

XVII.—*Researches having for their object the Elucidation of certain Phænomena in the Physiology of the Araneidea.* By JOHN BLACKWALL, F.L.S.

SINCE an epitome of my researches into the structure, functions and œconomy of the *Araneidea* was published in the 'Report of the Fourteenth Meeting of the British Association for the Advancement of Science, held at York in September 1844,' and in the fifteenth volume of the 'Annals and Magazine of Natural History,' I have repeated, with slight modifications, several of the experiments relative to the reproduction of the limbs of spiders therein detailed, and as they appear to present some interesting results I shall give them in the order of their occurrence, together with the inferences deduced from them.

1. The digital joint of the left palpus of an immature female *Tegenaria civilis* was amputated on the 28th of April 1845. On the 24th of the following June the spider cast its integument and the left palpus was reproduced; it was unsymmetrical in form, the axillary, humeral and cubital joints being equal in size to the corresponding parts of the right palpus, but the radial and digital joints were small. The digital joint of the new palpus was amputated on the 28th of June, and the limb was again restored at the succeeding moult, which took place on the 18th of August in the same year, when the radial and digital joints, though enlarged, were still inferior in size to those of the right palpus.

2. A very young female *Tegenaria civilis* had the right posterior leg detached at the coxa on the 30th of April 1845 by means of a fine pair of forceps. It moulted on the 19th of June, when the right posterior leg, of a small size, was reproduced. On the 26th of the same month the new leg was detached at the coxa, and was reproduced on the 30th of July, when the spider again cast its integument. This leg was detached in like manner on the 5th of August, and was reproduced on the 11th of September, at which period also the spider moulted. On the 14th of September the leg last restored was detached, and was reproduced on the 8th of November, when the spider underwent its final moult and arrived at maturity. The right posterior leg, which was reproduced four times, maintained its symmetry inviolate through the whole of these changes; but though its dimensions were enlarged with the growth of the spider at each successive change of integument, yet they were always greatly inferior to those of the corresponding leg on the opposite side.

3. On the 28th of June 1845 a very young female *Tegenaria civilis* had the right anterior leg detached at the coxa. It moulted on the 6th of July, but the coxa only of the mutilated leg was

produced. On the 8th of August it moulted again and the entire limb was restored. The same leg was detached at the coxa on the 14th of August, the 26th of September, and the 12th of November; and was reproduced on the 19th of September, the 8th of November, and the 20th of May 1846, respectively, at which periods the spider changed its integument. At the last date, the right palpus, which had been detached at the axillary joint on the 12th of November 1845, was also reproduced; both it and the right anterior leg were small but symmetrical, the latter having been reproduced four times.

4. A very young male *Tegenaria civilis* had the left posterior leg detached at the coxa on the 5th of August, the 14th of September, and the 29th of October 1845, and on the 18th of April and the 8th of June 1846. This spider cast its integument on the 10th of September and the 25th of October 1845, and on the 10th of April, the 5th of June and the 4th of July 1846, respectively, at each of which dates, except the last, the left posterior leg was reproduced, but on the 4th of July the coxa only was produced. The circumstances attending the restoration of this limb were similar to those recorded in experiments 2 and 3. I may add, that the spider frequently moistened the tarsus of the third leg on the left side with saliva and applied it to the injured part.

5. Half of the metatarsus, with the tarsus, of the right anterior leg of an immature male *Epëira antriada* was amputated on the 20th of August 1845. On the 8th of the ensuing September the spider moulted and the right anterior leg was reproduced. The coxa, femur and tibia of the new limb were of the same dimensions as those parts of the corresponding leg on the opposite side, but the metatarsus and tarsus were very small.

6. An immature female *Ciniflo ferox* had about a third of the tibia, the metatarsus and tarsus of the left anterior leg amputated on the 14th of March 1846. It moulted on the 14th of the following May, when the coxa, femur and genual joint of the left anterior leg, which was reproduced, were of the same size as the corresponding parts of the right anterior leg, but the tibia, metatarsus and tarsus were very diminutive. This spider moulted again on the 23rd of July in the same year; at the same time the tibia, metatarsus and tarsus of the new limb were considerably enlarged.

7. A young female *Tegenaria civilis*, which had the right posterior leg amputated near the anterior extremity of the tibia on the 16th of March 1846, cast its integument on the 24th of the ensuing May and the mutilated limb was reproduced; the coxa, femur and genual joint were of the same dimensions as the cor-

responding parts of the left posterior leg, but the tibia, metatarsus and tarsus were small.

