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The Insect Association of a Local Enviornmental Complex in the Dsitrict of Holmes Chapel, Cheshire.

Alfred E. Cameron

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THE INSECT ASSOCIATION OF A LOCAL ENVIRONMENTAL COMPLEX IN THE DISTRICT OF HOLMES CHAPEL, CHESHIRE.

BY

ALFRED E. CAMERON, M.A., D.Sc. (ABERD.), M.Sc. (VICT.)

[WITH TWO PLATES.]

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II.—The Insect Association of a Local Environmental Complex in the District of Holmes Chapel, Cheshire.

By **Alfred E. Cameron**, M.A., D.Sc. (Aberd.), M.Sc. (Vict.); Field Officer, Entomological Branch, Department of Agriculture, Canada; late Government Scholar of the Department of Agricultural Entomology, Manchester University. *Communicated by* Prof. R. Stewart MacDougall.

(With Two Plates.)

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Introduction.

That there is a decided need for the ecological study of insects and other animals was first brought home to the mind of the author whilst engaged upon the subject of a "General Survey of the Insect Fauna of the Soil" (vide *Jour. Econ. Biol.*, vol. viii, part 3, 1913). Much information has been collected at various times by numerous authors, and especially those who have treated of the habits and behaviour of animals, but very little attempt has been made to systematise the data variously gathered, to explain the cause and effect of many obscure phenomena, or to make important observations accessible for the use of the animal ecologist. Thus, at present, we find ourselves on the threshold of practically a new and undisputed field, with opportunities for original and interesting research extending in innumerable directions. Dr C. C. Adams, now of Syracuse University, New York, who has written a most useful work,* "the outgrowth of the effort as it has developed in the study and teaching of animal ecology," in which is listed most of the literature applicable to the science, says (p. 10): "The associational is the phase of animal activity which may be considered as the form of animal behaviour which has developed into the human social relations," and concludes that, because of the social character of human society, those interested in matters pertaining to the welfare of mankind, such as the sociologist, the physician, the sanitarian, and the agriculturist, will ultimately participate in a keener appreciation of the associational aspect. In another place the same author indicates briefly the magnitude of the problems involved when he says (p. 15): "The aim of the ecologist is professedly genetic or explanatory, because it is the study of *responses* to all conditions of the complete

* Adams, C. C., *Guide to the Study of Animal Ecology*, New York, 1913, 183 pp., 7 figs.

environment. But these responses must be described and the conditions influencing them as well, so that a descriptive aspect is an essential part in all phases of ecology. In the study of the responses of an individual, an order, or an association, pure description of the responses is necessary; but a description which will at once describe and show the working of the processes by which the results were produced is of quite a different order. This phase of explanation has been most concisely expressed and applied by the students of the physical sciences, and biologists may profit much from a study of their methods." Therefore, for the sake of accurate deduction, a method of measuring all the important factors of an environment which are likely to influence its *biota* is absolutely essential, and the reason why plant ecology is now quite a well-ordered and organised science is due to this very fact. It was almost essential that plant ecology should have precedence over animal ecology in point of time, because the latter involves a knowledge of the former, and, indeed, it will likely prove true, as VESTAL* has remarked (p. 13), that plant and animal associations are co-extensive and to a large extent interdependent, the animals being entirely dependent upon the plants, speaking broadly, and the plants being partly dependent upon the animals. This view-point has not been neglected in the present study, but the author recognises the difficulty of superimposing the structure of the insect association so as to show how it coincides exactly with that of the plant association. The problem might be tackled equally well from one of two standpoints :—

1. The insect proposition wherein, with a species, genus, family or order as the unit, an attempt is made to weave the web of which the physical and vegetational factors are the warp, the insect unit, its activities and behaviour, the woof.

2. The environmental aspect in which the unit is represented by the environmental factors of the habitat, and the relationships of all insects of various orders, family, genus, and species to these factors and to each other are discussed.

The first of these methods is perhaps the one most likely to be productive of detailed and accurate results. By multiplying the unit to include, say, every family represented in the habitat, our knowledge of any one is likely to be very exact. Necessarily, this method entails much application, besides time and labour. The second is more general, but has the advantage that by including all insect species in one study, it treats of the sum-total of biographical relationships and the interacting influences of every physical or other factor and the individual insect units. The latter of these is the method which has been adopted for this paper. But, either way, although the manner of attacking the subject may differ, the ultimate result would be the same.

* VESTAL, A. C., "An Associational Study of Illinois Sand Prairie," *Bull. Ill. State Lab. Nat. Hist.*, 1913, vol. x, art. 1.

Physiography and Topography.

In so far as the locality of our investigations is representative of the conditions which prevail throughout the lower-lying reaches of the Dane valley, it may be considered as physiographically typical of the whole area. Terraces of a fairly wide sweep, composed of river gravel, extend along the greater part of the valley.* Westwards from the North Rode viaduct the river winds from side to side of a flat of an average breadth of a quarter of a mile, on each side of which rise hills of red marl capped by a few feet of sandy gravel, and the valley shows here and there traces of two or three terraces. The river runs in a deep channel cut through this old alluvium well down into the red marl below. The pebbles in the gravel are of all sizes, up to that of a man's fist, and there are sometimes beds of sand: the gravel is at times stratified, but is oftener just such a rude tumbled mass of pebbles and boulders as now lies in the bed of the river; it has doubtless been formed mainly from the waste of the Drift Sand and Gravel. As this gravel rests on red marl without any trace of boulder beds between, it is likely that the valley of the Dane has been greatly deepened since the Drift period. From Congleton, eight miles to the west, to Holmes Chapel and beyond, on the north-east side of the valley, a pair of terraces may be made out, but they have been much cut up by river denudation. They soon give place to a broad, well-marked flat about 15 or 20 feet above the river, with here and there a ledge some 10 feet lower.

The farmland of the Holmes Chapel Agricultural College stands at about 225 feet above sea-level, which represents the altitude of Glover's Meadow, covering an area of 1·633 acres (Pl. I; Pl. II, fig. 2). This name has been used throughout the paper to designate the grassland situated on the top of the wooded declivity, at the bottom of which the Alluvial Pasture of 4·658 acres (Pl. I; Pl. II, fig. 1) extends along the south side of the River Dane. The Farm Pasture, on which is situated the filtering tank of the College sewage system, is 4·09 acres, wheat field 6·94 acres, and potato field 5·86 acres, about one-tenth acre being sown in oats and a small strip planted with cabbages as represented in the diagram (Pl. I) taken from the survey map of the farm. As the study is mainly concerned with the two fields, Glover's and Alluvial, the latter of which is confluent with the higher-lying Farm Pasture, the importance of the adjacent fields and woods lies in the fact that the crops and trees which they bear supplied numerous species of insects which invaded our more limited area and so had to be considered as temporary invaders or migratory forms.

The Alluvial Pasture stands at a height of about 155 feet above sea-level. Its surface soil is derived from the Post-Glacial Drift, and consists of alluvium. This is in decided contradistinction to the surface soil of Glover's Meadow, which is

* Hull, E., and Green, A. H., "The Geology of the Country round Stockport, Macclesfield, Congleton, and Leek," *Mem. Geol. Sur. Gt. Brit.*, London, 1866, p. 80.

derived from Middle Sand overlying Boulder Clay and Keuper Marl, evidences of which can be traced in the escarpment connecting the two meadows. Naturally, after a period of time, soils become modified by the accumulation of humus, which tends to make a soil "heavy." There is really very little difference to be found in the texture of the soils of the two meadows, although derived from such different sources, and very little variation in their water-content. That of Glover's Meadow, with its underlying strata of clay which prevents leaching, has a large retentive capacity for moisture. The Alluvial Pasture, by reason of its position on the banks of the Dane, does not dry readily, and its moisture content is continually being added to by the waters draining from the higher lands down the declivity on its southern side, so that at the base of the slope on the side distal from the stream the ground, even in midsummer, had almost always a tendency to be marshy. If anything, the soil of the Alluvial Pasture is the more friable when dry, that of Glover's Meadow tending to become compact and cloddy.

The Alluvial Pasture varies in evenness. It is flat on the west side and rises gradually at the east and south sides towards the escarpment (Pl. II, fig. 1.) Sundry undulations cause here and there the formation of moister hollows. The surface of Glover's Meadow is almost level, dipping slightly on one side towards the wood (Pl. II, fig. 2). The Farm Pasture is level for a great part, but its evenness is interrupted by the steep gradient leading down to the banks of the river.

It was not considered necessary to make chemical analyses of the soils of the habitat. A knowledge of the mechanical nature of the soil, its coarseness or fineness, is much more important for ecological purposes.* The texture of a soil determines and regulates its water-content, which is of far more importance to animal and plant life than its chemical composition. Mechanical analyses need not be too exact, and the measurement and separation of the particles according to definite units of size or variation represents a waste of effort. The results give no real clue to the nature of the soil as it actually exists, where the particles are all mixed up. Therefore, it is sufficient to know that the Alluvial Pasture soil is a dark-coloured loam, that of Glover's Meadow a reddish clay loam.

The Plant Environment and its Relation to Insects.

With the assistance of Mr C. H. Gadd, Lecturer in Biology at the Holmes Chapel Agricultural College, a thorough analysis was made of the dominant floral species. The vegetation is essentially of the mesophytic type. In Glover's Meadow the predominant herbage of the field consists of *Anthoxanthum odoratum* and *Holcus lanatus*. Among species which could be designated abundant, there were *Dactylis glomerata*, *Festuca ovina*, *Rhinanthus crista-galli*, *Rumex acetosa*, and *R. acetosella*, *Cynosurus cristatus*, *Ranunculus repens*, *Plantago lanceolata*, and

* Clements, F. E., *Research Methods in Ecology*, Lincoln, Nebraska, 1905, pp. 15, 80.

Bromus mollis. A close matting of moss, *Brachythecium rutabulum*, covered the surface of the ground, obscured to casual observation by the taller plants. In addition to these species there were also present in greater or less abundance *Poa trivialis*, *Ranunculus acris*, *Veronica chamædrys*, *Trifolium repens*, *Chrysanthemum leucanthemum*, *Bellis perennis*, *Bunium flexuosum*, *Cerastium triviale*, *Potentilla anserina*, *Potentilla reptans*, *Lolium perenne*, *Agrostis alba*, *Agrostis vulgaris*, *Prunella vulgaris*, *Phleum pratense*, *Ranunculus ficaria*, *Trifolium pratense*, and *Draba verna*.

In the south-eastern corner of the same meadow, in the vicinity of a pond, the plant species were essentially hygrophytic, and included *Lychnis flos-cuculi*, *Carduus palustris*, *Spiræa ulmaria*, *Lotus corniculatus*, *Ajuga reptans*, *Anemone nemorosa*, *Primula vulgaris*, *P. veris*, *Cardamine pratensis*, *Trifolium pratense*, together with species of *Carex*, *Juncus*, and *Equisetum*. In the north corner of the same meadow, surrounded almost wholly by trees, bracken (*Pteris aquilina*) flourishes, interspersed by blue-bells and yellow pimpernel. On its westerly exposure Glover's Meadow is bounded by an intermittent hedge of hawthorn, elm, and willow, interrupted here and there by isolated trees of oak and alder. At the base of this hedge the following species were observed:—*Rubus fruticosus*, *Rosa canina*, *Urtica dioica*, *Digitalis purpurea*, *Teucrium scorodonia*, *Sarothamnus scoparius*, *Equisetum* spp., *Stellaria holostea*, *Lychnis diurna*, *Anthriscus sylvestris*, *Heracleum sphondylium*, and *Vicia sepium*.

The trees on the eastern side of the meadow (Pl. II, fig. 2), forming the upper limits of the wood which clothes the declivity, are a mixed assortment of sycamore, elm, oak, holly, ash, hawthorn, hazel, and elder.

The herbage of the Alluvial Pasture has as its predominant constituents *Holcus lanatus*, *Trifolium repens*, *Lolium perenne*, *Anthoxanthum odoratum*, *Festuca ovina*, *Agrostis alba*, and *A. vulgaris*. Other grasses present are *Poa trivialis*, *P. pratensis*, and *P. annua*, *Festuca pratensis*, *Cynosurus cristatus*, and *Dactylis glomerata*. The wood on the southern side (Pl. II, fig. 1) contains alder, ash, sycamore, beech, holly, hawthorn, elder, hazel, oak, willow, mountain ash, and elm. In the shade of the trees overhanging the meadow the *Urtica dioica*, *Lychnis diurna*, *Mercurialis perennis*, and *Arctium lappa*, each of these species occurring in great profusion in this particular location.

A summary of the weeds in the Alluvial Pasture showed that the following species were abundant:—*Urtica dioica*, *Rumex acetosa*, *Ranunculus repens*, *R. acris*, *Bellis perennis*, *Achillea millefolium*, *Cerastium triviale*, *Luzula campestris*, *Carduus arvensis*, *Rumex obtusifolius*, and *R. crispus*.

It has been considered necessary to detail the floral species in this way, not only because of the important relations which exist between plants and phytophagous insects directly, but also because of the action and interaction continually exerted between the vegetational type and the climatic factors so important to animal life,

of which it serves as a general sort of index. Temperature, humidity, and wind velocity are each and severally modified by the particular kind of plant association, whether it be herbage, shrubs or forest, and each kind of association harbours its own kind of animal life, species which are characteristic of it and of no other. Often the line of demarcation between one association and another can be strictly delimited, so that species which may be introduced into an association which is alien to their habits react negatively to the prevailing physical factors of their new abode and tend to turn back. On the other hand, where two distinct associations are in juxtaposition and gradually merge into one another, as in the case of woodland and grassland, many species from both will intermingle, especially so at the places of transition. Thus the feeding habits of many larval forms will be actively pursued in the humus or decaying wood of forests, and will react negatively to light and to a dry atmosphere, whilst the winged adults will visit the herbage of meadows and pasture, bathing themselves in the rays of the sun. Migration, however, is more frequent from stratum to stratum, by which is meant the vertical divisions of a uniform area such as the subterranean, surface, plant, and aerial strata, for which VESTAL* has introduced the terms *subterricolous*, *terricolous*, *herbicolous*, and *aericolous* respectively. It is this process of interchange of either one individual or the same group of indivduals from one stratum to another that lends unity to the association. The process may be induced by changes of light intensity, or may be a direct response to the different needs and activities of an insect during different stages of its life-history. An analysis of migration reveals the presence of four factors, viz. motility, agency, proximity, and topography. Not all of these are present in every instance of migration, and in many cases where the proper distributive agent is lacking to eke out the motile powers of an organism, the effective operation of the two will be profoundly modified by distance and topography. In general, insects do not take long migratory flights except when there is some urgent necessity, such as lack of food due to enormous multiplication of a species, a phenomenon which occurs in the Rocky Mountain locust (*Schistocerca americana*). A curious example of migration, as yet unexplained, which the author had the opportunity of observing during a sojourn in America last summer, is that of two species of Salt Marsh mosquito, *Culex cantator* and *Culex solicitans*, which come off the extensive salt marshes bordering the New Jersey coast in enormous numbers. Specimens were taken in grasses and rank herbage as many as five to seven miles inland. Dr SMITH† first proved (1902) that the theory which maintained that mosquitoes do not fly far from the point where they breed, was not applicable to all the species of this family.

In a general way it is now recognised, as has been already remarked (p. 38), that

* VESTAL, A. G., "An Associational Study of Illinois Sand Prairie," *Bull. Ill. State Lab. Nat. Hist.*, 1913, vol. x, art. 1, p. 67.

