CHAPTER II.

MERISTIC VARIATION OF PARTS REPEATED IN LINEAR OR SUCCESSIVE SERIES.

SEGMENTS OF ARTHROPODA.

INDIVIDUAL Variation in the fundamental number of members constituting a Linear Series of segments can only be recognized in those forms which at some definite stage in their existence cease to add to the number of the series. Hence in a large proportion of the more fully segmented invertebrates this phenomenon cannot be studied, for in many of these, as for instance in Chilognatha, and in most of the Chætopoda the formation of new segments is not known to cease at any period of life, but seems to continue indefinitely. On the other hand, while in Insecta, and in Crustacea excepting the Phyllopods, the fundamental numbers are definite, no case of individual Variation in them has been observed.

Between these two extremes, there are animals in certain classes, for example, *Peripatus*, some of the Chilopoda among Myriapods, Aphroditidæ among Annelids, and some of the Branchiopoda among Crustacea, in which the number of segments does not increase indefinitely during life, but is nevertheless not so immutable as in the Insects and the majority of Crustacea. In the forms mentioned, certain numbers of segments, though not the same for the whole family, are characteristic of certain genera, as in the case of the Chilopoda (excepting Geophilidæ), or of certain species, as in some of the *Peripati*. But besides this, in some of the forms named, *e.g.*, the *Geophili* and *Peripatus edwardsii*, individual Variation has been recorded among members of the same species. It is unfortunate that for many of the forms in which Variation of this kind possibly takes place, no sufficient observation on the point has been made, but as examples of a phenomenon which, on any hypothesis, must have played a chief part in the evolution of these animals, the few available instances are of interest.

*1. **Peripatus.** The number of segments which have claw-bearing ambulatory legs differs in different species of this genus. While, moreover, in some of the species the number appears to be very constant for the species, in the case of others, great individual variation is seen to occur. SEDGWICK's observations in the case of *P. edwardii* shew *conclusively that these variations cannot be* ascribed to difference in age. There is besides no ground for supposing that increase in the number of legs occurs in any species after birth, and it is in fact practically certain that this is not the case. In *Peripatus capensis*, which was exhaustively studied by Sedgwick, the appendages arise in the embryo successively from before backwards, the most posterior being the last to appear, and the full number is reached when the embryo arrives at Sedgwick's Stage G. The following is taken from the list constructed by Sedgwick from all sources, including his own observations. As the bibliography given by him is complete and easily accessible it is not repeated here, and the reader is referred to Sedgwick's monograph for reference to the original authorities.

SEDGWICK, A., *Quart. Jour. Micr. Sci.* XXVIII., *1888, pp.* 431—493. *Plates.*

SOUTH AFRICAN SPECIES.

P. capensis: 17 pairs of claw-bearing ambulatory legs (Table Mountain, S. Africa).

P. balfouri: 18 pairs of legs, of which the last pair is rudimentary (Table Mountain, S. Africa).

Sedgwick has examined more than 1000 specimens from the Cape, and has only seen one specimen with more than 18 pairs of legs. This individual had 20 pairs, the last pair being rudimentary. It closely resembled *P. balfouri*, but differed in the number of legs and in certain other details (*q. v.*); Sedgwick regarded this form provisionally as a variety of *P. balfouri*.

P. mosleyi: 21 and 22 pairs of legs: near Williamstown, S. Africa. The specimens with 22 legs were two in number and were both females. They differed in certain other particulars from the form with 21 legs, but on the whole Sedgwick regards them as a variety of the same species.

P. brevis (DE BLAINVILLE): 14 pairs of legs. (This species not seen by Sedgwick.)

Other species from S. Africa which have been less fully studied are stated to have 19, 21 and 22 pairs of legs respectively.

In all South African forms, irrespective of the number of legs, the generative opening is subterminal and is placed behind the last pair of fully developed legs (between the 18th or rudimentary pair in *P. balfouri*). SEDGWICK, pp. 440 and 451.

