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# INTERSPECIFIC VARIATION OF PHOSPHOGLYCERATE KINASE IN DROSOPHILA

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**Abstract**—1. The phosphoglycerate kinase electrophoretic banding patterns of several Drosophila species were studied.

2. Three banding types were noted: A type with a slowly migrating band of activity, a type with a faster migrating band of activity, and a type with an intermediate migrating band.

3. These banding types appeared to be species specific and may be useful in evolutionary or taxonomical studies.

## INTRODUCTION

THERE has been much recent interest in the enzyme phosphoglycerate kinase [E.C. 1.1.1.95]. Much effort has been devoted to defining its regulatory and functional roles in glycolysis. However, major recent interest has arisen from the observation demonstrating that the gene determining phosphoglycerate kinase is X-linked in mammals (Valentine *et al.*, 1969; Cooper *et al.*, 1971; Meera Khan *et al.*, 1971). Polymorphisms have been demonstrated in phosphoglycerate kinase electrophoretic banding patterns in kangaroos (Cooper *et al.*, 1971; Vandeberg, Cooper, & Sherman, 1973), and in a human population from New Guinea (Chen *et al.*, 1971). However in most human samplings the enzyme has been rather monomorphic except for rare variants (Beutler, 1969; Chen *et al.*, 1971; Chen & Giblett, 1972). Ritter & Schmitt (1974) have recently demonstrated an interspecific variability in this enzyme in the primate order. We have noted a similar interspecific variability within the Drosophila genus and will report on this in this paper.

## MATERIALS AND METHODS

*Drosophila sources.* Drosophila species were kindly provided by several persons. In most cases the species were laboratory stocks cultured in small bottles and might therefore not show the same variability as the original wild populations. The one exception was a cage population of *D. melanogaster* which was initiated with 26 pregnant females collected in Ann Arbor. This population could fairly accurately represent the Ann Arbor natural population in major phenotypes and genotypes. Samples of *D. willistoni, D. nebulosa, D. simulans, D. pseudoobscura CH, D. pseudoobscura AR, D. virilis, D. americana, D. americana-texana, D. novamexicana,* and *D. mercaptorum* were provided by T. M. Riziki of the University of Michigan. S. Sluss and W. R. Heed of the University of Arizona provided the *D. nannoptera, D. acanthoptera,* and *D. cardini.* Samples of *D. melanogaster, D. persimilis, D. affinis, D. hydei, D. robusta, D. immigrans, D. pseudoobscura,* and *D. buskii* were provided by G. Hooper of Marist College. H. J. Barr of the University of Illinois provided samples of *D. simulans yw, D. virilis, D. hydei, D. melanopola, D. fulvimaculoides,* and *D. tuniditarsus.* B. Cort of Washington University provided *D. virilis, D. melanica, D. paramelanica, D. melanissima, D. euronotus,* and *D. multispina.* Finally, D. D. Miller of the University of Nebraska supplied *D. affinis, D. algonquin, D. athabasca* (eastern), *D. athabasca* (western), *D. azteca, D. narragansett,* and *D. tolteca.*

*Electrophoresis and staining.* Starch gels were prepared and run for 4 hr using the pH 7 histidine gel and citrate buffer system and electrophoretic set up described by Brewer (1970) for pyruvate kinase. Individual flies were extracted by grinding them with a glass rod in a test tube containing a few drops of the histidine buffer. The resultant extract was then placed in the appropriate gel slot and subjected to electrophoresis. At the end of the run the gel was sliced and stained for phosphoglycerate kinase as described by Oelshlegel & Brewer (1972). (There is an error in the original publication; for the ATP detection system, the concentration of $MgCl_2$ is 0·011M, of G6PD is 0·5 mg/100 ml and HK is 0·1 mg/100 ml).

## RESULTS AND DISCUSSION

Three basic banding patterns were noted in our study. Some Drosophila species had a phosphoglycerate kinase which migrated relatively slowly (about 2 cm from the origin and called an "S" band for our purposes), one species (*D. multispina*) had a phosphoglycerate kinase with a relatively fast migration (about 3·5 cm from the origin and called an "F" band), while the remaining species had a phosphoglycerate kinase with a band of intermediate mobility (I). In addition to a major phosphoglycerate kinase band, all three banding types had a minor band slightly ahead and a minor band slightly behind the major band. None of these

bands stained in the adenylate kinase system (Oelshlegel & Brewer, 1972).

