of the vertebrates.* It is in many cases dependent

* This is noticeable in even a cursory glance at the cosmopolitan distribution of the family.

on and confirmatory of geological changes. For these reasons and those noted at the beginning, viz. — wide distribution, terrestrial and conspicuous habits, numerical abundance, size, etc. — the family and its distribution is of high importance in a study of life zones in their relation to agriculture and of faunal regions in their relation to general science.

In conclusion, while the evidence here presented is drawn largely from personal experience, I wish to acknowledge my indebtedness also to Messrs. Scudder, Henshaw, Beutenmüller, McNeill, Harvey, and others through data furnished by their publications, collections, or notes of various kinds. Owing to the total lack of data from

broad portions of the district it is manifestly impossible to draw definite boundaries at present for the faunal areas of locust-distribution, and I am under great obligations to Mr. Scudder for permission to reproduce from his faunal and climatal map those portions and features most desirable for examination in this connection. The terminology used, in a few cases now needing revision, is, for convenience, the same as that in my "Notes on New England Acridiidae" (Psyche, Oct. 1894 to Dec. 1898), which contain fuller details — seasonal, physiographical, and geographical — of the distribution of each species in New England than can be given in the limits of this sketch.

POSTSCRIPT ON PERDITA.

I have now before me mounted heads of *P. semicrocea*, which is the nearest to Smith's typical species I have seen, and of *P. verbesinae* which is a typical *Cockerellia*. The actual palpal differences are as follows:—

P. semicrocea. Labial palpi with the first joint about or hardly as long as the other three together; second longer than third or fourth, which are about equal to one another. Maxillary palpi with the last three joints about equal to one another, and longer than first three.

P. verbesinae. Labial palpi with the first joint about or over twice as long as the other three together; the other three subequal, but the third the shortest. Maxillary palpi with the first joint longest, the others about equal to one another, except that the second is shortest.

I must admit that there is more difference than I had supposed.

T. D. A. Cockerell.

Mesilla Park, Nov. 7.

RECENT LITERATURE.

THREE entomological works of a more or less popular character have been issued recently and demand brief notice.

The readers of PSYCHE are well acquainted with the careful observations of the habits of insects made by Mr. and Mrs. Peckham of Milwaukee. The State of Wisconsin has now published a volume by them on the instincts and habits of the solitary wasps. It is replete with interest and merits unqualified praise. The care, patience and assiduity of the authors in following the study of their little friends to the minutest details of their daily life and by night as well as by day, has



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