# PRESIDENTIAL ADDRESS

BY F. MUIR.

This meeting brings to a close the ninth year of our Society. The first meeting was held December 15th, 1904; since then we have held 100 meetings. During this period we have published two volumes, consisting in all of 521 pages and 11 plates, as well as many text figures. At no time has our membership been greater than 40, and then many are patrons rather than members, whose generosity enable us to publish our "Proceedings". Besides the many papers dealing with our local insect fauna, which will be invaluable to future entomologists in these Islands, we have published descriptions of many new species from other places in the Pacific. The results may appear small when compared with those of some of the larger Societies on the mainland; but when we consider the small, isolated community from which we have to draw our members, I think you will all agree with me in looking upon the achievements of our little Society as fully justifying its existence. Nor does this represent the entire activity of our members, for, apart from professional work, which is published by the respective Bureau or Station of the members, several of our members have published extensively elsewhere.

I do not make these remarks in a spirit of vainglory, but simply because pessimism will ofttimes attack our hearts, and we wonder if all the trouble of keeping our Society in existence is in a worthy cause. Well, gentlemen, I consider anything that brings us together to discuss the science which we are devoted to, and enables us to place on record our observations and opinions, is well worth the time and trouble expended upon it.

Several of our active members are professional Entomologists whose energies are directed to the study of the economic aspect of our science. Although it is not within the scope of our Society to deal with such questions from a practical point of view, yet so many of these questions are so bound up with questions of biology and evolution, that we must consider them together.

The work which has attracted the greatest attention in our Islands, but not the only work undertaken, as some, unacquainted with our Islands, maintain, is the use of natural enemies to control insect pests. In this work there is a good example of the dependency of "economic" upon "scientific" entomology. In attacking a problem from this point of view, the first thing to be done is to correctly identify the species of the pest in question, to study its geographical distribution, and to judge of the most likely locality for its original habitat. Thus we are dependent upon the work of the systematist, and require his very best work. Had a wrong determination been acted upon in the case of *Perkinsiella saccharicida,* Messrs. Perkins and Koebele might have proceeded to some other part of the world from which they did, and their efforts might not have been crowned with the success that they were.

Another case, now historic, which will demonstrate this point, is that of *Ceratitis capitata.* Several entomologists searched in various parts of the world for natural enemies of this world-wide pest, and it was given out by more than one that none existed; not one of them visited that region which the study of the systematic position of the insect, and the geographical distribution of the genus, indicated to be its natural habitat. The fact that both North and South Africa suffered from the ravages of this fly turned people's attention away from any other portion of that continent; the presence of natural land barriers between these two places and Central West Africa being forgotten. Mr. W. M. Giffard, when organizing the expedition last year, on behalf of the Board of Agriculture and Forestry, took these facts into consideration, and we know the success attending Professor Silvestri's researches.

The time is now passed for discussing the value of parasites in controlling insect pests, or whether parasites do control the increase of their hosts; success has demonstrated that, under certain conditions, the value of parasites is very great. That all cases of insect ravages cannot be controlled by this means is best recognized by those engaged in such work. That this method cannot be greatly extended is due to our ignorance, and we shall never attain to the success possible until our knowledge of insect biology, systematics and geographical distribution is very much greater than it is at present. It would be easy to state cases where wrong identifications have made the center of distribution of a genus appear to be in one hemisphere whilst, in truth, it is in the other.

These considerations show how "practical" entomologists are dependent upon the work of their "scientific" brethren, and how they require the very best work that can be given them.

But the debt is not all on one side. When the "economic" entomologist has discovered the chief death-factors of an insect, and, by introducing them into another region produces the same condition as exists in the original habitat, the evolutionist must take these facts into consideration, and not place the whole burden of the struggle for existence upon some more conspicuous, but less-important, factors.

