Opusc. Zool. Budapest, IX, 1, 1969

The Tasks of Soil Zoology*

By

J. BALOGH**

The exploration of the flora and fauna of the world might well be considered completed today. According to moderate estimates, at least 2 million species of plants and animals have been described and, though this number continues to grow from year to year, new or surprising discoveries which might change our present ideas about the animal and plant population of the Earth are hardly to be expected.

Thus, on the whole the task of taking census of the living world has been performed, however, up to recent times very little was known on the mechanism by which the biosphere of the Earth regulates the circulation of organic matter and energy flow. After the Second World War the United Nations Organization launched a project to assess the potential energy resources of Mankind. Already at the initial stage it had become clear that in a number of vital questions, as e.g. the cultivation of virgin lands, the use of chemicals in agriculture, no satisfactory solutions can be found until a host of biological basic research was carried out. The tasks to be performed were, almost without exception, related to the above-mentioned issues of organic matter turnover and energy flow. In other words, it has become clear that production biology which, in the pre-war years emerged as a wholly theoretical discipline, has grown into one of the most significant scientific theories in the biological utilization of the Earth [1].

Experts engaged in the problems of the world's food supplies have more or less explicitly formulated the questions to which the world is looking to biologists for the answers.

1. The first requirement is that the natural photosynthetic potential of the Earth be assessed and an approximate estimate be given for the rate of efficiency, i.e. the quantity of organic matter produced by the main types of vegetation, the biomass.

2. Subsequently, endeavours should be concentrated on determining the quantity of biomass produced by photosynthesis and to explore by what energy transfers the biomass is being consumed and what the losses involved are.

* Inaugural lecture delivered at the Hungarian Academy of Sciences, 19th April, 1967.

** Prof. Dr. JÁNOS BALOGH, ELTE Állatrendszertani Tanszék (Zoosystematical Institute of the L. Eötvös University), Budapest, VIII. Puskin u. 3.

3. Finally, the biomass of dead organic matter laid down in the soil should also be assessed in a similar way and the processes which, under natural conditions hinder the biological degradation of soils are also to be studied.

From the way the above questions were posed it is evident that nutritionists wish to elicit the help of production biologists in seeking new ways and means by which the food supply of Mankind, foreseen to redouble its number in the next 50 years, can be solved.

In Hungary biological research work had a good start after a recession imposed by the Second World War and the economic encumbrances following in its wake, for two reasons. On the one hand, a keen interest for our endeavours and a readiness to help was shown on the part of our agricultural experts. On the other hand, in post-war times production biology could start work under propitious conditions. The reorganized Hungarian Academy of Sciences, having recognized the significance of biological studies has been ready to sponsor the necessary research work, ever since.

The field in which I and my collaborators have conducted research work is a special chapter of production biology, i.e. soil zoology. This chapter deals with the activity of soil animals in the decomposition of organic matter. The Hungarian Academy of Sciences has afforded me to report on my results on two occasions [8, 3] and therefore I feel that I might be excused for not going into details, or for not giving account of my work here so as not to lapse into repetitions. Instead, an outline of the present state and future tasks of soil zoology seems to be more to the point. My own scientific results and those of my collaborators who have been assisting me in this work over the past twenty years, form an integral part of the overall picture I wish to draw.

*

Apart from a very few exceptions of minor importance, the basis of all life on Earth is photosynthesis. In the course of this process—as is known—the radiation energy of sunlight is converted into the potential energy stored in plants. Directly or indirectly it is this source of energy which sustains all animal and human life. On the grounds of various estimates and calculations, that part of the radiation energy of the Sun which reaches the Earth is put at 5.10^{20} kilogramme calories. In conformity with the proportion of Oceans and lands, from the total of 5.10^{20} kilogramme calories $3{,}6.10^{20}$ falls to the Oceans and $1{,}4.10^{20}$ to the lands. Today sufficiently reliable data are available on the organic matter production of the various climatic zones, continents and vegetations to enable a good approximation of the total production of the terrestrial part of the Earth, the amount of which is put at about 3.10^{10} tons of dry matter. At least one third of that quantity, i.e. approximately 10^{10} tons of dry matter is being absorbed yearly in the soil of the Earth where it is decomposed through intricate and so far not sufficiently explored biological, chemical and physical processes. Thus the animal life of the soil takes an active part in the processing of an immense amount of organic matter. To give an idea of the vastness of the above quantity at least in order of magnitude, I should like to mention for the sake of comparison that the chemical, metallurgical and mining industries of the world produce but one tenth of that amount, 10^{9} tons a year.