AUSTRALASIAN SPECIES.

P. novæ-zealandiæ. 15 pairs of legs. New Zealand.

P. leuckartii. 15 pair of legs. Queensland.

In both of these species the generative opening is between the last pair of legs. (SEDGWICK, p. 486.)

NEOTROPICAL SPECIES.

In all the Neotropical Species which have been at all fully examined, the number of legs varies among individuals of the same species.

P. edwardsii: number of pairs of legs variable, the smallest number being 29 pairs, and the greatest number being 34. Males with 29 and 30 pairs of legs. The females are larger, and have a greater number of legs than the males.

The new-born young differ in the same way. From 4 females each having 29 legs, seven embryos were taken which were practically fully developed. Of these, 4 had 29 legs, 2 had 34, 1 had 32. An embryo with 29 and one with 30 were found in the same mother. An embryo, quite immature, but possessing the full number of legs, was found with a larger number of legs than one which occupied the part of the uterus next to the external opening. (Caracas.)

Peripatus demeraranus: 7 adult specimens had 30 pairs of legs; 6 had 31 pairs; 1 had 27 pairs. Out of 13 embryos examined, 7 have 30 pairs and 6 had 31. (Demerara.)

Peripatus trinidadensis: 28 to 31 pairs of ambulatory legs. (Trinidad.)

Peripatus torquatus: 41 to 42 pairs. (Trinidad.)

Specimens of other less fully known species are recorded as having respectively, 19, 28, 30, 32, 36 pairs of legs, &c.

In the Neotropical Species, irrespective of the number of legs, the generative opening is placed between the legs of the *penultimate pair*. (SEDGWICK, p. 487.)

Peripatus (*juliformis?*) from St Vincent: six specimens examined. Of these, 1 specimen had 34 pairs of legs, 2 had 32 pairs, 1 had 30 pairs, and 1 had 29 pairs. POCOCK, R. I., *Nature*, 1892, XLVI. p. 100.

In connexion with the case of *Peripatus*, the following evidence may be given, though very imperfect and incomplete.

2. **Myriapoda.** CHILOGNATHA. Variation in the number of segments composing the body in this division of Myriapods cannot be observed with certainty; for it is not possible to eliminate changes in number due to age, nevertheless the manner in which this increase occurs has a bearing on the subject.

In *Julus terrestris* the number of segments is increased at each moult by growth of new segments between the lately formed antepenultimate segment and the permanent penultimate segment. At each of the earlier moults *six* new segments are here added: in *Blaniulus* the number thus added is *four*, and in *Polydesmus?* two fresh segments are formed at each of the earlier moults. In each of these forms the number added is the same at each of the earlier moults. NEWPORT, G., *Phil. Trans.*, 1841, pp. 129 and 130.

CHILOPODA. The number of leg-bearing segments differs in the several genera of Chilopoda, but except in the Geophilidæ the number proper to each genus is a constant character. For instance in *Lithobius* this number is 15; in *Scolopendra* it is 21; in *Scolopendrops*, 23; in *Cryptops* 21, &c.

In Geophilidæ, however, the total number of moveable segments is much larger, ranging from about 35 to more than 200. Though not characteristic of genera, the number seems within limits to mark each particular *species*. It was found that male *Geophili* have fewer segments than the female. The males of *Arthronomalus longicornis* have 51 or 52 leg-bearing segments, while females usually have 53 or 54. Full-grown females of *Geophilus terrestris* have 83 or 84 pairs of legs and segments, and the males of the same species have 81 or 82. In a large Neapolitan species, *Geophilus lævigatus* BRUHL.? the variation is rather greater. In eight males the number varied between 96 and 99; in eleven females, between 103 and 107. Of two female *Geophilus sulcatus* one individual had 136 and the other 140. NEWPORT, G., *Trans. Linn. Soc.*, XIX. 1845, p. 427, &c.