8. The left posterior leg of an immature female *Tegenaria civilis* was amputated near the anterior extremity of the tibia on the 16th of March 1846. On the 30th of the following May the spider cast its integument and the mutilated limb was reproduced; the coxa, femur and genual joint were of the same size as the corresponding parts of the right posterior leg, but the tibia, metatarsus and tarsus were small. This spider moulted again on the 27th of June in the same year, when a considerable enlargement of the tibia, metatarsus and tarsus of the new limb took place.

9. A very young female *Tegenaria civilis* had the left posterior leg detached at the coxa on the 14th of September 1846. It moulted on the 23rd of the same month, but the mutilated leg was not reproduced till a subsequent moult, which took place on the 4th of May 1847. The same leg was detached at the coxa on the 13th of May, the 24th of June, the 22nd of July, the 30th of August, and the 13th of October; and the spider changed its integument on the 16th of June, the 16th of July, the 22nd of August, the 6th of October, and the 24th of November 1847, respectively, at which periods the left posterior leg was reproduced. Though this limb was restored six times, and was enlarged at each successive moult the spider underwent, yet it constantly retained a symmetrical figure, and through all its changes was greatly inferior in size to the corresponding leg on the opposite side.

10. On the 3rd of June 1847 the left posterior leg of an immature female *Tegenaria civilis* was detached at the coxa, and the right posterior leg was amputated near the middle of the tibia. This spider moulted on the 9th of the ensuing July, at which time the left posterior leg, of small dimensions, but symmetrical in form, was reproduced; the right posterior leg was also reproduced, but the tibia, metatarsus and tarsus, compared with the other joints of the same limb, were greatly disproportionate in size.

11. An immature male *Agelena labyrinthica* had the left posterior leg amputated near the anterior extremity of the metatarsus on the 4th of June 1847. It cast its integument on the 30th of the same month, when the left posterior leg was reproduced. The coxa, femur and tibia were of the same size as the corresponding parts of the right posterior leg, but the metatarsus and tarsus were small, the latter remarkably so.

12. The left posterior leg of a young female *Agelena labyrinthica* was detached at the coxa, and the right posterior leg was amputated near the middle of the metatarsus on the 5th of June

1847. The spider moulted on the 14th of the same month, when the stumps only of the mutilated limbs were produced. On the 7th of the following July it moulted again, at which time the left posterior leg, of small dimensions, but symmetrical in form, was restored; the right posterior leg was also restored, but the metatarsus and tarsus were disproportionately small.

13. On the 14th of June 1847 the right posterior leg of an immature female *Agelena labyrinthica* was amputated near the middle of the metatarsus. The spider cast its integument on the 2nd of the ensuing July, when the mutilated limb was reproduced. The coxa, femur and tibia were equal in size to the corresponding parts of the left posterior leg, but the metatarsus was very small, and the tarsus was extremely diminutive.

Experiments 2, 3, 4 and 9 serve to establish the fact, that if a leg of an immature *Tegenaria civilis* be detached at the coxa four or even six times consecutively, it may be reproduced at each succeeding moult the spider undergoes. This frequent renewal of the same part seems to warrant the conclusion that a reproduction of the limbs of the *Araneidea* generally, irrespective of mutilation, actually occurs whenever a change of integument takes place; and this view of the subject, which probably might be extended to numerous subdivisions of the Articulata, derives additional support from evidence supplied by the other experiments.

That the dimensions of reproduced limbs are in inverse ratio to the extent of the injury previously inflicted on the parts is manifest from experiments 1, 3, 10 and 12; thus, palpi and legs detached at the axillary joint and coxa are usually symmetrical, but diminutive, when reproduced; while those amputated at the articulation of the digital with the radial joint, and near the middle of the tibia or the metatarsus, on being restored are always very much larger and unsymmetrical; in point of fact, the development of the new limb depends upon the capacity of the undetached portion of the mutilated part; for if a leg be amputated near the middle of the metatarsus, as was the case in experiments 5, 12 and 13, the coxa, femur and tibia will be of the same dimensions as those joints of the corresponding leg on the opposite side, but the metatarsus and tarsus will be very diminutive; should the excision be made near the anterior extremity of the tibia, as in experiments 6, 7 and 8, then the size of the coxa, femur and genual joint will be normal, but that of the tibia, metatarsus and tarsus will be very abnormal. These curious results plainly demonstrate, that not only reproduced limbs in their totality, but that particular joints also are limited in their dimensions by the capacity of the undetached portion of the mutilated part in which they are developed, and that restored legs and

palpi are never symmetrical except when developed in the undetached coxa and axillary joint respectively.

