MAYFLIES FROM JAPANESE TORRENTS
IX. LIFE FORMS AND LIFE ZONES OF MAYFLY NYMPHS.
I. INTRODUCTION*

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In eight preceding papers by the author many Japanese mayflies were dealt with from the taxonomical standpoint. Now the topic will be changed to their habitat, especially their distribution, with which the present and the following paper shall be concerned.

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I. FUNDAMENTALS ON THE DISTRIBUTION OF MAYFLY NYMPHS

Life form

The term 'life form' which I wish to use in this study, is derived from the plant ecology. But when this term is used in the animal ecology, its meaning may be more or less modified, or extended. Animals, in general, must move about for their existence. In other words, animals have the function of moving about and in this respect the animal life differs from the plant life which is stationary in the occupancy of the earth surface. But this function is originally defined from the general structure of an animal. Then, one is scarcely possible to understand the actual life of an animal from its function only, unless he considers the function of an animal together with its structure.

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On the other hand, the structure itself without considering its function is nothing but a dead body of an animal. Therefore one can not understand the real life of an animal also from its structure only. Here one needs to consider the environment of an animal, and I should like to continue my discussion by recognizing the resultant phenomenon as a real life phenomenon that is produced through the reaction of the structure to the environment of the animal.

In this way, the distribution of an animal is recognized as a life phenomenon and it can be treated essentially as a problem relating to the occupancy. The term 'life form', which I wish to use in this study, means, more properly speaking, the mode of life or the category of life regulated by the structure and the environment of the animal.

Similarity of life form in mayfly imagines and its dissimilarity in their nymphs

The imagines of mayflies from Japanese torrents are more or less similar to each other in their general appearance. It will be natural that one expects from this similarity of their structure the similarity of their habits. Indeed, the most important habit in the adult stage of the insect is the habit concerning reproduction, and this may be emphasized especially in the imagines of mayflies, as they have only atrophied mouth-parts and never take food. This similarity in their habits is easily recognized, for instance, in their nuptial flights which are common in different genera and families.

In comparison with the similarity of structure in the imagines, the nymphal structure of mayflies is very different in different genera and families. From what cause does this dissimilarity originate? Here we must turn our attention to the environment of the nymphal life if we wish to solve this question. Mayfly nymphs dwell in the fresh water, or their lives are maintained in the fresh water as the medium. But they are in their habits not free-swimming animals in the strict sense such as used with most fishes. They are all bottom dwellers, so they constitute a part of the bottom-fauna in various types of the inland water, including the lake, the river, the spring, etc., but are especially important constituents in the bottom of the torrent.

How do they live their nymphal lives in such a situation? They are not sedentary. They move about, firstly, owing to the fact that they must get necessary food for their development, for their transformation and finally for their reproduction. Secondly, they must

escape from their enemies which catch them as their own food, though this may be the negative side for existence. And these are two principles for existence which should be recognized before the life form of any animal is discussed.

Substratum and occupancy of it by mayfly nymphs

Mayfly nymphs as bottom dwellers must succeed in their occupancy of the substratum for their existence, or for securing food and escaping from enemies. There are many kinds of the substratum of the inland water, but in this paper I may confine the subject to one kind of the inland water, namely, the torrent. Nevertheless, I will not consider the current of the water, one of the most characteristic property of the torrent, for a while, and will concentrate my attention only on the substratum itself.

The substratum is not so simple even in the torrent. It is rather most complicated in the torrent in all kinds of the inland water, if the materials, of which the stream bed is composed, are morphologically considered. But it is also simplest, on the other hand, in so far as it is considered from the vegetation which grows on it, and which usually consists of algae only, covering rocks and stones. And in this respect the stream bed may be contrasted with the barren, rocky ground of the mountain summit, where lichens only grow.

Let us consider, in the first place, a kind of the substratum which is composed of some fine material as the silt or the mud, and has a homogeneous, evenly stretched surface, offering no shelter or no concealing place. Even if provided with plenty of food, such an open place is very dangerous for such weak animals as mayfly nymphs against their enemies. They have not any weapon as does the crab nor any shell to conceal themselves as does the mussel or the snail. Perhaps they can live in such an open place, if they can move about as speedily as their enemies move. But the substratum here discussed is such a substratum that is too soft to resist against their vigorous crawling or their swift running, but permits them only to perch quietly upon its surface.