† SMITH, J. B. "Mosquitoes," *Rept. New Jersey State Agric. Exper. Station, Trenton, N.J.*, 1904, p. 5.

for a given terrestrial environment the animal and plant association is co-extensive, and that the boundaries of the one roughly coincide with the other, the whole forming what has been defined as a *biota* composed of animal and plant assemblages. This relationship, which must as yet be considered hypothetical when regarded broadly, has been here constantly kept in view, and the tables in which the various insect species have been listed are meant to indicate this basic principle. The plant ecologist recognises various kinds of association which have been designated by the name of the dominant type of vegetation, such as pine association, moorland association, etc. In our study the association which is recognised as rather heterogeneous belongs to the grassland + mixed wood type. Being a strictly local complex, the conditions must be referred to as dependent primarily on soil or edaphic, as contrasted with climatic factors which determine the kind of vegetation over wide areas, such as deciduous forest and steppe.

For the determination of the various species of an association, their abundance and grouping, the botanist has devised the *quadrat* method. By this means the most accurate information can be obtained of the facts as they exist within a definite square area. Although the space covered is minute, valuable data can be obtained, from which conclusions of a general nature can be deduced applying to the whole association of which the smaller area selected is representative. Such detail and thoroughness is scarcely required for our purposes, and only a general idea of the relative abundance of plant species has been attempted, expressed as common, fairly common, very common (*cf.* Tables X, XI).

By reason of their sessile habits the individuals of a plant association can be more easily studied than those of the more motile species of an animal association. It is often a very difficult matter to settle what species are peculiar to the association and what are merely invaders, temporarily or permanently. The clue to an insect's real habitat is the test of where it breeds. This may also be the situation where it feeds, but in a great many cases the two places are not the same. A knowledge of the larval habits is therefore essential as giving an indication of the animal's real habitat.

Physical Factors of the Environment.

The environment or habitat may be defined as the result of the action and interaction of the combined forces or factors present in any given region, and, according to Vestal,* who quotes Schimper, have been classified into two groups—climatic (geographic) factors which operate over very broad areas, and edaphic (local) factors which effect local modifications of the plant life (and the animal as well) within any such broad region. The composition of the animal association is primarily dependent upon the ecological type of the vegetation, which is again dependent upon various factors, enumerated by Clements † as water-content, humidity, light,

* *Op. cit.*

† *Op. cit.* p. 18.

temperature, soil, wind, precipitation, pressure, altitude, exposure, slope, surface (cover), and animals. To these are added gravity and polarity, which are practically uniform for all habitats. In their total effect they represent the controlling forces of the environmental complex, and it is often difficult to attribute to each one its proper rank and value in determining the facies of the plant or animal association, on the latter of which they also have a more or less direct influence.

The water-content of any soil is in inverse ratio to its fineness of texture, and is also for any particular area dependent upon the degree of humidity which prevails and upon the amount of rainfall at any given time. The question of soil-moisture has been already discussed in a previous paper * with regard to its relationship to soil-inhabiting insects. The author indicated its importance as bearing upon their welfare. In the same connection the questions of temperature and soil ventilation were also amplified.

It is very doubtful whether such factors as altitude and pressure in any given region will be found to exert a measurable stimulus upon insect behaviour. In the first place, it is very difficult to analyse the real effects of altitude. To some extent it is associated with rainfall, but only in an indefinite degree. CLEMENTS, who has just been quoted, says (p. 18) that its influence, so far as the plant is concerned, is really pressure, and that, in consequence, its effect is exerted upon the climatic and not the edaphic factors of the habitat. Therefore so far as the present study is concerned, the consideration of altitude and pressure may be neglected. Daily records have, however, been kept of the barometric pressures. These have been averaged (*cf.* Table XII) for the various months during which the investigation lasted, in the hope that they might prove useful for comparison with the pressures prevailing in regions of lower or higher altitude. Thus, perhaps, an approximation to the proper value of pressure in influencing the composition of animal associations may be derived. It is a well-known fact that many insects inhabit only localities of high altitude, but as to whether this phenomenon can be directly assigned to the decreased density of the atmosphere is a matter of conjecture.

From the standpoint of the animal association the surface covering of the soil, its nature and density, is recognised to be of such importance that it is customary to speak of insects of forest, of grassland, of corn and other cultivated crops. Sometimes the mere fact that a particular type of vegetation offers a favourable means of shelter and protection from enemies will explain the presence of many insect species. Or it may be that predatory habits will induce them to frequent a particular locality in their search for food, other than the one in which they breed. This fact was boldly confronted in the present investigation.

Wind as a distributive agent is perhaps more important to the plant than to the animal association, and, naturally, where soils are light and loose it may be quite effective in modifying the surface topography. In the Holmes Chapel locality its

* CAMERON, A. E., "General Survey of the Insect Fauna of the Soil," *Journ. Econ. Biol.*, vol. viii, p. 189.

effect in this way is negligible. Many insects are anemotropic, and in moderate breezes will orient themselves head-on to the air-current, maintaining a seemingly motionless attitude on the wing for quite appreciable periods. Species of *Bibio* will often be observed maintaining their bodies headed to a gentle breeze, changing their position to the windward as the breeze veers in one direction or another. Many Anthomyiidæ, Syrphidæ, and Chironomidæ have a similar behaviour, and FOLSOM * quotes WHEELER as having observed *Empidæ* swarming in one spot every day for no less than two weeks, probably on account of some particular odour emanating from the ground which attracts and arrests the flies as they emerge from their pupæ. In this latter case, perhaps chemotropism determines their curious behaviour as much as anemotropism.

Many insects are undoubtedly carried before the wind from one association to another, and it may be of decided importance in migration and invasion. Otherwise it would often be difficult to explain why certain insects which belong to woodland associations are sometimes met with in grassland. During violent disturbances of the atmosphere winged insects generally seek shelter near the ground amongst the herbage.

The readings for the temperature, pressure, and rainfall were made each day at 9 a.m. Standard instruments were used. For accurate results in the study of biological phenomena, however, it is recognised that self-recording apparatus is essential, whereby the actual temperature fluctuations throughout the course of the day are obtained. The monthly averages of the soil-temperature records at Holmes Chapel show a seeming discrepancy, in that apparently the temperature at a depth of six inches at no time, during the fifteen months covering the investigation, rose above that at the depth of eighteen. This is, of course, erroneous, and due to the fact that the readings were made at a time (9 a.m.) when the soil at the uppermost layer of six inches has lost most of its heat during the night by radiation to the layers beneath and to the atmosphere, whilst the effect of the sun's rays have not yet reached sufficient strength to warm it up. In the summer months at midday, in bright warm weather, the surface layer is generally a few degrees warmer than the layers immediately beneath. In the winter months, during periods of frost and snow, the converse prevails.

The earlier months of 1914 were milder than those of 1913, as a glance at Table XII will show at once. Whereas, in January 1913, the average maximum air-temperature was 42° F., in January 1914 it was as high as 58° F.; the average maximum for the same month of 1914 was 37° F. compared with 31° F. for the corresponding month of the previous year; the average minimum temperature on grass differed by 4° F., 31° F. in January 1913 and 35° F. in January 1914. The average soil temperatures for these same months also varied; at six inches depth, January 1913, 40° F., January 1914, 38° F., a drop of 2° F.; at eighteen inches below

* FOLSOM, J. W., *Entomology: its Biological and Economic Aspects*, Philadelphia, 1906, p. 348.

the surface, January 1913, 38° F., January 1914, 44° F., an increase of 6° F. Analogous variations were recorded for February and March, with an increase of temperature in 1914 favourable to the earlier emergence of insect species from their hibernating quarters, a fact which was actually observed during the latter year.

The facts regarding the relationship of temperature to the hibernation, æstivation, and growth of insects are but inadequately known. Several workers have recently made notable contributions to the subject, of which those of TOWER, SANDERSON, HEADLEE, and DEAN in America, and BACHMETJEW in Europe are important.

SANDERSON * has endeavoured to determine the existence of physical laws upon which the time of emergence of insects from hibernation and the date upon which they begin oviposition, depends. In experiments with the brown-tail moth (*Euproctis chrysorrhœa*), the tent caterpillar (*Malacosoma americana*), and the codling moth (*Carpocapsa pomonella*), he has also endeavoured to establish a "thermal constant" governing the emergence of insects from hibernation. "Thermal constant" is defined as *that accumulation of mean daily temperature above the "critical point" of the species which will cause it to emerge from hibernation or to transform from any given stage.* Active metabolism in insect species as well as in plants only occurs at or above a certain temperature, probably specific for each kind or group, and this temperature has been designated the "critical point" for the species concerned. Heretofore 43° F. was generally accepted as being the universal temperature at or above which all temperatures were effective, but recent work has proved that it varies for different species.

It has generally been accepted that a lowering of temperature causes or is at least associated with the phenomena of hibernation, but SANDERSON (*loc. cit.* p. 58) and TOWER † have shown that insects have persisted in hibernating, or at least have their activities curtailed, in spite of being subjected to high temperature just previous to the normal time for hibernating. The latter author asserts that all the species of the genus *Leptinotarsa*, which includes the notorious Colorado potato beetle, have but two generations, when a period of rest, hibernation, or æstivation ensues, either of which exert the same effect on the life-history phenomena of the insect. During the period of rest the insect loses about 30 per cent. water, causing a concentration of its protoplasm and body fluids, by virtue of which it can the more readily resist the injurious effects of lower and higher temperatures.

SANDERSON ‡ in a later paper also draws attention to the fact that for some species moisture content is very important, and often more so than temperature, in determining the optimum for development; and therefore it is necessary for accurate work on the effect of temperature that moisture conditions should be kept constant.

* SANDERSON, E. D., "The Relation of Temperature to the Hibernation of Insects," *Jour. Econ. Ent.*, vol. i, No. 1, pp. 56–65, 2 figs.

† TOWER, D. L., *Evolution in Chrysomelid Beetles of the Genus* Leptinotarsa, Carnegie Institution, No. 48, 1906.

‡ SANDERSON, E. D., "The Relation of the Temperature to the Growth of Insects," *Jour. Econ. Ent.*, 1910, vol. iii, No. 2, p. 121.

This aspect of the question is emphasised in a paper by HENNINGS * on the relation of temperature and moisture to the development of the scolytid beetle *Tomicus typographus*, L., in which he says: "Dass nicht nur 'kalte' sondern 'nasskalte' Witterung die Entwickelung verlangsamt, hatten schon früher die Beobachtungen im Freien gelehrt; mein Bestreben ging dahin, den Einfluss der Luftfeuchtigkeit ebenso wie den der Temperatur zahlenmässig darzustellen." In a series of tables he shows the relation between temperature and moisture and the time occupied in the development of the various stadia of the insect. Perhaps the most exhaustive inquiry into the temperature-moisture relations of insects has been made by BACHMETJEW in two large treatises,† where he states that there is an optimum degree of humidity for insect development which differs for different species. DEWITZ ‡ has also carried out similar experiments with various Lepidoptera and Diptera, notably *Cochylis ambiguella*, *Œnophthira pilleriana*, *Eudemis botrana*, *Phalera bucephala*, and *Calliphora erythrocephala*, in order to determine the maximum temperature beyond which the activities of these insects are retarded, and after what period death ensues. Both the time and temperature factors were varied with interesting results, which depended upon the stage of development of the larvæ employed in the tests.

All of this work is of the utmost significance to economic entomology. It is absolutely essential to know the fundamental factors which govern the various phases of insect life, and as SANDERSON (*loc. cit.* p. 64) has remarked: "Entomology, as well as all biological science, must consider its relations to the more exact and fundamental sciences of physics and chemistry, if we are to have exact knowledge of the life with which we are dealing." This author, along with PEAIRS,§ has lately published a more detailed account of his researches in bulletin form.

There is, however, an objection to indoor experiments in temperature-moisture work. It is doubtful in how far one can base one's conclusions on results obtained under laboratory conditions, which are generally radically different from those that prevail outside. There are probably other physical factors besides temperature and moisture which must be considered, such as light intensity and atmospheric gases. To control all of these is by no means easy, but it appears to the author that no matter how unimportant any single factor may seem, it must be considered as contributing towards the changes which the insect undergoes in its progress towards maturity.

At the Philadelphia meeting of the American Association of Economic

* HENNINGS, C., "Beiträge zur Kenntniss der die Insektenentwickelung beeinflussenden Faktoren," *Biologische Centralblatt*, 1907, vol. xxvii, p. 327.

† BACHMETJEW, P., (1) *Experimentelle Entomologische Studien: I. Temperature Verhältnisse bei Insekten*, Leipzig, 1910, p. 160. (2) *Experimentelle Entomologische Studien vom physikalisch-chemischen Standpunkt aus zweiter Band*, Sophia, 1907, pp. 999+cviii, pls. 31.

‡ DEWITZ, J., "Physiologische Untersuchungen auf dem Gebiet der Schadlingsforschung," *Naturwiss. Zeits. f. Forst- u. Landwirtschaft*, vol. x, pt. 7, pp. 539–549.

§ SANDERSON, E. D., and PEAIRS, L. M., "The Relation of Temperature to Insect Life," *Tech. Bull. No.* 7, *New Hampshire Coll. Agric. Exper. St.*, Durham, N.H., pp. 1–125.

Entomologists, December 1914, DEAN and NABOURS * described a new air-conditioning apparatus for maintaining a desired constant humidity and temperature within a reasonable degree of variation. If in nothing else, it does not lack elaborate structure. The principle seems to consist in passing a current of air through a spray chamber, where it acquires a certain degree of relative humidity depending on the temperature of the water. It then passes over a thermostat, where there is imparted to it the required change of temperature before entering the breeding chamber. Dr HEADLEE, with whom the author has had the opportunity of discussing the subject, described at the same meeting a simple apparatus for the same purpose, consisting of constant temperature and moisture incubators. It is his opinion † "that the response of insect protoplasm, as exhibited in variations of the rate of metabolism, appears to depend upon: (1) where in the particular insect's temperature range the temperature changes occur; (2) the type of metabolism characteristic of the insect, when the response (*to temperature change*) is taken; (3) the presence of any abnormal factor such as parasitism." The third of these is of peculiar interest, and, if neglected, might lead to an apparent discrepancy in the results. Quoting DAVENPORT, he further emphasises (*loc. cit.* p. 416) the effect of moisture on insect metabolism, where, according as the amount of moisture is increased, growth increases until an optimum is reached. The quantity available does not determine the amount imbibed, which is rather controlled by the needs and habits of the species.

SHELFORD ‡ is of the opinion that the best and most accurate index of the varying physical conditions surrounding land animals wholly or partly exposed to the atmosphere, is the "evaporating power of air." The standard of measurement is expressed by the amount of water which the atmosphere, under different conditions of air-temperature, pressure, relative humidity, and average wind velocity, absorbs from a free water surface in a given time. Evaporation is greatest in open associations, as has been demonstrated by TRANSEAU,§ where the absence of dense vegetation permits of the more rapid removal of water vapour. By means of the porous cup atmometer, as devised by LIVINGSTON,‖ quantitative evaporation experiments can be successfully carried out.

The significance of the evaporation aspect is likely to prove so important that SHELFORD'S ¶ conclusions, deduced from the results of a series of experiments on the reaction of various animals to atmospheres of different evaporation capacities, may

* DEAN, G. A., and NABOURS, R. K., "A New Air-Conditioning Apparatus," *Jour. Econ. Ent.*, vol. viii, No. 1, pp. 107–111.

† HEADLEE, J., "Some Data on the Effect of Temperature and Moisture on the Rate of Insect Metabolism," *Jour. Econ. Ent.*, 1914, vol. vii, No. 6, p. 414.

‡ SHELFORD, V. E., "Animal Communities in Temperate America," *Geog. Soc. Chicago*, Chicago, 1912, p. 161.

§ TRANSEAU, E. N., "The Relation of Plant Societies to Evaporation," *Bot. Gaz.*, pp. 217–231.