[In some of the Chilopoda[1] an increase in the number of segments takes place after the larva hatches, but the variations mentioned above are recorded as occurring in fully formed specimens independently of changes due to age.]

In the foregoing cases, a fact which is often met in the Study of Variation is well seen. It often happens that in particular genera or in particular species, a considerable range of Meristic Variation is found, while in closely allied forms there is little or none. Examples of this are seen in the variability of the Geophilidæ as compared with the other Chilopoda, and in the neo-tropical species of *Peripatus* which vary in the number of legs, while *P. balfouri*, for instance, is very constant. It will be noticed that in both these cases, the absolute numbers of parts repeated are considerably higher in the variable than in the constant forms. But though such cases have given rise to general statements that series of organs containing a small number of members are, as such, less variable than series containing more members, these statements require considerable modification; for it is not difficult to give instances both in plants and in animals, where series made up of a small number of members, shew great meristic variability.

The bearings of these cases on the nature of Meristic Repetition and the conception of Homology will be considered hereafter. Here, however, it may be well to call attention to the fact that we have now before us cases in which various but characteristic numbers of legs or segments differentiate allied species or genera; that in assuming the truth of the Doctrine of Descent, we have expressed our belief that in each case the species with diverse numbers are descended from some common ancestor. In the evolution of these forms, therefore, the number has varied: this on the one hand. On the other hand, in *Geophilus* and in *Peripatus*, we see

[1] According to NEWPORT (*Trans. Linn. Soc.* XIX. 1845, p. 268), *all* Myriapoda acquire a periodical addition of segments and legs, but according to later observers this is not true of all the Chilopoda.

contemporary instances of the way in which such a change at its origin may be brought about. Though there are several things to be gained by study of these instances, one feature of them calls for attention now, namely, the *definiteness* of the variations recorded. The change from a form with one number to a form with another number here shews itself not as an infinitesimal addition or subtraction, but as a definite, discontinuous and *integral* change, producing it may be, as in *Peripatus edwardsii*, a variation amounting to several pairs of legs, properly formed, at one step of Descent. This will not be seen always to be the case, but it is none the less to be noted that it is so here.

Among Insects I know no case of such individual variation in the fundamental number of segments composing the body. Among Crustacea two somewhat remarkable examples must be mentioned, though it will be seen that both of them belong to categories very different from that with which we are now concerned. But inasmuch as they relate to the general subject of Meristic Variation they should not be omitted.

3. **Carcinus mænas.** The abdomen of these crabs consists normally of seven segments, including the last or telson. In the female the divisions between all these seven are very distinct. The abdomen of the normal male is much narrower than that of the female, and in it the divisions between the 3rd, 4th and 5th segments are obliterated. Males, however, which are inhabited by the Rhizocephalous parasite *Sacculina* do not acquire these sexual characters, and in them there are distinct divisions between the 3rd, 4th and 5th segments. (Fig. 9 c.)

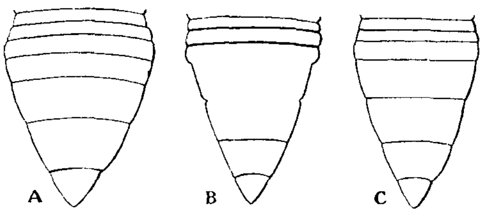

FIG. 9. A. Abdomen of *Carcinus mænas*, female, normal.
B. Abdomen of male, normal.
C. Abdomen of male infested by *Sacculina*. After GIARD and BONNIER.