There remain only two ways for the maintenance of their lives in this dangerous situation. Fortunately, the material of which the substratum is composed is soft enough. Then one way is to abandon the occupancy of the surface and to burrow into and conceal themselves in the substratum, and this has been achieved by the nymphs of

the burrowing form, belonging to the families Ephemeridae and Potamanthidae. Another way is to gain the swift locomotive faculty by clearing the surface of the substratum and by swimming. This has been achieved by the nymphs, which take the stream-line form in their general appearance as represented in the families Siphlonuridae and Baetidae.

We suppose that the material, of which the substratum is composed, becomes more and more coarse. This change is necessarily accompanied by the change of the environmental condition. But, on the other hand, this change also signifies the change of the topography of the surface of the substratum from the homogeneous, evenly stretched surface of the mud or the silt deposited, for instance, on the calm pool bottom to the irregular surface of rocks and stones which are rolled and heaped on the bottom of the mountain torrent. Of course the surface curvature of each particle or grain becomes smaller in proportion as it becomes greater in its dimention, if it is considered as an ideal ball. But when it becomes greater beyond some limit concerning the stretch of the legs of mayfly nymphs, they must perch on it, whether it is a pebble or a gravel. In such a change of the environmental condition, what advantage is expected from a stream-line form with its perching legs, without considering any current of the medium?

On or among stones or rocks the dorso-ventral flattened forms or the limpet-like forms seem to be far more suitable for the occupancy of the surface than the stream-line forms. This is so because they do not perch on but stick to the surface, and do not swim but glide swiftly upon it, if the surface is smoothed by the erosion. Moreover the dorso-ventral flattened forms enable them to conceal themselves easily in the crevice of rock surface or space between the overlapping rocks and stones. And where there is a strong current, it is evident that these forms are more effective. These forms are represented in the nymphs of the families Leptophlebidae and Ecdyonuridae, especially well represented in the latter family.

Life form and habitat segregation in mayfly nymphs

I shall not touch upon the question which of these three forms is the most ancestral one in the phylogeny of the order Ephemeroptera. But if any mayfly nymph must get its food, consisting in materials mainly of the plant origin, in the inland water and at the same time must keep itself secure as much as possible from its enemies, as al-

ready mentioned, then the burrowing form prefers such a bottom condition that enables it to live a burrowing life, while the stream-line form prefers such a bottom condition that enables it to live a perching and swimming life, and at last the dorso-ventral flattened form prefers such a pebble, a gravel or a boulder which enables it to live a sticking and gliding life, whether the current may be rapid or slow as I shall explain in the subsequent pages.

If these phenomena are originated from the necessity of occupying the habitat for any animal in order to live its life, then the habitat segregation through the differentiation of the structure is, in its contents, no more than the differentiation of the life form itself which I mean. Therefore the habitat segregation through the different forms of mayfly nymphs as mentioned above, means that such is the differentiation of the life form of mayfly nymphs. Such differentiation would have been accomplished in the ancient age in such an archaic order as Ephemeroptera, and it is interesting that such differentiation corresponds with the present system of the taxonomy of mayflies, based primarily upon the structure of the imagines.

Distribution of life forms of mayfly nymphs in the torrent

I shall here consider the distribution of life forms of mayfly nymphs in the torrent. Are they distributed at random or orderly? In the mountainous country as Japan, a river may be divided into two geographical or physiographical sections, namely the mountain section and the plain section. The mountain section is characterized by the predominance of the erosion by its water, and the plain section is characterized by that of the sedimentation by its water, though this classification is very rough and the sedimentation in the mountain section or the erosion in the plain section is recognized in some degree. And this may be inevitable if we try to classify a river into some sections, based upon the landscape.

But when we consider this from the distribution of the material, of which the substratum is composed, large boulders are almost confined to the mountain section, and where the river flows out from the foot-hill, there are still deposited many pebbles and gravels. Then the more the river flows seaward, the more the material, carried and deposited by the water, diminishes in the dimension of its particles, corresponding to such changes of the river that the velocity of its current is more and more decreased, though the volume of its water

is contiunously increased. And as the distribution of life forms of mayfly nymphs should correlate with the distribution of the habitat, the burrowing life form and the swimming life form may be distributed even in the typical mountain section if their habitat condition still exists in it, whereas the gliding life form may be distributed in the plain section in so far as there exist still pebbles and gravels.

