dromeda. The relative positions are shown in the adjoining cut.

The 'lines' at 18.6 and 19 appear, using the broad slit, as bright knots. That at 17.5 as a long line. The arrangement of the lines suggests certain bright lines in the spectrum of γ Casseopeiae and β Lyrae, and the settings agree with those made upon the spectrum of the said stars.

O. T. S.

Yale college observatory,
Sept 14.

The Mexican axolotl and its susceptibility to transformations.

Marie von Chauvin's experiments with the axolotl, as recounted in *Science* No. 130, under the above title, interested me very much indeed, inasmuch as they came upon me at a time when I was experimenting with upwards of two hundred of these animals by very similar methods.

My present field of research is in north-western New Mexico, and several forms of axolotls are to be found in the region. Last June (1885) I visited, near my present residence, on more occasions than one, a small pond that contained large numbers of them. This pond is nearly square, and its sides something over a hundred feet in length. It is divided in two nearly equal parts by an east and west embankment. This embankment has a narrow trench cut through it, so that when the rain fills the ponds they communicate with each other; but this is not the case when the water is low.

By the 1st of September each year these ponds are usually dried up; while during the spring and summer months, the south one has a mid-depth ranging between three and six feet, and the north one being considerably shallower. These depths vary with the amount of rainfall, and other meteorological conditions.

As I say, there were great numbers of axolotls in these ponds; and as far as I could see, and by the very kind assistance of Professor Cope, these were of two kinds: one very large one (20 cms $\pm$) seemed to be the larval form of Ablystoma mavortium; another much smaller one (9 cms $\pm$) proves to be A. tigrinum. In addition to these, there are some medium-sized ones that are very puzzling, and not yet satisfactorily diagnosed. With but few exceptions, the north division of the pond contained the small ones; while in the other side lived all the large ones, together with the great majority of the light-colored and undetermined forms.

The limits of this paper will not permit me to present all the conditions of environment under which these axolotls live, much less an account of the many observations I made upon their habits as they are to be seen in a state of nature. At different times I captured as many of these creatures as I desired, to carry on my experiments at home, the results of which I had the unusual opportunity of comparing with those changes undergone by these reptiles while existing in their natural element.

It is my sole aim in this paper to briefly present the results of some of these experiments, so far as they have gone, and compare them with those arrived at by Miss von Chauvin, as set forth in *Science*.

My observations confirm those of this talented authoress, in that, —

1. Axolotls are more readily converted into Amblystomas if kept in water containing but little air, and *vice versa*.

2. If transformation is forced up to a certain point in development, the reptile arrives at the higher form without any further interference.

3. Axolotls live in the water with apparent comfort a considerable and varying length of time after their gills have been absorbed.

4. After the metamorphosis is completed, their power to return to the water again to live, seems to depend upon the moult, and whether they have lived in moist or dry places since the metamorphosis.

5. By varying the conditions under which these animals live, we can at our pleasure retard or accelerate their development to the higher stages.

6. Young axolotls are more easily transformed than the older specimens, but this rule also depends largely upon the conditions under which these animals live.

There is another very important factor that enters into this metamorphosis, that, so far as the account in *Science* goes, is not touched upon; and that is, the question of their diet during the experiments. Axolotls are very voracious creatures, and eminently carnivorous. They are very fond of raw meat; and, upon the slightest provocation, they will feed upon each other. So I have found, during the course of my experiments, that, —

7. The metamorphosis is hastened by regularly supplying the animals with plenty of proper food. And what is still more interesting, when they are thus treated, it markedly affects the appearance of the transformed Amblystoma.

8. If, during the process of forcing the transformation of axolotls, the animals are regularly supplied with the requisite amount of fresh meat, the transformed Amblystomas are very much larger and stronger than those which are transformed without having received any food. In the case of A. tigrinum, those that received food, the transformed animal would hardly have been recognized as the same species: they were not only larger, but of a very deep, muddy, *black* color, without spots; while the others were mottled with bright yellow, and a pale brown.

9. The *depth* of the water has a wonderful influence upon the metamorphosis; and the fact is well known, that, the deeper the water in which the axolotls live, the slower their transformation.

Temperature is another important factor in the change, and its moderate increase seems to hasten the transformation.

Now, the most interesting part of all is to watch the operation of these laws, that I have given, in nature, and the manner in which the metamorphosis of axolotls is there effected.

