in the southern part. South Island legbone records refer to *robustus*.

It now remains to discuss the significance of this distribution. Fleming's map (1949) of his interpretation of the paleogeography of New Zealand during the early Whanganui Period, shows a small strait flooding the Manakau lowlands, near Auckland, and a much larger Manawatu Strait running roughly along a line below New Plymouth to below Gisborne, and Cook Strait closed on the eastern side.

Moa origins are unknown. It is possible that the *Dinornis* group had a different ancestry from the other six genera. Probably before the Waitotaran stage *Dinornis* had diversified into three size groups, and during the existence of the Manawatu Strait the *maximus-giganteus* and *hercules, robustus-ingens, torosus-novaezelandiae* pairs developed.

Original *Euryapteryx* stock was probably small, but *E. gravis* and *Zelornis haasti* became dominant in the South Is., leaving marginal small forms in the south (Stewart Is. was then joined to the mainland) and in the North Is. *E. gravis* spread over the Cook Strait land bridge up the east of the North Is. Volcanic ash showers obscure the evidence in the central North Island, but *Zelornis exilis, Euryapteryx cortus* and *E. tane* came from north of the Manakau Strait, spreading southwards when it closed. *E. geranoides* probably originated as a species between the Manakau and Manawatu Straits, later spreading north and south.

Emeus, closely related to *Euryapteryx,* is confined to eastern South Island, and *Pachyornis elephantopus* to that area and Nelson-Takaka. *P. mappini* and *P. septentrionalis* originated either in North Auckland or mid-North Island. *Anomalopteryx didiformis* originated south of the Manakau Strait, (fragmentary *A. antiquus* Hutton from Timaru is very close to it). *A. oweni* became distinct north of Manakau Strait.

Thus the three main moa faunal areas (see map) are (A) North of Manakau Strait. (B) Central North Island. (C) South Island, mainly east of the Alps, from Takaka to Stewart Is., and, for *E. gravis,* Eastern North Island. The distribution of *D. maximus* is shown by the dotted line.

REFERENCE

FLEMING C. A., 1949: *Tuatara* 2(2): 72-90.

Discussion

THE CHAIRMAN opening the discussion said the problem was to try to establish some community of pattern in the various ecological and biological factors present in the areas propounded as natural and see to what extent it was possible to make broad delineations of these areas Various points had emerged from the papers: the apparent significance of the 38th parallel; the effect of Cook Strait, which is a barrier to certain reptiles and some of the birds, but not to worms.

MR. DELL, answering a question on the discontinuous distribution of snails, said that some could be partly explained on the geological evidence but the geologists' plans of the post-pliocene area in New Zealand were rather indefinite. If Wellman's theory of glaciation in New Zealand was accurate one had to envisage everything being pushed up from south to north by advancing ice, and subsequently the whole area being re-colonised and the forest advancing as the ice face disappeared and moved south; it was possible that some species found the only suitable conditions in the regenerating forest following on the disappearing ice sheet; certain of them perhaps stayed behind and adapted themselves and others carried on, following the retreating ice. For a long time it was believed that glaciation was the key to the distribution of *Paryphanta,* but if the geologists were right and the South Island was fairly devoid of this type of life it was a hard situation to envisage.

MR. SCARLETT said the survival of certain groups of opilionids in Fiordland suggested that high country there was not as severely glaciated as some geologists thought.

MISS L. B. MOORE commented that the effects of glaciation might have been over-emphasised and mentioned that earthworms

had been found high up on Mount Ruenzori where they must be frozen every night of the year.

MR. LEE pointed out that in this country the earthworms were definitely forest animals.

DR. FALLA said that historically there may have been very significant changes in the availability of dispersal agents: birds of the petrel family had an association with terrestrial organisms in their subterranean burrows. Formerly the mountain ranges of New Zealand were honeycombed with burrows containing millions of petrels and every year there was a vast dispersal of these birds including many young still with down on them and carrying miscellaneous debris including soil organisms which in this way could be widely spread.

MR. ROBERTSON said that the 38th parallel had no significance from a climatological viewpoint.

MR. SCARLETT remarked that Dr. Falla had shown that the kakapo was to the west of his dividing line in the South Island in its present distribution; formerly it was more widely spread than indicated in Dr. Falla's map, having been found occasionally in Otago and Canterbury. DR. FALLA said his map was confined to the present historical period. It was evident that there were different climatic conditions in earlier periods.

P. C. BULL wondered whether the boundary between Cook Strait might not have some significance as an ornithological boundary: huia, in the North Island, and brown creeper, various nesting waders—wrybill, oyster catchers, black stilt—in the South Island. DR. FALLA replied that the line on his map seemed to have a broader biological significance.

G. R. WILLIAMS pointed out the need for study of the climate of the first metre above the ground, which would have more bearing on the ecology of animals than normal climatology studies had. THE CHAIRMAN mentioned that Dr. Mitchell had established a number of micro-climate stations in New Zealand where recordings were being taken daily which were being related to ordinary data taken in the course of climatological recordings.

MR. SCARLETT said that the distribution of the moas might perhaps be explained by their different habitat requirements: the bigger species seemed to have preferred grassland, the smaller ones to have been bush or scrub-dwelling birds and more adaptable.

MR. ZOTOV, in reply to a question from the chair, said that his mathematical technique should be applicable to any organisms; it depended on the two areas having a number of species in common and the difference in the number of common species would be an indication of the degree of isolation one from the other.

MR. BULL said the rabbit occurred from Norfolk Island to the Auckland Islands and was able to survive in a great variety of conditions, yet the areas where it flourished were limited to districts with low rainfall or well-drained soils; to explain the distribution of rabbits rainfall, soil type, and plant cover had all to be taken into consideration.

