questions of the practice of morals, and the nature of the future life. The evolution of mind consists of a continual advance from the known into the unknown, and a transfer of the unknown to the known. So long as there is any inducement to progress of this kind, and nature responds to inquiry, development will go on. Although it is true that it is only among men, and but few men at that, that the pursuit of knowledge is an occupation; most men add to their stock incidentally as they pursue other avocations. The knowledge of right and the inducements to its practice are learned in their every-day intercourse, so far as it can be acquired. But knowledge in these directions soon attains its limit, and accordingly, development dependent on knowledge must cease. If any further progress in practical morals is to be made, some new force must intervene at this point.

Here is the opportunity for the appearance of will or spontaneity; here it is at least needed. I am willing to believe that it may appear at this point, and that so long as we have to face the unknown in moral progress, so long it will remain. As a force it must be equivalent of other forces, but as a form of consciousness it is a new element of mind. As represented in new molecular organization, it may always continue, even after much of the unknown may have been conquered, and a stationary period may have ensued. Such an accession to character would be a fitting crown of evolution, and a justification of this labor of the ages. If a true factor in human development, it might be compared, in the creation of character, to the apical bud of a growing tree. As the part preëminently living, it leads the growth of the trunk and branches. They all follow of necessity the path it has marked out. Under its lead they are successively formed, become fixed, and finally decay.

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THE TONGUE OF THE HONEY BEE.

BY PROF. A. J. COOK.

THE bee is, and has long been, of great importance to the commercial world, and this, together with the fascination inseparable from its study, have led many of the ablest scientists to carefully investigate its structure and habits. Yet I know not if there exists to-day an accurate description of a bee's tongue, and the method by which the insect procures its food.

The literature of the subject abounds in confusion and inac-

curacy. The most learned scientists, those usually the most careful and accurate, like Reaumur, Newport and Carpenter, give voice to palpable errors. Even the last edition of the Encyclopædia Britannica gives further life to these old erroneous views. Let us give brief attention to some of these descriptions.

Hogg says the bee's tongue is cylindrical; Kirby, Spence and Neighbour state that it is flat; Reaumur and Chambers that it is between the two. Reaumur, Newport, Kirby, Spence, Carpenter, Shuckard, Bevan and Hunter all state that the tongue is solid, and that the honey is sopped up, or taken through a tube, formed by the close approximation of the maxillæ, labium, and labial palpi. Newport speaks of a hairy sheath along the under side of the basal two-thirds of the organ. Neighbour says there is a gutter throughout the entire length of the tongue, while Swammerdam, Lamarck, Burmeister, Wildman and Munn claim that the organ is tubular. Newport and Carpenter assert that the bee's tongue is muscular, which is denied by Cuvier, Reaumur and Chambers.

