Appendix N
Endocrine Disruption and Invertebrates

Considerations by the EDSTAC Screening and Testing Work Group (STWG) have predominantly dealt with vertebrate animals for several reasons. The first, and perhaps overriding one, is that the charge given to the work group of focusing on estrogen, androgen, and thyroid hormone actions is not especially relevant to important and well-studied hormones of invertebrates. The purported endocrine disruption effects of public concern are almost exclusively human health or vertebrate wildlife related. The expertise in the work group is, also, predominantly with the vertebrate classes. However, invertebrates represent over 95% of all animals, are ubiquitous, and are tremendously important ecologically and economically. Commercial fisheries of shrimp, crab, and oyster and agriculturally important insect pollination are but a few key examples. Because invertebrates are ubiquitous and are easily adapted for laboratory testing, they can serve as sentinels and surrogates for investigating environmental stress. For these reasons, invertebrates should not be ignored from consideration.

Endocrine disruption has been well studied and well exploited for certain invertebrates, especially the insects. The endocrine systems of insects have been intentionally targeted for insecticidal activity and several insecticides have been developed and used to suppress insect populations by disrupting their normal endocrine functions. Juvenile hormone mimics (e.g., methoprene), antijuvenile hormone analogs (e.g., precocene), chitin synthesis inhibitors (e.g., diflubenzuron), ecdysone analogs (e.g., tebufeno-zide), and molting disruptants (e.g., fenoxycarb) are some examples. These insect growth regulating compounds have also been observed to have adverse effects in related arthropods such as crustaceans, including disrupting normal molting processes, limb regeneration, and reproduction (Christiansen et al. 1977a,b, 1979; Cunningham 1976; Forward and Costlow 1978; Landau and Rao 1980; Nimmo et al. 1980; Touart and Rao 1987). Other substances like the organotin TBT have caused imposex and intersex conditions in gastropods (Gibbs and Bryan 1986; Reijnders and Brasseur 1992) and sewage outfalls have caused intersex conditions in harpacticoid copepods (Moore and Stevenson 1994), conditions indicative of endocrine disruption.

Although the relevance of estrogen and androgen hormones to invertebrates is unclear, invertebrates may be useful as surrogates for investigating phenomena relevant to these hormones in vertebrates. Estrogens have been reported to play a meaningful role in development and reproduction in echinoderms and molluscs (Takeda 1979; Brueggemeier et al. 1988; Shirai and Walker 1988). Daphnids have been used to investigate the effects of xenoestrogens on steroid

metabolism (Baldwin et al. 1995; Baldwin et al. 1997) and sex reversal (Shurin and Dodson 1997). Because of their generally shorter life cycles and relative ease of handling many species in the laboratory, invertebrates could be useful for evaluating endocrine disrupting phenomena. However, additional research is needed before this promise is realized.

There are, therefore, two aspects to considering endocrine disruption for invertebrates, one is relevance to the health of invertebrate organisms themselves and the other is relevance of invertebrates as surrogates for investigating vertebrate-related phenomena. Conventional risk assessment of toxic chemicals such as outdoor use pesticides and high volume industrial chemicals generally include a crustacean reproduction or life cycle test in the data set used in the assessment. Although specific endocrine system endpoints are not considered, the apical nature of these tests may be adequate to detect the adverse consequences of an endocrine disrupting chemical in crustacean arthropods. Additional information is needed to determine what is most useful beyond these conventional tests for the wider invertebrate taxa. As surrogates, more information on the correlation of endocrine phenomena between invertebrates and vertebrates would be helpful. For instance, to what degree does a substance which disrupts ecdysteroid metabolism in crustacea disrupt sex steroid metabolism in vertebrates? Perhaps good correlations may be found, but more comparative information is needed before recommendations of specific invertebrate tests useful for evaluating potential endocrine disrupting activity relevant to vertebrates can be made.

No invertebrate assays, therefore, have been evaluated for use in T1S for detecting estrogen, androgen, or thyroid hormone disruption. Invertebrate tests have been proposed for T2T. It is recommended that a workshop of invertebrate endocrinologists and toxicologists be convened to address first, the suitability of invertebrate assays for estrogen and androgen (not thyroid) for use in a screening battery, and second, future improvements to the broader consideration of endocrine disruption in the environment and the utility of invertebrates as surrogate test organisms.

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