DR. R. H. THORNTON, in reply to a question, said that in the tussock areas the micro-organisms were influenced more by the vegetation cover than by soil type.

I. J. POHLEN thought too much emphasis had been placed on the relationship of organisms to one aspect of their environment. Before 1930 attempts to separate soil on texture and other factors were unsuccessful; only when the soil continuum was considered in terms of its environment as a whole was it possible to separate soils out satisfactorily. Clay soils tended to end about the 38th parallel. A lot of things tended to be tied up with soils.

A. P. DRUCE considered that a natural area should be based on the same pattern or sequence of vegetation changes at different altitudes, not on uniformity within an area.

MR. ZOTOV agreed that a natural area implied two, not three, dimensions; altitudinal differences were irrelevant.

DR. THORNTON suggested that three very broad natural areas were apparent from the maps: a sub-tropical zone above the 38th parallel, and an east and a west zone.

S. H. SAXBY said the 38th parallel provided a useful subdivision marking the limit of some tropical grasses. Cook Strait would be useful as a sub-division of another group of introduced plants, the legumes. The scale on which the division was made depended on the detail wanted.

MR. DELL said that the apparent parallelism between opilionids, earthworms and land snails occurred largely because their habits were similar: a vertical distance of about twelve inches above or upon the forest floor accounted for all of them. The maps possibly indicated a picture of community distribution. A duality of approach to the problem was apparent; some people were concerned with the range and habitat requirement of species, others with boundaries separating groups of species.

MR. SCARLETT said that the former distribution of *Notornis*, dependent on its legs for dispersal, in Pyramid Valley, Grassmere, Nelson, and up the east coast of the North Island was explicable by invoking the connection across Cook Strait.

MR. WILLIAMS defined a natural area as one in which ecological conditions were uniform at any broad altitude and differed clearly from ecological conditions at the same altitude in any other area. This implied that the composition of the animal and plant communities within each such natural area was stable over a considerable time and differed in composition from the animal and plant communities in adjoining areas.

MR. TILLER said that it had been shown that with many plants, success was dependent on a very precise regime of temperature, particularly at night time, and it may be that some spread of night to day fluctuations might have an influence not shown up in the normal meteorological readings.

MR. ROBERTSON said that Nelson had a special climate of its own. It was enclosed on three sides by high ranges and practically the only winds coming in were north-easterlies or south-westerlies. The results of that circulation of air in the region were a long duration of sunshine, a low rainfall of about forty inches, a high temperature range with warm summer and cool winter temperatures, resulting in that little area being quite distinct climatically.

DR. J. F. GABITES pointed out that while for some biological purposes the climate should be measured low down and it would be theoretically possible to classify the climate into a dozen divisions over half an acre, for broad generalizations about climatic areas in New Zealand much detail had to be omitted and better results were obtained from measurements at 3 feet than at 3 inches. Mr. Robertson's map was a considerable advance, taking into account wind units, sunshine, the seasonal cycle in the various elements, and provided a simple synthesis. It represented a common denominator in the environment of a lot of organisms.

N. H. ELDER pointed out there was a considerable area in the central North Island where partly from inaccessibility, partly from altitude, no climatic data were available to tie up with distribution.

MR. DRUCE said that there appeared to be three primary divisions of New Zealand: north, east and west, and it would be useful if the meeting could agree on definite names for them.

MR. DELL voiced a strong objection to drawing boundaries to which other people must conform. He would rather see each individual find his own from his own internal evidence.

R. I. KEAN said the 38th parallel marked the effective limit of the northward expansion of the red deer; opossums were a serious trouble below the line, but not above. In his opinion the boundary was determined by fortuitous factors; and to give it a definite name might suggest an unwarranted physiological reality.

DR. THORNTON thought it would be sufficient to record that this symposium indicated three separate areas, and it was undesirable to try to define them exactly.

MR. ALLEN said that the east-west boundary of the South Island, as far as introduced fish were concerned, was in the foothills, and in the north the 39th parallel had more reality than the 38th. It was dangerous to agree upon a classification and expect different groups to fit in with it.

THE CHAIRMAN in closing said that in most of the groups discussed not enough was known about the biology, systematics, or distribution of the organisms to make it possible to reach agreement on even a broad distribution of smaller natural areas which would be acceptable to everybody. It was clear that the definition of a natural area may vary from one discipline to another. There was an obvious need for much more work to be done in New Zealand on the systematics and biology of the various organisms, a need for geologists to agree on an

accurate description of what had happened in the past to our water barriers, land forms and glaciation; and for a better understanding of the interrelationship of climatology and biology. The symposium had been an interesting experiment but it was a hundred years too soon to reach a satisfactory conclusion.

Exhibits

During the conference, facilities were provided in a laboratory adjoining the conference room for members to display photographs and equipment used in ecological work. Much interest was shown by members present in the resulting exhibition. Exhibitors and material exhibited were:

1. Victoria University College Zoology Department: Photographs of collecting and sorting of samples from Cook Strait. Samples of lines used for deep sea fishing in Cook Strait. Specimens of sharks, rays and shrimps collected.

2. Auckland University College: Miss Trevarthen exhibited a number of photographs, mainly of bird life, taken by an A.U.C. party on Poor Knights Islands.

3. Speakers in the symposium on natural areas in New Zealand displayed the maps they had prepared for the symposium.

4. Mr. A. L. Poole: Photographs and leaf specimens of species of *Nothofagus* known from New Zealand.

5. N.Z. Oceanographic Institute: Maps and charts of the Cook Strait area and a model showing ocean bottom relief of the Cook Strait area.

After the annual general meeting supper was served in the room where exhibits were displayed and members present made use of this opportunity to examine the exhibits.