have not made haustorial connections with the host roots. The slowly developing seedlings remained alive for several weeks in the initial purine solutions. Seedlings stimulated by, and left in contact with, the natural stimulant solution did not develop enlarged cotyledons or undergo elongation of the shoot apex (*8*).

A. D. WORSHAM
Department of Field Crops, North Carolina State College, Raleigh
D. E. MORELAND
Agricultural Research Service, U.S. Department of Agriculture
G. C. KLINGMAN
Department of Field Crops, North Carolina State College

References and Notes

1. R. Brown and M. Edwards, *Ann. Botany* **8**, 131 (1944); C. Fuller, *Agr. J. Union S. Africa* **1**, 684 (1911); H. H. W. Pearson, *ibid.* **3**, 651 (1912); A. R. Saunders, *Union S. Africa Dept. Agr. Sci. Bull.* **128**, (1933); K. B. Vallance, *Ann. Botany* **14**, 347 (1950).
2. R. Brown *et al.*, *Proc. Roy. Soc. (London)* **B136**, 1 (1949); ———, *Biochem. J.* **50**, 596 (1952); A. R. Lansdown, *Univ. of Cambridge Abstr. Diss.* (1953–54), p. 234; A. G. Long, *ibid.* (1952–53), p. 202; G. J. Tyler, *ibid.*, p. 213.
3. The kinetin used in this study was purchased from Nutritional Biochemicals Corp., Cleveland, O.
4. The other 6-substituted purines were generously supplied by Charles G. Skinner of the University of Texas, Austin, and by Parke, Davis and Co., Detroit, Mich.
5. C. G. Skinner and W. Shive, *Arch. Biochem. Biophys.* **65**, 567 (1956); *Plant Physiol.* **32**, 117 (1957).
6. F. M. Strong, *Topics in Microbial Chemistry* (Wiley, New York, 1958).
7. C. O. Miller, *Plant Physiol.* **31**, 318 (1956); *ibid.* **33**, 115 (1958).
8. These studies were cooperative investigations of the North Carolina Agricultural Experiment Station and the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture. This report is published with the approval of the North Carolina Agricultural Experiment Station as paper No. 1066.

30 July 1959

New Permian Insects Discovered in Kansas and Oklahoma

Abstract. The Midco insect bed of Oklahoma and a newly discovered insect bed above this were traced across Kay County, Okla., into Sumner County, Kan. As a result, a greater time span is available for study of insect evolution during the mid-continent Permian, and the exact stratigraphic correlation of the Wellington of Oklahoma and Kansas can now be demonstrated. Four insect orders have thus far been identified from the new insect bed: Protodonata, Odonata, Protoperlaria, and Ephemeroptera. Numerous new species and higher categories are included in the collections from the two insect beds.

In 1939 the famous Midco insect bed (Permian, Leonardian, Wellington formation) of Noble County, Okla., was discovered by G. O. Raasch (*1*) and subsequently explored by Raasch and F. M. Carpenter (*2*). Slightly northwest of a locality in southern Kay County where Raasch had previously reported no insects, Tasch, aided by his assistant, Bernard Shaffer, found insects in the Midco bed. In addition, some 8 ft above the Midco, a new insect bed was discovered (NW-SW, sec. 31, T 25 N, R 1 W).

The Midco insect bed and the new insect occurrence above it were both traced to northern Kay County (NE-NW and also SE-NE, sec. 23, T 28 N, R 28 W), where an excellently preserved insect fauna was found. At this locality algal beds occur respectively below and above the two insect beds. Equivalent algal beds were traced to Sumner County, Kan. (SE-SW, sec. 11, T 35 S, R 1 W). Insects were found associated with the upper algal bed.

This is the first stratigraphically related correlation of the Oklahoma and Kansas Wellington formation. As a result, dozens of fossil conchostracan beds that Tasch found in the Oklahoma Wellington can be related to those discovered in Kansas. This, in turn, provides the necessary stratigraphic basis for study of evolutionary changes in Permian conchostracans.

Previous work by Tasch in Kansas (*3*) established that there were two distinct insect beds: the well-known Carlton insect bed of Dunbar in Dickinson County and one below it in Marion, Harvey, and Sedgwick counties. The Midco insect bed and the newly discovered insect bed above it are stratigraphically above (that is, geologically younger than) the two insect beds of Kansas. Thus, four distinct insect beds are now known for the mid-continent Wellington formation.

Fossil Permian insects belonging to the following orders and families have been identified by Zimmerman, who is doing the insect systematics for this project.