In male *Carcinus mænas* inhabited by the Entoniscian parasite, *Portunion*, a similar deformity may occur, but is often very much less in extent, sometimes being only apparent in a slight alteration in the contour of the sixth abdominal somite. In specimens of *Portunus*, *Platyonychus*, *Pilumnus* and *Xantho* inhabited by Entoniscians, no change was observed. GIARD and BONNIER comment on the remarkable fact that the change in the sexual characters effected by *Sacculina* is greater than that resulting from the presence of Entoniscians; for since the latter are more internal parasites, preventing the growth of and actually replacing generative organs entirely or in part, it might have been expected that the consequences of their presence would be more profound. GIARD, A., and BONNIER, J., Contrib. à l'étude des Bopyriens, *Travaux de l'inst. zool. de Lille et du laboratoire zool. de Wimereux*, 1887, tom. V. p. 184.

4. **Branchipus** and **Artemia.** As it has been alleged that variation may be produced in the segmentation of the abdomen of these animals by changes in the waters in which they live, it is necessary here to give the facts on which this statement rests. The further question of the relation of *Artemia salina* to *A. milhausenii* is so closely connected with this subject, that though not strictly cognate, some account of the evidence on this point also must be given.

Some years ago SCHMANKEWITSCH[1] published certain papers on variations of *Artemia salina* induced by changes in the salinity of the water in which the animals lived. The statements there made excited a great deal of interest and have often been repeated both by scientific and popular writers. The facts have thus at times been somewhat misrepresented, and so much exaggeration has crept in, that before giving any further evidence it will be well to give Schmankewitsch's own account. It is frequently asserted that Schmankewitsch observed the conversion of *Branchipus* into *Artemia* and of *Artemia salina* into *A. milhausenii* following upon the progressive concentration of the waters of a salt lake. Strictly speaking however this is not what was stated by Schmankewitsch. His story is briefly this: That the salt lagoon, Kuyalnik, was divided by a dam into an upper and a lower part; the waters in the latter being saturated with salt, while the waters of the upper part were less salt. By a spring flood in the year 1871 the waters of the upper part of the lake swept over the dam and reduced the density of the lower waters to 8° Beaumé (=about sp. g. 1·051), and in this water great numbers of *A. salina* then appeared, presumably having been washed in from the upper part of the lake, or from the neighbouring salt pools. After this the dam was made good, and the waters of the lower lake by evaporation became more and more concentrated, being in the summer of 1872 14° B (about sp. g. 1·103); in 1873, 18° B (about sp. g. 1·135); in August 1874, 23·5° B (about sp. g. 1·177) and later in that year the salt began to crystallize out. In 1871 the *Artemiæ* had caudal fins of good size, bearing 8 to 12, rarely 15, bristles, but with the progressive concentration of the water the generations of *Artemia* progressively degenerated, until at the end of the summer of 1874 a large part of them had no caudal fins, thus presenting the character of *A. milhausenii* Fischer and Milne Edw. The successive stages of the diminution of the tail-fins and of the numbers of the bristles are shewn in the figures, with which all are now familiar.

A similar series was produced experimentally by gradual concentration of water, leading to the extreme form resembling *A. milhausenii*. It was found also that if the animals without caudal fins were kept in water which was gradually diluted, after some weeks a pair of conical prominences, each bearing a single bristle, appeared at the end of the abdomen.

It is further stated that the branchial plates[2] of the animals living in the more highly concentrated water were materially larger than those of animals living in water of a less concentration.

Schmankewitsch next goes on to say that by artificially breeding *Artemia salina* in more and more diluted salt water he obtained a form having the characters of SCHÄFFER's genus *Branchipus*, and that he considers this form as a new species of *Branchipus*. He explains this statement thus: In the normal *Artemia*, the last segment of the post-abdomen is about twice as long as each of the other segments, while the corresponding part in *Branchipus* is divided into two segments. He states that in his opinion the condition of the last segment of the post-abdomen constitutes the essential difference between *Artemia* and *Branchipus*, and that such division of the last segment occurred in the third generation of the form produced by him from *Artemia* by progressive dilution of the water. A second distinction between the genera is found in the fact that *Artemia* is reproduced parthenogenetically, while *Branchipus* is not known to be so reproduced. As to the condition of his new form in this respect, Schmankewitsch had no evidence.

