ADVERSE ASSESSMENTS OF *GAMBUSIA AFFINIS*

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While mosquito research and control personnel have been almost unanimous in their approval of the use of *Gambusia affinis* for mosquito control, members of the ichthyological community have viewed introduction of the fish into non-native habitats with alarm, because of real and potential damage to these ecosystems. This paper presents a brief review of adverse opinions to provide mosquito control personnel with another perspective to consider when planning to use the fish outside its native habitat.

The basic text for mosquito control workers, *Biological Control of Mosquitoes* (Chapman, ed., 1985), has a 14-page chapter on *Gambusia affinis affinis* by Meisch. Writing from a mosquito control perspective, Meisch has a section on "Negative Aspects," although these negative comments are vitiated by insertion of positive statements about *Gambusia.* There is a chapter on "Other Fish" by Bay. The concluding chapter of *Biological Control of Mosquitoes,* by Laird, notes the World Health Organization (WHO) recommendation against the introduction of *Gambusia* to non-native habitats. This chapter presents the position that the introduction of predatory agents should -not result in "the destruction of the already-present natural enemies of mosquitoes," recommends cost/risk benefits studies as an essential part of any control program, and concludes, most realistically, no adverse impacts means no mosquito control.

In 1967, Bay reviewed positive and negative aspects of the use *of Gambusia* and later (WHO/VBC/72.403) reviewed opposition to use of *Gambusia* in West Africa, citing anti-*Gambusia* feelings of "most ichthyologists".

Another source, long familiar to mosquito control workers, is "Guide to the use of the mosquito fish, *Gambusia affinis,* for mosquito control" by Scholdt et al. (1972). Scholdt warned "the impact of the fish on the aquatic environment cannot be underestimated as there is good evidence that the indiscriminate use of mosquito fish can be as detrimental as the misuse of pesticides."

Much the same sentiments were echoed by Laird (1977) who wrote, "Time has proved that mosquitofish eventually became harmful in some areas to which they were introduced half a century ago---the harm ranged from eating the eggs of economically desirable fish, to endangering rare indigenous species." Later, in 1988, he cited Miura's work in the ricefields of California as indicative of the lack of adverse effects on one environment, an environment Harrington (personal comment) referred to as "artificial". Laird cited Legendre's 1937 article in the *Bulletin Economique Indochine* pointing out the threat to indigenous fish from *Gamhusia* predated Myers' 1965

article, which referred to events of the mid-1930's, but seemed unaware of Sweetman's *The Biological Control of Insects* (1936) which had preceded Legendre by a year and would have been more readily accessible to mosquito control practitioners in this country. However, Laird reminds us, "Too much should not be expected, though, of such indigenous fish in natural waters of high taxonomic diversity," and indicated, in relation to *Aplocheilus panchax,* that omnivorous fish can maintain themselves well in nature without mosquito larvae, and *Gambusia* is indeed an omnivore. He also cited Russian feeling that "the general effectiveness of this fish has been disappointing."

Speaking of biocontrol programs, Laird (1988) commented on use of *Aplocheilus latipes* (an egglaying cyrpinodont) in Russia, following tests of larval consumption rates of the fish in aquaria, "It is submitted that biocontrol introductions of this kind, based upon a mosquito larvivore that is very probably of far more catholic tastes than univariate laboratory experiments could reveal, are only likely to prove successful where mosquito production is unusually high in rather short-lived larval habitats habouring a limited flora and fauna; or in more complex aquatic ecosystems where preliminary habitat manipulations is undertaken to give, for example, *Aplocheilus* unrestricted access to dense concentrations of larval Culicidae."

These caveats are mild compared to the opinion presented by ichthyologists Courtenay and Meffe (1989) in the conclusion to their section on *Gambusia in Ecology and Evolution of livebearing Fishes:*

In summary, mosquito fish almost invariably present a multitude of problems when introduced beyond their native range and offer no real compensatory or biological control advantages. The species should not be used as a larvivore, with native species much preferable in that role whenever possible (e.g. Lloyd 1984). Mosquitofish are far too aggressive and predatory to be indiscriminately spread throughout the world without recognition of dangers to native biota. An international ban on their use as a control agent is biologically appropriate and warranted.