‖ LIVINGSTON, B. E., "The Relation of Desert Plants to Soil Moisture and Evaporation," Publ. No. 50, Carnegie Institution.

¶ SHELFORD, V. E., *loc. cit.* p. 163.

be stated here: "(1) The animals studied react to air of a given high rate of evaporation whether the evaporation is due to moisture, temperature, or rate of movement; (2) the sign and degree of reaction to the given rate of evaporation are in accord with the comparative rates of evaporation in the habitats from which the animals were collected; (3) the animals of a given habitat are in general agreement in the matter of sign and degree of reaction; the minor differences which occur are related to vertical conditions and kind of integument, but no agreement between survival time and habitat when a number of members of a community are taken together."

The Insect Association.

A large number of the insect species which occur in meadows and pastures are not peculiar to them. The real index of an insect's habitat is where it breeds, and, although this may be the same as where it feeds during various of its life-history stages, there are innumerable instances where this is not so. If this fundamental principle be recognised, it is a very simple matter to distinguish between those forms which are proper or peculiar to an association (*endemic*) and those which are invaders (*polydemic*), provided always the larval habits are known. The second of these classes may be again subdivided into two groups, viz.:—1. Temporary invaders. 2. Permanent invaders. Only the first of these concern us. The second may be better considered in a discussion of the phenomena of *succession*. In any given area the physical conditions, climatic or topographical, may undergo such a change that its fauna or certain members of it can no longer exist within the environment. The new conditions may, however, be suitable to another set of organisms which invade the locality and make it their own. Thus a new order of things is established, lasting only so long as the fresh conditions do not vary to any great extent. Similar results may also be produced by a change of the biological conditions. In time, living organisms may render their surroundings toxic to their own kind by the accumulation of waste matter or excreta, or it may be that the food supply will give out. On the other hand, other organisms will thrive in just those conditions and replace their benefactors (Shelford, pp. 308, 309).* In the process of reduction and demolition of a felled log to humus one obtains a good idea of what is meant by succession, where the Scolytid and large Cerambycid beetles are followed by the larvæ of Elateridæ. With the advance of decay these forms give place to the larvæ of Muscidæ, Tipulidæ, Mycetophilidæ and attendant predaceous forms, such as the larvæ of Leptidæ, Xylophagidæ, Staphylinidæ, and Carabidæ. Ants will frequently rear their broods in the old burrows of the wood-boring forms. In the final stages, when fungus and moisture have aided materially in reducing the wood to pulp, earthworms enter and complete the processes of demolition.

We also recognise definite changes or succession of organisms from season to

* *Op. cit.*

season. For any given locality the same changes in the same order occur year after year. It may merely be a succession of the various life-history stages of the individual species. Every collector and ecologist knows that many insects are only to be found on the wing for a certain, well-defined period of each year.

Apterygota.

It has not been considered necessary to draw up a detailed table of the various species of the Apterygota. In the first place, their numbers were comparatively few, and in the second, their habits are probably all alike, viz. : humus-feeders requiring fairly moist conditions. The following occurred :—

Campodea staphylinus, Westw.
Onychiurus fimetarius, L.
Onychiurus ambulans, L.
Isotoma viridis, Bourl.
Isotoma grisea, Lubb.
**Tomocerus tridentiferus*, Tullb.
Entomobrya nivalis, L.
Entomobrya albocincta, Templ.
**Lepidocyrtus curvicollis*, Bourl.
**Orchesella cincta*, Lubb.
**Dicyrtomina ornata*, Lubb.

The species marked * were found mostly among dead leaves on the boundary of Glover's Meadow near the wood (Pl. II, fig. 2), and in similar situations in the Alluvial Pasture (Pl. II, fig. 1). They are probably characteristic of forest floors. The remaining species occurred at the roots of grasses.

Plectoptera, Neuroptera, Mecaptera, Trichoptera.

Of the various species (Table VIII) only *Chrysopa vulgaris* and *C. perla* belong to the association. The others, except *Panorpa communis*, are members of aquatic communities. Only the proximity of their habitats, neighbouring ponds and the River Dane, will account for the occurrence of the adult forms in grassland. They were taken very frequently when attracted by artificial light. The larva of *P. communis* is a soil inhabitant generally found in moist, wooded areas. The male of the species possesses a curious clasping organ near the anus.

Diptera.

This order (Tables I, II, III) is especially well represented in grassland. In our particular locality the various species are referable to several distinct classes, chief among which are :—

1. Those peculiar to grassland and consisting mostly of species, the larvæ of which are predaceous either in the soil or other vertical strata, or truly phytophagous, depending chiefly for their subsistence upon grassland plants and weeds (Table I).
2. Those the larvæ of which are coprophilous or subsist on decaying animal or vegetable tissue. The imagines have generally the same habits or frequent flowers. Some may become pests of cultivated crops, e.g. *Dilophus*, *Bibio* (Table II).

3. Those species which are aquatic as larvæ. The adults frequent and shelter among grasses often in large numbers (Table III).
4. Those species which invade from adjacent wood and ruderal associations, *e.g.* *Chortophila brassicæ*. They have been indicated in the tables (*q.v.*).

The classes are not mutually exclusive, as many species might be equally well included in one or other. Primarily, the tables are meant to apply only to the area of our investigation, but as a basis of comparison for other similar areas the data will prove useful. Where the larval habits are not known it is impossible to relegate the species to its proper habitat with any degree of accuracy, but a knowledge of allied species will often furnish a clue.

An interesting case of unorthodox habits may be cited of one family of Diptera. It is considered by most students of Leptidæ that the larvæ are predaceous. Whilst this may undoubtedly be the case, the author had convincing evidence that this statement cannot be considered absolute. Almost mature larvæ of *L. scolopacea* and *L. tringaria* (Table I) were found well buried in decaying, pulpy (seed) tubers. They seemed suspiciously engrossed in satisfying a depraved appetite on the liquefying, evil-smelling mass. In some cases, it is true, they were associated with scavenging larvæ of Staphylinidæ, *Oxytelus* and *Stenus* (Table V), and also *Onychiurus*. The author was, however, successful in rearing the adults from larvæ in decaying potatoes where no other insects were present. On several occasions the larva of *L. scolopacea* has been taken among decaying vegetable matter, which would appear to be their true habitat.

It is not intended to enter into a lengthy discussion of the various species. The information which has been culled from the author's observations in the field, and supplemented here and there from well-known and authenticated sources, has been conveniently tabulated for the reader's reference. In all cases the authorities have not been quoted, not because of any pre-conceived idea of neglect, but because their very familiarity renders this unnecessary.

Coleoptera.

Practically the same classes (Tables IV, V) can be distinguished as in the case of Diptera. Although the consideration of the aquatic forms is quite relevant because of the proximity of field ponds and the river to our grassland association, yet they have been neglected, as the imagines are very rarely, if ever, found among herbage. In their behaviour they practically do not contribute towards influencing the constitution of the insects of the grassland association. They are best confined to a consideration of aquatic communities.

One point of significance was the occurrence of forms peculiar to moist localities. For instance, both in the Alluvial Pasture and in Glover's Meadow species of Coleoptera, besides Diptera, Lepidoptera, and Hemiptera, were taken, which are, as a rule, confined to humid places. The physical and vegetational conditions supply an

indication of the fauna. Conversely, the composition of the latter will in a very general way be a reflex of these same factors.

Some species of Coleoptera that are pests of grassland are equally injurious to cultivated crops. Wireworms will adapt themselves to various root and graminaceous crops besides natural grasses. This accounts for the fact that rotation has very little effect in diminishing the numbers of this pest.

The Nitidulid beetle, *Epuræa æstiva* (Table V), is probably a scavenger feeding on débris in the nests of wild bees. According to Fowler * the species is said to have been reared in numbers by CHAPPELL from those of *Bombus lucorum*. Another member of the same family, *Rhizophagus bipustulatus* (Table IV), which the author has found under bark in the early part of the year, preys upon wood-boring larvæ. An allied species, *R. depressus*, has been recorded attacking the larvæ of the Scolytid beetle *Hylesinus*.

Those species which could be traced to habitats other than those of grassland have been indicated in the tables (IV, V) by means of symbols (*q.v.*).

Lepidoptera and Tenthredinidæ.

The night-flying moths of the family Noctuidæ (Caradrinidæ) are typical of grassland associations (Table VI). Their larvæ, surface-caterpillars or cutworms, burrow into the soil or hide beneath some ground-shelter during the day and feed on the surface at night. In general, those Lepidopterous species will occur in any given locality where their food-plant is at hand. Isolated trees of willow along the banks of the Dane and elsewhere in close proximity provided food for *Smerinthus populi*, *Earias clorana*, and *Acronycta rumicis*. Quite a number were invaders from woodland, whilst ruderal species were not uncommon. The Pieridæ, for instance, affect cabbage (*Brassica*) principally, and several Agrotids have a like habit. In the north corner of Glover's Meadow, closely grown over with bracken (*Pteris aquilina*), *Pseudopanthera petraria* and *Melanchra pisi* occurred in fair numbers.

The nomenclature of MEYRICK † has been adopted in designating the various species recorded.

Of the Tenthredinidæ (Table VI) which have been included in the same table as the Lepidoptera because of the similar larval habits of both, the species and specimens were preponderantly of the genus *Dolerus*. They appear first in the late spring and fly lazily about among herbage on which their larvæ feed, never, seemingly, undertaking very extensive flights. The fully fed larvæ do not spin a cocoon, but pupate free in an earthen cell. *Allantus arcuatus* also occurred in great abundance. Species of *Selandria*, *Blennocampa*, *Fenusa*, and *Nematus* were taken occasionally.

* FOWLER, C., *British Coleoptera*, 1899, vol. iii, p. 228.

† MEYRICK, E., *Handbook of British Lepidoptera*, London, 1895.

Hemiptera.

Although the various species of Aphididæ occurring in the association were not studied, their importance must not be lost sight of. The species of this important family are the prey of lace-wing flies, lady-bird beetles and the larvæ of hover-flies. As many of the predatory species seem to confine their activities to one or perhaps a few species of Aphids (*oligotrophic*), the presence and numbers of the latter are in great measure determinative of the abundance of the various species of their enemies.

Capsidæ are fairly well represented in the herbage of meadows. One species, *Pithanus Maerkeli*, rarely occurs in the fully developed form, and likewise the Reduviid bug, *Nabis limbatus*, was always micropterous. Of the Cimicidæ, two species of *Anthocoris* were quite common (Table VII).

Cuckoo spits were abundant during the summer months, and, of the three species, *Philænus spumarius*, which occurred in great numbers, must exact quite a heavy toll from its host grasses.

Hymenoptera.

The parasitic species of this order represent one of nature's most efficient controls of injurious insects. Various species were taken in large numbers among herbage and, including those reared from hosts occurring in the association, there were in all thirty distinct species, without Chalcids. The host was not determined in each case, but in order to make Table IX (*q.v.*) fairly complete, the works of Morley * and Brischke † were frequently consulted, and probable hosts suggested. The extent of this indebtedness has been indicated in this table.

Other Hymenopterous species which frequent meadows and pastures are the anthophilous bees (Apidæ), of which *Andrena trimerana*, *Andrena fulva*, and *Andrena nitida* occurred commonly on the flowers of *Trifolium repens* and *T. pratense*.

Vespa vulgaris, which had its nest under the shady bracken in Glover's Meadow, —where the soil was rather light—was noted as especially busy in late summer frequenting the foliage of potatoes in the adjacent field. Its activities seemed to be related in some way with the potato-infesting aphis, probably gathering the sweet secretion which the latter exudes on the leaves.

The black variety of the fossorial wasp *Crabro quadrimaculatus* invades meadows from wooded areas. This species burrows in rotten wood and provisions its nest with gnats and other small Diptera, frequenting herbage in search of its prey. It is one of the most abundant species of the genus.

Ants occurred commonly in the Alluvial Meadow in midsummer. They seemingly all belonged to the same genus, *Myrmeca*. A black ant of larger size, *Lasius* sp., was found near the boundary of meadow and wood. It was evidently the same

* Morley, C., *British Ichneumons*, 4 vols., 1903–11, Plymouth.

† Brischke, C. G. A., "Die Ichneumoniden der Provinzen West- und Ost-Preussen," *Schr. d. Naturfors. Ges. Danzig*, vol. iv, pt. 3, pp. 35–121 ; *loc. cit.*, vol. iv, pt. 4, pp. 108, 210 ; *loc. cit.*, vol. v, pt. 3, pp. 121–199.

species as the author found early this year (1915) hibernating in the larval galleries of *Rhagium bifasciatum* in a felled tree at Whaley Bridge, Cheshire.

Soil-Insect Census.

The interest of an analysis of the insect numbers and species of definitely measured samples of soil first appealed to the author after perusing the data collected by various workers in their investigations upon the food of birds. In any given locality, a study of the relative abundance of the insect species and of the various birds which prey upon them, would be productive of much important information. Hitherto, most insectivorous birds have been classified as "useful," but one must discriminate between those which feed on pests and those which feed on insects that are themselves predaceous and therefore beneficial. It is extremely doubtful if a bird distinguishes between different insect species so far as to select one more than others as its prey. The fact that one species may predominate in a bird's diet, as shown in post-mortem dissection, merely demonstrates that at a given time the particular insect was either very abundant or the most accessible in the district from which the bird was taken. Necessarily, to be complete, the insects which belong to each of the vertical strata of an association should be considered. But for such birds as starlings, rooks, and lapwings, which are typically ground-feeders, only the surface and subterranean insect strata need be dealt with.

At the outset of the survey, whilst tentative efforts were being made to grasp the associational aspects of the insect complex, the very great abundance of Tipulid larvæ in the Alluvial Pasture and their practical non-existence in Glover's Meadow seemed to require explanation. In the case of wireworms, the facts were almost exactly reversed. Therefore, in order to ascertain whether there were similar or parallel phenomena with regard to other species due to the same or allied causes, the analysis assumed the form of a comparison between definitely measured samples of the two grasslands. It must be remembered that they differed principally as regards altitude and exposure, water-content of their soils, which were respectively alluvial and clay loams, and also in the texture of their soils, a fact which naturally depends on their different origins. In its ultimate composition, the flora did not differ greatly in the two. One field, however, the Alluvial, was grazed by cattle whilst Glover's was left undisturbed. As these points have already been dealt with in detail, this brief restatement will be quite sufficient here.

The method of procedure consisted in cutting out samples of soil of one cubic foot capacity. After the adhering plant-species had been determined, and, in a general way, their relative abundance, each sample was thoroughly and systematically investigated in the laboratory. As far as possible all insects, whether in the egg, larval, pupal, or adult condition, were enumerated. Tables X and XI represent briefly the results which this research produced. All insect specimens, whether they lived in the ground or merely inhabited the surface, are included in the two tables.

Although it may be argued that some of the species are not strictly soil insects according to the strict usage of the definition, viz. parasitic Hymenoptera (Table X, sample 1), yet it may just be possible that even they may be identified with the soil or with soil-inhabiting forms at some stage of their life-histories.

The census was carried out during the period extending from October to March (1913–14). The author recognises that, for completeness sake, the investigation should have covered a whole year. This, however, was not possible at the time, as the work was interrupted by his departure for America. Still, there is this much to be said in favour of a winter census, that the variation in the constitution of the subterranean and surface fauna is less at this season than during any other of the year. Most soil insects hibernate as larvæ and pupæ, and so the variation is reduced to one of size and development of the individual species. Many larval forms do not even vary to this extent, as, with a cessation of feeding and a general suspension of all activities consequent on the lowering of temperatures, there is an inhibition of growth. Before and after the two months stated, metamorphoses progress much more rapidly. From April to September many of the larvæ of the soil inhabitants have attained the imaginal stage, the adults now frequenting the aerial stratum. Therefore it may be justly contended that one is likely to get a much better idea of the soil-insect fauna during the winter than at any other season.