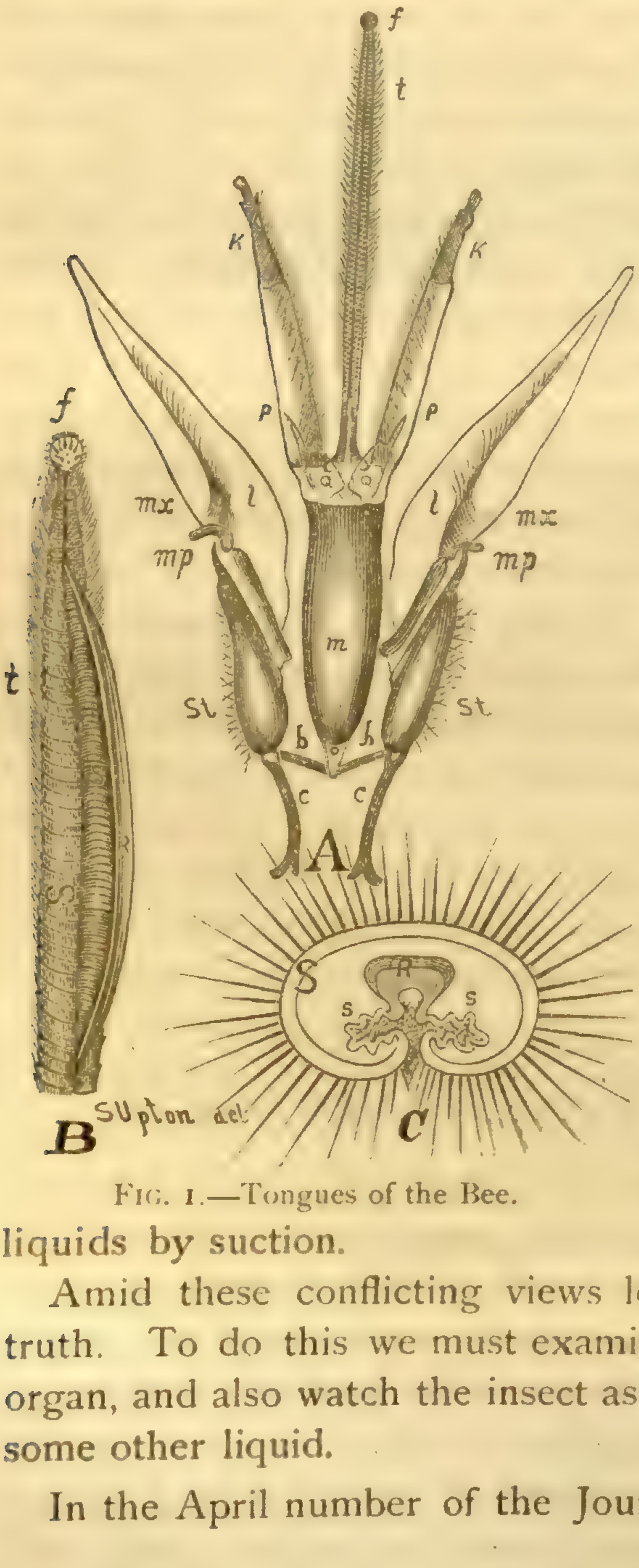

FIG. 1.—Tongues of the Bee.

That bees lap the nectar is affirmed by Reaumur, Newport, Kirby and Spence, Savigny, Carpenter, Bevan and Hunter; while Swammerdam, Wildman, Lamarck, Burmeister, Munn and Neighbour claim that the bees take liquids by suction.

Amid these conflicting views let us see if we may find the truth. To do this we must examine closely the structure of the organ, and also watch the insect as it is taking its fill of honey or some other liquid.

In the April number of the Journal of the Cincinnati Society

of Natural History, for 1878, Mr. V. T. Chambers, an able entomologist of Covington, Kentucky, published a very admirable paper upon this subject. In the American Quarterly Microscopical Journal for 1879, p. 287, the subject was again presented in a beautifully illustrated article by Mr. J. D. Hyatt, President of the New York Microscopical Society. I learn that Wolff has published a fully illustrated memoir on the anatomy of the honey-bee which, I regret to say, I have not seen. From Messrs. Chambers and Hyatt's papers, and my own researches and observations, I am able to present the following facts:

The mouth-parts of the honey-bee brought into requisition when the insect takes a liquid into its pharynx, are the maxillæ and the labium.

The maxillæ or second jaws (see *m x* in Fig 1, A) are situated each side of the labium. They are hinged to the head by the strong cardos (see *c c* in Fig. A) which are chitinous rods. Extending forward from the cardo is the more flattened stipes (see *st*, *st* in Fig. A) which is also mainly chitinous. From the stipes projects the triangular, deeply grooved lacinia (see *l*, *l* in Fig. 1, A). This is more membranous, but it is strengthened by a ridge of chitine which extends to the apex. At the base the very rudimentary maxillary palpi (see *mp*, *mp* in Fig. 1, A) are visible, while scattering hairs project from the inner margins. When the maxillæ are brought close together a tube is formed, which is continued by aid of a colorless membrane to the opening into the pharynx. This opening is beneath the labium and between the mandibles. The colorless membrane is continuous with the epipharynx. The muscles which move the maxillæ are attached mainly to the cardo and stipes.

The labium or lower lip of the worker honey-bee is from twenty-three to twenty-seven hundredths of an inch long. It consists of a central portion, and two pairs of appendages, the paraglossæ (see *p*, *p* in Fig. 1, A) and the labial palpi (see *k*, *k* in Fig. 1, A). The central portion is divided into a basal two-sevenths, or mentum (see *m* in Fig. A) and the terminal five-sevenths or ligula (see *t* in Fig. 1, A and B). The mentum is about seven-hundredths of an inch long. It is hinged to the sub-mentum (see *o* in Fig. 1, A) which in turn is hinged to the maxillæ by two chitinous rods (see *b*, *b* in Fig. 1, A). These rods permit free motion,

and to them are attached muscles, which in part affect the movement of the labium. The mentum is a flattened cylinder, the floor and sides of which are thick and opaque, because of the abundance of chitine contained in their structure. While lining this chitinous gutter and completing the tube is a thin colorless membrane, which is but the anterior prolongation of the pharynx. There also abundant muscles within the mentum which extend even for a short distance along the sides of the base of the tongue. These not only affect the motion of the whole labium, but also protrude and retract the ligula or tongue.