However, these mean values do not give a true picture of the regional patterns of distribution of the Earth's organic matter resources, since the production of the various climatic zones and vegetations differs widely. The productivity of deserts and sparse grasslands of the world is a mere 0.1 gr/m^2 per day. 45 p.c. of the terrestrial part of the Earth belongs to this zone, inclusive of the Antarctic regions and the other ice-covered parts of the Earth, as well as of the artifical deserts and industrial areas. Ten times the amount mentioned above, i.e. 1 gr/m^2 per day of dry matter is produced by the steppes and subtropical grasslands of the Earth where, due to adverse weather conditions, only periodical agriculture can be pursued. These parts of the Earth add up to 17 p.c. of the surface of the Earth. The productivity of the lands covered with forests and evergreen pastures, as well as that of the intensively cultivated areas soars again to ten times that of the former category, i.e. to 10 gr/m^2 per day with an upper limit of 25 gr per day. 28 p.c. of the lands covered with forests and 10 p.c. of the intensively cultivated areas come under that category. Thus about 80 p.c. of the dry matter production of the Earth is yielded by the lands under intensive cultivation and those covered by forests. Therefore the research work conducted all over the world, among others, also the soil zoological examinations pursued by myself and my collaborators are concentrated on the above-mentioned zones.

The astonishing amount of organic matter absorbed by the soil is only paralleled by the biomass of soil animals. I and my collaborators have spent 20 years in studying the amounts involved. My first results were published between 1946 and 1952; our methods were described in my books published in 1953 [1] and 1958 [2]. Numerous new achievements were reported by LOKSA in his work published only recently [14]. Our most important results were cited in the relevant international literature. Our methods, some of them with improvements, are in use today, too. My own results and the studies conducted into similar topics in the various parts of the world enable a calculation by which the biomass of the present-day human population numbering 3 million thousand human beings is 20 times surpassed by that of the soil fauna of the zones of the Earth now under agricultural cultivation and covered by forests.

The immense biomass of soil animals is concentrated only in a very few animal species. The greater part, about 80 p.c. of the biomass is represented by earthworms. These animals abund in great quantities in almost all soils of the Earth. The biomass of Diplopods is much less, however still significant in number, together with that of soil insect larvae, ants and termites. Lastly, though their biomass is much less than that of the previous two groups, the representative of the mesofauna, the Nematods, soil mites and Collembols play—due to their enormous numbers—a most important role in the energy flow. These animals can be found in all kinds of soil all over the world, except for territories where they cannot survive due to absence of water or to everlasting ice. These are the animal species which, together with the microorganisms living in the soil, take part in the processing of the 10^{10} tons of dry matter decomposed in the soil yearly. That is why I and my collaborators have concentrated our efforts on the production-biological examination of these groups of animals.

According to a former production-biological classification of organisms, three main types were distinguished:

1. producents, that which increase the living matter by photosynthesis;

2. consumers, that which decrease the store of living matter, and

3. reducents, that which help decompose or directly decompose or reduce dead organic matter produced by organisms.

It is evident that soil animals come under the third group. This classification, like most typological classifications, reflects reality only imperfectly. Already as early as in 1953 [1] I proved that the food chains through which the energy flow passes and the organic matter turnover is realized are built on two completely and fundamentally different sources of energy. Accordingly, the soil animals can also be divided into two types: those feeding on living organisms and those on dead organic matter. Organisms feeding on living matter, naturally, also decrease the supplies of organic matter; the organisms feeding on dead organic matter, however, have besides decomposition, other functions, too. Within the latter type two sub-types can be distinguished: The first sub-type includes organisms of very small size and high metabolic rate. Microorganisms and a part of the mesofauna come under this group. These decrease the energy supplies of the Earth bound in dead organic matter at a quick rate. The other sub-type is composed of larger animals which, consuming relatively less energy, store in their body a significant quantity of same. In addition they produce a larger quantity of excrement which again is consumed by coprophagous organisms for building up their own body and for further storage. It is evident that microorganisms and the above-mentioned larger coprophagous invertebrates living on litter and excrements are antagonistic in their activities. The latter slow down the energy loss of organic matter and, in a way recover a part of the energy supplies of the system from the bacteria to the energy level of the biomass. The above function of the litter consuming and coprophagous organisms is termed recuperation [1, 4].