What are the reasons presented for this condemnation? Let us look at some of the evidence they present in their review of the literature dealing with the adverse effects of the use of *Gambusia.*

The first complaint is that *Gambusia* is not really that effective in mosquito control and better control has been achieved with native species (Table 1). As far back as 1949 Bates was noting, "The success of practical operations along these lines [biological control] has not been very remarkable." In 1967 Harrington (personal comment) was saying, "very few entomologists have sound evidence of the alleged efficacy of *Gambusia* where it has been introduced."

In Australia, Allen (1989) remarked on *Gambusia's* lack of efficacy in mosquito control, and in 1993 Dennis C. Haney of the National Biological Survey of the U. S. Department of the Interior wrote (personal comment), "I think you will find that there is little or no evidence for *Gambusia* being particularly effective in controlling mosquito larvae. In fact, almost all the evidence indicates that *Gambusia* is no better at

controlling larvae than are native fish."

Recognizing there is testimony on both sides of the issue and that *Gambusia* may not be so universally successful as we have been led to believe, let us turn to what ichthyologists consider a more serious issue. The failure to effect larval control is a concern of the mosquito control community, but *Gambusia's* impact on non-target organisms affects a broader community of interests.

The concern with environmental impacts goes back more than half a century when, in 1936, Harvey Sweetman warned in his pioneering *The Biological Control of Insects:*

Finally, it should always be held in mind that the introduction of any foreign animal is apt to cause repercussions on the native fauna in unexpected ways. *Gambusia* has been spread far and wide in anti-mosquito work, frequently in ignorance of valuable native species. *Gambusia affinis and G. holbrookii* are for their size, among the most voracious and destructive of fishes, and although no reports of damage to the young of valuable food fishes in areas into which they have been introduced have appeared, it is possible that introduction into certain places will prove to have been a mistake.

Myers, writing in 1965, noted some 30 years previously "the crew of the California State Fish and Game Department's black-bass hatchery at Friant had to discontinue using *Gambusia* as a 'forage fish' with which to feed the bass. *Gambusia* was destroying a large proportion of the young bass!" He also reported removing *Gambusia* from a pond shared with goldfish and seeing the goldfish population double and redouble in 2 years.

Gambusia's effectiveness as a predator as well as its omnivorous feeding patterns make it a hazard to native species and any other aquatic organisms that can be eaten (Courtenay and Meffe 1989). *Gambusia* does not specialize in mosquito larvae and pupae (Harrington and Harrington 1961; Myers 1965; Washino and Hokama 1967, Meisch 1985). Myers (1965) reported the loss of 5 species subsequent to the introduction of *Gambusia: Poeciliopsis* sp. (USA); *Aplocheilus panchax* and *Phenacostethus* sp. (Thailand); *Gulaphallus* sp. (Philippines); *Micropanchax sholleri* (Lower Nile). Courtenay and Meffe (1989) listed other species and organisms reduced or eliminated by the introduction of *Gambusia* (Table 2). Lynch (I 99 1) reported on the impact of *Gambusia* on the plains topmlnnow, *Fundulus sciadicus,* in Nebraska in an experimental release program. His comments on such research are instructive: "Most experiments are done under controlled circumstances where the experimenter has some notion of what to expect. . . . The release of self-replicating agents into the environment is fundamentally different, because as soon as they are released, any controls are lost."

Gambusia's pugnacious and omnivorous nature is not helpful to other species' reproduction (Myers 1965). Eggs and fry, even of intensive-care fish like the centrarchidae, are grist for their reproductive mill (Myers 1965), and competition for resources is not the problem- it is predation (Courtenay and Meffe 1989).