The investigation of the various death factors which make up the struggle for existence of a species, and the transportation of certain of them to a new locality, naturally leads one to consider what part in natural selection they play. It is in the hope of turning attention towards certain aspects of these complex problems that I bring before you the following notes on:

## The Effect of Parasitism on the Struggle for Existence and Natural Selection.

Darwin laid great stress upon the severe competition among closely allied organisms. These animals, living under the same conditions, and upon the same food, are brought into closer competition than those having different habitats and food. Among the higher animals an active, physical struggle is presumed to take place, while among the lower animals this struggle is presumed to be passive.

Among phytophagous insects it is difficult to follow all the stages of this competition, for there is never a direct struggle, and only on rare occasions, and as an abnormal phenomenon, is there a shortage of food which causes a direct competition.

The phenomenon familiar to every field entomologist, of two or more closely allied species of equal fertility, and living under similar conditions, standing in vastly different numerical ratio to one another, is bound up with this question of competition. If we study these allied species *separately* it is very difficult to find a reason for this numerical difference; but if they be studied *as a group* then the cumulative effect of the various death factors acting upon them, some of which, taken separately, may appear insignificant, may appear as a sufficient reason.

An allied phenomenon, of an introduced insect supplanting a native allied species, of which *Pieris rapae* in Canada is a good example, is also connected with the same question of the struggle for existence. In some such cases it is possible that the intruder upsets the balance of parasitism, and thus brings about the reduction or extermination of the native species.

In the following examples the figures are imaginary for the sake of convenienc, and should be considered as proportions rather than individuals; but the original observations and deductions that led to them were made on a genus of Delphacidae (*Perkinsiella*) during four years' observations, extending over the Western and Southern Pacific. My own observations, added to those of Messrs. Perkins and Koebele, have shown that the main death factors working upon the genus in China, Java, Borneo, the Moluccas, New Guinea, Australia and Fiji are similar; yet in those regions in which two or more species exist side by side there is often a great difference in the proportional numbers of the species.

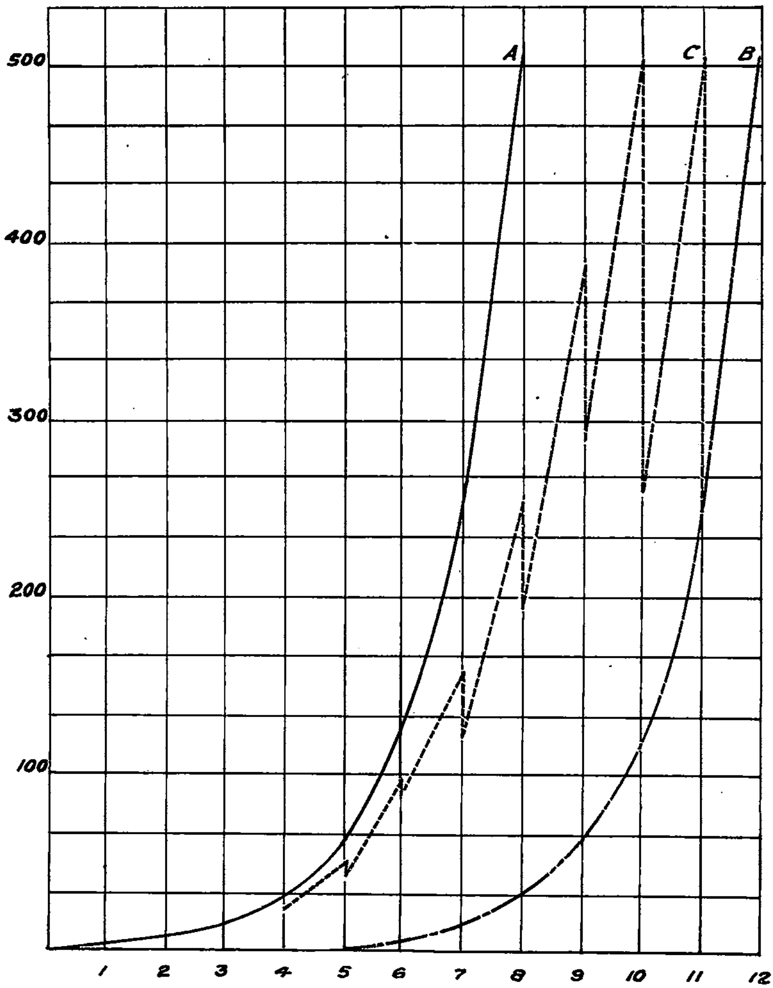
As my observations have been confined to tropical countries, where insects breed during the whole year, I have left out of consideration the effect of climate. Hyperparasitism has been left out of consideration, as it only complicates the ultimate results and shifts the question back a stage; fungus and other diseases have also been ignored, as they only retard, but do not alter, the final results.