Southern Kay County, Okla. Upper insect bed, 8 ft above the Midco: Protodonata; Odonata, Protozygoptera, Kennedyidae, *Kennedya* sp.; Protoperlaria, Lemmatophoridae.

Northern Kay County, Okla. Upper insect bed, 9.9 ft above the Midco: Ephemeroptera. Mideo: (extinct orders) Protodonata, Megasecoptera, Protelytroptera, Protoperlaria, Protorthoptera; (living orders) Ephemeroptera, Odonata, Blattaria, Corrodentia, Homoptera, Neuroptera, Mecoptera.

South Haven, Sumner County, Kan. Upper algal-insect bed, 9.3 ft above the Midco equivalent: Megasecoptera.

These findings are of unusual interest. Our knowledge of insect speciation and evolutionary trends during the American Permian had previously been limited to data from two beds: Midco and Carlton. Extension of the vertical range of Leonardian insects—above the Midco and below the Carlton—enlarges the geologic time span through which they may now be studied (*4*).

PAUL TASCH
Department of Geology, University of Wichita, Wichita, Kansas
JAMES R. ZIMMERMAN
Department of Biology, Indiana Central College, Indianapolis

References and Notes

1. G. O. Raasch, thesis, University of Wisconsin (1946).
2. F. M. Carpenter, *Proc. Am. Acad. Arts Sci.* **76**, 25 (1947).
3. P. Tasch, "Stratigraphic position of the Wellington conchostracan-bearing beds in Kansas," *Abstr. AAPG-SEPM Program, Dallas meeting* (1959), p. 60.
4. This research was supported by National Science Foundation grants Nos. G-7320 and G-4150.

31 August 1959

All-Female Strains of the Teleost Fishes of the Genus Poeciliopsis

Abstract. In addition to the viviparous fish *Mollienesia formosa*, two other species of poeciliids have recently been found to produce only female offspring. The young of these females, however, unlike those of *M. formosa*, inherit characteristics from any one of the several species of males used in experimental matings.

Self-perpetuating populations of unisexual vertebrates have been experimentally demonstrated only among the viviparous fishes of the New World family Poeciliidae—of which the guppy

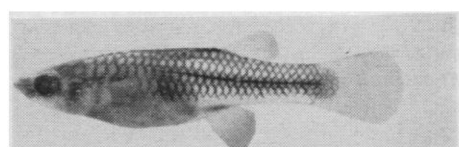

Fig. 1. Mating a clear-fin, all-female strain of species C (top) to a spot-fin male of species F (middle) results in spot-fin, all-female offspring (bottom); this demonstrates that, unlike the finding for *Mollienesia formosa*, characters of the male are transmitted to the all-female hybrids.

(*Lebistes reticulatus*) is perhaps the most widely known representative. Nearly 30 years ago Hubbs and Hubbs (*1*) announced the discovery of a remarkable fish which has only one sex. This is the so-called Amazon molly (*Mollienesia formosa*), which inhabits coastal and inland waters of northeastern Mexico and adjacent Texas. These females are able to maintain themselves as natural populations by utilizing the males of *M. sphenops* in certain parts of their range and the males of *M. latipinna* in others. Fourteen years of experimental work has demonstrated that this species, evidently of hybrid origin, produces daughters only, and that these are invariably like their mothers despite the fact that the mothers were mated with the males of many related species, including even the guppy. Development is clearly induced by sperm, though no evidence of paternal inheritance has been found in resulting generations. These authors subsequently concluded (*2*) that "the most plausible explanation for the genetic behavior of *Mollienesia formosa* is that this unisexual species is a permanently fixed diploid," and that active sperm is essential to initiate embryonic development (gynogenesis).

Recently Hubbs, Drewry, and Warburton (*3*) reported the discovery of what they interpreted as a naturally occurring phenotypic male of *M. formosa* in a population of this species taken near Brownsville, Tex. We and others (*4*) feel, however, that it is quite possible that *M. sphenops* is occasionally liberated near Brownsville by aquarists or tropical-fish fanciers, or that it may occur there naturally on occasion. If so, the "male of *M. formosa*" may actually be a hybrid between *sphenops* and *latipinna*, which readily cross in aquaria and produce bisexual offspring. Only experimental evidence can reveal the correct explanation.

At this time we wish to announce the discovery of unisexual types in two other species belonging to the same family as *M. formosa*. These, members of the genus *Poeciliopsis*, inhabit coastal streams of northwestern Mexico. Unlike the Amazon molly, these two allopatric species each have two kinds of females —those which produce both sexes and those which, although mated to the same male as the former, produce daughters only. Four generations of these fishes have been reared in the laboratory, with consistent production of bisexual young from the "normal" females and of unisexual offspring from the "aberrant" females.