In passing, it may be worth while to draw attention to the fact that many of the insect larvæ which one commonly encounters in the soil have not as yet been adequately described, and some, indeed, not at all. Insufficient knowledge of the premature stages of an insect renders accuracy of identity oftentimes extremely difficult and uncertain. Where not otherwise possible, the species of the larva or pupa can only be determined with exactness by rearing the imago and having this identified. Where success did not always attend the rearing of a species, it was at least possible to indicate the family and sometimes also the genus.

Assuredly a wide field exists for the scientist who is willing to undertake life-history studies of either predaceous or phytophagous, soil-inhabiting insects. Especially is there a lack of information of the facts pertaining to the life-histories of species of Empidæ, Asilidæ, Therevidæ, Leptidæ, and Tabanidæ. As for the Stratiomyiidæ, the larvæ have been classified by LUNDBECK,* but the key must be used with reserve, as his examination did not exhaust the larvæ of all species. In the course of our investigations one or two larvæ of the family were collected, the characters of which would not fit with the descriptions of any in this author's list. The same lack of information applies to the larval forms of most other families and orders besides those of Diptera.

In point of number of species as well as of specimens, the orders most extensively represented in our soil census are Coleoptera and Diptera. Of Lepidoptera, there were a few surface caterpillars (Noctuidæ) which occurred in 4 of the 11 samples

* LUNDBECK, W., *Diptera Danica*, Copenhagen, 1907, pt. 1, pp. 73–75.

taken from Glover's Meadow and in 1 of the 14 from the Alluvial Pasture. Three species of sawfly, 2 cocoons and 1 larva, 2 specimens of an adult Ichneumon (*Hemiteles necator*), and 1 specimen of an adult Braconid (*Blacus ruficornis*) represented the sum-total of Hymenoptera, all taken in 4 samples (Table X, examples 1, 3, 4, 7) from Glover's Meadow. Hemiptera, except for the occurrence of the remains of the 7 specimens of *Schizoneura* sp. in sample No. 6 of the Alluvial Pasture, were entirely lacking. This circumstance would tend to show that the grassland Hemiptera winter in the egg stage, which may have been overlooked. Of course, it is possible that they betake themselves to winter quarters elsewhere, or, perhaps, in an alternate form (*Aphidæ*), migrate to other plant species outside the grassland association. The Apterygota were fairly well represented, considering the location of the two fields and the size of the samples investigated. Being principally humus-feeders, the species of this order are generally associated with decaying vegetable substance. They occurred in 2 Glover's samples and in 6 of the Alluvial.

It was at first thought that some degree of relationship might be discovered between certain of the phytophagous soil insects of the two grasslands and some of the plant species existing therein; but for definite and conclusive results, it is recognised that a more restricted analysis would be necessary. In meadows and pastures, with their heterogeneous mixture of grasses and weeds, it is extremely difficult to diagnose the constancy, or otherwise, of the feeding habits of any one species, especially if it be graminophilous and also polytrophic. Again, many forms that find nourishment in the roots of grass will subsist equally well on those of various weeds.

The samples taken from the Alluvial Pasture, in which perennial rye-grass (*Lolium perenne*) predominated or was common, generally yielded several specimens of Cecidomyiidæ (*C. destructor*, *L. auricincta*), Bibionidæ (*B. Marci*), and Tipulidæ (*T. oleracea*); but, probably, according to the evidence as obtained from Glover's Meadow samples, *L. auricincta* is equally attached to sheep's fescue (*Festuca ovina*). General conclusions, however, are difficult to establish. In sample No. 4 (Table XI) none of the insect species of the families above mentioned were taken, and in sample No. 12 only 2 Cecidomyiidæ occurred. A greater or less degree of association could be traced between the numbers of species of these same families and the relative abundance of perennial rye-grass in Glover's Meadow, but in sample No. 1 (Table X), where the only grass was Yorkshire fog (*Holcus lanatus*), both Cecidomyiidæ and Tipulidæ are represented; whereas, in sample No. 5, with perennial rye-grass predominant, no specimens of either family were present.

It may be interesting to mention here that the larvæ of *Bibio Marci* and *Tipula oleracea*, especially the younger stage forms, more often than not occurred gregariously, which socialistic mode of existence—a phase of the phenomenon of what DEWITZ calls stereotropism *—seems to be the result of a response to the stimulus of contact between larvæ of the same species.

* DEWITZ, J., "The Bearing of Physiology on Economic Entomology," *Bull. Ent. Res.*, vol. iii, pt. 4, p. 345.

Out of the 25 samples from both fields specimens of Neuroptera, cocoons of *Chrysopa vulgaris*, occurred only once in sample No. 7 of Glover's Meadow, selected from the western boundary adjacent to the wood. The larvæ had probably been feeding on tree-infesting aphids before descending to the ground to spin up the silken domiciles in which they spend their period of inactivity.

It will be at once evident by consulting Tables X and XI that the majority of the species of soil insects, according to our census, belong to the two great orders Coleoptera and Diptera. In the first of these orders, again, they are ranked for the great part in the families Carabidæ, Staphylinidæ, Silphidæ, Scarabæidæ, Sphæridiidæ, Lampyridæ, Telephoridæ, Elateridæ, and Curculionidæ. The kind of soil determines in great measure the species that may be present in any given locality; thus, many Carabid species will be found only in light soils, whilst others are more frequently met with in damp and heavy soils, e.g. *Anchomenus*, *Nebria* (Table IV). Similar selective habits hold good for Staphylinid species, e.g. *Tachinus*, *Tachyporus*, *Xantholinus Oxyporus* (*loc. cit.*), for many of which the presence of decaying vegetable matter or humus is essential. Some, for instance, are invariably associated with dead moist leaves on the forest or woodland floors and, being negatively phototropic, will retreat from more open conditions. Species of Sphæridiidæ, Silphidæ, and Scarabæidæ are associated with decaying animal and excrementitious matter, the species of Sphæridiidæ being chemotactic to dung, those of Silphidæ to putrefying flesh. The larvæ of Telephoridæ often occur in grassland soil where they also pupate. Their food-habits are believed to be predaceous, but it is the author's suspicion, engendered by observation and experience, that certain of them may also be vegetarian and even find nourishment in the products of decaying vegetable tissue. Lampyrid larvæ frequent moist localities, where they are most likely to find their terrestrial slug-hosts. As for wireworms, any sort of meadow seems to offer suitable conditions, provided it is not too damp, and our investigation shows that the higher-lying and drier situation of Glover's Meadow harboured these pests in far larger number than the fluviatile pasture below. But it is just possible that the proximity of the former to the ruderal associations of cultivated root crops, such as potatoes and mangolds,—where examination showed that wireworms were quite common—might adequately explain this difference of infestation. The imagines often migrate from cultivated crops to meadows and pastures and, being the nearer of the two, Glover's Meadow would be likely to receive the larger quota of migrants.

Among Diptera, the families most extensively represented in the soil—generally in the egg, larval, and pupal stages—are Cecidomyiidæ, Mycetophilidæ, Chironomidæ (a few), Bibionidæ, Tipulidæ, Stratiomyiidæ, Tabanidæ (in moist earth near water), Asilidæ, Therevidæ, Empidæ, Dolichopodidæ, Platypezidæ, Syrphidæ, Sarcophagidæ, Muscidæ, Anthomyiidæ, Cordyluridæ, Lonchæidæ, Sapromyzidæ, Sepsidæ, Borboridæ, and Phoridæ (a few). The larval habits vary. Some are predaceous and forage for their prey, such as those of Leptidæ, Asilidæ, Therevidæ, Empidæ, and Dolichopo-

didæ probably. In the majority of cases, dipterous larvæ are attracted to those soils which are rich in decaying vegetable or animal matter. Some, however, will attack healthy growing roots, as witness the depredations of *Tipula oleracea*, *Dilophus febrilis*, and *Chortophila brassicæ*. Many more examples of pest species might be cited, besides others suspiciously near the border line. Observations require to be made in order to ascertain to what extent an insect species is capable of adapting itself to new feeding habits in the absence of the accustomed diet—whether, indeed, there may not be a certain faculty of accommodation of taste for healthy or decaying animal and vegetable tissues or matter. The author has on one occasion taken an almost mature larva of *Tipula oleracea* at the roots of grass with a partly destroyed Anthomyiid larva in its jaws. Had it mistaken the maggot for a grass root? Surely a novel diet!

Those samples wherein the weed species were rather common—*Ranunculus repens*, *Trifolium repens*, and *Plantago lanceolata*—seemed to provide better conditions for the activities of predaceous soil-inhabiting larvæ on account of the lesser binding effect of their roots on the soil particles, than is the case with those grasses. So it was in these that species of Empidæ occurred most frequently, but at no time in any great abundance, like the phytophagous Bibionid and Tipulid larvæ. In those areas of the Alluvial Pasture which were sodden with moisture, they occurred not at all, but, otherwise, would be about equally represented in both fields.

The herbaceous perennials of grasslands, by the death and decay of their leaves and flowering parts, add annually to the soil an appreciable amount of rotting vegetable tissue and humus, which serve to attract numerous scavenging Diptera and Coleoptera. The component species were in this respect very similar in the two fields, a fact which applies with equal truth to the species of humus-feeding Apterygota for which moisture is essential. Seeing that the Alluvial Pasture was grazed by cattle whilst Glover's Meadow was undisturbed, one would have naturally concluded that coprophilous Coleoptera would have been scarcely, if at all, represented in the latter. As regards the larvæ, this was actually the case, but, as Table X shows (samples Nos. 5, 6, 11), the imagines of *Aphodius fimetarius* occurred fairly frequently; whereas, at the time of the census, no species of Scarabæidæ were taken in the Alluvial Pasture samples. As a matter of fact, *Aphodius fossor*, *A. fimetarius*, *A. contaminatus*, and *A. prodromus* occurred frequently at cow-droppings in the Alluvial Pasture. That *A. fimetarius* was taken in Glover's Meadow may be accounted for by the fact that it may have been merely an invader sheltering or resting amongst the herbage. But some specimens occurred beneath the surface of the ground where, on several occasions, the remains of this pretty Scarabæid were met with. It is just possible that after oviposition in the autumn, the adults may burrow into the soil near where the eggs have been laid, or they may wing their way to meadows further afield previous to their demise at the roots of grasses. The presence of *Sphæridium scarabæoides* in Glover's Meadow may be readily explained

on the supposition that this species, besides being coprophilous, may also feed on humus and decaying vegetable matter.

Of Curculionidæ, species of *Sitones* were more numerous in the Alluvial Pasture, but the only two species of *Hypera* occurred in Glover's Meadow (*cf.* samples Nos. 2, 4). Larvæ of *Otiorhynchus sulcatus* were about equally distributed in both fields, but never very numerous.

Perhaps with such small numbers as our census represents, no really strict comparison should be drawn between the faunistic composition of the two areas. The physical-factor differences of the two were very restricted and confined mostly to those of soil, water-content, altitude, and exposure, to which is added the fact of the Alluvial Pasture being also grazed. Impartially, the facts as revealed by the census, in broad outlines, tend rather to indicate that, in this country at least, the soil-insect fauna of grassland in any given locality is not likely to vary to any great extent. Of one thing the author is convinced, and that is, large numbers of specimens must be treated of in order to throw minor differences due to variable local conditions into bold relief.

In addition to insects alive and dead, one encounters in the soil representatives of Araneida and Acarina, Annelida and Mollusca, not to mention fruits and seeds, all of which may form food for ground-feeding birds. In many cases they are definitely associated with insects, either preying on or being preyed upon by the latter. Spiders are quite prevalent, and mites of the genera *Gamasus*, *Trombidium*, and *Smaris* are not infrequent, as are likewise various species of worms. Generally, in those samples which bore a covering of moss on their surface, two species of shelled Mollusca, *Cochlicopa lubrica* and *Vitrea nitidula*, were quite common, as well as specimens of the slug *Arion circumscriptus*, and innumerable slug eggs. Earthworms of various species and their cocoons, as one would naturally expect, were abundant in almost every sample.

Soon after the work of the soil-insect census had been commenced, the author's attention was directed to a paper by M'Atee,* in which, from an enumeration of all the insects and other invertebrates, besides seeds and fruits, present in four square feet of forest floor near Washington, U.S.A., it was calculated that, for the particular locality specified, there were in each acre 1,216,880 animals belonging variously to Insecta, Arachnida, and other Arthropoda, Annelida, and Gastropoda, and 2,107,810 seeds and fruits. Truly formidable figures! which almost pale into insignificance in the light of this same author's calculation, on a similar basis, of the numbers in one acre of meadow land for the same locality, viz. 13,654,710 animals and 33,822,745 seeds!

Of course, these numbers only apply to the class of soil surface indicated and to the particular locality stated. As a basis for general conclusions they avail nothing. It would, further, be absurd to deny that these figures might not be

* M'Atee, W. L., "Census of Four Square Feet," *Science*, N.S., 1907, vol. xxvi, pp. 447–449.

easily reversed. If an area of four square feet in a forest included a decaying tree with its myriads of Scolytidæ and other wood-borers, the figures which would be obtained would probably surpass any that could be derived from a census of any meadow area of the same size.

In conclusion, it is my privilege to be able to express here my gratitude to the following gentlemen who courteously assisted in the identification of much of the material, more particularly Diptera, Coleoptera, and Hymenoptera:—Mr F. E. Edwards, Natural History Museum, London; Mr J. E. Collin, Newmarket; Mr C. Morley, Natural History Museum, London; and Mr J. Ray Hardy, Manchester Museum. For the rest, the author found the entomological collections under the charge of the last-named of invaluable assistance, and they were constantly consulted.

Summary.

1. In any given locality the composition of the insect association is determined by a complex of factors, which may be classified as follows, viz. physical, physiographical, topographical, and vegetational. Primarily, it is dependent upon the ecological type of the vegetation.

2. The most accurate index of the various physical factors surrounding animals is the "evaporating power of air."

3. The insects of a given association may not be strictly confined to it. It is therefore necessary to distinguish between those species which are peculiar or proper to an association, and those which owing to a response to varying stimuli, play the rôle of invaders.

4. In all cases the criterion of an insect's true surroundings or habitat is the place where it breeds. It must be also recognised that as the facies of a habitat changes so also will its fauna (phenomenon of *succession* of organisms).

5. A census of soil-inhabiting insects is of interest in relation to the problem of the food-habits of ground-feeding birds.

6. A comparison of the soil-insect fauna of two areas which differ radically as regards their soil-types and vegetational covering is of intrinsic importance in obtaining a solution to the question in what measure the faunistic differences can be explained by variations of edaphic factors.

7. In a restricted way the study of the two grasslands, Glover's and Alluvial, was productive of much information on differences of their soil-insect fauna. In this connection the food-habits of the various species rank as of primary consideration.

Correction.

It is necessary here to rectify an error which occurs in the explanation of the plates on p. 203 of the paper, "The Insect Fauna of the Soil," *Jour. Econ. Biol.*, vol. viii, pt. 3. Larva of *Rhyphus fenestralis* should read larva of Tipulid.

Table I.

Diptera proper to the Association recorded from Alluvial, Glover's, and other Meadows and Adjacent Wooded Coppices.

In the first column the family name applies to all species opposite it and which follow it in column two. In the third column the numbers refer to the various months in which the adults were collected.

Abund. = abundant; v. com. = very common; com. = common; f. com. = fairly common; occ. = occasional; infreq. = infrequent; † indicates that the species has also been found in cultivated crops or ruderal associations; * in forest associations; ‡ generally found in moist situations.