The significance of the recuperational processes having once been recognized, the scheme of organic matter and energy flow established earlier by LINDEMAN [13] had to be modified. According to that theory ELTON's pyramid of numbers could be considered as the succession of links in a chain ranged one above the other. Each link of the chain represents an energy level which hands on energy to the next stage. The first energy step, which LINDEMAN denoted "level" was marked by the Greek letter lambda (λ) standing for the plants taking part in photosynthesis. The second level, λ_2 for herbivores, the so-called primer consumers, the third (λ_3) level for secondary consumers feeding on primary consumers, and so on... Without going further into that question, it is evident that the ELTONian pyramid symbolizing the biomass of living organic matter has to be supplemented by a second pyramid representing the dead organic matter in each community, the energy levels of which should be marked by λ_1 and λ_2 and so on.

Thus LINDEMAN's pyramid of numbers has to be substituted by two superimposed pyramids the points of which meet and which represent the energy flow of the Earth also taking into account the recuperative processes.

Having dealt with the general aspect of recuperation, I and my collaborators concentrated our efforts on the quantitative aspect of the issue. First we wished to establish the rate of body maintenance and the production of excrement in soil animals feeding on forest litter. On the other hand we set ourselves the aim of assessing the population density of invertebrates feeding on forest litter in the main types of forest in Hungary. From these two main parameters we thought to be able to define the recuperating and decomposing activity of the soil fauna of the Hungarian forests. For the purpose of that dual task laboratory experiments had to be carried out on the one hand, and large-scale soil fauna samplings all over the country, on the other. Our research group allotted the tasks to be performed, accordingly. Later the work was extended also to the examination of agricultural soils. My collaborators, IMRE LOKSA, ISTVÁN ANDRÁSSY, GÉZA GERE and ANDRÁS ZICSI had often to develop new specific methods for the work they carried out with different groups of soil animals, since the work undertaken was overwhelmingly one where they had to break fresh ground. Their work was summed up in four excellent dissertations for which they were granted the degree Candidatus Scientiarum. Interest for our work was also shown from abroad. At that time similar researches were conducted in several European countries, thus the results obtained could be compared. The examinations conducted in various parts of the Continent independently proved that the rate of excretion of soil animals living on organic litter is exceedingly high. From 100 units of consumed food 85—95 is being returned to the soil in the form of excrement. The results related to recuperation have drawn attention to the quantitative measurements of excrement production. Thus, the recuperative phenomena related to measurements of the excreted biomass of primary consumer herbivores was also studied. B. LAURENCE carrying out production-biological studies on English pastures found that the quantity of cattle excrements produced on English pastures exceeded 19 times the weight of the animals producing the excrement [12]. And in turn, the coprophagous insects feeding on the excrements reincarnated one fifth of the weight of cows in the course of their recuperative activity. In other words, cows representing 500 kg give rise to a population of coprophagous insects the weight of which is equivalent to 100 kg at a cost of consuming approx. 10,000 kg of excrement.

These proportions reveal surprising interrelations. Biomass measurements carried out in the various parts of the Earth showed by comparison that e.g. in the big National Parks of Africa, the annual excrement production in terms of dry matter is 40,000 kg per ha [11], more than the litter production of the Middle-European deciduous forests. The maximum was found on intensively cultivated pastures in Holland (250,000 kg per ha), the minimum on the pampas in the Argentines (10,000 kg per ha).

Taking coprophagous insects at a 1 p.c. annual rate, it is found that in the National Parks of Africa, on the Dutch pastures, and on the Argentine pampas the weight of the recuperating coprophagous insects produced per year amounts to 40 kg/ha, 250 kg/ha and 10 kg/ha, respectively. In connection with these data the total weight of these soil animals should again be recalled as given in the introduction, i.e. 60 kg/ha, approximately as much as the weight of the coprophagous insects found in the National Parks of Africa. Thus, the biomass of coprophagous insects computed for the entire world, similarly to that of soil animals, surpasses many times the biomass of Mankind.