But the distribution of such habitats or life forms are in reality determined by the velocity of the current, so I consider a cross-section of the river where it meanders as already Shelford* did. Then the material, of which the substratum is composed, is arranged from small to large in the dimension of its particles according to the increase of the velocity of the current, and with this the burrowing and swimming life forms will succeed to the gliding life form, but this is indeed schematic. Where the different habitat conditions intermingle with each other, then the different life forms will also live side by side. It is remembered that the boulder does not shut out the swimming life form totally, as this form and the gliding life form are both the dwellers of the surface of the substratum originally. But it is evident, as already mentioned, that the swimming life form becomes unfavorable with the increase of the velocity of the current, then the predominance of the sliding life form among the big boulders of the rapid mountain torrent is very natural.

Convergence and divergence of life form of mayfly nymphs

In this respect, the current or the velocity of the current as an environmental factor must be considered again, in the torrent, and here we can understand the divergence among the life forms originally belonging to the same category as well as the convergence among them originally belonging to the different category. Thus if the convergence and divergence imply the differentiation of the life form, however small, they must be attended with the habitat segregation in the same degree. If we consider them from the structural standpoint, it is usual that they correspond with the differentiation of the genera among the same family or of the species among the same genus.

For instance, in the different genera among the family Siphlonuridae, which is typical of the stream-line form or the swimming life form, the genus *Siphlonurus* is in its distribution limited to the less rapid current in accord with the finer constitution of the substratum,

* Shelford, V. E., 1913, Animal communities in temperate America, p. 107.

while the genus *Ameletus* is used to prefer the faster current agreeing with the coarser constitution of the substratum than *Siphlonurus*, and the genus *Isonychia* is sometimes found in the still faster current than *Ameletus*. Among the species belonging to the family Baetidae, *Baetis thermicus* is one of the strongest species to stand against the velocity of the current in Japan and is found even among the large boulders of the mountain torrent. Although its structure is still the stream-line form, it seems to sacrifice its swimming ability as it must cling to the rock surface firmly, as already discussed by Dodds and Hisaw*. But in this respect, the endemic genus *Baetiella* of the same family is most curious, for *Baetiella japonica* withstands the rapidest current by spreading its legs and sticking to the rock surface as in some species of the family Ecdyonuridae. And the fact that it has lost completely its median caudal filament seems to exhibit a convergence between this species and *Baetis bicaudatus* in Colorado studied by Dodds and Hisaw** as well as a convergence between this genus and the genus *Epeorus* of the family Ecdyonuridae, also the inhabitant of the rapid current. But *Baetiella*, probably derived from the clinging *Baetis*, can not glide on the rock surface as *Epeorus*, though it can stick firmly on it, so that in its habit it rather tends to converge to that of another inhabitant of the rapid current such as represented in the larva of the dipterous family, Blepharoceridae.

In the family Ecdyonuridae, too, which is a representative of the gliding life form, the life form is differentiated according to the environmental condition. If we consider the destitution of the median caudal filament to be a criterion of the modification caused by the rapid current, we take at once the genus *Epeorus* for this reason, as it is a true inhabitant of the rapid torrent, but we have to exclude the hygropetric *Blepatus* as an exception. If we consider the enlarged first gill-lamella to be a criterion of the same kind, then we may take some species of the genus *Epeorus* and *Rhithrogena* as equivalent ones. But *Rhithrogena* is not exactly the associate of *Epeorus* or in other words its life form is not the same as that of *Epeorus*. *Rhithrogena*, which is morphologically not so flattened as *Epeorus*, or does not so stretch its legs as *Epeorus* and is rather similar in its general appearance to some species of the genus *Paraleptophlebia*, is also an inhabitant of rather smaller stones as *Paraleptophlebia*. That is to say, *Epeonus* seems to occupy

* Dodds, G. S. and F. L. Hisaw, 1924, Ecological studies of aquatic insects. I. Adaptation of mayfly nymphs to swift stream. Ecology, vol. 5, pp. 137–148.

** Ibid., p. 142.

larger stones than those *Rhithrogena* chooses for its habitat, if the velocity of the current in these two habitats is in equal strength.

The genus *Cinygma*, which is closely allied to *Rhithrogena*, is also distributed in the substratum which is composed of the small stones as that in which *Rhithrogena* is distributed. Therefore we can classify the gliding form further into two life forms according as the substratum is composed of the large stones or the small stones. Then it seems that the family Ecdyonuridae is also to be classified at least into two main groups corresponding to this classification of the life form. One group is composed of the genera *Ecdyonurus* and *Epeorus*. And the unique *Blepatus fasciatus*, the only hygropetric mayfly nymph hitherto known in Japan, seems to be related to such a species as *Epeorus curvatulus*, which is able to crawl skillfully when the condition of the substratum is not suited for gliding. The other group is composed of the genera *Cinygna* and *Rhithrogena*. To which of these two groups the genus *Heptagenia* belongs is still doubtful, as I have not aquainted myself with nymphs of this genus except only one species, *Heptagenia kihada*. This species is distributed exclusively in the spring or the spring-fed, slowly flowing rivulet, the bed of which is constituted mainly of fallen leaves.