Family.	Species.	Month.	Occurrence.	Remarks on Habits.
Cecidomyiidæ .	*Lasioptera auricincta*, Winn.	5	occ.	Larvæ and pupæ at roots of *Festuca ovina*.
	†*Cecidomyia destructor*, Say.	5, 8	com.	Pupa is the "flax-seed" in decaying grass; the species commonly attacks meadow grasses, *Triticum* and *Phleum*.
	†*Diplosis tritici*, Kirkby .	5, 6	„	Attacks *Triticum* besides cultivated graminaceous crops; fully fed larva, "Red-Maggot," pupates in the soil.
Mycetophilidæ .	*Sciara Thomæ*, L. . .	10	occ.	Larvæ among grass at the base of the stems.
	„ *quinquelineata*, Mcq.	3	„	Larvæ among decaying tubers.
	„ *pulicaria*, L. . .	10	„	„ „ „
Bibionidæ . .	*Bibio Marci*, L. . .	3, 4	v. com.	Larvæ often in masses at roots of meadow grasses.
Tipulidæ . .	**Pachyrrhina histrio*, F. .	6	occ.	Larvæ in rotten wood.
	† „ *maculosa*, Mg.	5	v. com.	Larvæ infesting adjacent potato crop and also in meadow soil.
	Tipula nigra, L. . .	9, 10	occ.	A single larva taken at roots of grass pupated at the end of September.
	„ *lateralis*, Mg. .	6, 8	com.	Larva infesting potato field.
	† „ *oleracea*, L. . .	7, 8	abund.	Larva attacking root crops and meadow grasses.
	† „ *ochracea*, Mg. .	7	occ.	Larva probably similar to that of previous species.
Leptidæ . .	†*Leptis scolopacea*, L. .	4, 7	v. com.	Larva free in soil and also in decaying seed tubers.
	† „ *tringaria*, L. . .	7, 8	com.	Larva in decaying seed tubers.
	„ *lineola*, Fab. . .	6	„	Larva probably in the soil.
Empidæ . .	‡*Rhamphomyia sulcata*, Fln.	7, 8	„	Larva free in soil, adults on low herbage in moist places.
	„ *longipes*, Mg.	6	„	Larva free in soil, adults on low herbage. Hitherto recorded mostly in the South of England, from the New Forest.
	Empis livida, L. . .	6, 7	abund.	Larvæ free in soil; adults frequent herbage to prey on smaller Diptera.
	„ *lutea*, Macq. . .	6	occ.	Habits probably similar to those of *E. livida*.
	„ *unicolor*, Brullé .	8	„	„ „ „ „
	Hilara maura, F. . .	8	com.	Larvæ according to Brauer (p. 61)[1] in mole-burrows.
Dolichopodidæ .	*Dolichopus griseipennis*, Stann.	8	occ.	Larvæ probably in decaying vegetation.
	Dolichopus atratus, Mg. .	6, 8	„	„ „ „ „
	‡*Pœcilobothrus ducalis*, Lw.	8	v. com.	Adults on low herbage in damp places.

[1] Brauer, F., "Die Zweiflügler des Kaiserlichen Museums zu Wien," *Denkschr. der Kais. Akad. der Wiss., math.-naturwiss. Classe*, Wien, 1883, vol. xlvii.

TABLE I—*continued.*

Family.	Species.	Month.	Occurrence.	Remarks on Habits.
DOLICHOPODIDÆ. (*cont.*)	‡*Gymnopternus metallicus*, Stan.	8	com.	Adults very active, living in communities in damp herbage.
	Porphyrops spinicoxa, Lw.	8	v. com.	Larva probably in soil as described by BELING (p. 226, 1882)[1] in the case of *P. crassipes*.
PLATYPEZIDÆ .	*Platypeza modesta*, Ztt. .	9, 10	occ.	Larva in humous soil in meadow land and may also be coprophilous.
SYRPHIDÆ . .	*Pipiza quadriguttata*, Mcq.	5, 6	,,	Larva aphidivorous, adult anthophilous like most Syrphids.
	Melanostoma mellinum, L.	6	infreq.	Larva aphidivorous, adult anthophilous like most Syrphids.
	Ascia podagrica, Fab. .	6	,,	Larval habits unknown; adults on low herbage.
TACHINIDÆ . .	*Siphona geniculata*, Deg. .	5, 6	com.	Larva probably parasitic on Lepidopterus larva.
ANTHOMYIIDÆ .	†*Chortophila brassicæ*, Bché.	6, 9	v. com.	Larva attacks cabbage roots; adult sheltering among herbage.
	Pegomyia bicolor, W. .	6–9	com.	Larva mines in leaves of *Rumex* spp.
	,, *nigritarsis*, Ztt. .	6–9	occ.	,, ,, ,,
	,, *hyoscyami*, Pz. .	6–9	,,	Larva mines in leaves of marigolds and other plants (CAMERON, p. 50, 1914)[2]; adults taken rarely, resting among herbage.
	Caricea tigrina, F. . .	7	infreq.	One specimen reared from larva at roots of grass; adults in moist meadow places.
	Cœnosia lineatipes . .	6	,,	One larva found and reared under similar conditions as the previous; probably both species are more often coprophilous.
MICROPEZIDÆ .	**Calobata petronella*, L. .	8	,,	Adults on low shrubs.
TRYPETIDÆ . .	*Spilographa zoë*, Mg. .	5, 8	occ.	Larva mines in leaves of *Senecio* spp.
OPOMYZIDÆ. .	*Balioptera tripunctata*, Fln.	7, 8	v. com.	Larva probably lives in stems of herbaceous plants; adults numerous in herbage.
	,, *combinata*, L. .	7, 8	,,	Habits similar to the previous species.
	Opomyza germinationis, L.	7, 8	abund.	Larva unknown; adults in herbage.

[1] BELING, TH., "Beitrag zur Metamorphose der zweiflügeligen Insecten aus den Familien Tabanidæ, Leptidæ, Asilidæ, Empidæ, Dolichopidæ, und Syrphidæ," *Archiv für Naturges.*, Jahrg. 48, Heft 2.

[2] *Op. cit.*, 1913, vol. viii.

TABLE II.

Coprophilous and other Scavenging Diptera recorded in the Association, Intruders.

Abbreviations as in Table I. † indicates that the species is also a pest on cultivated crops; * indicates that the species is characteristic of forest or wood associations; ‡ the species is generally found in moist situations.

Family.	Species.	Month.	Occurrence.	Remarks on Habits.
BIBIONIDÆ .	*Scatopse notata*, L. . .	5–9	com.	Larvæ in cow-dung, humous soil and decaying vegetable matter.
	,, *inermis*, Ruthe. .	6–9	,,	Larval habits similar to the previous.
	†*Dilophus febrilis*, L. . .	6–10	v. com.	Larva in cow manure.
CHIRONOMIDÆ .	*Orthocladius stercorarius*, Deg.	...	occ.	Larva in cow-dung and humous earth.
PSYCHODIDÆ .	*Pericoma*, sp. . . .	6–9	com.	Larva in decaying vegetable substance.
TIPULIDÆ .	*‡*Poecilostola punctata*, Schrk.	8	occ.	Larva probably in rotten wood in marshy places.
	‡*Limnophila discicollis*, Mg.	6	,,	BRAUER (p. 54)[1] quotes PERRIS, who took the larva of an allied species, *L. dispar*, in the stems of *Angelica sylvestris*. *L. fuscipennis* has been reared from larvæ in rotten wood.
	Trichocera hiemalis, Deg. .	12–3	com.	Larva in decaying vegetation.
RHYPHIDÆ .	*Rhyphus fenestralis*, Scop.	6–9	,,	Larva in decaying vegetable substance.
STRATIOMYIIDÆ	*Chloromyia formosa*, Scop.	6, 7	infreq.	One specimen reared from larva found in meadow soil probably associated with humus or manure.
	Microchrysa polita, L. .	6–9	com.	Larva in decaying vegetable matter and in dung.
	,, *flavicornis*, Mg.	6, 7	infreq.	A single specimen reared from a larva found in meadow soil.
	Chorisops tibialis, Mg. .	...	rare	A single larva found in meadow soil.
XYLOPHAGIDÆ .	*Xylophagus* sp. . .	...	,,	Larvæ in rotten beech, 30.1.13.
LONCHOPTERIDÆ	*Lonchoptera lutea*, Pz. .	7, 8	abund.	Larvæ in decaying vegetable substance.
SYRPHIDÆ .	*Orthoneura elegans*, Mg. .	6	rare	The larvæ of all live either in decaying vegetable or animal matter; that of *P. albimanus* I have also observed feeding on Aphids.
	Liogaster metallina, Fab. .	7, 8	com.	
	Chrysogaster hirtella, Lw.	6, 7	,,	
	,, *viduata*, Fall.	6	occ.	
	Platycheirus albimanus, F.	5–8	v. com.	The adults frequent various meadow flowers, Compositæ and Ranunculaceæ.
	,, *clypeatus*, Mg.	5	com.	
	,, *scalaris*, Fab.	6	,,	
MUSCIDÆ .	*Onesia sepulcralis*, L. .	5, 9	,,	Larva in decaying vegetable and animal matter; adults, which frequent flowers, are said by GEOFFROY and ROBINEAU-DESVOIDY (SCHINER, vol. i, p. 576)[2] to be oviparous.
	Pollenia rudis, F. . .	9	,,	Larvæ in humous soil and in dung; adults sluggish and lazy often cluster on walls.
	Myiospila meditabunda, F.	9	,,	Larvæ in decaying vegetable substances.
	Pyrellia cadaverina, L. .	6, 9	,,	Larva in cow-dung.
ANTHOMYIIDÆ .	*Hyetodesia incana*, W. .	9, 10	,,	Larva in humous soil and decaying vegetable matter.
	,, *lucorum*, Fln. .	6	infreq.	,, ,, ,, ,,
	,, *errans*, Mg. .	6	occ.	,, ,, ,, ,,
	,, *signata*, Mg. .	9	com.	,, ,, ,, ,,
	Spilogaster duplicata, Mg.	8	occ.	Larva in cow-dung.

[1] BRAUER, F., *loc. cit.*

[2] SCHINER, J. R., *Fauna Austriaca: Die Fliegen*, Wien, 1862, vol. i.

TABLE II—*continued.*

Family.	Species.	Month.	Occurrence.	Remarks on Habits.
ANTHOMYIIDÆ (*cont.*)	*Spilogaster depuncta*, Fln.	6	com.	Larva in cow-dung.
	Hydrotæa irritans, Fln.	8	,,	Larva in humous soil and cow-dung.
	,, *dentipes*, F.	6, 7	,,	Larva in manure.
	Hylemyia variata, Fln.	5, 8, 9	v. com.	Larva probably in decaying vegetable and other substances.
	,, *pullula*, Ztt.	8	infreq.	Habits of larva similar to the previous species.
	,, *strigosa*, F.	5, 9	com.	Larva in manure and fungi.
	†*Anthomyia radicum*, L.	5–11	v. com.	Larva in dung, humous soil; also attacks cabbage roots like *C. brassicæ*.
	,, *sulciventris*, Ztt.	8	occ.	Larval habit unknown; adults shelter among herbage.
	Chortophila striolata, Fln.	5, 8	com.	Larva in dung.
	† ,, *sepia*, Mg.	5	,,	Larva said to live in cornstalks (BRAUER, p. 71).[1]
	Homalomyia scalaris, F.	8	infreq.	Larva probably in manure.
	,, *canicularis*, L.	7–10	com.	Larva in manure, dung, decaying vegetable substance.
CORDYLURIDÆ	*Norellia spinimana*, Fln.	8	infreq.	This species said to have been reared from the larva of *Anthomyia versicolor*; larva also said to have been found in the stems of *Rumex aquaticus* (BRAUER, p. 93).[1]
	Scatophaga scybalaria, L.	7	com.	Larva in cow-dung; adults frequent herbage to prey upon other smaller insects.
	,, *stercoraria*, L.	6–10	abund.	
	,, *squalida*, Mg.	6, 7	com.	
HELOMYZIDÆ	‡*Helomyza pectoralis*, Lw.	9	occ.	Larva in fungi and decaying vegetable matter; adults frequent moist, shady places.
LONCHÆIDÆ	*Lonchæa chorea*, F.	5, 7	com.	Larva in manure.
	Lauxania ænea, Fln.	8	occ.	Larva said by WINNERTZ (BRAUER, p. 90)[1] to live in stems of *Viola tricolor*; probably live in manure.
SEPSIDÆ	*Sepsis cynipsea*, L.	7, 9	v. com.	Larva in decaying vegetable substance.
BORBORIDÆ	*Borborus nitidus*, Mg.	7, 8	,,	Larva in dung and refuse.
	,, *equinus*, Fln.	7, 8	,,	,, ,, ,,
	Limosina fontinalis, Fln.	7, 8	com.	Larva in decaying vegetable matter and dung.
PHORIDÆ	*Phora rufipes*, Mg.	6	infreq.	Larva in decaying vegetable matter; various authors record it as parasitic on other Diptera and Lepidoptera.

[1] BRAUER, F., *loc. cit.*

TABLE III.

Aquatic Diptera recorded in the Association, Intruders.

Abbreviations as in Table I. † Indicates that the larval habits are not definitely known and only tentatively indicated.

Family.	Species.	Month.	Occurrence	Remarks on Habits.
SIMULIIDÆ	*Similium maculatum*, Mg.	8	occ.	Adult in moist places in herbage.
CHIRONOMIDÆ	*Chironomus annularis*, Deg.	8, 9	,,	,, ,, ,,
CULICIDÆ	*Culex pipiens*	7, 8, 9	,,	Adults rest among meadow grasses.
TIPULIDÆ	*Ptychoptera albimana*, Mg.	8	com.	Larva in stagnant water.
	†*Rhypholophus nodulosus*, Mg.	5, 6	infreq.	Larva probably in marshy places or wet margins of ponds.
	†*Erioptera trivialis*, Mg.	6	,,	Supposedly either wholly aquatic or mud-inhabiting in larval stage.
	†*Amalopis* sp.	6	occ.	Larva of an allied species, *A. Schineri* (BRAUER, p. 54)[1] in spring water.
TABANIDÆ	*Hæmatopota pluvialis*, L.	5–7	com.	According to BRAUER (p. 60),[1] larva lives in earth; more probable that it is aquatic.
LEPTIDÆ	*Atherix Ibis*, F.	8	occ.	The adult female lays her eggs on twigs overhanging ponds. The eggs are cemented together and to the body of the female by a sticky substance. Often whole masses of eggs and dead females may encrust a twig.
SYRPHIDÆ	*Eristalis tenax*, L.	8	com.	The larvæ in stagnant water. *E. tenax* is cosmopolitan and will breed in drains and sewage systems. The larva is the reputed "rat-tailed" form.
	,, *horticola*, Deg.	8	occ.	
	Helophilus pendulus, L.	5	,,	
	,, *lineatus*, Fab.	8	com.	
SCIOMYZIDÆ	†*Neuroctena anilis*, Fln.	6	occ.	Adults frequent moist meadows.
	†*Tetanocera lævifrons*, Lw.	7	,,	Probably aquatic. Larva of *T. ferruginea* has been found under leaves of water weeds, *Lemna* and *Callitriche* (BRAUER, p. 84).[1]
EPHYDRIDÆ	†*Hydrellia griseola*, Fln.	10, 11	v. com.	Larvæ probably semi-aquatic, inhabiting leaves of water plants. Adults occur abundantly in moist places. *H. albilabris* occurs as larva and pupa in the leaves of *Lemna*. Other species are recorded from sap of trees by WILLISTON (p. 306).[2]

[1] BRAUER, F., *loc. cit.*

[2] WILLISTON, T. W., *North American Diptera*, 3rd ed., 1908.

Table IV.