What has been said so far leads to the surprising conclusion that the animal life attains its highest concentration in the soil, first and foremost in forest soils and in excrements, all over the Earth. The numeric value of that concentration moves at about 500 kg/ha, i.e. it is about twice the number of the highest figures found for big game on the Earth under natural conditions even in the National Parks of Africa.

No doubt, our ideas formed on the distribution of Animal Kingdom will have to be changed at the sight of these astounding figures. However, these findings afford even more important conclusions to be drawn from them. In territories where, due to human interference, the quantity of dead organic matter suddenly decreases, the greater part of the coprophagous fauna and soil fauna is exterminated. The question is how this affects the life of the soil and through it the nutrition of man. The Indian example might well be remembered to demonstrate the point. In India, as in many other countries where fuels are scarce, cow-dung is used for heating. The amount of cow-dung thus burnt amounts to 65 million tons a year, 24 p.c. of the total dung production. By burning the said quantity of dung such a vast amount of potential coprophagous insects is exterminated which is equivalent to the weight of 10 million humans. Over a long period of time dung burning was only thought of in terms of organic matter losses, however, recently it has been found that the extermination of potential coprophagous insects implies an additional loss of very grave consequences.

Almost as a demonstration to prove the above, a large-scale field experiment was set up by mere chance in Australia. As is well-known, mammals are missing from the native animal life of Australia. Kangaroos are the only large-size herbivores, however, their excrement differs in character from that yielded, e.g. by cattle. Thus the characteristic coprophagous insects (dung-beetles) are almost completely absent from the animal world of Australia. After the introduction of cattle to Australia, but mainly by the time cattle breeding had grown into mass proportions, the absence of dung-beetles lead to a surprising result. The excrement, i.e. the dung did not become decomposed, although weather conditions, temperature and moisture content seemed most favourable. Instead, the excreted dung piled up and barred ever increasing territories from being used as pastures. My aim in visiting Australia in 1965 was, among others, to carry out investigations along these lines on the spot. Together with Dr. F. G. Bornemissza, a Hungarian-born expert of the question, I visited various parts of the Continent, covering 3,000 km from the pastures of the temperate zone to the tropic regions in North Australia. The state of the Australian pastures was appalling. It should, however, be made clear that the pastures concerned were among the finest of the World and maintained according to the most advanced methods. Especially in Queensland, Brisbane district, meat production was exceedingly high. However, according to F. G. Bornemissza's data, a yearly amount of dung equivalent to 33 million tons of dry matter remains lying on the pastures due to the absence of dung-beetles and other coprophagous insects, by the activity of which the dung could be consumed and brought into the soil. The loss subtained by the territory is composed of various factors. The dung remaining on the surface of the soil is washed out, the greater part of its valuable materials is wasted. The 33 million tons of dung is practically a 100 p.c. loss in nutritive materials. The residual mass of washed out dung persists for a long period (from 2–3 years) on the surface; the grass underneath perishes and its immediate neighbourhood becomes grown over with weeds not suitable for grazing. Thus a yearly 1,000 km^2 of the territory is lost for grazing and even according to rough calculations the potential loss in milk and meat yealds alone amounts to 10 million dollars a year. In order to restore the biological equilibrium of the soil, coprophagous insects have to be introduced and propagated until their population will have reached an annual 300,000 tons of total weight [5].

To give an idea of the orders of magnitude involved, it should be noted that the necessary amount of insects is equivalent to the weight of 5 million men, i.e. of half of the present-day population of Australia.

*

The expeditions which I and my collaborators undertook to the tropics of Africa and South America were also aimed at clearing scientific issues of primary importance. These expeditions were sponsored by the UNESCO with the aim of collecting the soil fauna of tropical rain forests and of comparing the soil fauna of virgin lands, as well as of cultivated and degraded areas. Thus, the work was started with the aim of collecting data and revealing facts, however, the ultimate end of the work opened up prospects beyond the immediate aims. Tropical rain forests produce almost three times the amount of organic matter yielded by the best forests in the temperate zone. The investigations which were small in number and rather haphazard in nature in the last years, have shown that although the soil fauna of the tropical rain forests is exceedingly rich in species, the biomass yielded by them is surprisingly small. According to available data based mainly on estimates, it was found that the litter of fallen leaves was very thin in these forests and did not seem to be proportional to the vast masses of trees and leaves produced by photosynthesis.