In a subsequent paper, *Z. f. w. Z.*, 1877, further particulars are given, respecting especially the natural varieties of *A. salina*. Of these he distinguishes two, var. *a* and var. *b*. The first of these is distinguished by its greater size (8 lines instead of 6 lines, the average for the type) and by the greater length of the post-abdomen. In the type the bristles on each caudal fin are generally 8—12, and in

[1] *Z. f. w. Z.*, XXV., 1875, 2, p. 103 and XXIX., 1877, p. 429; also in several Russian publications, to which references will be found *l. c.*

[2] Upon this point a good deal of interesting evidence is given in Schmankewitsch's papers, but as it does not bear immediately on the question of the specific differences, it has not been introduced here.

var. *a*, 8—15, rarely more. *Amongst specimens of var. a, as also among those of* the type, specimens may be found having three, two, or even only one bristle on the caudal fin. The second antennæ of the male are less wide in var. *a* than in the type, and the knobs on the inner border are rather larger than in the type.

The variety *b* was found in pools of a concentration of 4° Beaumé. It differs from the type in having the post-abdomen shorter in proportion, though the whole length is about the same. The number of bristles on the caudal fins is greater in the variety. The second antennæ of the male are narrower in the variety than in the type, and bear a tooth and a thickening of the skin internal to the rough knob-like projections. But the most important difference characterizing var. *b* is the appearance of transverse segmentation in the last (8th) post-abdominal segment. This, according to Schmankewitsch, does not amount to an actual segmentation, but is really a transverse annulation, which may be more or less conspicuous, and suggests an appearance of segmentation. Schmankewitsch looks on this second variety as a transitional form between *Artemia* and *Branchipus.*

Before going further it may be remarked that Schmankewitsch gives no figures of these varieties, except in so far as they are represented in the well-known series of sketches of the caudal forks with varying numbers of bristles. No analysis of the waters is given.

It will be seen that two principal and distinct statements are made:

(1) That *A. milhausenii* may be reared from *A. salina* by gradually raising the concentration of the water.

(2) That by diluting the water a division is produced in the last (8th) segment of *A. salina:* that this is a character, or, as Schmankewitsch says, the chief character, of the genus *Branchipus.*

First as to the relation of *A. salina* to *A. milhausenii.* The species *milhausenii* was made by G. FISCHER DE WALDHEIM[1] on spirit specimens sent to him, and the absence of caudal fins and bristles was taken as the diagnostic character. Fischer's figures are very poor, and indeed are scarcely recognizable: they are also incorrect in several points, giving for instance 12 pairs of swimming feet instead of 11. The *description is also very imperfect. In the course of this he speaks of the male,* saying that its second antennæ are larger than those of the female, in which he declares the second antennæ may be sometimes absent. From Fischer's account it is quite clear that his material was badly preserved, and indeed, as Schmankewitsch says, specimens of these animals preserved with spirit only are of little use.

In 1837 RATHKE[2] gave a better figure of *A. milhausenii* ♀ from the original locality of Fischer's specimens. The tail, ending in two plain lobes, is shown. The male is *not* mentioned. The following analysis of the water is given:

Potassium Sulphate	0·7453
Sodium Sulphate	2·4439
Magnesium Chloride	7·5500
Calcium Chloride	0·2760
Sodium Chloride	16·1200
	27·1352

in 100 of the water.

Other authors mention *A. milhausenii,* but there is, so far as I am aware, no special account of the male, or any material addition to the above.

I will now give an abstract of such further evidence on this subject as I have been able to collect.