In order to obtain a satisfactory explanation of the phenomena stated above, it must be conceded that the limbs of spiders produced at each successive moult, from the period at which the animals quit the cocoon till they arrive at maturity, are absolutely new organs resulting from the vital functions of assimilation and accretion; indeed, the renewal of a repeatedly detached leg at each succeeding change of integument, and the circumstance of the dimensions of entire limbs or portions of limbs depending upon the space allowed for their development at the time of restoration, present difficulties which do not admit of a solution on any other physiological principle that I am aware of.

Sometimes the stump only of a partially amputated leg is produced at the succeeding moult, especially when the injury has been inflicted but a short time previously to the change of integument, as may be seen on referring to experiments 3, 9 and 12. As the formative process in this case must have made considerable progress before the excision of the part was effected, there is nothing extraordinary in the result; but a similar consequence occasionally ensues when the partial amputation of a leg takes place very soon after a change of integument, before the formative process can be supposed to have commenced; experiment 4 presents an instance of this kind; a much more remarkable one, however, is given in the 'Annals and Magazine of Natural History,' vol. xv. p. 233, experiment 12, from which it appears that the stumps only of the palpi of a young male *Linyphia cauta* were produced at two consecutive moults after the parts had suffered mutilation, though several legs of the spider, mutilated at the same time, were renewed at the next moult after the infliction of the injury.

If these facts are inexplicable at present upon the principle of the reproduction of lost parts by the *Araneidea* which I have been advocating, it may be attributed to the obscurity in which they are involved, and as they are decidedly opposed to every other view of the subject, it is not necessary to notice them more particularly in this place.

I avail myself of the opportunity afforded by this communication to correct a statement contained in the epitome of my researches into the structure, functions and œconomy of the *Araneidea*, (Report of the Fourteenth Meeting of the British Association for the Advancement of Science, held at York in September 1844, p. 73; and the Annals and Magazine of Natural History, vol. xv. p. 234,) to the effect, that if part only of a limb of a spider be amputated, as the tarsus of a leg or the digital joint of a palpus, all the joints of the limb when reproduced,

though small, will be proportionate to those of the corresponding limb on the opposite side ; whereas it is evident from the preceding experiments that legs and palpi restored after mutilation are never symmetrical except when respectively developed in the undetached coxa and axillary joint alone.

So little appears to have been done for the purpose of determining the longevity of spiders with some approach to accuracy, that a few observations on the subject probably will not be regarded as superfluous.

A young female *Tegenaria civilis*, disengaged from the egg on the 6th of July 1842, after quitting the cocoon was placed in a separate phial and was abundantly supplied with nutriment. It continued in excellent health and condition apparently till the 8th of July 1845, when it died suddenly, having completed the third year of its existence.

On the 27th of June 1842 a young male *Tegenaria civilis* was disengaged from the egg. It quitted the cocoon on the 21st of the following month, and underwent its last moult on the 17th of October 1843. During the winter of 1844 it became greatly reduced in bulk, and died on the 30th of March 1845.

The egg of a *Tegenaria civilis* hatched on the 27th of June 1842 produced a female spider, which completed its final change of integument on the 5th of August 1843. It took its food well, and appeared to be in good health till the 6th of July 1846, when it died, having attained to the age of four years and nine days.

Allowing for the disadvantages to which spiders are subjected in a state of captivity, I think the duration of life in the species upon which the observations were made should not be estimated at less than four years, and I have elsewhere shown (*Annals and Magazine of Natural History*, vol. xv. p. 232, experiment 4 ; and pp. 235, 236) that the life of *Segestria senoculata* is protracted to an equally long period. Whether any spiders enjoy a more prolonged existence or not remains to be ascertained ; but there can be no doubt that *Dolomedes mirabilis*, *Chubiona erratica*, *Agelena labyrinthica*, *Epëira quadrata*, *Tetragnatha extensa*, *Linyphia montana*, *Theridion lineatum*, and numerous other species, do not usually survive the second winter after quitting the egg in this northern climate.

