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CONTROL OF MOSQUITOES BY THE USE OF FISH IN ASIA WITH SPECIAL REFERENCE TO INDIA: RETROSPECTS AND PROSPECTS
(Pengendalian Nyamuk dengan Penggunaan Ikan di Asia dengan Rujukan Khusus ke India: Tinjauan Masa Lalu dan Masa Depan)

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Abstract

Fish have their greatest potential as biocontrol agents against the aquatic stages of mosquitoes and are used as a major component of the integrated vector control programme. Many countries in Asia including India have used mosquito larvivorous fish for the containment of mosquito borne diseases, especially malaria. Present review is an attempt to prepare a list of potential mosquito larvivorous fish used in different countries in Asia with special emphasis on India.

Keywords: Biocontrol agents - larvivorous fish - mosquito control.

Abstrak

Ikan berpotensi paling besar sebagai agen hayati terhadap stadia akuatik nyamuk dan digunakan sebagai komponen utama dalam program pengendalian vektor terpadu. Banyak Negara di Asia termasuk India telah menggunakan ikan pemakan jentik untuk menanggulangi penyakit bawaan nyamuk, terutama malaria. Tinjauan pustaka ini mencoba memberikan suatu daftar jenis-jenis ikan pemakan jentik yang digunakan di berbagai Negara di Asia dengan penekanan khusus di India.

Kata kunci: Agen pengendalian hayati – ikan pemakan jentik – pengendalian nyamuk

INTRODUCTION

In the present communication we have reviewed the fish species used in mosquito control in Asia. In view of the growing concern over insecticidal contamination of the environment and its subsequent detrimental effect to biotic community along with the continuing appearance of multiple resistance of mosquito vectors to most chemical insecticides with their rising cost, the search for alternative vector strategies, has thus assumed a priority demand. The use for environment-friendly materials for vector control initiates a vigorous search for biological agents either as an alternative and/or complementary to chemical treatment. Potential biological control agents have so far been selected from organisms naturally found in fields. There are fairly good numbers of biological agents against

mosquito larvae and pupae such as viruses, bacteria, fungi, protozoa, parasites, predacious mosquitoes. Various species of fish have been found to posses enormous potentiality of being a biological agents against mosquitoes. The widely used potential fish species are *Gambusia affinis, Aplocheilus panchax, Poecilia reticulate.* In addition to that there is an impressive account of use of various other species in the control of mosquitoes all over the world (Bhattacharya, 1992)[1].

EVALUATION OF FISH AS LARVIVOROUS

Larvivorous fish are those that feed on immature stages of mosquitoes. In survey of the larvivorous potential of local fish individual species must be investigated separately in the laboratory and in the field. Optimum larvivores should be small, appear in large numbers in the field population and should remain in stagnant water system. They should be drought resistant and capable of growing in both deep and shallow waters as well as living in drinking water tanks and pools without contaminating the water. They must be able to withstand rough handling and transportation for long distances. They should be prolific breeders having shorter span of life cycle. It is important to know whether the fish prefer mosquito to other foods (insects, algae, plants, etc).They should not be preferred by fish-eating people. Their potential spread in the habitat and their impact on other animals in the biotope and their antagonists should be known. (Weiser,1991) [2]. It is a tedious work to find a species that satisfies all the above parameters. Hence, the choice usually depends upon that very species, which satisfy as many of the above qualities as possible.

TYPES OF SOME POTENTIAL LARVIROROUS FISHES

The position of the mouth in the fish is one of the important characteristics to determine its larvivorous capability. From the point of view of their efficacy in controlling mosquito larvae, Hora & Mukherjee[3] classified the larvivorous fish into the following categories: Typical surface feeders such as *Aplochelius* and *Gambusia*, which fulfill the characteristic features of larvivorous fish; Some surface feeders, which are less efficient owing to their mode of life, *e.g., Oryzias, Lebistes (Poecilia), Aphanius, etc.*; Sub-surface feeders like *Amblypharyngodon mola, Danio, Rasbora, etc.*; Column feeders like *Puntius* spp., *Colisa, Chanda, Anabas, etc.*, which feed on mosquito larvae when chance permits;

Fry of carps and mullets, which are helpful in controlling mosquito larvae; Predatory fishes like *Wallago, Channa, Notopterus* and *Mystus* whose fry may destroy mosquito larvae but whose adults may predate upon other fish including larvicidal fish species.

PROBLEMS

Mosquito borne diseases like malaria, dengue, filariasis, chikungunya, encephalitis and yellow fever are causing enormous health problem in various parts of the world, especially in the developing world. Apart from the loss of millions of human life , they are also responsible for huge economic loss. Mosquito borne diseases can be referred to as ecological disease where environment plays an important role in disease dynamics. Mosquito vector control is an effective means in the containment of the above mentioned diseases. The use of environment friendly materials for vector control initiates a vigorous search for biological agents either as an alternative and/or complementary to chemical treatment. Various species of fish have been found to possess potentiality of being a biological agent against mosquito vectors. In the stricter sense , in spite of the proven efficacy of fish as bio-control agents there are certain instances where fish have proved ineffective, specially in case of container breeders in domestic situation. Proper

evaluation of each candidate larvivorous fish is required before introducing in a particular bio-geo situation so as to avoid any harmful effect on non-target organism.