In the course of a journey in Western Central Asia and Western Siberia I collected samples of Branchiopods from a great variety of localities. Of these *two consist of Branchipus ferox (Milne Edwards), one of Branchipus spinosus (Milne* Edwards), three of a species of *Branchipus* not clearly corresponding with any species of which a description is known to me, and the remainder of *Artemia.* All the species of *Branchipus* collected are quite clearly defined both in the male and the female, and have certainly nothing to do with the *Artemia.* Of the latter some preliminary account may now be given, as the facts bear on Schmankewitsch's problem. Omitting those which were badly preserved and those which do not contain adults, there remain twenty-eight samples, satisfactorily preserved with corrosive sublimate, from as many localities. Of these, eight contain males, all of them having the

[1] *Bull. Imp. Soc. Nat. Moscou,* 1834, VII. p. 452.
[2] *Mém. Ac. Sci. Pét.,* 1837, III. p. 395.

distinctive characters of *A. salina*. It is difficult to speak with confidence as to the species of an *Artemia* from the female alone, but by careful comparison I can find no point of structure which differentiates any of the remainder from the females found with males, and I therefore regard them as all of the same species, *A. salina*. The waters were of many kinds, some being large salt lakes, while others were small salt ponds or even pools. The specific gravities of these waters varied from 1·030 to 1·215, and judging from the results of the analysis of six samples, the composition of the waters is also very different. The specific gravities were measured in the field with a hydrometer reading to ·005, and on comparing these readings with the determinations of the Sp. G. of the samples brought home it appears that they were approximately correct, and I think therefore that these rough readings are fairly trustworthy. As to the composition of the waters not analyzed, nothing can be said with much confidence. As the analyses shew, some of these lakes contain chiefly chlorides, others chiefly sulphates, and so on. In a few (*e.g.* xxix) there is a great quantity of sodium carbonate, so much that the water was strongly alkaline and felt soapy to the hands. This can generally be recognized on the spot in various ways.

The first point raised by Schmankewitsch's work is that of the caudal fins. Among my samples I have every stage between the large fins with some twenty bristles, down to the condition with no distinct fin or bristles. The following table gives the results as regards the number of bristles on the caudal fins, and this

No. in Catalogue	Sp. G.	Bristles on single caudal fin. Eggbearing ♀♀ only	Remarks
XXIX.	1·030	10 to 24	Analyzed. Strongly alkaline. ♂♂ present.
LI.	1·050	11—13	
XXXIV.	1·056	9—17	♂♂ present.
XXV.	1·065	2— 7	♂♂ present.
XLII.	? 1·070		
XXXVII.	1·075	8—13	
XXXIX.	1·075	5— 7	
XLI.	1·085	13—15	
IV.	1·095	20—28	♂♂ present. This and III. both pools in one dry stream-bed.
XIV.	1·100	8—14	Analyzed.
XLV.	1·100	8—12	
XXVII.	1·100	4—10	
XXXI.	1·105	5— 9	♂♂ present.
XXXV.	1·105	4— 8	
XLIII.	1·115	1— 6	Analyzed.
XIX.	1·115	5— 9	
XL.	about 1·130	12—16	Pool in a stream-bed. ♂♂ present
LII.	1·140	3— 7	
XXXVI.	? 1·150	4—10	
XLIV.	1·150	7— 8	Analyzed.
XVI.	1·150	0— 1	
III.	1·160	16—19	♂♂ present. This and IV. both pools in one dry stream-bed.
XII.	1·165	1— 3	
XXII.	1·165	1— 5	
XVIII.	1·170	6— 8	
XXIII.	1·175	1— 5	
XXVI.	1·179	4— 9	Analyzed.
XXIV.	1·204	2— 5	Analyzed.
XXXII.	1·215	2— 4	
XXXIII.	1·215	2— 7	

number is a fair guide to the size of the fins, large fins for the most part having many bristles and small fins having few. In the third column the range of this number in several individuals is shewn, and for this purpose only *adult females bearing eggs in the ovisac* are reckoned, as with sex and age there are changes in respect of the number of bristles.