## "Constant" Number.

One of the facts upon which Natural Selection is based is the constant number of a species within a certain period and area. During the period the number may rise and fall, but eventually returns to the normal. The period between the two minimum points may comprise only one generation; in this case the eggs are the most numerous, the larvae less numerous, the pupae still less and the fertile imagoes least of all. Or the period between the minimum points may embrace several generations, in which case the host will increase until it appears likely to become a pest, then it suddenly drops off.

In Diagram I, I have shown the results of an imaginary case in which the numbers are kept low for convenience. The curve A represents the increase of a host-insect that produces four young, the sexes being in equal numbers. At the eighth generation, if nothing interferes, it will number 512 individuals. Curve B represents the increase of a parasite which also lays four eggs, the sexes being in equal proportion, and each young causes the death of one immature host; it will therefore have a curve similar to A. We will consider that it appears upon the scene at the fourth generation of the host; curve C

DIAGRAM I.




A=Host insect.
B=Parasite.
C=Effect of parasite on host.
Lower numbers are the number of generations.

will represent the effect it will produce upon A. The four eggs of the parasite will be deposited in four of the 32 hosts so that only 28 of them will come to maturity; these will give birth to 56 young, eight of which will be killed by the parasites and 48 come to maturity; these will give birth to 96 young, of which 16 will be killed by the parasites. This process will continue to the eleventh generation of the host, when it will only equal the parasite in number and so be totally destroyed. Right up to the last generation the host appears to be predominant and the final reduction is sudden. This is a feature that one often observes in nature.

## Ratio Between Host and Parasite.

That the utter extinction of the host does not take place is a very difficult problem to explain. Hyperparasitism only pushes the question back one degree, and accidental death acts upon host and parasite alike.

Observations on several species of insects, extending over wide areas, indicate that there is a certain ratio between the numbers of the host and parasite. One would expect some such ratio from inductive reasoning: parasitism could not exist without it.

How this ratio is maintained it is difficult to tell. It is not through the birth rate, for many parasites are very much more prolific than their hosts, and the length of time occupied in their life cycle is often much shorter. It appears likely that the ratio is due to the capacity of the parasite to discover its host. In some species this capacity appears to be low, and the maximum rate of parasitism is therefore low; in other cases this capacity is high, and the maximum rate of parasitism is consequently high.

When living in Africa, I often accompanied a friend shooting; he was by far the better shot, but whether game was scarce or plentiful my bag generally stood in the same proportion to his. This would indicate that we each had a certain capacity for finding and bagging our game, and, within certain limits, acted up to it.

Uncivilized men, hunting with bow and spear, seldom, if ever, exterminated game. Where game was plentiful the family or tribe could increase till the district could not longer support it; then it would decrease or wholly or partly migrate.

This would not mean that the game in the district was exterminated, but that it was reduced so low that the amount the tribe was capable of securing was not great enough to support it. With the decrease or migration of the tribe the game would increase. Another tribe with higher capacity for hunting, or with better weapons, could have become still more numerous and have reduced the game to a lower number before being compelled to migrate. Even white man with his superior arms never exterminated game when he was wholly dependent on it for existence; it is only when he has other sources of supply that he can pursue it to extermination.

