natural species we are so much accustomed to apply the term reversion or atavism to the reappearance of a lost part that we are liable to forget that its disappearance may be equally due to this same cause.
As every modification, whether or not due to reversion, may be considered as a case of variation, the important law or conclusion arrived at by the mathematician Delbœuf, may be here applied; and I will quote Mr . Murphy's condensed statement (" Habit and Intelligence," 1879, p. 241) with respect to it: "If in any species a number of individuals, bearing a ratio not infinitely small to the entire number of births, are in every generation born with any particular variation which is neither beneficial nor injurious to its possessors, and if the effect of the variation is not counteracted by reversion, the proportion of the new variety to the original form will constantly increase until it approaches indefinitely near to equality." Now in the case advanced by Fritz Müller the cause of the variation is supposed to be atavism to a very remote progenitor, and this may have wholly prevailed over any tendency to atavism to more recent progenitors; and of such prevalence analogous instances could be given.

Charles Darwin

## Blumenau, St. Catharina, Brazil, January 21, 1879

## My Dear Sir,

If I remember well, I have already told you of the curious fauna which is to be met with between the leaves of our Bromeliæ. Lately I found, in a large Bromelia, a little frog (Hylodes ?), bearing its eggs on the back. The eggs were very large, so that nine of them covered the whole back from the shoulders to the hind end, as you will see on the photograph accompanying this letter, Fig. I (the little animal was so restless that only after many fruitless trials a tolerable photograph could be obtained). The tadpoles, on emerging from the eggs, were already provided with hind-legs ; and one of them lived with me about a fortnight, when the fore-legs also had made their appearance. During this time I saw no external branchiæ, nor did I find any opening which might lead to internal branchiæ.


Fig. $x$.
There is here another locality in which a peculiar fauna lives, viz., the rocks of waterfalls, which are of very frequent occurrence in almost all our mountain rivulets. On these rocks, along which the water is slowly trickling down, or which are continually wetted by the spray of the waterfall, there live various beetles not to be met with anywhere else, larvæ of diptera and caddis-flies, and a tadpole remarkable for its unusually long tail.
The pupæ of caddis-flies living on the rocks of waterfalls (I examined three species belonging to the Hydropsychida, Hydroptilida, and Sericostomatidae [Helicopsyche]), as well as those living in the Bromeliæ (a species belonging to the Leptocerida), are distinguished by a very interesting feature. In other caddis-flies the feet of the second pair of legs (and in some species those of the first pair also) are fringed in the pupæ with long hairs, which serve the
pupa, after leaving its case, to swim to the surface of the water for its final transformation. Now neither on the surface of bare or moss-covered rocks, nor in the narrow space between the leaves of Bromeliæ, the pupæ have any necessity, nor would even be able, to swim, and in the four species living on such localities which I examined, and which belong to as many different families, the feet of the pupæ are quite hairless, or nearly so, while in allied species of the same families or even genera (Helicopsyche) the fringes of the legs, used for swimming, are well developed.

This abortion of the useless fringes in the caddis-flies inhabiting the Bromelix and waterfalls appears to me to be of considerable interest, because it cannot be considered, as in many other cases, as a direct consequence of disuse; for at the time when the pupæ leave their cases and when the fringes of their feet are proving, either useful or useless, these fringes as well as the whole skin of the pupa, ready to be shed, have no connection whatever with the body of the insect; it is therefore impossible that the circumstance of the fringes being used or not for swimming, should have any influence on their being developed or not developed in the descendants of these insects. As far as I can see, the fringes, though useless, would do no harm to the species, in which they have disappeared, and the material saved by their not being developed appears to be quite insignificant, so that natural selection can hardly