The "all-female" strains of the two species of *Poeciliopsis* (here referred to as *F* and *C*) were discovered by chance, since they are virtually indistinguishable from the normal females. A slight but consistent difference in dentition noted in preserved specimens first revealed the existence of two types of females in F and subsequently led to the studies now in progress (*5*). On similar grounds, the unisexual strain of C was later predicted and its occurrence has recently been verified.

Although the genetic explanation of these remarkable strains is not yet clear, sufficient data have accumulated to indicate that this all-female condition is not the result of (i) a sex-linked lethal, (ii) parthenogenesis, (iii) gynogenesis, (iv) cytoplasmic inheritance, or (v) sex reversal. We have established on the basis of genetical evidence that these fish have sex chromosomes and that, unlike most other viviparous fishes, the female is heterogametic and the male homogametic. Using marker genes, we have been able to show that paternal traits of the male of F are transmitted through the all-female of C to the F_1 hybrid (Fig. 1).

These unisexual strains are of interest as possibly representing a transitional stage in the development of an all-female form like that of *M. formosa*.

ROBERT RUSH MILLER
R. JACK SCHULTZ

Museum of Zoology,
University of Michigan, Ann Arbor

References and Notes

1. C. L. Hubbs and L. C. Hubbs, *Science* **76**, 628 (1932).
2. ———, *Records Genet. Soc. Am.* **14**, 48 (1946).
3. C. L. Hubbs, G. E. Drewry, B. Warburton, *Science* **129**, 1227 (1959).
4. C. Hubbs, personal communication, 1958; C. P. Haskins, personal communication, 1959.
5. Since 1955 these studies have been supported by grants from the Horace H. Rackham School of Graduate Studies, University of Michigan, and, since 1958, by a grant from the National Science Foundation (NSF G-4854).

6 August 1959

Wave-Riding Dolphins

I wish to take issue with P. F. Scholander (*1*) on the problem of how dolphins ride waves (*2*). The problem of wave-riding dolphins was posed by Woodcock (*3*) and by Woodcock and McBride (*4*), who estimated the hydrodynamics of a dolphin riding a wave propelled by its own weight times the angle (in radians) of the wave. Woodcock and McBride showed that with a reasonable estimate of the hydrodynamic drag, the submerged weight of the dolphin was insufficient to provide the necessary balancing thrust. I resolved the problem by showing that it is the total weight of the dolphin, rather than its submerged weight, which is significant in wave riding.

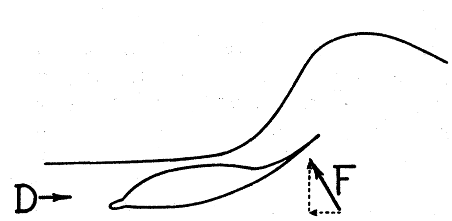

Fig. 1. Forces on the dolphin in Scholander's model.

Scholander has rejected my explanation and has substituted an explanation of his own for the phenomenon. In my opinion Scholander has discarded a satisfactory and rational explanation to substitute one which violates fundamental physical laws.

Scholander's criticism of my explanation (*5*) appears to involve some lack of understanding of this explanation. In the critical part of his discussion of it Scholander confuses the concepts of acceleration and velocity. Here I must admit that my earlier article was written in quite a terse style. Though the article states the argument completely, it includes little expositional detail and might be fully convincing only to a theoretical hydrodynamicist willing to supply this detail. The conclusions of the article are nonetheless sound: A streamlined body in a steady incompressible flow does experience a force very nearly equal to its volume times minus the average ambient pressure gradient in the flow field. This effect provides the dolphin with a net forward thrust approximately equal to its displaced weight times the wave angle. Scholander admits that his experiments testing this effect do not represent a fair evaluation, and he gives but little description of them.

The principle of a hydrodynamic force proportional to the ambient pressure gradient is an old one and plays a part in classical aerodynamics. [See, in particular, the work of Taylor (*6*).] Taylor's paper gives not only a thorough theoretical treatment but also a description of experimental verification of the basic effect. The additional induced mass over the displaced mass is small for a slender body, and was neglected in my earlier article (*5*).

Scholander's alternative explanation is based upon a model, in which the dolphin derives a large upward force *F* on its tail fluke (see Fig. 1). The tail fluke is in a part of the wave in which the water is rising, with the result that the upward force has an appreciable forward component which balances the drag on the dolphin. So far, Scholander's model is satisfactory. The difficulty lies in the fact that both horizontal and vertical components of the forces on the dolphin must balance, and so must the