We do not expect uncivilized men to exterminate their game, so we should not expect insect parasites to entirely destroy their hosts.

## Action of Predators.

Predators of many kinds attack the host at every stage of its existence; they also attack the parasitized and unparasitized in their relative proportions, so that they do not greatly disturb the balance. Such predators as mammals, birds and lizards are fairly liberal in their choice of food and seldom show a choice for one particular species. With those species on which they do feed they follow the line of least resistance and take them as they come, the most common forming the larger portion of their food.

Owing to their power of locomotion, especially birds, they cover large areas in search of food; as soon as their food in one district becomes scarce they move off to another. Bates has described how flocks composed of several species of insectivorous birds move about the country in Brazil, and I have observed the same thing in Africa and the Malay Islands. Thus predators act more as a movable death-factor; where the egg-parasites have been scarce there will they gather together to feed off the larvae, and where the larva-parasites have not been effective there will they feed off the adult.

In the following table I have confined the action of the predators to the adult stage, but this action would be felt on larva and pupa, but the results would be the same.

## Death Factors Acting Upon Closely Allied Species

In studying the death factors of two or more closely allied species it is often very difficult to say why one should be common and the others scarce. Their fecundity may be similar and the chief death factors acting upon them identical. Close observation will often show that a very small percentage of the scarce species is killed by a factor that does not attack the more common. If we study the species separately this would not account for the difference of numbers, but if we consider them as forming one group then this small factor will make the difference.

Table I tries to illustrate this. What we have previously said must be borne in mind, viz.:

1 The number of an insect in a district is constant within certain periods.
2 There is a ratio between host and parasite.
3 That predators follow the line of least resistance when feeding, and, owing to their powers of locomotion, act as a movable factor to keep the numbers constant.

TABLE I.

| | A | B | C | Aggregate |
|---|---|---|---|---|
| First generation | 20 | 20 | 20 | 60 |
| Eggs 80% killed | 500 | 500 | 500 | 1500 |
| Larvae 50% killed | 100 | 100 | 100 | 300 |
| Pupae killed: A nil; B 25%; C 50% | 50 | 50 | 50 | 150 |
| Adults hatched | 50 | 37.5 | 25 | 112.5 |
| Adults reaching maturity (2nd generation) | 26 | 20 | 14 | 60 |
| Eggs 80% killed | 650 | 500 | 350 | 1500 |
| Larvae 50% killed | 130 | 100 | 70 | 300 |
| Pupae killed: A nil, B 25%, C 50% | 65 | 50 | 35 | 150 |
| Adults hatched | 65 | 37.5 | 17.5 | 120 |
| Adults reaching maturity (3rd generation) | 32 | 19 | 9 | 60 |
| Eggs 80% killed | 800 | 475 | 225 | 1500 |
| Larvae 50% killed | 160 | 95 | 45 | 300 |
| Pupae killed: A nil, B 25%, C 50% | 80 | 47.5 | 22.5 | 150 |
| Adults hatched | 80 | 35.6 | 11.2 | 126.8 |
| Adults reaching maturity (4th generation) | 37 | 17 | 6 | 60 |

In Table I, A B and C represent three allied species living in the same locality, feeding on the same food-plant and having similar fecundity and length of life. Let 60* represent the aggregate constant number in the locality. If the death factors acting upon each were absolutely identical then the constant number 20 for each species would not vary, but remain the same each generation. Let us suppose that 80% of the eggs are killed by a parasite and 50% of the larvae likewise killed by another parasite, of the pupae A has none killed, B 25% and C 50%. Then the number of adults hatching out would be 50, 37.5, and 25 respectively. Predators acting upon these to bring them to the constant number 60 would leave them in the proportion of 26, 20, and 14. At the fourth generation they would stand 37, 17 and 6. Theoretically this would lead to the extermination of C and then B, and it is possible that such has happened at times, but most likely the scarcer species have been able to maintain existence in small, favorable localities.