The low organic matter resource of tropical plantations set up on the soil of former rain forests might well be related to the above fact which might explain why these cultivated areas have not been able to come up to expectations. The crops of the first years frequently decreased within the next few years and the soil has become degraded, so much so that it is absolutely unsuited for cultivation.

The situation seems to be more favourable where the rain forests were turned into permanent pastures. It is mainly in Queensland, Australia, that well-maintained tropical pastures of high yield can be found. The agricultural experts of Australia might well be proud of their results.

In setting up the Australian pastures various ideas taken from production biology were adopted. However, in order to go into these we have to revert to the examinations conducted in our Institute on the metabolism of soil animals. It is a known fact that the metabolic rate of animals of various body sizes differs even with external conditions being unchanged. The ratio of big and small animals approximately similar in form is equal to $\sqrt[3]{g^2}$, where g denotes the weight of the animal. This ratio means in other words that the smaller the animal the more intensive its metabolic activity, i.e. the greater its activity as decomposer in the soil. Consequently its food consumption is also proportionally increasing with the former relation. At that time the laboratory breeding of Diplopods had not been solved, one of my collaboratores, Géza Gere had to develop a suitable method for the purpose [10]. The long-range experiments carried out with the new method proved our assumption: Van der Drift's constant $\frac{c}{\sqrt[3]{g^2}}$, where c is equal to the consumption per time unit, is valid for animals of various species and of various ages.

On the ground of these findings the oxygen or food consumptions of two groups of animals or of two species of different size can also be compared and computed if the body weight and population density of the species is known. Such computations for the ratio of the macrofauna and mesofauna of Hungary's deciduous forests yielded the results of 6 : 1 to 10 : 1; the oxygen consumption, however, varied with the disparity in body size according to formule $3\sqrt{g^2}$ from 1 : 20 to 1 : 40 [1, 8]. Thus it has been proved that, due to its high metabolic activity the mesofauna plays a most important part in the decomposition of forest litter, in spite of the small volumes of the individuals involved.

Before embarking on our researches in the tropics I resolved to depart from the fact that the laws found to have governed our investigations conducted in Hungary and outlined in the foregoing, would hold true also for tropical soils. One factor, however, is of decisive significance in the metabolic activity of soil animals in the tropics and that is temperature. Since temperature factors had not been investigated for tropical soils, I tried to find analogies in hydrobiology. DIETRICH and KALLE [6] carried out computations to establish how temperature influences the biomass of aquatic animals. According to them, the well-known fact that the fauna of the Arctic seas is much richer than that of the tropical ones can best be explained by the difference in temperature, which is about 25 °C in the above-mentioned respect. This temperature difference causes an increase of the metabolic rate in tropical seas due to which accumulating becomes impossible and the animals are forced to consume $^9/_{10}$ of their biomass.

A similar phenomenon might well be conceived in the case of tropical rain forests, as well. The metabolic activity of the soil animals is exceptionally high due to the high temperature which may also affect the microbiological processes in a similar way. Due to the high metabolic activity all dead organic matter is completely decomposed in the soil, even though the quantity of organic matter in tropical rain forests is treefold of that to be found in the forests of the temperate zone. As a result, soil life in tropical rain forests is limited to a very thin active layer in which the biomass of the soil fauna is not greater than in European soils. Beneath that layer, almost without any transition, a layer completely lacking biological structure is to be found. The soil of rain forests does not possess a sizable organic matter resource in the sense of the term as applied to the deciduous forests of the temperate zone, since the organic matter supplies of the system are stored in the bodies of the living plants. Therefore the clearing of the rain forests by burning is tantamount to the destruction of almost the entire organic matter supplies of the system a true cataclism, more devastating than any similar destruction in the forests of the temperate zone.