Australian ichthyologists talk of *Gambusia almost* as Australian agriculturists speak of

the rabbit. Brought in with good intentions, the fish has spread widely across the continent and is viewed as a threat to native species (Arthington and Lloyd 1989, Allen 1989); in coastal regions of southeast Asia, Bardach et al. (1972) cite *Gambusia* as well as the common guppy as pest species. Wildekamp (1993) notes the impact of the introduction of *Gambusia* on 4 species of *Aphanius* in the first of a multi-volume set about killifish of the world: *A. anatoliae transgradiens (Turkey); A. apodus* (Algeria); *A. fasciatus* (Rhone delta-Camargue); A. *iberus* (Spain and Algeria).

More recently, Gratz (personal comment) wrote of a fish expert for FAO coming into his WHO office complaining about the stupidity of people releasing *Gambusia* into an area where he was trying to develop fish populations to feed indigenous populations only to find the *Gambusia* eating the eggs of the desired fish species.

It is instructive to compare the commentary on *Gambusia* in 2 standard field guides to freshwater fishes of North America. The Audubon Guide (1983) notes that *Gambusia* has been widely introduced for use in mosquito control. The Peterson guide (Page and Burr 1991) is much more specific: "Introductions of this species, often for mosquito control, have caused or contributed to the elimination of many populations of fishes with similar ecological requirements. Introductions into western drainages have been especially deleterious to the survival of certain rare fishes."

Are hazards posed by use of *Gambusia* real? One suspects arguments presented by ichthyologists must have substance, and the evidence presented is real. Critics of *Gambusia* "ask why native species are not used to control mosquitoes?" There are several reasons may be posited. If a fish is in its native habitat and is an effective predator (like saltmarsh killies) the need to institute a biocontrol program is unnecessary. However, when it comes to habitats where native fish are not as numerous or numbers have been reduced by introduction of exotics, then cultivation and stocking of native egg-laying fish, it is assumed, take more effort. Live-bearers are supposedly easier to raise than egg layers; the fry are larger, free swimming, and feeding at birth; they grow more quickly and become predators faster. However, in this writer's experience, egg-laying minnows *(Pimphales promelas* "Rosy") produced thousands of fry in a 10-foot garden pond over the course of a summer with minimal parental predation. However, *Gambusia* are easy to use, require minimal training for application, and. more importantly, have been thought safe. They have good public relations value (Duryea 1993), showing mosquito control's ability to not be totally reliant on pesticides in a period of chemophobia. Further, their easy availability has allowed us the luxury of not having to seek other tools.

One question never effectively raised, because *Gambusia* is a biological organism, was the question automatically asked about any pesticide: What are the nontarget effects? Were a label sought for use of *Gambusia* as a pesticide today, one suspects it might well prove unacceptable to the Environmental Protection Agency (EPA) because of adverse environmental impacts, particularly as those effects would be revealed in the review process. Being a highly goal-oriented community, one

suspects mosquito research and control people have looked at *Gambusia* with rose-colored glasses. One other question not asked is "if *Gambusia is* so effective a predator, how is it there are so many mosquitoes in areas which are its native habitat?"

Mosquito research and control people find their origins in the disease-preventitive programs of the past. Their concerns have been oriented toward human wellbeing, so it is not surprising they welcomed a tool like *Gambusia.* However, if health concerns are given as a reason for introduction of *Gambusia,* it should be remembered that it is not an effective control against vector-competent species such as *Aedes aegypti, Ae. albopictus, Coquillettidia perturbans or Culiseta melanura.* One should also note that if disease is a factor, then control should be effected as promptly and as completely as possible. It is more responsible to use an insecticide whose environmental breakdown is a known factor rather than a biological agent whose environmental fate can only be guessed at.

The role of Gambusia in disease control has not been judged as impressive. Service (1983, 1995) and Mahmoud (1985) both have indicated *Gambusia* has not been effective in the control of malaria.

Mosquito control's thinking over the years has been conditioned by what mosquito researchers, not ichthyologists, have said about *Gambusia* and its efficacy, particularly about the numbers of larvae consumed in aquaria or other artificial habitats. Our thinking needs to expand its horizons to learn what other specialists in the aquatic world have to say about *Gambusia,* and it needs to factor in that knowledge so we can avoid ecological mishaps in areas not already destabilized by introduction of exotics.

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