The ligula or tongue (Fig. 1, A and B, *t*) extends from the anterior extremity of the mentum. It consists of a sheath (Fig. B, *s*) which from the many rows of yellowish hairs appears annulated. When not distended, the sheath, as seen in cross-section (Fig. 1, C), is kidney-shaped. It has a slit (Fig. 1, C, *h*) along the under surface, from the base very near the end. In some specimens the slit seems to reach quite the end. Within the sheath is a small colored, triangular rod (Fig. 1, C, R) darker than the sheath, which except for a slit (Fig. 1, C, *h*) on its under surface, would form a tube Fig. 1, C, R); in fact the sides of the rod along the slit can be brought in such close contact as virtually to form a tube. Fine hairs project from the walls either side the slit (Fig. 1, C, *h*) into the tube, which doubtless aid in making the tube more perfect. Along the back of the rod is a conspicuous layer which Mr. Hyatt asserts is muscular. If this be so we can readily see how its action would spread the walls and open the slit. The rod projects beyond the sheath, as an imperfect funnel, the "button" of Reaumur (Fig. 1, A. and B, *f*). The wanting section of the funnel harmonizes with the slit in the rod. Near the end, the rod seems firmly attached to the sheath. Any attempt to draw the rod from this position is quite certain to rupture the sheath. The rod when extended projects from sixteen to eighteen-hundredths of an inch beyond the mentum. At the base the rod is colorless, and its tube connects above with the membranous sack next to be described, and through this with the tube of the mentum and with the pharynx.

Attached to the edges of the sheath, next to the slit, and possibly, as Mr. Chambers thinks, entirely lining the latter, and also to the corresponding edges of the tubular rod is a thin membrane (Fig. 1, C, *s*). Mr. Chambers thinks this passes over the slit in the rod, making the tube of the latter complete. I have reasons to

think he is mistaken, as will appear in the sequel. When not distended this membrane lies in folds (Fig. 1, C, *s*); but when distended it with the rod pushes out of the sheath, so as to form with the latter a large tubular sack (Fig. B S, *s*), with the tubular rod (Fig. C, R) along the surface opposite the sheath. At the base this sack has a chitinous support (Fig. A, Q Q), and connects through the tube of the mentum with the pharynx, and receives the tube of the rod. It extends nearly if not quite to the end of the sheath, certainly as far as the slit in the latter extends, and is, anteriorly, imperforate.

The labial palpi (Fig. 1, A, *k*, *k*) like the maxillæ, are deeply grooved, and when brought close together form a tube which also has a membranous connection with the mouth opening into the pharynx.

The paraglossæ are short, leaf-like organs (Fig. 1, A, *p*, *p*) with a hollow membranous base, which also connects with the tube of the mentum and the sack of the ligula.

When not in use the ligula, with the labial palpi and maxillæ, all double back under the head, and the tongue is so retracted that it extends no further than the labial palpi. This shortening of the ligula seems to be effected by drawing the more membranous and less hairy base into the mentum.

How do bees take liquids into their stomachs? This question, as we have seen, has received various answers. Some have thought that the nectar was drawn through a tube formed by the approximation of the ligula, the palpi and the maxillæ. Others that suction was the force and the tongue the tube. Still others have believed that the nectar was lapped up by the bees. I hope to be able to show you that all are right.

Look at the bee through a good lens (I have used Toll's one-half inch) while sipping honey containing grains of solid matter, and the fine particles will often be seen to ascend through the tube formed by bringing the maxillæ together. We have already seen how this liquid passes to the mouth and through this into the pharynx. Or we can color some rather thin honey or syrup by aniline (I have found deep red to be the best), and while the bee is sipping this colored liquid, which it does as eagerly as though the poisonous aliline were not present, cut off its head, which, with a pair of dissecting scissors is done in an instant. Examination plainly shows the track along the channeled maxillæ

and palpi, even to the mouth, which clearly reveals the path of the liquid. These conduits are much the larger approach to the pharynx; thus we see why bees take honey so fast when they can get freely at a large quantity, and why a few days of good basswood harvest are so fruitful.