Table 1 lists the Drosophila species we studied along with the banding types we found. Also listed are the number of individuals studied within each species. There seems to be little relation of gel phenotype type to geographical area of sampling. However, an inspection of the data does indicate that there is a species specificity in phosphoglycerate kinase gel banding patterns. Such specificity could be utilized in evolutionary or taxonomical studies. There seems to be a tendency for species within a group to have the same phosphoglycerate kinase phenotype although there are exceptions. Because of the laboratory stock nature and small numbers of the species we studied, no statements can be made about the degree of polymorphisms within a species. As mentioned, a phosphoglycerate kinase polymorphism has been found in a natural population

Table 1. Phosphoglycerate kinase electrophoretic banding patterns of several species of Drosophila

| Species | | Original collection site* | Band type | No. analyzed |
|---|---|---|---|---|
| Sophophora Subgenera | | | | |
| willistoni group | *D. willistoni* | Icana, Brazil | I | 9 |
| | *D. nebulosa* | Belem, Brazil | I | 16 |
| nannoptera group | *D. nannoptera* | Oxaca, Mexico | I | 3 |
| melanogaster group | *D. melanogaster* | Ann Arbor, Michigan | I | 225 |
| | *D. melanogaster* | Hyde Park, New York | I | 2 |
| | *D. simulans* | Missouri | I | 17 |
| | *D. simulans yw* | — | I | 28 |
| obscura group | *D. pseudoobscura CH* | — | S | 9 |
| | *D. pseudoobscura AR* | — | S | 9 |
| | *D. pseudoobscura* | Pine, Arizona | S | 1 |
| | *D. persimilis* | Yosemite, California | S | 5 |
| | *D. affinis* | Grand Rapids, Minnesota | I | 9 |
| | *D. affinis* | Hyde Park, New York | I | 6 |
| | *D. algonquin* | Halstad, Minnesota | S | 3 |
| | *D. athabasca* (east) | L. Shaintheau, Minnesota | S | 1 |
| | *D. athabasca* (west) | Eugene, Oregon | S | 1 |
| | *D. azteca* | Chilpancihgo, Mexico | I | 1 |
| | *D. narragansett* | Bastrop Pk. Texas | S | 1 |
| | *D. tolteca* | Medellin, Colombia | S | 1 |
| Sordophila Subgenera | | | | |
| | *D. acanthoptera* | Oxaca, Mexico | I | 4 |
| Drosophila Subgenera | | | | |
| virilis group | *D. virilis* | Dexalucan, Texas | S | 36 |
| | *D. virilis* | — | S | 4 |
| | *D. virilis* | Texmelican, Texas | S | 1 |
| | *D. americana* | Anderson, Texas | S | 9 |
| | *D. americana-texana* | New Orleans, Texas | S | 46 |
| | *D. novamexicana* | Texas | S | 10 |
| repleta group | *D. mercaptorum* | — | S | 24 |
| | *D. hydei* | — | S | 7 |
| | *D. hydei* | Hyde Park, New York | S | 3 |
| | *D. melanopola* | — | I | 4 |
| | *D. fulvimaculoides* | — | I | 3 |
| robusta group | *D. robusta* | Princeton, New Jersey | I | 14 |
| immigrans group | *D. immigrans* | Hyde Park, New York | I | 3 |
| melanica group | *D. melanica* | St. Louis, Missouri | I | 7 |
| | *D. paramelanica* | St. Louis, Missouri | I | 1 |
| | *D. melanissima* | Columbia, South Carolina | I | 2 |
| | *D. euronotus* | St. Louis, Missouri | I | 1 |
| cardini group | *D. cardini* | Duaca, Venezuela | I | 3 |
| funebris group | *D. multispina* | Sapporo Forest, Japan | F | 13 |
| Drosophila Subgenera | | | | |
| | *D. buskii* | Princeton, New Jersey | I | 5 |
| Other | | | | |
| | *D. tuniditarsus* | — | I | 3 |

* In some cases original collection site not known or only incompletely known and is listed accordingly.

of *D. melanogaster* (Chew & Cooper, 1973). Three phosphoglycerate kinase alleles were found based on gel mobility; $Pgk^3$ with a gene frequency of 0·97, $Pgk^2$ of 0·01, and $Pgk^1$ of 0·01. A $Pgk^2$–$Pgk^3$ polymorphism also was found in a laboratory stock of *P. hydei*. No polymorphisms were found in a natural population of *D. simulans* and one of *D. immigrans*. From the Ann Arbor *D. melanogaster* population we studied it can be concluded that if a polymorphism exists in this population the minor alleles are not common. Our gel band types can not be compared to those of Chew & Cooper since electrophoretic conditions differ in the two studies.

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*Key Word Index*—Drosophila; phosphoglycerate kinase.