## Immigrant Supplanting Endemic Species.

The figures in Table I could be used to illustrate this section but I prefer to present others. Let us take another imaginary case of a species D (Table II) whose constant number in a given area is 100, in which the sexes are in equal proportion and each female gives birth to one hundred eggs. Let the eggs and larvae be attacked by parasites, each to the extent of 50%, and the pupae to the extent of 25%. Under normal conditions there will be 837.5 adults for the predators to feed upon, leaving the constant number of 100 to carry on the race.

Into this area let us introduce an allied species whose fecundity, food, life-cycle, and susceptibility to parasites are the same, with the exception of the larva which, for one of the many causes easily imagined, escapes free. Let us imagine that this immigrant succeeded in laying her eggs without otherwise upsetting the balance of life. At the end of the first generation there will be 875 adults for the predators to take, leaving 96.15 D and 3.85 E to carry on the two races. In the following generation these proportions will be 92.59 and 7.41, and at the end of the sixth generation the immigrant species will be the pre-

* Here as elsewhere in this paper the figures should be considered as proportions more than individuals.

TABLE II.

| Generation | Constant number | Eggs 50% killed | Larvae D 50% E nil killed | Pupae 25% killed | Adults hatched |
|---|---|---|---|---|---|
| 1ST D | 100 | 5000 | 2500 | 1250 | 937.5 |
| 1ST E | ............ | 100 | 50 | 50 | 37.5 |
| 2ND D | 96.15 | 4807.5 | 2403.75 | 1201.87 | 901.40 |
| 2ND E | 3.85 | 192.5 | 96.25 | 96.25 | 72.19 |
| 3RD D | 92.59 | 4629.5 | 2314.75 | 1157.37 | 868.03 |
| 3RD E | 7.41 | 370.5 | 185.25 | 185.25 | 138.94 |
| 4TH D | 86.20 | 4310 | 2155 | 1077.5 | 808.12 |
| 4TH E | 13.80 | 690 | 345 | 345 | 258.75 |
| 5TH D | 75.75 | 3787.5 | 1893.75 | 946.87 | 710.15 |
| 5TH E | 24.25 | 1212.5 | 606.25 | 606.25 | 454.69 |
| 6TH D | 60.96 | 3048 | 1524 | 762 | 571.5 |
| 6TH E | 39.04 | 1952 | 976 | 976 | 732 |

dominant form. The remarks as to extermination made in the former example apply equally well here.

The difference in parasitism has been made great, and the constant number low to hasten the results, but with these figures altered the ultimate results would be the same.

There are two other results brought about by the introduction of this species; firstly the decrease of the larval parasite from 1,250 to 762; and secondly the increase of the adults of

D and E combined from 975 to 1,303. This latter result might lead to an increase of the number of predators in the area, or to an increase of the more cryptic forms of the food of the predators, owing to a greater amount of a more easily procured food.

I do not imagine that this is the only method by which an introduced species supplants an endemic form; many complex causes may lead to the same result. During a discussion on this subject at a former meeting, Dr. Back stated the case of two species of Aleyrodes in Florida attacking Citrus: *Aleyrodes citri* and *A. citrifolia.* When *citrifolia* is present in quantities in an orange grove and *citri* is introduced, the latter soon supplants the former as a pest. In this case, Dr. Back stated, there is no reason to consider that parasites, insect or fungus, play any part, but that the ascendancy of *citri* over *citrifolia* is due more to a slight difference in fecundity and life history. The elucidation of this, and similar problems, is of great interest, and of value to bionomics as well as economics.

## Specific Characters and Mortality of Immature Individuals.

One of the chief things that has been impressed upon me during many years of observations of the death factors of insects, is that the mortality is highest in the immature stages. Natural Selection has but a limited field in the adult stage. It would be easy to quote figures to show this, especially among the Homoptera. Mr. J. C. Kershaw, after many years' study, came to the same conclusion in regard to the Lepidoptera of South China. This fact must be borne in mind when we consider the origin of adult specific characters by Natural Selection.