Bees as surely take honey through the triangular rod which is enclosed within the sheath. I have proved this in several ways as follows:

I have placed honey in fine glass tubes and behind fine wire gauze, so that the bees could just reach it with the funnel at the end of the rod. So long as they could reach it with the funnel so long would it disappear. I have held the bee in my hand, by grasping the wings, while observing it with a good lens. I would gradually withdraw it from the drop of honey, which it would sip so long as the drop was within reach of the funnel. I have in such cases seen the red axis when the bee was sipping colored syrup. Subsequent examination by dissection revealed the red liquid still in the tube of the rod, clearly showing its course in passing to the pharynx. If we place the tongue with a drop of water on a glass slide and cover with a thin glass, and then look at it through the compound microscope, with a magnifying power of eighty diameters, we can readily see the liquid pass back and forth in the tube as we press with a pencil on the thin glass cover. As Mr. Chambers states, this tube at the base of the funnel is only one five-hundredth of an inch in diameter. We now understand why bees are so long in loading their stomachs when gathering from small tubular flowers, as then this minute tube is the only avenue by which the bee secures the nectar. We can also well understand why they gather so much faster from some flowers than from others. In the one case they secure the liquid sweet through both the channels above described, in the other, when the honey is scarce or deep down in small tubular flowers, they can only use this microscopic tube.

We also note the admirable construction of the tongue, which permits it to probe these tiny flowers, and also see the advantage of even a little additional length in this important and wonderful organ.

I also believe that bees lap up the honey. If we spread a thin layer of honey on a glass, and permit the bees to visit it, we shall see the bees wipe it up with their ligulæ. Fine drops dis-

appear even though the funnel does not touch them. From this observation, as well as the structure of the organ—if I am right in believing that the slit in the rod opens on the surface—we can but conclude that the slit in the rod, no less than the funnel, may be the door whereby liquids pass to the tube. If Mr. Hyatt is right in thinking that the dorsal band of the rod is muscular, we can readily see from its position and the form of the rod, how the slit might be opened. If the liquid is very thick the bees are seen frequently to retract the ligula and then extend it, as if to clear the organ by scraping it between the maxillæ and palpi.

While sipping honey the bee performs a kind of respiratory movement with the abdomen. This shows that the force of suction comes partly, if not wholly from the stomach, which organ is situated in the abdominal cavity. The tongue is also retracted and extended rythmically while the bee is sipping. The tip passes alternately back and forth from its greatest distance from the mentum to the end of the palpi. This movement may be something analogous to swallowing.

I am not certain as to the function of the membranous sack. I have found that if I killed a bee by compressing its thorax, very soon after it commenced to sip the colored liquid, that the latter was always in the stomach but not in the sack. If I waited longer I found the sack also partially filled. This leads me to conclude that it acts as a storehouse, enabling the bee to carry a load beyond the capacity of its stomach. It also appears glandular, when distended, so possibly it secretes an animal juice or ferment which aids in changing cane sugar into glucose or grape sugar; for we find upon analysis that pure cane sugar after passing through the stomach of the bee has partially undergone this transformation.

After the bees have sipped the colored liquid, I find invariably that the tip of the tongue—the small portion where the slit in the sheath seems obscure, and where the rod seems more firmly attached to the sheath, is highly colored, as though full of liquid. Possibly the sac does not extend into this portion, and the tube may be larger in this part. By a little pressure the liquid is made to pass out of this portion of the tube, either through the funnel or slit, perhaps both.

I have measured hundreds of tongues, under the microscope, with the camera lucida, and have been much interested to observe

the wondrous uniformity in length where the bees were from the same colony or from the same apiary, especially if close breeding had been practiced. Tongue after tongue would show a variation of less than .025 of an inch. I have found the length of the American black bee's tongue to average about .24 of an inch in length, from the base of the mentum to the tip of the ligula. American-bred Italian bees I have found, when measured by the same scale, to have tongues .02 of an inch longer. Some bees, said to be Cyprians, but closely resembling our black bees, except that the down on the thorax was a little more yellow, I have found to possess tongues a little shorter than those of our American Italians, though the average is but very little less. I have examined bees' tongues from workers reared from two different imported Italian queens, and found that in both cases they exceeded in length those of our American-bred bees, though the difference is very slight.

In 1878 I measured the tongues of some bees sent me for Cyprians. The bees were very yellow and beautiful. I found them to possess the longest tongues I have ever met, but there was very great variation. I had but few bees and sent for more, which never came. I had arranged the present season for bees of the various European races, and had been promised specimens, but greatly to my regret and disappointment, the bees have failed to come, so I have to make this but a partial report.