And in each of these two groups the differentiation is recognized in their structure as well as in their habitat segregation arranged by the velocity of the current. As a consequence *Epeorus* and *Rhithrogena*, the rapid current inhabitants, are distinguished from *Ecdyonurus* and *Cinygma*, the slow current inhabitants. Now I shall convince myself of the validity of separating these two groups from another standpoint which is concerned in the very important habit of the mayfly nymphs, namely the method of their transformation to the subimagines. This transformation means the essential change of the habitat character, or the change from the aquatic life to the terrestrial life.

Types of the transformation of mayfly nymphs to subimagines

There are three types of the transformation from nymphs to subimagines. The first type: nymphs which are the burrowing life forms as *Ephemera* and *Potamanthodes* come out of their habitats and float to the surface of the water for transformation. Subimagines emerge, floating at the surface and fly away. The second type: nymphs which are the perching and swimming life forms as *Ameletus*, usually come together

to the side of the stream and climb up a pebble or a gravel in the shore to the surface of the water or a little higher. Here subimagines emerge, leaving the nymphal skins attached to the surface of the stone. And at last the third type: nymphs belonging to the genus *Ecdyonurus* and *Epeorus*, a group of the gliding life forms correlated with the large stones as their habitats, remain as they stick to the submerged surface of the boulder, even when ready for transformation. Therefore subimagines achieve to emerge under the water, leaving the cast skins on the surface of the boulder and fly up in the air as soon as they float up to the surface of the water.

But it is worthy of mention here that *Cinygma* and *Rhithrogena*, another group of the gliding life forms correlated with the small stones as their habitats, do not perform their transformation by this method, but by the second method, though in *Baetiella*, one of the typical rapid current inhabitants belonging to the family Baetidae, subimagines emerge also by the third method. Is it not dangerous to emerge floating at the surface of the water in such a rapid and turbulent current as in the mountain torrent? Is it not to be infered that the same method of their emergence in such different genera as *Epeorus* and *Baetiella* means the same modification of their habits caused by the rapid current and that for these reasons, *Rhithrogena* is not so successful in the rapid current as *Epeorus* or *Baetiella*? But how can we explain *Ecdyonurus* which also emerges by the third method, though it is a slow current inhabitant? For example, *Ecdyonurus yoshidae* is distributed not only in the calm side of the steam but also in the lake shore where there will be sometimes no action of the waves all day long, but in every case there must be stones large enough for its life form.

These stones are surely accumulated by the action of the waves, but the primary necessity for *Ecdyonurus yoshidae* is in these stones and not in the action of waves as generally admitted. It seems to me that the method of emergence is not an adaptation to the velocity of the current but is the consequence of the life form, and the dorso-ventral flattened *Ecdyonurus* and *Epeorus* with their wide-stretched legs are originally the life forms which correspond to sticking and gliding, but not to floating, so that not to the first and second method of emergence. And this explanation will be also applicable to the case of *Baetiella*. And here we shall consider the relation between *Epeorus* and *Rhithrogena* once more. The enlarged first gill-lamellae which are found in some species of *Epeorus*, formerly recognized as the genus *Iron* by this nymphal character, and in *Rhithrogena*, will be evidently a convergence

on the rapid current. But such a convergence of one organ among different genera does not mean that they are always equally successful in every grade of the velocity of the current. The morphological inferiority of *Rhithrogena* to *Epeorus* (*Iron*) in the increasing velocity is already discussed in detail by Dr. Hora.* Although I recognized the fact that the large stone inhabitant *Epeorus* (*Iron*) is distributed in the swifter part of the current than is the small stone inhabitant *Rhithrogena*, is due to the fact that the former in its structure is more effective to resist against the washing mechanism of the current than the latter, I cannot help recognizing at the same time, the fact that there are distributed more of large stones in the swifter part of the current than smaller stones. Then I consider this problem to be understood only as another example of the life form theory or the structure-habitat correlation. Thus considering from the life form it is evident that *Cinygma* and *Rhithrogena* belong to a life form group different from that of *Ecdyonurus* and *Epeorus*, and as there are found no direct connection between these two groups, Hora's diagram** illustrating the evolution of the nymphs of the family Ecdyonuridae must be revised.