Fig. 2.
Fig. 3.
Fig. 2.-Tibia and tarsus of the two pairs of legs of the pupa of 2 speciesof Leptoceridæ, inhabiting Brone liz. Fig. 3 -The same of a nearly allied species ishabiting rivulets. have come into play in this case. The fringes might disappear casually in some individuals; but, without selection, this casual variation would have no chance to prevail. There must be some constant cause leading to this rapid abortion of the fringes on the feet of the pupæ in all those species in which they have become useless, and I think this may be atavism. For caddis-flies, no doubt, are descended from ancestors which did not live in the water, and the pupre of which had no fringes on their feet. Thus there may even now exist in all caddis-flies an ancestral tendency to the production of hairless feet in the pupx, which tendency in the common species is victoriously counteracted by natural seleztion, for any pupa, unable to swim, would be mercidessly drowned. But as soon as swimming is not required and the fringes consequently become useless, this ancestral tendency, not counterbalanced by natural selection, will prevail, and lead to the abortion of the fringes.
I do not remember having seen, in any list of cleistogamic plants, the Podostemaceæ. These curious little aquatic plants, which Lindley placed near the Piperaceæ, Kunth between the Juncagineæ and Alismaceæ, and which Sachs considers as being of quite dubious affinity, cover densely the stones in the rapids of our rivers; on the branches which come above the surface of the water, there are pedunculated, open, fertile flowers; but there are numerous sessile flower-buds also on the branches.
which probably remain submerged for ever; I have not yet ascertained whether these submerged flowers are fertile ; if they are so, they can hardly fail to be cleistogamic.

Fritz Müller

## A STUDY IN LOCOMOTION ${ }^{1}$

II.
III. The Paces of the Horse.-Every one can recognise whether a horse is walking, trotting, or galloping, and yet few would be able to point out the rhythm and order of succession of the movements of the limbs in different paces. These movements, in fact, succeed each other


Fig. 8.-Registering apparatus for horse's paces
too rapidly tor the eye to follow them, and their rhythmic succession is more readily perceived by the ear than by the eye. It is indeed ordinarily by the ear that we become aware of a horse's pace. When at each return of the step (revolution du pas) we hear two distinct strokes of the hoofs, we call it an amble, or a trot ; three


Fig. 9.-Synoptic table of the different paces of the horse, after-the classic authors: 1, amble; 5 , foot-pace; 8, trot, \&cc.
strokes unequally separated denote a gallop; lastly, four strokes indicate a foot pace. But these paces may be
${ }^{x}$ "Motenrs animés ; Exfériences de Physiolcgie graphique." Lecture by Prof. Marey at the Pans meeting of the French Association, August 20, 1878.
more or less irregular, variable, or crippled; besides that, when an animal passes in a very short space of time from one pace to another, how shall we decide upon the manner in which the transition is effected? To clear up these points great efforts have been made by horse-


Fig. no.-Notations of two airs, A and B, executed upon the keyboard of a harmonium.
trainers and yeterinary surgeons, to whom the questions involved are of considerable importance.
Now, as I have just said, the ear judges better than the eye as to the rhythm of successive movements, but in order to demonstrate the production of these rhythmic strokes in twos, and threes, and fours, it is essential to know to which foot each separate sound is to be attributed. Ingenious experimenters have attached to the four feet of the horse bells of different tones, but in perfect barmony with each other. Varied melodies or harmonies are thus produced, according to the succession or synchronism of the strckes. But such an arrangement would certainly not give the length of time each foot remained upon the ground, therefore the question of the paces of the horse has not been entirely resolved even by this method. Turn to any special treatises on the subject, and you will see that beyond the amble, the downight


Gallop of 3 steçs. A, indications of the three s'eps; s, indications of the number of feet which form the support of the büdy at each instant of the gall p cf 3 steps.


Gall :p or 4 steps.
Fic. ir.-Nctaticns of the gallop of 3 and 4 steps.
trot, and the three-step gallop, there is perhaps, not a single pace respecting which contradictory theories are not held. In face of the difficulties of this problem, you will doubtless foresee what will be my conclusion; it will be necessary to have recourse to the graphic method which will solve the question in the simplest manner fossible.