The vast majority of specific characters are such that we cannot conceive of them being selected on account of their utility and they have no connection with the earlier stages of the insect. We have only to take up a Monograph of some one large genus and note the characters which distinguish the species from one another; it is only by insisting upon our ignorance that we can maintain our belief in their vital utility. Take for instance our genus of *Proterhinus;* he would be a bold man who would try to maintain that each specific character was of a life-and-death value to its possessor. Or take the genus *Perkinsiella;* here are some fourteen species living on the same food plant, and in some places four or five species living in the same locality: their specific characters lie in the male genital organs, color of body and wings and granulation of tegmina. It is hard to conceive that these distinctions arose gradually, and were conserved by Natural Selection on account of their vital importance, especially when we remember that the greatest mortality is among the young, before these characters have appeared.

When considering the evolution of the characters of a group of allied species, whether these characters be colors or structures, we must remember that they are all the results of physiological processes, and that it is the changes in these processes which constitute the real evolution; the characters are the result of the physiological changes.

There are certain cases where it appears highly probable that internal physiological processes have had great effect upon the external characters. Kershaw, in his work on the anatomy of the "Candle fly",* and in a subsequent paper, has shown that in many families of Homoptera there is an enormous diverticulum of the stomach, just behind the aesophagal valve, which, filling up such space in the thorax as is available, proceeds into the head. In *Pyrops, Dictyophorodelphax,* and several (perhaps all) other cases where the head is greatly elongated, this diverticulum entirely fills this elongation**. Has this structure been brought about because a slight increase in size was of vital importance to the insect; or through direct use, such as pressure at all stages of development; or by some other means? At present I incline to the second belief.

The low percentage of nutriment in the liquid food of Homoptera makes it necessary for the insects to pass great quantities through their digestive organs, and the process of separating the wax and indigestible substances is of supreme impor-

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* A Memoir on the Anatomy and Life-History of the Homopterous Insect Pyrops candelaria (or "Candle fly"). Zool. Jahr. XXIX, Abt. f. Syst., pp. 105-124, Taf. 8-10, 1910.

** The knowledge that this elongated head of *Pyrops* is filled with stomach may help to settle the much-controverted point as to the luminosity of this structure. It has been suggested that the light is due to bacteria, and as there is a luminous bacterium which lives in the stomach of silkworm larvae, and makes the whole insect quite luminous, it is highly probable that bacteria in the stomach of *Pyrops* is responsible for the light seen on the head on rare occasions.

tance in their economy. The large diverticulum from the stomach is, no doubt, to this end. In certain Homopterous families a filter is formed between the aesophagus and the rectum through which the excessive juices pass, only the more nutritive substances passing through the whole alimentary canal. In the case of the "Frog-hoppers" the young stages are passed in some of the secreted liquids, and it has been suggested that this forms a protection to them, and has been brought about by Natural Selection. It has also been suggested that the liquid surroundings are necessary for the protection of the tender bodies against atmospheric changes. In reply to the first suggestion it must be remembered that the young insects are heavily attacked by their enemies, to whom the white mass of liquid only serves as a guide. In regard to the second suggestion there is good reason to believe that these insects descended from ancestors whose nymphs did not live in "spittle" and had normally hardened integuments. To me it appears more feasible that the secretion is due to the feeding habits, and the soft integument a direct result of those habits.

## Isolation.

The Rev. John T. Gulick in his writings* on this subject, on which Romanes placed "a higher value than any other work in the field of Darwinian thought since the date of Darwin's death", has shown that geographical and topographical isolation has played the chief part in the evolution of Hawaiian land shells. These writings should be better known to Hawaiian entomologists than they are, as I believe still further evidence can be found for these theories among the insects. In this connection it is of interest to consider the numerous species in some of the flightless genera, a condition that facilitates isolation.

