into a space completely encircling the tip of the bulbus. Through the septa the parenchym surrounding the ductus meets with that of the bulbus proper.

This complexity of structure can of course only be clearly exhibited by drawings.

I shall make mention of only one more organ—namely the vitellaria which consist of a longitudinal canal on each side of the intestine from whose sides pass off numerous short ducts, the necks of the flask-shaped follicles: about two thirds of its length from the anterior end each longitudinal canal bends downwards and gives off the transverse canals figured by Voeltzkow and which unite at the vitelline sac to form the unpaired vitelline duct.

## 4. On the Conjugation of Cambarus.

By E. A. Andrews, Baltimore.

eingeg. 7. Mai 1895.

Some observations upon the breeding habits of *Cambarus affinis* show that there are important differences between the American crayfish, *Cambarus*, and the European crayfish *Astacus* and that certain structures hitherto known only as specific and generic characters are necessary accessory reproductive organs.

1) When kept in confinement *Cambarus affinis* conjugated in November and in February, March and April.

2) The process lasts several hours.

3) The male exhibits great skill and persistency and is visibly excited throughout the process while the female is from the first passive and inert and shows scarcely any evidence of excitement.

4) The sperm is introduced into the cavity in the **annulus,** which thus serves as a sperm receptacle as in the lobster, *Homarus americanus*, as described by Professor Bumpus (Journal of Morphology, V. 1891.)

5) The well known hook on the ischiopodite of the third walking leg of the male is used in the process of conjugation to firmly attach the male to the female. The tip of the hook depresses the membrane between the coxopodite and the basiopodite of the fourth walking leg of the female and the hook catches firmly against a stiff ridge on the basiopodite.

6) The sperm is conveyed down the groove of the stylet or first pleopod of the male from the penis-like everted end of the vas deferens into the cavity of the annulus of the female. The annulus becomes filled and a plug of sperm and protective secretion projects from its orifice after conjugation.

7) At a definite stage in the process the male always passes either the right or the left fifth, or last, walking leg across under his thorax so that it projects horizontally from the other side. This limb then holds the first and second male pleopods, the intromittent apparatus, depressed at an angle of more than forty-five degrees from the ventral surface of the male and thus ensures their entrance into the annulus when the male moves forward over the female.

8) During the process the ventral sides of the two animals are closely applied to one another and the abdomen of the male partly encloses the abdomen of the female. The latter lies in the back or partly on one side and is firmly held by both large chelae of the male which grasp all the chelate appendages of the female.

9) There is no wide distribution of sperm as has been described for *Astacus*: it is all placed in the annulus. The oviducts of the female are not concerned in the process of conjugation.

Since the sperm rapidly disintegrates when removed from the protecting secretion that envelops it in spermatophore like masses and the male organs in this species are so nicely adjusted to convey it to the annulus, we may assume that the different forms the annulus presents in different species may be correlated with the well known differences in the male organs so that in all the sperm is placed in a protected cavity by tools that will not operate in other species thereby tending to maintain specific distinctness.

During the process of conjugation the small pleopods of the first abdominal segment of the female lie with their tips near the annulus and the male intramittent organs. As they tend to disappear or are quite lost in *Astacus*, where no such carefully adjusted process of sperm-transfer takes place, we may suppose that in *Cambarus* they function as sense organs to assist in the more accurate adjustment of the male and female organs.

In the one case in which eggs were laid in captivity the nervous system of the female was very irritable for several days. During this time by assiduous labour with both of the fifth walking legs she carefully removed all foreign matter from the ventral surface of the abdomen and from the pleopods.

The sperm plug remained in the annulus for two days after the eggs were laid and then disappeared. It was probably removed by the female. The process was, however, abnormal and the eggs did not develop.

Johns Hopkins University, Baltimore Md., U.S.A.