Coleoptera proper to the Association, recorded from Alluvial, Glover's, and other Meadows and Adjacent Wooded Coppices.

Abbreviations as in Table I. † indicates authenticated pests of trees or crops; ‡ indicates species frequenting damp places; * species which generally frequent woods or forests.

Family.	Species.	Month.	Occurrence.	Remarks on Habits and Habitat.
Carabidæ	*Carabus nemoralis*, Müll.	9–12	f. com.	Several specimens found hibernating in Dec. under rubbish.
	Notiophilus aquaticus, L.	8–12	v. com.	Common everywhere in the locality.
	Leistus fulvibarbis, Dj.	10	occ.	In herbage.
	,, *ferrugineus*, L.	6, 7	infreq.	,,
	‡*Nebria brevicollis*, F.	7–11	abund.	The most frequently occurring Carabid; very general in moist places and especially so along banks of River Dane.
	‡ ,, *gyllenhali*, Sch.	7–11	infreq.	Often taken along with the previous species; not so general.
	‡*Loricera pilicornis*, F.	11–3	occ.	On the banks of the Dane, also at roots of trees; generally in moist places.
	Clivina fossor, L.	6–10	com.	Ubiquitous, in the soil.
	,, *collaris*, Hbst.	5–8	occ.	,, ,,
	Dyschirius sp.	4	...	Remains of a single specimen on banks of Dane.
	Bradycellus similis, Dj.	8–10	occ.	Usually in dry places in the meadows.
	†*Pterostichus madidus*, F.	6, 8	v. com.	Frequents cultivated as well as meadow land.
	,, *vulgaris*, L.	6, 7, 8	,,	Ubiquitous, in grass, under stones, cultivated land.
	‡ ,, *vernalis*, Pz.	4, 6	,,	Frequents marshy places, banks of Dane, and roots of grass.
	,, *striola*	6, 8	com.	Ubiquitous, but especially frequent amongst herbage.
	Amara apricaria, Pk.	6, 7	,,	In herbage.
	Calathus flavipes, Fourc.	8	infreq.	At roots of grass, in dry situations.
	Anchomenus angusticollis, F.	11, 5	v. com.	Abundant in grass and at roots of trees.
	,, *dorsalis*, Müll.	8, 5	,,	At roots of grass and trees.
	‡ ,, *parumpunctatus*, F.	11, 5	com.	Frequent in damp places; most specimens were collected in Glover's Meadow.
	‡*Bembidium littorale*, Ol.	6–12	,,	On banks of Dane and marshy places.
	‡ ,, *fluviatile*, Dj.	6, 12	v. com.	,, ,, ,,
	,, *lampros*, Hbst.	7, 9	occ.	Among meadow grasses.
	Trechus minutus, F.	5, 10	com.	In dry situations among meadow grasses.
Staphylinidæ.	*Homalota vicina*, Steph.	3–6	,,	At roots of grasses; this species was also taken among refuse.
	Tachyporus obtusus, L. var. *nitidicollis*, Steph.	7, 8	,,	All three species occurred in moss in Glover's Meadow.
	Tachyporus solutus, Er.	7, 8	occ.	
	,, *hypnorum*, F.	6, 7, 8	com.	
	‡*Quedius molochinus*, Gr.	7, 8	,,	At roots of grasses especially in moist places.
	Ocypus olens, Müll.	7, 9	,,	Larva frequently taken in herbage and in loose soil.
	,, *brunnipes*, F.	2	infreq.	A few specimens under stones in alluvial meadow.
	‡ ,, *cupreus*, Ross.	2	,,	Under stones and moist leaves.
	Philonthus politus, F.	8–10	com.	Occurred frequently in meadow soil.

TABLE IV—*continued.*

Family.	Species.	Month.	Occurrence.	Remarks on Habits and Habitat.
STAPHYLINIDÆ. (*cont.*)	‡*Othius fulvipennis*, F. .	2	infreq.	In humous soil and moist leaves; also under bark of trees.
	Lathrobium fulvipenne, Gr.	10	,,	In moss in Glover's Meadow.
	*‡*Syntomium æneum*, Müll.	2	occ.	In moss in meadows; more frequent in leaves under trees.
COCCINELLIDÆ .	**Adalia bipunctata*, L. .	6, 3	com.	Adults hibernate under wood; in summer they occur on trees, shrubs, and herbage.
	**Coccinella 10-punctata*, L.	7–12	f. com.	Adults hibernate under logs and leaves.
	**Halyzia 14-guttata*, L. .	8, 2	infreq.	Adults occur on alder and other trees; hibernate as adults.
NITIDULIDÆ .	*Brachypterus urticæ*, F. .	6	com.	Adults on nettles.
	Meligethes rufipes, Gyll. .	6	,,	On flowers of Ranunculaceæ.
	† ,, *æneus*, F. . .	6	abund.	On flowers of Compositæ, Cruciferæ, Ranunculaceæ.
	,, *difficilis*, Heer. .	6	com.	On flowers of Labiatæ (*Lamium album*, *Stachys sylvatica*).
	,, *flavipes*, Stm. .	6	,,	On flowers of Labiatæ, Umbelliferæ, and Compositæ (*Cirsium* sp.).
	**Rhizophagus bipustulatus*, F.	2	infreq.	Adults under bark; probably predaceous on wood-inhabiting larvæ.
BYRRHIDÆ .	‡*Simplocaria semistriata*, F.	8	occ.	Adults in damp herbage, larvæ in decaying wood.
ELATERIDÆ .	‡*Cryptohypnus riparius*, F. .	...	,,	Adults and larvæ in soil on banks of Dane.
	†*Athous hæmorrhoidalis*, F.	5	com.	Adults and larvæ in meadow soil as well as cultivated.
	†*Agriotes lineatus*, L. . .	5, 6	v. com.	,, ,, ,, ,,
	,, *pallidulus*, Ill. .	5	com.	Adults in herbage.
	‡*Corymbites quercus*, Gyll .	8	,,	In soil on banks of Dane.
	Campylus linearis, L. .	7, 8	,,	Larvæ in soil at roots of grasses.
TELEPHORIDÆ .	**Podabrus alpinus*, Pk. .	5	occ.	On coppice, shrubs, oak, birch.
	Telephorus pellucidus, F. .	5	freq.	On meadow flowers and on shrubs at the margins of meadow.
	,, *nigricans*, Müll.	5	com.	,, ,, ,, ,,
	,, *bicolor*, F. .	5	f. com.	In grass and on flowers in meadow.
	Rhagonycha testacea, L. .	5	com.	,, ,, ,,
	**Malthinus punctatus*, Fourc.	6, 7	infreq.	On oak, hazel, hawthorn.
	Malachius bipustulatus, L.	6	f. com.	In herbage and on flowers.
CHRYSOMELIDÆ	**Phyllodecta vitellanæ*, L. .	6	com.	Adults on willows, hazel, and poplar.
	Longitarsus melanocephalus, De G.	9	,,	On herbage.
	†*Phyllotreta nemorum*, L. .	7–9	v. com.	On cruciferous weeds.
	,, *vittula*, Redt. .	7–9	com.	,, ,,
	,, *undulata*, Kuts.	7–9	occ.	,, ,,
	Aphthona sp. . . .	2	...	One specimen hibernating under dead leaves.
	Plectroscelis concinna, Marsh.	9	com.	In herbage.
ANTHICIDÆ .	*Anthicus floralis*, L. . .	6	occ.	In herbage; a few were taken among vegetable refuse which is perhaps the true habitat of this species.
CURCULIONIDÆ	*Apion rubens*, Steph. .	7–9	com.	On *Rumex acetosella*.
	† ,, *apricans*, Hbst. .	7, 8	,,	On *Trifolium pratense*.
	,, *virens*, Hbst. . .	7, 8	,,	,, ,,
	†*Otiorhynchus sulcatus*, F. .	5, 6	,,	Larva at roots of grasses in meadows; adults on surface of ground.
	**Strophosomus coryli*, F. .	7	occ.	On hazel and oak.

TABLE IV—*continued.*

Family.	Species.	Month.	Occurrence.	Remarks on Habits and Habitat.
CURCULIONIDÆ (*cont.*)	*Phyllobius urticæ*, De G. .	5	v. com.	On nettles.
	* ,, *argentatus*, L. .	5	,,	On birches and young oaks.
	†*Barynotus obscurus*, F. .	5, 6	occ.	Larvæ at roots of grasses, adults on surface of ground.
	Sitones hispidulus, F. .	9, 10	com.	In pasture, larvæ at roots of clover, vetch.
	† ,, *lineatus*, L. . .	9, 10	,,	,, ,, ,, ,,
	,, *puncticollis*, Steph.	9, 10	,,	In pasture; larvæ at roots of clover, trefoil, and vetch.
	Hypera punctata, F. . .	9	f. com.	Larvæ at roots of clover.
	,, *polygoni*, L. . .	8, 9	com.	On *Leguminosæ*, *Polygonum*.
	,, *variabilis*, Hbst. .	10	occ.	On *Leguminosæ*.
	Mecinus pyraster, Hbst. .	9	,,	The larva lives in the galled flower-heads of *Plantago lanceolata*.
	Cœliodes quadrimaculatus, L.	5	com.	On the common nettle, *Urtica dioica*.
	Ceuthorhynchus hirtulus, Germ.	6	occ.	Larva in ovoid swellings at the base of the stem of *Draba* (*Erophila*) *verna* (Whitlow Grass).
	Ceuthorhynchus pollinarius, Först.	5	com.	On nettles.
	‡*Phytobius canaliculatus*, Fabr.	6	,,	On herbage in moist places.
SCOLYTIDÆ .	*†*Scolytus destructor*, Ol .	...	...	A single dead specimen taken in Glover's Meadow; its habitat is the elm tree.

TABLE V.

Coprophilous and other Scavenging Coleoptera recorded in the Association, Intruders.

Abbreviations as in Table I. The species represented are all more or less beneficial, being active in hastening the decomposition of organic substances and rendering it available as food for plants. * indicates species generally found in wood and forest.

Family.	Species.	Month.	Occurrence.	Remarks on Habits.
HYDROPHILIDÆ .	*Sphæridium scarabæoides*, L. .	2	...	Remains of a few specimens among grass in meadow.
	Cercyon depressus, Steph. .	7	occ.	In decaying vegetation.
	,, *melanocephalus*, L. .	7, 8	,,	In cow-dung.
STAPHYLINIDÆ .	*Homalota æneicollis*, Shp. .	2, 3	f. com.	In decaying leaves.
	,, *sodalis*, Er. . .	2, 3	,,	,, ,,
	Tachinus rufipes, De G. . .	3, 5	,,	Dung, also in moss.
	Quedius fulgidus, F. . .	8	occ.	In decaying vegetation.
	,, *cinctus*, Pk. . .	10	com.	Vegetable refuse and dung.
	,, *tristis*, Gr. . .	7	,,	Decaying vegetation.
	,, *picipes*, Man. . .	7	occ.	Decaying vegetation and wood, also in moss.

TABLE V—*continued.*

Family.	Species.	Month.	Occurrence.	Remarks on Habit.
STAPHYLINIDÆ (*cont.*)	*Quedius boops*, Gr.	3	com.	Decaying vegetation, roots of grass.
	Philonthus laminatus, Creutz.	7–9	v. com.	In dung.
	,, *varius*, Gyll.	8–10	com.	Dung and vegetable refuse.
	,, *ebeninus*, Ol.	2, 4	occ.	,, ,, ,,
	Xantholinus linearis, Ol.	9–11	com.	Vegetable refuse and in soil.
	,, *longiventris*, Heer.	9–11	,,	,, ,, ,,
	Platysthethus arenarius, Pk.	11, 3	,,	Vegetable refuse, dung.
	Stenus speculator, Lac.	9	,,	Larvæ and adults in decaying tubers and vegetation.
	,, *tarsalis*, Ljun.	6	,,	
	,, *similis*, Hbst.	9	,,	
	Oxytelus rugosus, F.	7, 8	,,	Decaying vegetable substance and dung.
	,, *nitidulus*, Gr.	7, 8	,,	,, ,, ,, ,,
SILPHIDÆ	*Choleva fusca*, Pz.	9	occ.	Decaying vegetation.
NITIDULIDÆ	*Epuræa æstiva*, L.	9	,,	Decaying vegetation. FOWLER, vol. iii, p. 228, says it has been reared from nests of *Bombus lucorum*.
MYCETOPHAGIDÆ	*Typhæa fumata*, L.	1, 2	com.	In vegetable refuse and flood rubbish on banks of Dane.
SCARABÆIDÆ	*Aphodius fossor*, L.	8, 9	,,	In dung.
	,, *fimetarius*, L.	8–10	,,	In dung; adults also in meadow grass.
	,, *prodromus*, Brahm.	5	infreq.	In dung.
	Geotrupes stercorarius, L.	4, 5	com.	Larvæ abundant in manure.
	**Serica brunnea*, L.	10	...	Remains of one specimen in meadow soil; adult generally on poplars and decaying birch.
ELATERIDÆ	**Melanotus rufipes*, Hbst.	5, 6	infreq.	Larvæ in rotten wood.

TABLE VI.

Lepidoptera and Tenthredinidæ recorded in the Association.

Abbreviations as in Table I. * indicates species which are invaders from adjacent woods; ‡ species frequenting damp localities; † species that are authenticated pests of cultivated crops and trees.

Order and Family.	Species.	Month.	Food Plant of Larva.
LEPIDOPTERA—			
PIERIDÆ	†*Pieris brassicæ*, L.	6, 8	*Brassica*.
	† ,, *rapæ*, L.	5–8	,,
	† ,, *napi*, L.	6–8	,,
SPHINGIDÆ	*Smerinthus populi*, L.	5, 6	*Salix* and poplar.
ARCTIADÆ	*Earias clorana*, L.	5, 6	*Salix*.
	‡*Lithosia griseola*, Hb.	7, 8	Lichens and dead leaves in marshy places.
	Diacrisia lubricipeda, Esp.	5, 6	*Rumex*, *Plantago*.
	,, *menthrastri*, Esp.	5, 6	,, ,,
HEPIALIDÆ	†*Hepialus humuli*, L.	6, 7	Roots of grasses, *Rumex*, *Urtica*.
OCNERIADÆ	*†*Euproctis chrysorrhœa*, L.	7, 8	Hawthorn, elm.
NOTODONTIDÆ	**Odontosia camelina*, L.	5, 6	Oak, beech, hazel.
	*†*Phalera bucephala*, Hb.	5, 7	Elm.