*

Production-biological examinations have also proved that long food chains are much less effective than short ones. Plants utilize only 0.1 p.c. of radiation energy; primary consumers and the further levels utilize, at best 10 p.c. of the energies stored in plants. This, however, is but a rough approximation. What was said about the body size and metabolic activity of animals makes it clear that the storing capacity or efficiency of small-size animals is less than that of larger ones, thus food chains built on links of small-size animals will necessarily be of low efficiency. The food chains of tropical rain forests unite both drawbacks, thus it is not at all surprising that the big animals, birds, mammals in the West African rain forests which constitute the last links in the food chains of the zone, represent a much smaller biomass as compared to the short food chains of savannas. Experience shows that food chains comprising more than three links are only exceptionally suitable for human consumption. One of these exceptions is found in fishery where the end-product of a four, or sometimes even five-link food chain, the biomass of predatory fish, can also be utilized. However, under natural conditions, the storing capacity of predatory fish is exceedingly low. On the basis of the data collected over two decades it was found that the fisheries along the shores of the United States yield 5 gr-caloric/m^2/day energy for human consumption from the fish meat at the end of the food chain converted from 3.10^6 gr-calorie/m^2/day radiation energy. The efficiency of that system is but 0.00015 p.c. With the above data in mind, it is easy to understand why the Oceans constituting 71 p.c. of the surface of the Earth produce not more than the same amount of 3.10^{10} tons of plant dry matter than the terrestrial parts of the Earth and why aquatic products contribute only 1 p.c. to the nutrition of Mankind. To come back to the fishery example, it is worthwhile to consider what results could be attained by artificial short-cuts in long food chains. This is what actually happens in fish ponds where fish is bred for consumption through four and three-link chains. Fish yield in such cases often exceeds several quintals per hectar. By successful experiments in fish ponds the food chain has been reduced to two links and in this way a new method of fish meat production has been found. Through this two-step food chain fish meat production is a thousand times more efficient than through natural marine food chains; and in theory, by the addition of hay efficiency can be increased almost indefinitely.

The examples were taken from hydrobiology by design, since that branch is more advanced than soil biology and its results have already served as guiding principles for soil biology in the past. Thus the foregoing clearly indicate that the short-cuts in food chains having proved efficient for fisheries should be applied in farming establishments set up on the territory of former rain forests, too. Experience so far has shown that the soil of plantations on the sites of former rain forests becomes degraded within a few years. As already mentioned, animal husbandry has been found to bring better results, because by setting up pastures in the place of rain forests to rear cattle for meat, has been successful. In Queensland this work seems to have been carried out according to the present results, satisfactorily. With the help of a suitable mixture of papilionaceae the immense photosynthetic potencial, by which the original plantations of Eucalyptus forests had been built up can be concentrated into the tropical pasture lands enabling highly efficient meat production. The continued undisturbedness of pastures, as against plantations seems to constitute a decisive factor in the process of regeneration and in reaching a new biological equilibrium in the soils of the tropic zones.

In the introductory part of my report the three questions put to production biologists by nutritionists working on the problems of world food supply were listed. The first was the assessment of the photosynthetic potencial of the Earth; the second, the definition of the efficiency of the main natural food chains; and the third, tracing the path of organic matter in the soil.

All three issues were studied by researchers all over the world. The answers were given more or less exactly. In many cases the answers are based on not satisfactorily proved suppositions with even more gaps to be filled. Approximately and in general the limitations of photosynthetic production can be set. However, one reassuring certainly was established: i.e. that the biological reserves of the World are sufficient for feeding Mankind in numbers many times exceeding that of the present population of the Earth without danger of starvation, even if food production should persist in relying on traditional agriculture, i.e. on the photosynthetic way of food production. The main laws governing the energy flow through food chains have also been cleared. Based on that knowledge new food chain models of much higher efficiency were developed by which much higher energy concentrations than through the natural ones can be attained. The fauna of the European soils has been explored; the volume of the organic matter to be decomposed in the soil has also been assessed on the whole, together with the biomass of the soil animals active in decomposition. Some of the laws governing decomposition have also been cleared and finally, in the last few years the first steps towards the exploration of the completely new territory of tropical soils have also been made.

This short summary draws a perplexing picture of the state of production biology and within it of soil zoology in particular. It seems almost unbelievable that there exist but four or five research groups all over the world which, like my own five-member team are engaged in persistent and carefully planned research work on the theoretical problems of decomposition in soils and on the part soil animals play in same. The scientists all over the world who are engaged in similar basic research could well be seated in a smaller lecture hall. It is this handful team of researchers who tries to clear the processes by which 10^{10} tons of dry matter, tenfold the volume of materials produced by the mining, metallurgical and chemical industries of the world annually is decomposed and partly chanelled into food production. In 50 or 100 years humanity will be completely at a loss to understand how their forefathers in the early 20th century could burn up tropical rain forests the expanse of which had surpassed many times that of whole Europe and the potentialities of which would have sufficed to solve the food problems of entire humanity at that time. And all that for the sake of momentary gain, only to set up plantations in their place without the slightest knowledge of soil biology, so that the greater part of those plantations became degraded into useless bushland. At that time, except for a very few, keen and clear-sighted zoologists, nobody seemed to be concerned with the soil fauna of the Earth, although the fate of Mankind was dependent to a great extent on that.

