THE USE OF DROSOPHILA MELANOGASTER FOR IN SITU BIOmonitorING

Lawrence G. Harshman
Department of Entomology and
Department of Genetics
University of California
Davis, California 95616
Bruce D. Hammock
Burroughs Wellcome Toxicology Scholar
Department of Entomology and
Department of Environmental Toxicology
University of California
Davis, California 95616

INTRODUCTION

Drosophila melanogaster was the principal organism used for the development of diploid transmission genetics at the beginning of the century and more recently has been the subject of pivotal studies on eucryptic gene regulation, development, and behavior. D. melanogaster is potentially valuable in situ bio-monitoring because it is convenient to test different life stages, it can be used for a multi-faceted analysis of environmental genotoxins and a rapidly expanding base of information on its molecular genetics facilitates the development of new methods for bioassay.

LIFE CYCLE ASSAYS

Drosophila melanogaster is relatively easy and inexpensive to rear which is important for genotoxicity tests that often require large sample sizes. Mass handling procedures and automatic counting devices will become increasingly useful in this regard. The short generation time of the flies means that investigators could rapidly identify health hazards.

With D. melanogaster it is possible to conduct toxicological surveys with different life stages. There are various ways to expose D. melanogaster to toxic compounds. These include adding compounds to fly food, leaving a compound residue in an otherwise empty vial, topical application, injection and absorption of airborne agents. Techniques are also available for mass collection of eggs and larvae (Roberts 1985). Numerous pupal stages can be identified (Roberts 1985) and it is possible to monitor metamorphosis after exposing either larvae or pupae to potentially teratogenic environments.

The adult stage can be used for tests of toxins on male and female reproduction, viability and senescence. It may be useful to determine...
reproductive effects since insect chemosterilants often are mutagens (Barkovec, 1973) and/or carcinogenic agents (Hayes 1968). Sterility can be assessed by the inability of females to lay fertile eggs or males to successfully inseminate females. Effects on female reproductive output (fecundity) can be measured by transferring inseminated females to fresh medium daily and counting the number of progeny that emerge from the set of transfers. Male reproductive output (viriility) is more difficult to assess. One method is to place a male in a vial containing medium and virgin females. After one day the females can be transferred to individual vials with medium to determine their fecundity. The male can be repeatedly confned with females to measure reproductive output.

Adult mortality is a convenient parameter for in situ monitoring because it is possible to transport large numbers of flies to test sites and the proportion that die after exposure can be quickly determined. A more speculative approach would be to hold adults in suspect environments for several weeks and then examine them for evidence of accelerated aging. In this manner it may be possible to rapidly identify subtle physiological risks in the environment.

Various life stages of D. melanogaster can be used to evaluate terres-
trial or aquatic samples from the field. Often contaminated materials are a complex mixture of compounds which are rarely evaluated (Persl, 1983). Suitable solvent fractions of the samples can be tested for cytotoxicity or genotoxicity with different life stages of D. melanogaster to monitor a range of possible biological effects.

GENETICS AND TOXICOLOGY

The widespread availability of commonly used laboratory stocks of D.
 melanogaster makes it possible to standardize the results of different inves-
tigations. In many in situ bioassays the genetic differences between the test organisms used by the same or different investigators are ignored. Yet there may be substantial genetically-based differential sensitivity to the effects of toxins. This makes it difficult to compare results from different studies or to be sure the difference between treatment and control organisms are due only to the environment.

The extensive genetics of D. melanogaster may be useful for toxico-
logy studies. For instance, chromosomes with multiple inversions and a dominant mutation can be used to control the transmission of homologous chromosomes. It would be possible to place chromosomes with high or low detoxification enzyme activity into a common genetic background and thus construct lines with a range of detoxification potential. Such lines could facilitate study of detoxification or activation of toxins. Another possibility is to use low or no activity mutations in detoxification genes as a way of creating geno-
types which are more sensitive or less sensitive to the presence of geno-
toxins or cytotoxins (Harchman et al., submitted manuscript).

There are numerous mutation tests available for D. melanogaster. This includes tests for sex-linked lethals, autosomal recessive lethals, sex-
linked lethal somatics, recessive visible mutants, sex-chromosomes ano-
ployidy, translocations, position effects produced by chromosome rearrange-
ments and somatic mutations (Abrahamsen and Lewis, 1971; Valencia et al.,
1984; Zimmering et al., 1986). One D. melanogaster chromosome mutation test alone can detect non-disjunction, chromosome exchange and deletion (Valencia et al., 1984; Zimmering et al., 1986). In contrast, for most organisms chromosomes aberrations must be detected by tedious cytological methods. The availability of efficient chromosome mutation tests in D.
 melanogaster may be particularly significant because half of the...
spontaneous human abortions and many birth defects are a result of chromo-
some aberrations (Sankaranarayanan, 1979). Chromosome mutation tests have
been used to test volatile genotoxins (Sharkarman, 1969; Verburg and
Vogel, 1977; Abraham et al., 1979; Elsming and Kamemeyer, 1983). For
assessment of human health hazards D. melanogaster may be particularly
valuable when chromosome mutation tests are used to evaluate volatile
genotoxins in situ.

A recent advance is to develop chromosome mutation tests in D. melano-
gaster based on defined molecular changes. The white-ivory eye mutation is
a result of a 2.9 kb duplication of a portion of this gene and reversals are
the corresponding deletion. Green et al. (1986) constructed a quadratic
of the white-ivory locus to increase the frequency of reversals. Using
this test they found that compounds which specifically promote dele-
tions produce a high mutation rate (Green et al., 1986).

BIOASSAY DEVELOPMENT

There are opportunities to use the extensive genetics of D. melano-
gaster and molecular biology to increase the utility of this species as an
indicator of human health hazards. For instance, the P-element transforma-
tion system of D. melanogaster should prove useful for constructing new
indicator strains. It might be possible to transform D. melanogaster with the
human TCDD receptor and monitor Pa50 response for a dioxin bioassay
(Jones et al., 1985). In general, it may be possible to construct D.
melanogaster lines with mammalian receptors, regulatory elements and detoxi-
cation enzymes to parallel the human response to environmental health
hazards.

It would be useful to develop mutation tests based on insecticide
resistance. One way to employ insecticide resistance might be to expose
adults in the field then bring them back to the laboratory for mass collec-
tion of eggs. The number of eggs collected could be determined by an auto-
matic counting device or by weight. The eggs would then be transferred
onto medium with insecticide and the few individuals surviving could easily
be counted to determine a "mutation rate" by resistance per given number of
eggs. The progeny of these individuals would also be tested to ensure the
resistance is heritable. This type of test would allow the investigator to
assess environmental genotoxicity without having to examine a large number of
flies.

Induction of detoxification enzymes is a potential biological indicator
of exposure to toxic substances. In D. melanogaster it has been possible
to indirectly select for induction of a glutathione S-transferase activity
(Abram et al., submitted manuscript). The implication of this work is that
it should be possible to select for modified inducibility of detoxi-
cation enzyme activities in D. melanogaster and other species to increase
the specificity or sensitivity of the induction response.

In summary, D. melanogaster is potentially useful for in situ biononi-
toring. In this capacity it may be especially valuable for monitoring
volatile genotoxins in the environment. Drosophila melanogaster may also
be valuable as a model for the development of new bioassay methods.

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