TABLE VI—*continued.*

Order and Family.	Species.	Month.	Food Plant of Larva.
CARADRINIDÆ .	*†*Acronycta psi*, L. . . .	5, 6	Birch.
	,, *rumicis*, L. . .	6	*Polygoni*, *Salix*, hawthorn.
	†*Diloba cæruleocephala*, L. .	9	Hawthorn.
	†*Charæas graminis*, L. . .	8	Meadow grasses.
	Leucania comma, L. . .	7, 8	,, ,,
	‡*Caradrina micacea*, Esp. . .	8, 9	*Rumex*, *Equisetum*.
	,, *quadripunctata*, F. .	7	Meadow grasses and corn.
	†*Melanchra brassicæ*, L. . .	6–8	*Brassica*, *Rumex*.
	‡ ,, *oleracea*, L. . .	6	,, ,,
	* ,, *thalassina*, Rott. .	5, 6	Birch, *Polygonum*.
	,, *pisi*, L. . . .	6	*Pteris*, scabious.
	Hadena nictitans, Bork. . .	8	Meadow grasses.
	,, *lithoxylea*, Fb. . .	7	,, ,,
	,, *basilinea*, Fb. . .	6	Meadow grasses and wheat.
	,, *gemina*, Hb. . .	7	Meadow grasses.
	†*Agrotis segetum*, Schiff. . .	6–8	Roots of *Brassica*, *Rumex*.
	† ,, *exclamationis*, L. . .	7, 8	Roots of *Brassica*.
	,, *corticea* Hb. . .	6, 7	*Chenopodium*, *Trifolium*.
	† ,, *tritici*, L. . . .	8	*Plantago*, *Brassica*.
	,, *augur*, Fb. . . .	7	Hawthorn, *Rumex*.
	,, *c-nigrum*, L. . .	7, 8	*Rumex*.
	,, *orbona*, Hufn. . .	7, 8	Roots of grasses, *Ranunculus*.
	† ,, *pronuba*, L. . . .	6, 7	Roots of *Brassica*, *Rumex*, grasses.
	Orthosia ypsilon, Bork. . .	7	*Carex*, *Ranunculus*.
PLUSIADÆ . .	†*Plusia gamma*, L. . . .	6, 9	*Urtica*.
	Panemeria tenebrata, Scop. .	5, 6	*Cerastium*, seed capsules and flowers.
SELIDOSEMIDÆ .	*Ourapteryx sambucaria*, L. .	7	Hawthorn.
	Opisthograptis luteolata, L. .	6	Birch, hawthorn.
	Deileptenia abietaria, Hb. .	7	Not discovered.
	Pseudopanthera petraria, Hb. .	6	*Pteris aquilina*.
GEOMETRIDÆ .	*Geometra papilionaria*, L. .	7	Birch.
	Nemoria viridata, L. . .	6	Hawthorn.
STERRHIDÆ . .	*Leucophthalmia trilinearia*, Hb.	5, 6	Beech.
HYDRIOMENIDÆ .	*Hydriomena albulata*, Schiff. .	6	*Rhinanthus cristagalli*.
	Xanthorrhœ montanata, Bork. .	6	Grasses, *Plantago*.
	,, *ferrugata*, Clerck.	6, 8	*Galium*.
HYMENOPTERA—			
TENTHREDINIDÆ .	*Allantus arcuatus*, Forst. . .	5–7	Alder, milfoil.
	Dolerus gonagra, Klug. . .	5–9	*Festuca*, *Poa*.
	,, *hæmatodis*, Klug. .	5	*Juncus*, *Scirpus*.
	,, *niger*, Klug. . .	5	*Festuca ovina*.
	,, *coracinus*, Klug. . .	5	Meadow grasses?
	‡*Selandria serva*, Ste. . .	6, 7	Grasses in marshy places.
	Blennocampa sp. . . .	6	...
	Fenusa betulæ, Zad. . . .	6	Birch.
	Nematus sp.	8	...

TABLE VII.

Hemiptera[1] *recorded in the Association.*

† Indicates pest species.

Sub-Order and Family.	Species.	Month.	Occurrence.	Habitat.
HETEROPTERA—				
REDUVIIDÆ	*Nabis limbatus*, Dahlb.	11	com.	On herbage ; developed form rare.
CIMICIDÆ	*Anthocoris confusus*, Reut.	7, 8	,,	On herbage.
	,, *nemorum*, L.	8	,,	On shrubs.
CAPSIDÆ	*Pithanus Mærkeli*, H. S.	8	occ.	On herbage ; developed form rare.
	Leptopterna dolobrata, L.	6, 7	com.	On grass in dry situations
	Pantilius tunicatus, Fab.	9	occ.	Hazel, birch, and alder.
	Calocaris sexguttatus, Fab.	6	freq.	On grass.
	Liocoris tripustulatus, Fab.	8	com.	On nettles.
	Dicyphus pallidicornis, Fieb.	7	,,	On foxglove in wet situations.
	Mecomma ambulans, Fieb.	8	,,	On rushes and grass in dry situations.
HOMOPTERA—				
CERCOPIDÆ	†*Philænus spumarius*, L.	7, 8	abund.	On meadow grasses.
	,, *campestris*, Fall.	7, 8	occ.	On low herbage in dry situations.
	,, *lineatus*, L.	7, 8	v. com.	On all kinds of herbage.
PSYLLIDÆ	*Psylla alni*, L.	6	occ.	On alder ; some nymphs were taken.

[1] No attempt was made to review the various species of Aphididæ abundant alike on trees, shrubs, and herbage. Likewise the Coccidæ were not studied. The inter-relationships existing between these families and the various species of lace-wing flies, lady-bird beetles, and ants are, of course, important, as well as the interaction between these same families and the food-plants which their species severally affect.

TABLE VIII.

Plecoptera, Neuroptera, Mecaptera, Trichoptera recorded in the Association.

* Those starred are invaders from aquatic habits.

Order and Family.	Species	Month.	Remarks on Habits.
PLECOPTERA—			
PERLIDÆ	**Perla* (3 spp.)	8	Larvæ probably in River Dane; adults taken at artificial light in pasture near the river banks.
NEUROPTERA—			
CHRYSOPIDÆ	*Chrysopa vulgaris*, L.	5, 8	Peculiar stalked eggs laid on stems ; larvæ are aphidivorous and pupate in the ground, forming a densely woven cocoon.
	,, *perla*, L.	6, 8	
MECAPTERA—			
PANORPIDÆ	*Panorpa communis*, L.	8	Very common species at artificial light ; eggs laid in moist earth in margins of ponds, larva in the ground (SHELFORD, p. 203),[1] adults carnivorous, taken at light.
TRICHOPTERA—			
PHRYGANEIDÆ	**Stenophylax radiatus*, Ramb.	8	Larva in case of small stones fixed or lodged in bed of stream ; River Dane.
	* ,, *alpestris*.	9	Larva makes case of stones as in the case of the previous species.
	**Halesus digitatus*, Schrk.	8	Larval case of vegetable fragments arranged longitudinally or obliquely. Often a long piece of wood at one end. Pupal case closed with stones ; River Dane.
LEPTOCERIDÆ	**Odontocerum albicorne*, Scop.	8	Larval case of sand, cylindrical, slightly curved ; blackish membrane with central slit closes tail-end ; mouth closed by single stone before pupation ; River Dane.

[1] SHELFORD, W. E., "Annual Communities in Temperate America," *Geog. Soc.*, Chicago, 1912.

Table IX.

Parasitic Hymenoptera recorded in the Association.

Family.	Species.	Month.	Remarks.
Ichneumonidæ	*Amblyteles armatorius*, Forst.	5, 7	Parasitic on *Triphæna pronuba*.
	Phæogenes ophthalmicus, Wesm.	8	Common species among herbage in marshy places.
	Alomyia debellator, Fab.	5, 9	A few specimens among meadow grass.
	Microcryptus nigrocinctus, Grav.	9	This species has been bred from winter moth (Morley, vol. ii, p. 41).[1]
	Glyphicnemis brevis, Grav.	8	Among herbage; has been recorded as a parasite of *Carpocapsa pomonana* (Ratzeburg).
	Phygadeuon fumator, Grav.	8	Adults taken at roots of meadow grasses: reared from *Mamestra* (*Melanchra*) sp.; also has been reared from *Chortophila brassicæ*.
	Hemiteles necator, Grav.	3	Taken at roots of grass, probably hibernating.
	,, *similis*, Gmel.	8, 9	Morley (vol. ii, p. 149)[1] says this species is a common parasite of Microgaster cocoons; also has been reared from garden spider, various moths, and the *Cynips* of the oak-marble gall.
	Stenomacrus laricis, Hal.	8	Taken on *Pteris aquilina* and on grasses.
	Bassus tricinctus, Grav.	8, 9	Reared from pupa of *Platycheirus albimanus*; the adult frequently taken on herbage and flowers.
	Homocidus pectoratorius, Grav.	7, 8	Probably parasitic on Syrphid species.
	,, *tarsatorius*, Panz.	6–9	Parasitic on larvæ of *Platycheirus albimanus*.
	,, *dimidiatus*, Schr.	6–9	
	Promethus sulcator, Grav.	5–9	Very abundant on grass in marshy places.
	,, *coynatus*, Hlgr.	5–9	Very common on grass in marshy places.
	,, *laticarpus*, Thoms.	8	Rare, on low herbage in marshy places.
	,, *pulchellus*, Hlgr.	6, 9	Common on grass. Morley (p. 21),[1] quotes Gravenhorst having reared this species from *Curculio* (*Hypera*) *polygoni*.
	,, *festivus*, Fabr.	8, 9	Swept occasionally from herbage.
	Tryphon vulgaris, Hlgr.	8	Taken on herbage.
	Mesoleptus typhæ, Fourc.	6, 8	Taken on herbage in marshy places.
	Perilissus rufoniger, Grav.	6, 8	Taken on herbage; probably parasite of saw-fly.
	Adelognathus dorsalis, Grav.	8	This species is rare in England (Morley, vol. iv, p. 318),[1] taken on herbage.
	Campoplex pugillator, L.	5, 6	Common on meadow grasses. Brischke (p. 206)[1] reared this species from *Cidaria rubidaria* and *Odontopora dentaria* and *Notodonta dictæoides* (p. 147), *Mamestra dysodea* (p. 149), and *Cuculia* sp. (p. 153).
	Campoplex sp.	8, 9	Taken on herbage.
	Cymodusa cruentata (Grav.)	8	,, ,,
	Omorga difformis, Grav.	8	,, ,,
Braconidæ	*Alysia* sp.	6	Parasitic on *Phytomyza* sp.
	Opius nitidulator, Nees	7, 9	Parasitic on *Pegomyia hyoscyami*.
	Blacus ruficornis	3	Taken at roots of grass in alluvial meadow.
Proctotrypidæ	*Proctotrypa* sp.	6	Taken on grass.

[1] For literature references in last column, *vide* p. 53.

TABLE X—GLOVER'S MEADOW.

Census of Soil Insects in Measured Samples.

In the column of plant species, (*pre.*) signifies predominant; (*com.*), common; (*f. com.*), fairly common; (*v. com.*), very common; (*occ.*), occasional; (*r.*), rare. Each abbreviation applies to the immediately preceding species or group of species. In the columns of insect species, (*l.*), larva; (*p.*), pupa.

Sample No.	Floristic Composition of Sample.	Analysis of Insect Species.							Total No. of Specimens and Species.
		Apterygota.	Neuroptera.	Coleoptera.	Diptera.	Lepidoptera.	Hymenoptera.	Hemiptera.	
1	Ranunculus repens, Holcus lanatus (*com.*); Trifolium repens (*occ.*); Draba verna (2 *specimens*).	2 *Entomobrya nivalis*, 1 *Onychiurus ambulans*.		2 *Anchomenus parumpunctatus*, 1 *Quedius boops*, 2 *Aphodius fimetarius*, 5 *Agriotes lineatus* (l.), 1 *Sitones lineatus* (l.), 1 *Ceuthorhynchus hirtulus* (l.) in gall.	6 *Cecidomyia destructor* (p.), 2 *Tipula oleracea* (l.), 2 *Empis unicolor* (l.), 1 Anthomyiid puparium, 1 *Phytomyza* sp.		2 *Hemiteles necator*, 1 *Blacus ruficornis*.		30, 15 species.
2	Festuca ovina (*pre.*); Cynosurus cristatus, Dactylis glomerata, matting of Brachythecium rutabulum on the surface (*com.*); Ranunculus repens, Plantago lanceolata (*f. com.*); Draba verna (*r.*).			2 *Homalota vicina*, 1 *Tachinus marginellus*, 1 *Quedius tristis*, 9 *Agriotes lineatus* (l.), 2 *Hypera punctata* (l.), 2 *Ceuthorhynchus hirtulus* in galls.	12 *Cecidomyia destructor* (p.), 1 *Scatopse flavicollis*.	1 *Triphæna orbona* (l.), 1 *Agrotis exclamationis* (l.).			32, 10 species.
3	Festuca ovina (*pre.*); Dactylis glomerata (*v. com.*); Holcus lanatus, Ranunculus repens (*com.*); Plantago lanceolata, Brachythecium rutabulum, Poa pratensis, Draba verna (*r.*).			1 *Quedius boops*, 2 *Philonthus laminatus*, 1 *Cryptohypnus riparius* (l.), 2 *Ceuthorhynchus hirtulus* in galls (l.).	2 *Hyetodesia incana* (l.).	1 *Hepialus humuli* (l.).	1 *Selandria* sp. Cocoon parasitised by species of *Pimpla*?		10, 7 species.
4	Lolium perenne (*pre.*); Festuca ovina (*v. com.*); Agrostis vulgaris, Ranunculus repens (*f. com.*); Brachythecium rutabulum (*com.*); Anthoxanthum odoratum, Phleum pratense, Dactylis glomerata, Plantago lanceolata (*occ.*); Trifolium repens, Lotus corniculatus, Prunella vulgaris (*r.*).			2 *Agriotes lineatus* (l.), 1 *Otiorhynchus sulcatus* (l.), 1 *Hypera variabilus*.	1 *Tipula oleracea* (l.), 1 *Rhamphomyia sulcata* (l.).		1 Tenthredinid pupa parasitised by Ichneumon sp.		7, 6 species.
5	Lolium perenne (*pre.*); Agrostis vulgaris, A. alba (*com.*); Trifolium repens, Rumex acetosa (*occ.*); Ranunculus repens (*r.*).	2 *Entomobrya albocincta*, 3 *Isotoma grisea*.		1 *Aphodius fimetarius*, 3 *Agriotes lineatus* (l.), 2 *Campylus linearis* (l.).	2 *Rhamphomyia longipes* (l.).				13, 6 species.

TABLE X—*continued.*

Sample No.	Floristic Composition of Sample.	Analysis of Insect Species.							Total No. of Specimens and Species.
		Apterygota.	Neuroptera.	Coleoptera.	Diptera.	Lepidoptera.	Hymenoptera.	Hemiptera.	
6	Dactylis glomerata (*pre.*); Ranunculus repens, Trifolium repens, Agrostis vulgaris (*f. com.*); Rumex acetosa (*r.*).			1 *Anchomenus albipes* (l.), 1 *Xantholinus longiventris*, 1 *Aphodius fimetarius*.	6 *Cecidomyia destructor* (p.), 5 *Tipula oleracea* (l.), 1 *Hilara maura* (l.).				15, 6 species.
7	Plantago lanceolata (*pre.*); Brachythecium rutabulum, Holcus lanatus (*occ.*); Ranunculus repens (*r.*).		5 *Chrysopa vulgaris*, cocoons; 2 of them parasitised by a Braconid, *Apanteles* sp.	1 *Leistus ferrugineus*, 1 *Sphæridium scarabæoides*, 2 *Athous hæmorrhoidalis*, 3 *Agriotes lineatus* (l.).	1 *Borborus equinus* (p.), 2 *Leptis lineola*.		1 *Blennocampa* sp. (sawfly (l.).		16, 6 species.
8	Ranunculus repens (*pre.*); Lolium perenne, Brachythecium rutabulum (*f. com.*); Trifolium repens, Rumex acetosella (*occ.*).			2 *Sphæridium scarabæoides*, 1 *Clivina fossor*, 2 *Tachinus rufipes*.	1 *Cecidomyia destructor* (l.), 1 *Leptis scolopacea* (l.), 2 *Empis* sp. (l.), 2 *Hilara maura* (l.), 1 *Dolichopus* sp. (l.).				12, 8 species.
9	Festuca ovina (*pre.*); Brachytecium rutabulum, Trifolium repens (*com.*); Dactylis glomerata, Ranunculus repens (*occ.*).			1 *Pterostichus vulgaris*, 5 *Agriotes lineatus* (l.).	5 *Bibio Marci* (l.), 2 *Rhamphomyia sulcata* (l.), 1 Anthomyiid larva.				14, 5 species.
10	Holcus lanatus (*pre.*); Brachythecium rutabulum (*com.*); Dactylis glomerata, Draba verna (*r.*).			3 galls of Draba verna containing each a larva of *Ceuthorhynchus hirtulus*.	1 *Tipula lateralis* (l.).				4, 2 species.
11	Lolium perenne (*pre.*); Ranunculus repens, Agrostis vulgaris, Dactylis glomerata (*occ.*); Draba verna (1 *specimen*).			5 *Philonthus laminatus*, 5 *Philonthus varius*, 11 eggs, probably of Carabid sp. 4 *Aphodius fimetarius*. 1 *Otiorhynchus sulcatus* (l.). 1 *Ceuthorhynchus hirtulus* (l.) in gall.	24 *Cecidomyia destructor* (p.), 1 *Tipula lateralis* (l.), 2 *Leptis scolopacea* (l.), 2 *Empis* sp. (l.), 1 Anthomyiid (l.).	1 *Agrotis xanthographa* (l.).			58, 12 species.