To return to our days, what else can we, soil zoologists do besides the tasks outlined, and we Hungarians with them? We have also to shoulder the tasks left undone by our predecessors and collect and describe new faunas, while molecular biology is engaged in examining the minutest structure of matter, and production biology tries to throw light on the vast fundamental relationships between the organic matter turnover and the energy flow of the Earth. Today, soil biologists are united in recognizing the fact that unless the tasks left undone by earlier generations is carried out, tropical soil biology will not be able to advance by an inch.

While our expedition worked on the circumtropical scientific programme approved by UNESCO in Brazzaville-Congo, the first step of which was to discover the unknown soil fauna, in Paris the representatives of numerous countries from all parts of the world were engaged in setting up and preparing an international scientific programme. As a result of the talks, the International Biological Programme was launched, setting seven main tasks for the biological sciences of the world. One of these tasks was to examine the productivity of the terrestrial communities of the Earth in general, and within that the organic matter turnover and energy flow of the soil, in particular. In this way, our expedition, and with it our research work conducted together with our collaborators, botanists, soil ecologists and microclimatologists in Hungary was integrated into the International Biological Programme as an organic part of same at the very moment of its realization. Our work has been pursued along these lines, ever since. The programme has formulated, besides the scientific tasks, also a general principle, the importance of which is obvious. It says that biology has to work for the welfare of man and for the improvement of human life. In other words, the biologists of the world look upon their discipline as a means of production and wish to evolve it as such. Therefore it is my firm belief that soil zoology will have ever increasing tasks and responsibilities to shoulder in the future.

REFERENCES

1. Balogh, J.: *A zoocönológia alapjai — Grundzüge der Zoozönologie.* Budapest, 1—248, 1953.
2. Balogh, J.: *Lebensgemeinschaften der Landtiere, ihre Erforschung unter besonderer Berücksichtigung der zoozönologischen Arbeitsmethoden.* Budapest—Berlin, 1—560, 1958.
3. Balogh, J.: *A talajzoológiai kutatások eredményei és feladatai hazánkban.* MTA Biológiai Csoportjának Osztályközleményei, **2**, 79—93, 1958.
4. Balogh, J.: *On some problems of production biology.* Acta Zool., *4*, 89—114, 1958.
5. Bornemissza, G. F.: *Could dung eating Insects improve our pastures?* Journ. Austral. Inst. Agric. Science, **26**, 54—56, 1960.
6. Dietrich, G. & Kalle, K.: *Allgemeine Meereskunde.* Berlin, 1957.
7. Van der Drift, J.: *Analysis of the animal community in a beech forest floor.* Wageningen, 1—168, 1950.
8. Dudich, E., Balogh, J. & Loksa, I.: *Erdőtalajok ízeltlábúinak produkciósbiológiai vizsgálata.* MTA Biológiai és Agrártudományi Osztálya Közleményei, **3**, 505—532, 1952.
9. Gere, G.: *Élőlények produkciósbiológiai csoportosítása és szerepük az életközösségekben.* Állatt. Közl., **46**, 71—78, 1957.
10. Gere, G.: *Methode zur Lebendhaltung und Zucht von Arthropoden der Waldböden.* Acta Zool. Hung., **3**, 225—231, 1957.
11. Huxley, J.: *Les bases ecologiques en Afrique Orientale.* Endeavour, **82**, 98—107, 1962.
12. Laurence, B.: *The larval inhabitants of cow pats.* J. Anim. Ecol., **23**, 234—260, 1951.
13. Lindemann, R. L.: *The trophic-dynamic aspect of ecology.* Ecology, **23**, 399—428, 1942.
14. Loksa, I.: *Die bodenzoozönologischen Verhältnisse der Flaumeichen-Buschwälder Südostmitteleuropas.* Budapest, 1966.