Life forms of the nymphs of the family Ephemerellidae

Here I shall consider the life form of the nymphs of the family Ephemerellidae, untouched in the preceding discussion. Suppose they are also dwellers of the surface of the substratum in their origin. But they can neither swim nor glide as they are neither true streamline forms nor dorso-ventral flattened forms. They are relatively stout-built in their general appearance, with flattened ventral surfaces and are clumsy, sprawling creatures in their activities. Judged from my field experience, at least some large-sized species among them as *Ephemerella basalis*, for example, may take animal food. As these characters are quite different from those of other mayfly nymphs, it seems to me that they belong to the fourth category of the life form of Japanese mayfly nymphs.

What kind of habitat is occupied by them? Small-sized species prefer loose pebbles or gravels in the slow current as their habitats but they are used to hide themselves in the debris or the slime which fills up the interval between these small stones, and in this respect they approach a step toward the burrowing life form. Large-sized species

* Hora, S. L., 1930, Ecology, bionomics and evolution of the torrential fauna. Phil. Trans. Royal Soc. London, Ser. B, vol. 218, pp. 189-190.

** Hora, opt. cit., p. 191.

such as *Ephemerella trispina* or *Ephemerella basalis* are often found on the underside of a boulder in the rapid current, but as they are also found among the smaller stones, their life form seems to be connected with the large stone not so closely as in the case of *Epeorus* or *Baetiella*. Perhaps the stream-bed, on which boulders lie, is also one of their habitats, where the velocity of the current is reduced and at the same time more or less small stones as well as various kinds of debris are deposited. And if such is the life form of the nymphs of the family Ephemerellidae, it is noticeable that it resembles rather the life form of some dragonfly nymphs, in the torrent, for instance, those belonging to the subfamily Gomphinae or the family Epiophlebiidae.

The mayflies of the family Ephemerellidae were classified into some genera by some authors but in recent years Needham and Traver again united various genera into one original genus *Ephemerella* and I followed their classification in the preceding paper*. But infering from their life form it seems to me that there are at least two groups in the Japanese species of the genus *Ephemerella* as mentioned above, namely one group being composed of the more or less large stone inhabitants distributed in the more or less rapid part of the current as *Ephemerella trispina* or *Ephemerella basalis*; the other group being composed of the more or less small stone inhabitants distributed in the more or less slow part of the current as *Ephemerella nigra* and almost all other small-sized species. Then is there any morphological differentiation corresponding with this habitat segregation? I wish to denote such a morphological differentiation as follows:

	Species of the *trispina* group	Species of the *nigra* group
In the nymphs	Frontal horns present.	Frontal horns absent.
	Fore femur flattened, with spines on its anterior margin	Fore femur not flattened, without spines on its anterior margin.
	Knee spines present.	Knee spines absent.
	Tail fringed with dense hairs from the base to the tip.	Tail with whorls of spines at each joining; if hairy, only on its distal portion.
In the imagines	Caudal prolongation of scutellal lamellae absent.	More or less developed caudal prolongation of scutellal lamellae present.
	In the male, third joint of the forceps long.	In the male, third joint of the forceps short.

These are the differentiation of life form of the nymphs of

* Imanishi, K., 1937, Mayflies from Japanese torrents VII. Ann. Zoo. Jap., vol. 16, pp. 321-329.

Ephemerella in so far as the Japanese species I have examined are concerned. I will not claim at present that these characters are sufficient to recognize these two groups as different genera but it is doubtless that this is a step representing the differentiation of life form due to the change of the environmental condition.

I have already reported in one of my preceding papers* that the enlarged first gill-lamellae are not the sufficient character separating the genus *Iron* from *Epeorus* by the existence of *Epeorus aesculus*, the individuals of which possess either large or small first gill-lamellae. Then, species with the enlarged first gill-lamellae among *Epeorus* offer also an example which represents a step in the process of the differentiation among the same genus toward the increasing velocity of the current.