Romanes and Gulick have shown that Natural Selection without the aid of some other form of isolation leads only to monotypic evolution, but with the help of physiological isolation Romanes considers that it can lead to polytypic evolution. This is a point that I cannot agree with. If a variety arises with a character which gives it a better chance of existence than the parent species, and if the character follows the Mendelian law of inheritance and so does not become "swamped", it will

* Journal Linn. Soc. (Zoology) XX and XXII.

eventually supplant the parent species, whether it be sterile with it or not.

Romanes placed very little stress upon morphological isolation, but he did not consider the case of the aedeagi of insects. This form of isolation, which we may term "phalic", is of such great importance that it will have to be given an important position in the final consideration of evolution. How far the sterility of allied species is due to "physiological" and how far to "phalic" isolation is a matter to decide by experiment.

Of the various problems that confront the student of insect evolution, none is more difficult than that presented by the male genital structures. It has been recognized for a long time that these sructures present the most definite characters upon which to base the species in many groups of insects. In many cases this is the reason to believe that correlated structures exist in the opposite sex, and this further complicates the problem. An organ of such vital importance to the life of the species must have been functionally adequate from the earliest period of insect physiology, so that it is highly improbable that a series of slight variations, each more advantageous than the former, could have been preserved by natural selection; still more improbable that a corresponding series of changes should have simultaneously taken place in the female. Again, natural selection would have led only to monotypic evolution. A comparison of the male organs of some of the allied species of Hawaiian beetles, especially in those cases where geographical isolation appears to be the chief factor of evolution, would be of great interest.

These brief remarks on very complex subjects are only to show how many important and interesting subjects await the investigation of the naturalist, and all the time such great questions await elucidation there is need for such societies as ours. We may not be able to answer the questions ourselves, but every correct observation is a new stone in the final edifice.

The labors of Blackburn and Perkins mainly, and of several members here present secondly, have placed the Hawaiian insect fauna on a systematic basis which enables us now to grasp and study the interesting problems connected with its evolution; to understand more thoroughly the causes which keep our insects from increasing in numbers; the various means which lead to their isolation; the adaptations that have taken place to enable them to fit their various present habitats and habits and to estimate how far isolation has been the cause of the origin of species.

Personally I believe that "isolation", together with the comparative absence of "Natural Selection", owing to the simple conditions of the biological environments, has been the chief agent in the production of species of our insect fauna.

NOTE:—The above notes were written before I had the pleasure of reading Dr. R. C. L. Perkins' "Introduction" to the Fauna Hawaiiensis. It was of great interest to me to read his conclusions, founded upon so detailed a study of the insect fauna, on several of the subjects that I have touched upon. One of the great values of this work is that it is the first time that an isolated tropical island, or group of islands, has been anything like thoroughly worked and then analyzed. The results are of great value, the volume forming the most important of recent contributions to biology. Those who have the pleasure of a personal acquaintance with the author regret that he has not more fully entered into many of the questions discussed, and drawn more fully from his wealth of observations, in a manner that makes his personal discussion of these subjects so interesting.

## On Some Derbidae from Formosa and Japan.*

BY F. MUIR.

During a short trip to Formosa in December, 1913, the writer was only able to get three days collecting in the forest, one of which was wet. It was therefore not possible to do very much work, but several new Derbidae were among the Homoptera. Thanks to the kindness of Messrs. I. Nitobe, M. Maki and M. Ishida, he was able to procure several interesting specimens, and to examine others. Besides the species mentioned below there were also female specimens of three species of *Rhotana,* one *Goneokara* near to *pullum,* one *Sikaiana* and one *Herpis.* This indicates that when more fully worked the Derbidae of Formosa are likely to be numerous.

Thanks are also due to Prof. S. Matsumura for the loan of certain Japanese specimens.

The types of the following new species are in the collection

* This contribution from Mr. Muir was received at a later date, but it seems desirable to publish it at this time.—Ed.