TABLE XI—ALLUVIAL PASTURE.

Census of Soil Insects in Measured Samples.

Abbreviations as in Table X.

Sample No.	Floristic Composition of Sample.	Analysis of Insect Species.							Total No. of Specimens and Species.
		Apterygota.	Neuroptera.	Coleoptera.	Diptera.	Lepidoptera.	Hymenoptera.	Hemiptera.	
1	Trifolium repens (*pre.*); Lolium perenne, Ranunculus repens (*com.*).	2 *Entomobrya nivalis*, 3 *Onychiurus ambulans*.		1 *Nebria brevicollis* (l.), 1 *Pterostichus vulgaris* (l.), 1 *Tachyporus obtusus*, 1 *Xantholinus linearis* (l.), 1 *Agriotes lineatus* (l.), 2 *Sitones lineatus* (l.).	6 *Lasioptera auricincta* (l.), 10 *Tipula oleracea* (l.).				28, 10 species.
2	Agrostis alba (*pre.*); Brachythecium rutabulum (*com.*); Trifolium repens, Ranunculus repens, Luzula campestris, Lolium perenne (*f. com.*); Alopecurus pratensis (*occ.*).	7 *Onychiurus ambulans*, 9 *Isotoma viridis*, 5 *Isotoma grisea*, 6 *Entomobrya nivalis*.		1 *Tachinus rufipes* (l.), 4 *Xantholinus linearis* (l.), 1 *Othius melanocephalus*.	23 *Sciara* sp. (l.), 1 *Empis livida* (l.), 1 *Dolichopus* sp. (p.).				58, 10 species.
3	Lolium perenne (*pre.*); Ranunculus repens (*occ.*).	2 *Onychiurus ambulans*.		2 *Pterostichus vulgaris* (l.), 1 *Oxyporus maxillosus* (l.), 3 *Xantholinus linearis* (l.), 3 *Quedius fulgidus* (l.), 1 *Otiorhynchus sulcatus* (l.).	4 *Cecidomyia destructor* (one l. and 3 p.), 3 *Sciara* sp., 3 *Leptis scolopacea* (l.) (one specimen evidently eating roots of R. repens), 7 *Rhamphomyia sulcata* (l.), 3 *Tipula oleracea* (l.), 2 *Borborus nitidus* (l.), 1 *Pyrellia cadaverina* (p.).				35, 13 species.
4	Lolium perenne (*pre.*); Trifolium repens, Ranunculus repens, Holcus lanatus (*occ.*).				2 *Myiospila meditabunda* (l.), 1 *Hyetodesia incana* (l.).				3, 2 species.
5	Lolium perenne, Trifolium repens (*com.*); Bellis perennis, Festuca ovina (*occ.*).			1 *Homalota vicina*.	2 *Tipula oleracea* (l.), 1 *Hyetodesia signata* (l.), 1 Anthomyiid larva sp. in process of being devoured by a larva of *Tipula oleracea*.				5, 4 species.
6	Lolium perenne (*pre.*); Ranunculus repens, Trifolium repens (*com.*); Brachythecium rutabulum (*occ.*); Agrostis vulgaris (*r.*).			1 *Nebria brevicollis* (l.), 1 *Anchomenus dorsalis* (l.), 3 *Philonthus laminatus*, 1 *Quedius molochinus*, 1 *Sitones punctilicollis* (l.).	4 *Empis* sp. (l.).			Remains of seven Aphids, *Schizoneura* sp.	18, 7 species.

TABLE XI—*continued.*

Sample No.	Floristic Composition of Sample.	Analysis of Insect Species.							Total No. of Specimens and Species.
		Apterygota.	Neuroptora.	Coleoptera.	Diptera.	Lepidoptera.	Hymenoptera.	Hemiptera.	
7	Lolium perenne (*pre.*); Ranunculus repens (*com.*); Agrostis vulgaris (*occ.*).	38 *Onychiurus fimetarius*, 1 *Isotoma grisea*, 1 *Lepidocyrtus albus.*		*Anchomenus dorsalis* (l.), 1 *Quedius fulgidus* (l.), 2 *Xantholinus longiventris* (l.).	15 *Cecidomyia destructor* (some as larvæ, others as pupæ), 3 *Sciara præcox* (2 adults and 1 pupa), 4 *Sciara pulicaria*, 9 *Tipula oleracea* (l.), 2 *Orthocladius stercorarius* (l.), 2 *Rhamphomyia* sp. (l.), 1 *Hyetodesia signata* (l.), 40 *Bibio Marci* (l.), 1 *Borborus equinus* (l.).				122, 15 species.
8	Lolium perenne (*pre.*); Ranunculus repens (*com.*); Agrostis alba, Agrostis vulgaris, Avena flavescens (*occ.*); Trifolium repens, Taraxacum dens-leonis, Rumex acetosella (*r.*).	7 *Onychiurus ambulans.*		1 *Pterostichus vernalis*, 1 *Nebria brevicollis* (l.), 1 *Cercyon analis* (l.), 1 *Quedius fulgidus* (l.), 1 *Platysthethus arenarius* (l.), 1 *Agriotes lineatus* (l.).	1 *Cecidomyia destructor* (p.), 20 *Sciara Thomæ* (l.), 1 *Orthocladius stercorarius* (l.), 6 *Tipula oleracea* (l.), 2 *Chloromyia formosa* (l.), 1 *Chorisops tibialis* (l.), 1 *Platypeza* sp. (l.), 1 *Pegomyia nigritarsis* (p.), 1 *Rhamphomyia sulcata* (l.).				47, 16 species.
9	Lolium perenne (*pre.*); Trifolium repens (*com.*); Agrostis vulgaris (*f. com.*); Ranunculus repens (*r.*).			1 *Nebria brevicollis* (l.).	1 *Cecidomyia trifolii*, 1 *Cecidomyia ranunculi*, 1 *Tipula oleracea* (l.), 4 *Platypeza* sp. (l.), 5 *Rhamphomyia sulcata* (l.), 1 *Empis* sp. (l.), 1 *Borborus equinus* (l.).				15, 8 species.
10	Lolium perenne (*pre.*); Trifolium repens (*com.*); Ranunculus acris (*occ.*).			1 *Sphæridium scarabæoides*, 1 *Quedius boops* (l.), 1 *Philonthus ebeninus*, 1 *Philonthus* sp. (p.), 1 *Sitones punctaticollis.*	12 *Cecidomyia destructor* (p.), 1 *Cecidomyia* sp. (l.), 6 *Bibio Marci* (l.), 2 *Tipula oleracea* (l.), 1 *Leptis lineola* (l.), 3 *Rhamphomyia longipes* (l.), 2 *Empis* sp. (l.), 2 *Platypeza modesta* (l.), 1 *Pyrellia cadaverina* (p.), 2 *Hyetodesia signata* (l. and p.), 1 *Borborus equinus* (l.), 1 *Phora rufipes.*				39, 17 species.

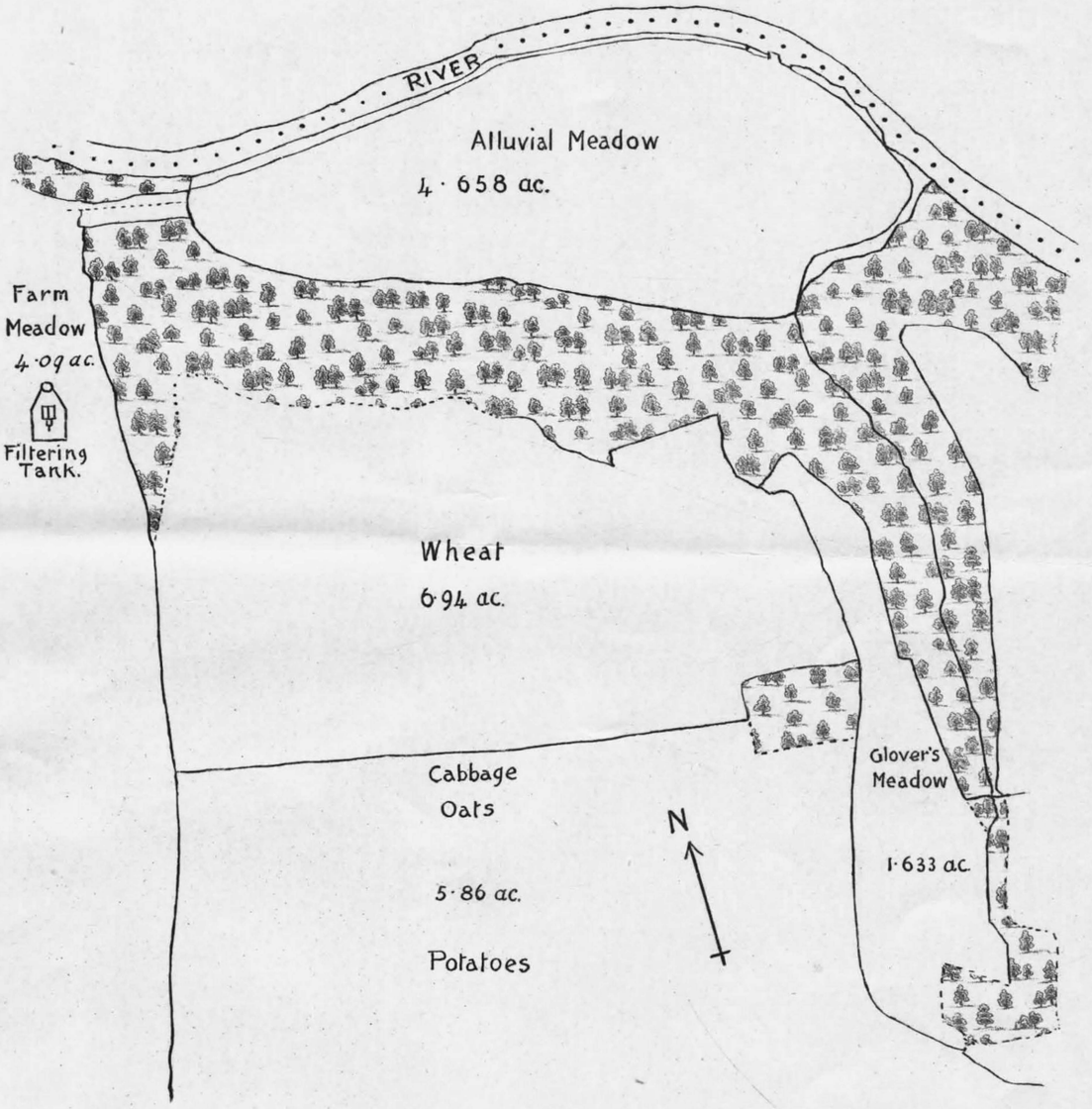
TABLE XI—*continued.*

Sample No.	Floristic Composition of Sample.	Analysis of Insect Species.							Total No. of Specimens and Species.
		Apterygota.	Neuroptera.	Coleoptera.	Diptera.	Lepidoptera.	Hymenoptera.	Hemiptera.	
11	Ranunculus repens, R. acris, Trifolium repens, Lolium perenne (*com.*).			1 *Xantholinus linearis* (l.), 2 *Sitones punctaticollis* (l.).	14 *Cecidomyia destructor* (13 p. and one l.), 9 *Bibio Marci* (l.), 3 *Tipula oleracea* (l.), 3 *Rhamphomyia sulcata* (l.), 5 *Hilara maura* (l.), 1 Muscid larva, 1 *Borborus equinus* (l.).	1 *Agrotes* sp.			40, 10 species.
12	Lolium perenne (*pre.*); Trifolium repens (*com.*); Ranunculus repens (*occ.*); Festuca ovina (*r.*).			1 *Nebria brevicollis* (l.), 1 *Tachyporus rufipes*, 1 *Philonthus varius*, 2 *Xantholinus linearis* (l.), 1 *Xantholinus* sp. (l.).	2 *Lasioptera auricincta* (l.), 3 *Leptis scolopacea* (l.), 3 *Empis* sp. (l.), 3 Anthomyiid larvæ 1 *Hyetodesia signata* (l.).				18, 10 species.
13	Lolium perenne (*pre.*); Ranunculus repens, Trifolium repens (*com.*).	5 *Onychiurus ambulans.*		1 *Quedius* sp. (remains), 2 *Sitones lineatus* (l.).	4 *Cecidomyia destructor* (p.), 10 *Tipula oleracea* (l.), 1 *Leptis lineola* (l.), 2 *Rhamphomyia sulcata* (l.), 6 *Empis* sp. (l.), 1 Muscid larva, 1 *Borborus equinus* (l.).				33, 10 species.
14	Brachythecium rutabulum, Agrostis vulgaris, Lolium perenne (*f. com.*); Ranunculus repens, Trifolium repens (*occ.*).			1 *Xantholinus* sp. (l.).	9 *Cecidomyia destructor* (p.), 9 *Tipula oleracea* (l.), 4 *Rhamphomyia sulcata* (l.), 1 *Empis* sp. (l.), 1 *Dolichopus* sp. (l.), 3 *Rhyphus fenestralis* (l.), 2 *Orthocladius stercorarius* (l.), 2 *Borborus equinus* (l.), 1 *Microchrysa polita* (l.).				33, 10 species.

Table XII.

Physical Factor.	Year 1913.												Year 1914.		
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.
Average barometric pressure	29·51	29·788	29·52	29·58	29·8	29·91	29·89	29·89	29·77	29·66	29·55	29·74	29·90	29·40	29·17
Average maximum air temperature, F.	42·6	47·5	49·6	56·0	60·5	64·76	65·6	68·1	65·7	62·3	59·3	58·0	60·0	56·2	59·4
Average minimum air temperature, F.	34·1	34·5	39·6	44·8	50·9	1·7	50·9	53·4	49·8	53·3	41·9	42·0	35·5	34·6	39·7
Average minimum temperature on grass, F.	31·3	32·5	35·6	39·8	43·1	47·1	46·1	46·5	44·4	44·2	36·6	37·3	37·9	42·2	43·0
Average soil temperature, F., 6 inches deep	38·9	38·9	39·3	45·4	49·8	56·0	58·3	59·1	56·7	50·9	42·9	42·3	44·5	41·0	40·2
Average soil temperature, F., 18 inches deep	40·5	40·5	40·7	45·4	50·3	56·5	58·3	60·0	58	52·9	45·7	43·6	38·6	42·4	41·7
Total rainfall in inches .	2·16	1·01	3·17	3·11	3·59	2·77	1·13	2·83	1·85	7·2	5·00	3·88	2·91	4·75	6·84

DR. A. E. CAMERON: INSECT ASSOCIATION.—PLATE I.



DIAGRAMMATIC REPRESENTATION OF THE AREA STUDIED.

A. RITCHIE & SON, EDIN.ᴿ

Fig. 1. Alluvial Pasture, South-West Aspect.

Bemrose, Collo., Derby

Fig. 2. Glover's Meadow. North Aspect.

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