ANALYSIS OF WATER FROM SIX LOCALITIES CONTAINING *ARTEMIA SALINA*.

Catalogue Number	XXIX.	XIV.	XLIII.	XXVI.	XLIV.	XXIV.
Chlorine Cl_2	2·6950	24·8646	54·7793	70·8130	57·6653	61·0830
Sulphuric anhydride SO_3 ...	5·9105	13·3585	30·3797	53·8150	71·8775	74·4463
Carbonic anhydride CO_2 ...	7·0125	·3185	·3926	·2398	·3231	·2451
Lime CaO	·0311	·2256	·0678	·2266	·1466	·5175
Magnesia MgO	·0384	3·3561	6·0367	4·7514	4·5115	9·8394
Soda and Potash Na_2O, K_2O.........	16·7471	27·4589	63·6088	96·7906	100·0803	97·2084
Total	32·4346	69·5822	155·2649	226·6364	234·6043	243·3397
Oxygen equivalent to the Chlorine...	·6082	5·6112	12·3620	15·9804	13·0133	13·7846
Total solids in 1000 grams...............	31·8264	63·9710	142·9029	210·6560	221·5910	229·5551
Sp. G. compared with Water at 20°	1·03074	1·05196	1·11787	1·17999	1·19586	1·20441

These analyses were undertaken for me by Mr H. Robinson, of the Cambridge University Chemical Laboratory, and my best thanks are due to him for the care with which he has conducted them.

The table shews the great variability in the development of the tails and bristles. In specimens from the same locality there is generally great difference, and even the numbers on the two fins of the same individual are rarely the same. It will be seen that on the whole the forms with few bristles came from waters of high specific gravity, thus generally agreeing with Schmankewitsch's statement. This relation to the salinity is not however very close, but Schmankewitsch never asserted that it was. He frequently refers to the existence of individuals with tails in several conditions of degeneration in the same water, and especially (*Z. f. w. Z.*, 1877, p. 482) he expressly states that in the original locality of *A. milhausenii* he found this form and with it several others intermediate between it and *A. salina*.

It will also be seen in the Table, that the three samples, IV, XL and III stand out as having far more bristles than other samples from waters of equal specific gravity. Each of these localities was exceptional, and all belong to one class. III and IV were pools in the dry bed of a stream in the Ḳara Ḳum, near the Irghiz river. They were close together, and must be joined in each spring. XL. was a pool in a somewhat similar dried stream-bed, coming down to the lake Tulu Bai in the district of Pavlodar. The conditions in these pools must be very different from those of the large, shallow, permanent salt lakes from which the other samples mostly came, and it is only fair to Schmankewitsch's case to remember that the water in such pools must be almost fresh during the early part of each summer.

On the whole, then, it seems satisfactorily shewn that the tailless form is connected by intermediate stages with the fully-tailed *A. salina*, and that this transition is at all events partly connected with the degrees of salinity of the water in which it lives. Almost each locality has its own pattern of *Artemia*, which differs from those of other localities in shades of colour, in average size, or in robustness, and in the average number of spines on the swimming feet, but none of these differences seem to be especially connected with the degree of salinity.

Passing now to the question of the distinctness of *A. milhausenii*, it seems clear that, as Rathke said, it should never have been considered a distinct species. The character of the finless tail, which is now seen to be one of degree, does not differentiate it satisfactorily, and, as Schmankewitsch found, it is to be seen swimming with fin-bearing individuals. It has never been shewn that there is a male *A. milhausenii*, with distinctive sexual characters, and among the Branchiopoda the various sexual characters of the second antennæ in the male are most strikingly distinctive of the several forms. While being in no sense desirous of disparaging the value of Schmankewitsch's very interesting observation, I think it is misleading to describe the change effected as a transformation of one species into another. Schmankewitsch himself expressly said that he did not so consider it, and it is unfortunate that such a description has been applied to this case.

