it covers, and as to the way in which it covers it.

It may be doubted whether the review in question performs this function. It leaves the impression that the book reviewed is, on the whole, a pretty poor sort of book, when it is really an excellent one. It is not beyond criticism—no book is. The reviewer indicates some of the weak points, and seems to regard as weaknesses several of the strong features. A number of the criticisms might be appropriate if the book were intended primarily as a reference work, but they hardly seem applicable to a book which is intended as a text-book for beginners. An excellent text-book is not necessarily the best book for reference. The classification of subject matter for ideal books of the two types would be, in many respects, very different. In a text-book, it is certainly no weakness that one must 'go to three or four separate parts of the book' 'to learn about sandstones,' though this might be a weakness in a book of reference. The reviewer's attitude leads one to suspect that he uses books for reference only, not as texts, and that this has influenced his point of view.

In spite of the reviewer's statement, the diagrams of the book are, on the whole, excellent and readily understood, and the notes and questions which accompany them are to be especially commended.

The criticism that the book is largely physiographic is nothing against it, and when we remember the class of pupils for whom the book is intended—high-school pupils—the absence of 'references to other books' is certainly much less serious than the reviewer seems to think.

The statement that 'the bog ore, silicious and phosphatic deposits that get a brief mention in Le Conte are not here referred to' leads one to make the further suggestion that a book should be carefully read before detailed criticism of this sort is indulged in, for bog ore is mentioned on page 53 and silicious deposits on pages 52, 178 and 261. Other similar criticisms of the reviewer might be cited. The omission of such subjects as phosphatic deposits is to be commended in a book of this type, for it must be remembered that most elementary books treat of too many, not too few, topics. In the writer's judgment the book takes rank at once among the best of the elementary text-books on geology.

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SPECIAL ARTICLES

THE SIGNIFICANCE OF THE GRASPING ANTENNÆ OF HARPACTICOID COPEPODS

THE character of the secondary sexual differentiation of the first pair of antennæ of male free-swimming Copepoda and the associated manner of copulation divide these copepods into two well-marked groups: one group in which only one antenna forms a grasping organ and in which the act of copulation is relatively short; and a second group in which both antennæ are grasping organs by which the male holds the female for a long time in copula. The duration of this union is shown by two records: one of an apparently normal pair of *Harpacticus uniremis* which remained in copula at least twenty-nine and possibly thirty-eight hours; another of a pair of undetermined genus which remained in copula eight days, at the end of which both male and female died. The persistence of the male is shown by the fact that he can be torn apart, but still maintains his hold until the paralysis of death frees the female. Claus[1] observed that the males of the Peltidiæ were found in copula with females one molt from maturity and speculated upon the meaning of the phenomenon without arriving at a satisfactory conclusion.

During the spring of 1906, a large number of copulating pairs of *Harpacticus uniremis* and *Tachidius littoralis* appeared in the tow taken in Narragansett Bay and a number of pairs were separated in watch glasses for observation. We were fortunate in examining a pair of the first species just when the female was beginning to molt. The ecdysis occupied about five minutes and as the slough came away, the male, which had been holding the female by the hinder edge of the carapace,

[1] Claus, C., 'Die freilebenden Copepoden,' Leipzig, 1863, p. 71.

dropped the cast and grasped the female between the abdomen and thorax, and, moving around from the dorsal surface of the female, deposited the spermatophore in its place upon the genital segment. He then freed the female and made no attempt to renew his hold. In six days the female produced eggs which hatched in seven days.

Despite a great deal of effort, we have never again been able to observe the molt and subsequent copulation, but we have complete evidence that, in three species of two genera (*Harpacticus uniremis, H. gracilis* and *Tachidius littoralis*), the spermatophore is never attached before the female molts, and that, in every case, the male holds the female until she molts. Whenever a normal pair, left a short time before in copula, were found separated, careful examination revealed the cast of the female in the watch glass and a spermatophore attached to the female. In other words, every successful copulation must be prolonged until the female molts.

The longest period in copula observed with a successful issue was between twenty-nine and thirty-nine hours. In two cases the female died in molt, an antenna and a furcal bristle respectively being caught in the cast. In several instances the male, the female, or both died before the molt, probably because of the abnormal conditions of the experiments. In one case the male of a copulating pair was killed and, after the female had molted, another male was introduced, but no copulation took place.

These observations are by no means the first of this character, for there is a general impression among students of Crustacea that ecdysis and copulation or ovulation are closely connected processes. There is evidence that copulation follows a molt of the female in several crabs[2] and in the isopod Gnathia.[3] There is also evidence that ovulation follows the molt in some isopods and amphipods.[4] Finally, Della Valle[5] finds that the male of *Gammarus pungens* holds the female until she molts, assists in freeing her from the cast, and then deposits the sperm.

The males of Amphipoda, Isopoda, *Artemia* and related Phyllopoda, *Limulus,* and of the Copepoda of the group under discussion all have the same habit of carrying or holding the female and all have structures modified for this purpose. Hence, it is possible—it is even probable—that this habit and these structures indicate that, in these forms, the female must molt before fertilization can be accomplished.

Our attempts to find the meaning of this presumably general habit of the Crustacea mentioned have been unsuccessful, but we believe that the softened condition of the shell may be necessary for the attachment of the spermatophore or the extrusion of the eggs.

Leonard W. Williams

[2] See Herrick, F. H., 'American Lobster,' Fish, Comm. Bull., 1895, p. 39. Williamson, H. C., 'Contributions to the Life History of the Edible Crab, *Cancer pagurus*,' Rep. Fish. Board, Scotland, V., 22, 1904. Barnes, E. W., 'Natural History of the Paddler Crab, Callinectes hastatus,' 34th Report Comm. Inland Fisheries of Rhode Island, p. 69, 1904.

[3] Smith, G., 'Metamorphosis and Life History of *Gnathia maxillaris*,' *Mitt. Zool. St. Neapel,* XVI., pp. 469–471, 1904.

[4] Langenbeck, C., 'Formation of the Germ Layers in the Amphipod *Microdentopus gryllotalpa*,' *Jour. Morphology,* XIV., p. 303. See also Korschelt & Heider, 'Text-book of Embryology' (English translation), Vol. II., p. 105.

[5] Della Valle, A., 'Gammarini del Golfes von Napoli,' Fauna and flora des golfes von Neapel, 20, p. 276, 1893.

BLOWING SPRINGS AND WELLS OF GEORGIA, WITH AN EXPLANATION OF THE PHENOMENA[1]

The blowing springs and wells of Georgia may be divided, for convenience of description, into two classes, namely, those in which the air passes inward for a time and after a short period of quiescence reverses its course, and those in which the quantity of the air is constant and moves in one direction only. One of the best illustrations of the former class of springs is the Grant Blowing Spring, near Chattanooga, Tennessee, a description of which is as follows:

The Grant Blowing Spring is located at the base of Lookout Mountain near the Georgia-Tennessee state line about three miles from the corporate limits of Chattanooga. The

[1] By permission of the state geologist.