But is there not any person who says that *Epeorus* of small first gill-lamellae is derived from that of large first gill-lamellae by differentiating toward the slower current? There is some aquatic insect which is distributed only in the rapid part of the current and is not traced to the slow current in its origin as the larva of the dipterous family Blephaloceridae. But I consider that in mayfly nymphs the more specialized habitat corresponds to the more specialized life form and also the more generalized habitat corresponds to the more generalized life form. If it is admissible that the more specialized structure is derived from the more generalized structure, and the contrary is not right in general, then it is also to be admissible that the more specialized habitat is occupied when the specialized structure is differentiated from the generalized structure. If this be true, the differentiation of life form here discussed is always directed toward the maximum velocity of the current. I will represent the relation in the following notation, but will note here once again that the differentiation of life form should be arranged according to the respective life form group, for instance, *Ecdyonurus*⟶*Epeorus*⟶*Epeorus* with enlarged first gill-lamellae or *Cinygma*⟶*Rhithrogena* or *Ephemerella nigra* group⟶*Ephemerella trispina* group, etc.

*Synusia*** and life zone*

I will finish this paper by considering the distribution of mayfly nymphs from the synecological standpoint. Here I wish to apply to

* Imanishi, K., 1934, Mayflies from Japanese torrents IV. Ann. Zoo. Jap., vol. 14, p. 381.

** Imanishi, K., 1937, Community classification and community analysis (in Japanese). Geog. Rev. Jap., vol. 13, pp. 725-736.

animal ecology, the term 'synusia', which means a community defined by the life form in plant ecology, though in this case also its meaning needs to be modified or supplemented to a certain extent. It has been recognized above that there are four main life form groups in Japanese mayfly nymphs, namely, the burrowing life form, the perching and swimming life form, the sticking and gliding life form and at last the concealing and sprawling life form of the family Ephemerellidae. Are these four life form groups immediately recognisable as representing four synusiae if we are to isolate the actual distribution of such a life form group as an object of our field study, from the biotic community as a whole which consists of so many overlapping synusiae?

But I consider the concept of a synusia is only relative to the biotic community as a whole. We may recognize four synusiae according to four life form groups as mentioned above, but as we have already recognized two different life form subgroups in the gliding life form, then we may also recognize two different subsynusiae according to these two different life form subgroups. On the other hand, we may recognize that all life forms of mayfly nymphs constitute a synusia together with other aquatic insects or invertebrates of the stream bed, because the life form of mayfly nymphs is more closely related to that of the other aquatic insects or invertebrates than any other life form, for instance, the life form of the fish. Moreover, we may recognize these aquatic invertebrates inhabiting the stream bed together with the terrestrial invertebrates inhabiting the earth surface constitute a synusia, because the life form of the aquatic invertebrates is more closely related to that of the terrestrial invertebrates than any other life form of the larger and higher vertebrates.

When such a life form group of wide range is considered as constituting a synusia, then it follows that the stream bed inhabitant belongs to only a subsynusia, and the boulder inhabitant belongs to a division of a subsynusia? I do not intend to attempt such a classification here, but I shall content myself with applying the old term 'life zone' with some modernized meaning, to a part of a synusia which is to be segregated by the different life form group. Then the terrestrial part and the aquatic part may be two different life zones if these two are covered by one synusia. Various life zones may also be recognized which are arranged according to the increasing velocity of the current, if the stream bed community is considered as corresponding to one synusia. Therefore, even in any one of the life form groups in mayfly nymphs, which is considered as representing a

synusia in the torrent, the differentiation corresponding to the change of the environmental condition may also be recognized as an index of a series of life zones which segregate the same synusia. For instance, one of the series of the gliding life form is now recognized as such a series of life zones as *Ecdyonurus*⟶*Epeorus*⟶*Epeorus* with enlarged first gill-lamellae. And at last we will be able to trace down such a life zone segregation to the specific differentiation among the same genus, since the synusia analysed into quite homogeneous life forms is nothing but a synusia of a species. Then the above-mentioned series of life zones in the synusia of one of the gliding life forms may be recognized once again by the series of life zones of species, for instance, as follows: *Ecdyonurus yoshidae*⟶*Epeorus latifolium*⟶*Epeorus curvatulus*⟶*Epeonus uenoi*.

These are the relations between life form, synusia and life zone. It is needless to say that such a life phenomenon can be recognized by us only because every animal has a visible form or a definite structure. And I have demonstrated how closely such a life phenomenon is, as a rule, correlated with the structural differentiation as well as the structural affinity among the animals, or it may be said that the system of the biotic world itself is based upon the structural differentiation as well as the structural affinity among the organisms. Then taxonomy, which aims to study the structural differentiation as well as the structural affinity, should be properly recognized as an integral field research indispensable in the synecological studies.

(to be continued)