It would, indeed, be hard to find anywhere a more perfect and beautiful example illustrating the extremely sensitive balance that may exist between the surrounding conditions on the one hand, and their effect upon an animal organism on the other. This year, for instance, the very pond that I have alluded to above, gradually dried up; the north half of it entirely. This took a number of weeks; but during that time *all* the modifications of which the metamorphoses of axolotls are subject to, or capable of, were, so far as their necessity goes, most lucidly demonstrated. A shallow corner in this pond would, after a torrid day or two, dry up; whereupon all the axolotls that happened to be caught within its limits, would be found, perhaps several hundred of them, under the *débris*, rapidly assuming the Amblystoma form. Numbers of the same generation, however, in the deeper parts, would be unaffected by the change of environment so suddenly precipitated upon their brethren. If the drying-up continued, these trans-

formed animals quit the site, and, during the next few days, could be found under logs, and in other suitable places at some considerable distance from it. On the contrary, should a rain in the mean time fill the pond again, and flood over these shallow parts, the transformations were checked; and those with gills and branchiae in all stages of change, once more took to the water. When huddled together in the shallow places, the large and strong ones devoured the smaller and feebler forms; and the different appearance of the two was very striking upon the most superficial examination.

One day in July the whole north half of this pond suddenly ran dry; and I must confess the sight its bottom presented during the following day was one of the most extraordinary, and at the same time most interesting, that I ever beheld, and, after what has been said, can be better imagined than described. It absolutely swarmed with these creatures, whose organizations were accommodating themselves to the new condition of affairs as rapidly as the laws governing the changes permitted. The study would have furnished food for a small volume.

Axolotls are also affected by the character of the ponds or swamps they live in, the same species showing all manner of shades in their coloration. Those in shallow ponds with little or no vegetation, and hard clay bottoms, grow to be very light colored, and long retain their larval forms.

No doubt many such ponds as I have described exist all over this south-western country; and a moment's reflection will make it clear to us how the metamorphosis of this creature tends to save thousands of their lives, when the region is visited by a protracted drought, and their places of water resort fail them. The preservation of the form is thereby, to a great extent, protected.

DR. R. W. SHUFELDT.

Fort Wingate, N. Mex.,
Aug. 12.

THE SONG-NOTES OF THE PERIODICAL CICADA.

THERE are few more interesting subjects of study than the notes of insects and the different mechanisms by which they are produced. They interest every observant entomologist; and it is difficult to record them in musical symbols that can be reproduced on musical instruments, some of the more successful and interesting attempts in this direction having been made by Mr. S. H. Scudder. I have studied closely the notes of a number of species, and have published some of the observations.[1]

In the notes of the true stridulators more particularly, as the common tree-crickets and katydids, I have been impressed with the variation both in the pitch and in the character of the note, dependent on the age of the specimen, and the condition of the atmosphere, whether as to moisture, density, or temperature. Yet, with similarity in these conditions, the note of the same species will be constant and easily recognizable.

A few remarks upon Cicada septendecim will doubtless prove of interest now that the species has been occupying so much attention. I do not find that the notes have been anywhere very carefully described in detail, nor would I pretend to put them to musical scale. Writing seventeen years ago, I described the notes in a general way, as follows: —

"The general noise, on approaching the infested woods, is a compromise between that of a distant threshing-machine and a distant frog-pond. That which they make when disturbed mimics a nest of young snakes or young birds under similar circumstances, — a sort of scream. They can also produce a chirp somewhat like that of a cricket, and a very loud, shrill screech, prolonged for fifteen or twenty seconds, and gradually increasing in force, and then decreasing."[1]

There are three prevalent notes, which, in their blending, go to make the general noise as described above. These are, —

First, That ordinarily known as the *phar-r-r-r-aoh* note. This is the note most often heard during the early maturity of the male, and especially from isolated males or from limited numbers. It is variable in pitch and volume, according to the conditions just mentioned as generally affecting insect melodists. Its duration averages from two to three seconds; and the *aoh* termination is a rather mournful lowering of the general pitch, and is also somewhat variable in pitch, distinctness, and duration. In a very clear atmosphere, and at certain distances, an individual note has often recalled that made at a distance by the whistling of a rapid train passing under a short tunnel. But when heard in sufficient proximity, the rolling nature of the note will undoubtedly remind most persons more of the croaking of certain frogs than of any thing else. I have heard it so soft and low, and so void of the *aoh* termination, that it was the counterpart of that made by Oecanthus latipennis Riley late in autumn, and when shortened from age and debility of the stridulator.

Second, The loudest note, and the one which is undoubtedly most identified with the species in the popular mind, is what may be called the 'screech.' This is the note described by Fitch as "represented by the letters *tsh-e-e-E-E-E-E-E-e-ou*, uttered continuously, and prolonged to a quarter or half a minute in length, the middle of the note being deafeningly shrill, loud and piercing to the ear, and its termination gradually lowered till the sound

[1] 3d rep. ins. Mo., 14, 153, 154; 4th do., 139; 6th do., 150-169.

[1] 1st rep. ins. Mo., 24.