The question of the division of the 8th post-abdominal segment of *Artemia*, stated to occur on dilution of the water, directly concerns the subject of Meristic Variation. As to the facts, there is no doubt that the tail of *Branchipus* appears to be made up of seven segments besides the two which bear the external generative organs, in all, nine, while in the commonest forms of *A. salina* there are only eight such segments; and that the difference lies in the fact that in the long terminal segment of *A. salina* there is generally no appearance of division. But as CLAUS[1] has shewn, the last apparent division in *Branchipus* is of a different character from that of the other abdominal segments. This is indeed easily seen in *B. ferox*, *B. stagnalis*, *B. spinosus*, &c., in which the appearance of the last division is very different from that of the other divisions. It appears, in fact, to be rather an annulation than a segmentation. In longitudinal sections the distinction is quite clear. Such a division, according to Schmankewitsch, appears in the third generation of *A. salina* bred in diluted salt water.

Among my own specimens an appearance of division in the last segment occurs in a considerable number, and these are not by any means from the most dilute waters alone, some of them being from waters of great concentration. For instance, the specimens in XXIX, LI, XXXVII, XXXIX and XIV, all have no trace of such division. On the other hand, it was found in several specimens from XXVI (Sp. G. 1·179) and XLIII (Sp. G. 1·115), while others from these localities did not shew it. These facts relate to adult females bearing eggs. I do not think, therefore, that the relation of this appearance of division to the salinity of the water is a constant one.

Lastly, as regards the relation of *Artemia* to *Branchipus*, Schmankewitsch has maintained that the division of the last abdominal segment is the only structural character really differentiating *Branchipus*. Claus (*l. c.*) pointed out that there are many other points of difference, and that the supposed division is not a structural character of great moment. But above all these, it should be remembered that by the sexual characters of the males, *Branchipus* is absolutely separated from *Artemia*. No *Branchipus* has any structure at all resembling the great leaf-like second antennæ of the male *A. salina* or *A. gracilis*[2] Verrill. Schmankewitsch remarks (*Z. f. w. Z.*, 1877, p. 492) that there are species of *Branchipus* (e.g. *B. ferox*) without the appendages characterizing the second antennæ of *B. stagnalis* ♂, &c., and that the males of *Artemia* bear on the second antennæ a knob, which is possibly the representative of the appendages of *Branchipus*, but nevertheless there is no resemblance whatever between the males of *B. ferox* or of any other *Branchipus* and those of *Artemia*, and there is no reason to suppose that these sexual characters are modified by the degree of concentration of the water. The statement that the descendants of an *Artemia* can be made to assume the characters of *Branchipus* Schäffer, depends entirely on the acceptance of Schmankewitsch's criterion of that genus, which is set up in practical disregard of the far more distinctive sexual characters. It is, besides, as has already been stated, only an irregular and possibly misleading relation which subsists between this appearance of segmentation and the salinity of the water[3].

[1] *Anz. Ak. Wiss. Wien*, 1886, p. 43; see also *idem*, *Abhandl. Göttingen*, 1873, Taf. III. Fig. 10, Taf. V. Fig. 16.

[2] For two samples of this American form I am indebted to Dr A. M. Norman, who received them from Professor Packard.

[3] I cannot leave this subject without expressing astonishment at the comparatively slight and evasive differences in the structure of *Artemiæ* and other Crustacea inhabiting waters of different salinity and composition. It is not a little

surprising that the animals living in No. XIV, for example, are scarcely distinguishable from those in No. XXIX, though the water in the latter was so strongly alkaline as to feel soapy. The conditions of animal life in these two waters must surely be very different, and yet no visible effect is produced. It is of course certain that there are great differences in the physiology of these forms, for, as I have often seen, animals (Copepoda, Cladocera, &c.) transferred from one water to another of materially different composition, die in a few minutes, though the second water may be inhabited by the same species; but in visible structure, the differences are for the most part trifling and equivocal.