The following particulars, extracted from observations made by M. Doumerc on *Theridion triangulifer*, are given by Baron Walckenaer in his ' *Histoire Naturelle des Insectes Aptères*, ' supplément à l'histoire naturelle de l'ordre des Aranéides, t. ii. p. 506 :—" Prise à la fin de décembre 1839, cette Aranéide fit un premier cocon le 23 avril suivant, les œufs ont éclos le 5 mai ; il n'en est sorti que des mâles. Le 10 mai, formation d'un nouveau cocon ; le 24 mai, les œufs ont éclos, il n'en est sorti que

des femelles. Le 16 juin suivant, accouplement de l'Aranéide mère avec un de ses petits, mâle, provenant de la première couvée. Deux cocons formés du 26 au 28 juin. Les œufs d'un des deux cocons ont éclos le 27 juillet, et il n'en est sorti que des femelles. Les œufs du second cocon ont éclos le 31 juillet, et il n'en est sorti que des mâles." The events to which attention is here directed are represented as succeeding each other with a degree of rapidity unparalleled in the records of arachnology.

It appears that on the 23rd of April 1840 a female *Theridion triangulifer* deposited in a cocoon a set of eggs which produced young on the 5th of May; they all proved to be males, and on the 16th of the following June one of them paired with its parent, which enveloped a set of eggs in a cocoon on the 26th and a second set in another cocoon on the 28th of the same month; the first set was hatched on the 27th of the ensuing July and produced males only; the second set was hatched four days later, and from it proceeded females only.

Now, though many of the *Theridia* are very short-lived, and, consequently, pass through their several mutations and arrive at maturity earlier than those spiders whose existence is of longer continuance, yet, in my researches into the œconomy of the *Araneidea*, which have occupied a considerable portion of my leisure hours during many years, an instance of the young of these animals becoming adult in the same season that the eggs were deposited from which they were disengaged has never come under my observation; but in the example before us, an egg laid on the 23rd of April is stated to have produced a male spider which on the 16th of the ensuing June was capable of propagating its species. If the small size of spiders on quitting the egg be borne in mind, and if it be taken into consideration also that an advance in growth, particularly of the cephalo-thorax and its appendages, is limited to the periods at which the integument is changed, a suspicion can scarcely fail to be induced that there may have been some latent source of error in the observations of M. Doumerc, which it is very desirable should be carefully repeated. As regards *Theridion triangulifer* depositing two sets of eggs at different times, each of which produced young of the same sex only, one males, and the other females, I will merely remark, that hitherto I have had no opportunity of investigating the œconomy of this species; but that the case is very different with *Tegenaria civilis* conclusive evidence is not wanting, for I have brought up individuals of both sexes from the same set of eggs, deposited in a cocoon by this common and widely distributed spider on the 27th of May 1842.

A passage in the 'Introduction to Entomology,' by Messrs. Kirby and Spence, fifth edition, vol. iv. letter xlv. p. 214, merits

a brief notice ; it is this : "Spiders are reputed to be subject to the *stone* : I do not say *Calculus in Vesica* ; but we are informed by Lesser that Dr. John Franck having shut up fourteen spiders in a glass with some valerian root, one of them voided an ash-coloured calculus with small black dots." This singular opinion seems to have originated in a misapprehension of an ordinary occurrence, which I shall proceed to explain. If the fæces of spiders, which consist of a white fluid comprising black particles of greater density, happen when voided to be suspended in the webs or among the lines spun by these animals, they assume, under the influence of molecular attraction, the spherical figure common to fluids in general when similarly circumstanced, and soon becoming indurated by desiccation, a change of colour from white to gray or grayish brown spotted with black uniformly takes place, and in this state they constitute, I doubt not, the substance which Dr. Franck mistook for a calculus.

XVIII.—*On some Points in the Structure and Growth of Monocotyledons.* By ARTHUR HENFREY, F.L.S. &c.*

[With two Plates.]

ALTHOUGH the views which are advocated in the following paper do not possess much originality, I have been induced to lay my observations before this Section by several considerations. In the first place, I believe that the subject is one to which a comparatively small amount of attention has been paid in this country, and therefore, dependent as we have been on foreign observers for our knowledge of it, indigenous investigations may have some interest ; secondly, the theories of monocotyledonous structure held by the chief continental authorities are at present not generally-received views, but to some extent individual opinions, conflicting more or less one with another ; and, lastly, as I have devoted a considerable amount of time to the examination of this most intricate subject, I have thought that independent observations, carefully and repeatedly made, might by their publication be of some service to the science of Botany, either by pointing out the errors or confirming the statements of other anatomists.

I have directed my attention to the structure of those Monocotyledons which can be readily obtained in a living state in this country ; the structure of the stems of Palms I have not had the opportunity of studying, and therefore with regard to them I have been obliged to depend upon the observations of others. So

* Read at the Meeting of the British Association, June 1847, and communicated by the Author.



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