That the added length is of practical importance I have proved as follows: Honey in a vessel covered with fine gauze was placed before Italians till they ceased to eat because the honey was beyond reach. The vessel was then placed before black bees, which failed to reach the fluid. The vessel was then filled and given first to the black bees, which worked till the liquid was inaccessible, when it was placed before Italians. These would invariably commence to sip the honey. Again, a box one-half inch deep, without top or bottom, was covered with fine gauze having fifteen meshes to the inch. A glass was then placed in the box so inclined that while one end rested against the gauze the other was one-half inch from it. The glass was thinly spread with honey on the side next the gauze. This was placed in a hive of Italians, when the glass was cleaned of honey for a distance of twenty-four meshes from the edge where the glass rested on the gauze. The black bees could only reach and only

cleaned for nineteen meshes. Many trials gave the same result. This then shows why Italians can gather, and often do collect from flowers which fail utterly to attract the black bees. The nectar is beyond their reach.

It would seem from the above that American-bred bees have shorter tongues than those direct from Italy. It seems very probable that "natural selection," the very law which raised the Italians to their position of superiority, also gave to them their longer tongues. Shut up in their mountain home, a mere isolated basin, where competition must have been very excessive, nature took advantage of every favorable variation and developed those striking excellences peculiar to the Italian. During these ages there was no kindly bee-master possessed of the intelligence sufficient to nurse the weaklings, nor any "Dollar Queen business" to stimulate indiscriminate breeding, and the weak died victims to starvation. And so we are indebted to the stern, inexorable law of nature for the incomparable breeding which wrought out such admirable results in far-famed Liguria. Unquestionably the crowded apiaries of Austria and Germany have heightened the "struggle for life," and had a similar tendency to develop superior excellence in the European black bees. It is more than probable that the German bees of crowded Europe have longer tongues and are generally superior to the same in America, where they have long been favored with broad floral areas and comparative absence of competition. I should expect that this very law might have developed varieties of the black race which are superior to others of the same race. It is more than possible that "survival of the fittest" explains the origin of the superior varieties which are said to exist in various provinces of Europe. For the same reason we should surely expect superior excellence in the Cyprian bees. Crowded as they have been for long years or ages in their small island home, the principle of "survival of the fittest" must have been working powerfully to weed out the inferior and to preserve and make stronger the superior. And so the great poet has well said: "Sweet are the uses of adversity."

From the above considerations it seems obvious, that would we perpetuate the excellencies given us by the skillful breeding of nature, though we may not destroy all the feeble, as nature has done, we must assuredly study and observe so closely, that we shall know of a surety which are our very superior queens, and be even

more careful to breed from no other. Whether care or carelessness will be most promoted by our present system I leave for you to say. But I do wish that we might have at least a few breeders with time, means, caution, skill and patience, who would work with earnest zeal to not only keep all the excellence we now have, but to augment this excellence, as I am sure it may be augmented.

But if our cheap queen system is to continue, then, surely, we may well stimulate frequent importations from Italy and Cyprus, and thus hope to compensate in part for what will be lost by hasty, careless and indiscriminate breeding.—*American Bee Journal.*

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RECENT LITERATURE.

BREHM'S ANIMAL LIFE.[1]—This volume treats of the fishes, and is smaller than the others of the series. Beginning with the Dipnoans, the larger part of the space is devoted to the bony fishes, closing with the Selachians, the Cyclostomata and Amphioxus. The style is highly popular, as few anatomical details are given, but the text is taken up with very general accounts of the natural history of the more interesting species, with popularized illustrations in wood and full-page copper plates. In the preliminary glance at the life of fishes in general, their structure and physiology, habitats, distribution, habits and mode of development are, as well as fisheries and fish culture, briefly discussed. The Dipnoans are too briefly disposed of, only the Protopterus or lung-fish of Africa being figured and described; nothing is said of the Australian lung-fish (Ceratodus), nor of the relations of the Dipnoans to their mesozoic ancestors. The opportunity of working up a fresh and attractive account of the most interesting group of fishes in existence is not taken, and this part is nearly twenty years behind the times. The bony fishes are finely illustrated, the drawings of the eel, lump-fish and goose-fish, for example, being particularly good. We should have liked to have learned more of the singular breeding habits of the sea-horse; as to the garpike the reader is left in ignorance of its breeding habits so well known in this country, and the ganoids are too briefly treated; Ammocœtes is still regarded as an adult fish, though well known to be simply a young lamprey. On the whole, however, the volume is interesting and attractive, and so rich in good illustrations as to be of considerable value to the naturalist.

[1] *Brehm's Thierleben.* Achte Band. Die Fische. Von Dr. A. E. BREHM. 114 cuts and 11 plates. Leipzig, 1879. 8°, pp. 426. For sale by B. Westermann & Co., New York.