Fish species used in different parts of Asia as biological control agent against various species of mosquito larvae

Countries	Fish Species	Mosquito Species	References
Afganis-than	*Gambusia* sp.	*Anopheles hyrcanus*, *Anopheles pulcherrimus*	25.
China (Provinces of Taiwan)	*Poecilia reticulata*	*Culex pipiens fatigans*	26
Indonesia	*Poecilia reticulata*, *Gambusia* sp., *Aplocheilus panchax*, *Trichogaster trichopterus* (mostly used), *Glossogobius giurus*(least used), *Rasbora argyrotaenia.*	*Anopheles aconitus*	27
Iran	*Gambusia affinis holobroki*	*Anopheles sp.*	28,29
Iraq	*Gambusia affinis* (most efficient), *Gambusia sp., Aphanius dispar.*	*Anopheles stephensi*	30, 31
India	*Gambusia* sp., *Gambusia affinis*, *Gambusia affinis holobroki*, *Gambusia affinis affinis*, *Esomus dandricus*, *Nothobranchius guentheri*, *Aplocheilus panchax*, *Aplocheilus lineatus*, *Aplocheilus blockii*, *Danio spp.*, *Channa orientalis*, *Oryzias latipes*, *Oryzias melastigama*, *Rasbora daniconius*, *Poecilia reticulata*, *Puntius sarana subnastus*, *Tilapia mossambica*, *Puntius spp.*	*Culex pipiens fatigans*, *Anopheles stephensi*, *Aedes aegypti*, *Aedes vittatus*, *Aedes albopictus*, *Culex quinquefasciatus.*	32, 33, 34, 35,36, 37, 38,39,40, 41.
Japan	*Gambusia affinis*, *Poecilia reticulata*, *Gambusia affinis affinis*, *Oryzias latipes.*	*Culex pipiens* , *Culex pipiens fatigans*, *Culex pipiens molestus*, *Culex pipiens pallus*, *Anopheles hyrcanus sinensis*, *Aedes dorsalis*, *Aedes aegypti*, *Culex tritacniorhynchus.*	42,43,44, 45,46,47.
Korea	*Aplocheilus latipes*, *Poecilia reticulata*, *Zacco platypus.*	*Culex pipiens pallus.*	48.
Myanmar	*Poecilia reticulata.*	*Culex pipiens fatigans*	49.
Philippines	*Tilapia sp.*, *Carassius auratus*, *Xipophorus helleri*, *Molliensia sp.*	*Anopheles sp.*	50.
Pakistan	*Poecilia reticulate*, *Oreochromis mossambicus.*	*Anopheles sp.*	56,57.
Russia	*Gambusia* sp., *Aplocheilus latipes*, *Poecilia reticulata*, *Nemacheilus dorsalis*, *Pseudorasbora parva.*	*Anopheles sp.*, *Anopheles maculipennis*, *Anopheles maculipennis maculipennis*, *Culex pipiens fatigans*, *Aedes vexans*, *Aedes cinereus.*	51,52,53.
Sri Lanka	*Oryzias melastigama*, *Rasbora daniconius*, *Aplocheilus dayi* (effective)	*Anopheles sp.*, *Aedes aegypti.*	54.
Thiland	*Poecilia reticulata*	*Culex pipiens fatigans*	55.

OBJECTIVE

The objective of this present review is to know the fish species used in controlling mosquitoes, in different parts of Asia and their effectiveness. Eco-behaviour of three most commonly used potential mosquito larvivorous fishes such as *Poecilia reticulate*, *Gambusia affinis* and *Aplocheilus* sp. will also be highlighted in this review.

COMMONLY USED MOSQUITO LARVIVOROUS FISHES AND THEIR ECO-BEHAVIOUR

Aplocheilus sp.

Species belonging to the genus *Aplocheilus* are widely used all over the world as active vector control agent. Commonly known as killi-fish, these are small and active surface feeders that mainly inhabit fresh waters and also brackish waters of moderate salinity. Among them Aplocheilus *latipes, Aplocheilus panchax, Aplocheilus lineatus, Aplocheilus blockii* are mostly used. They are efficient larvivorous fish among indigenous larvivorous species. The genus is commonly distributed in India (West Bengal, Bihar, Orissa, Assam, Punjab, Uttar Pradesh, Madhya Pradesh, and Rajasthan); Sri Lanka; Malaya; Myanmar; Thailand; and Indonesia.

Ecology and behaviour: The species is quite hardy and active and inhabits clear shallow fresh and brackish water at low altitudes and are suitable for wells, marshes, lagoons and polluted water drains and any other stagnant water bodies containing organic pollutants. *Aplocheilus panchax* is a potent fish in controlling several vector species in different types of natural and man-made habitats[4]. It controls *Anopheles culicifacies* in breeding habitats like rain water pools, irrigation channels, river bed pools; burrow pits, cemented tanks, swimming pools, sluggish streams with sandy margins and little vegetation, freshly laid rice fields *etc*. *An. sundaicus* was controlled in brackish waters with algae, behind embankments protecting rice fields, tanks, cleared mangroves and lagoons, ponds, lakes and borrow pits in coastal areas. *A. panchax* also controlled *Culex vishnui* in drains water ponds, polluted waterways, septic tanks, disused wells, well, manure pits, rice fields, marshes, ditches, borrow pits, irrigation channels, pools, streams, field wells *etc*.

Gambusia affinis

A native of coastal waters of United States from New Jersey southwards, introduced into India about 40 years ago from Italy and Thailand. The mosquito fish, *Gambusia*, is a top-feeding minnow and is a known good larvivorous fish with wide distribution in countries in the Eastern Mediterranean Region. It is unique in its global distribution and is small, tiny, grey or greyish black, measuring up to 4–6 cm in length. *Gambusia* has been used in many parts of the world to control mosquito larvae. The fish occupies some curious habitats, such as tunnels, abandoned pools, ponds, rainwater pools, stagnant rice fields, etc. It is viviparous (lays young ones and not eggs), breeds prolifically and requires no special egg-laying site.

Ecology and behaviour: They are found in freshwater, brackish water and marshes with high salinity. They feed on aquatic and terrestrial insects. Terrestrial insects that fall in the water show preference to mosquito larvae. According to Chatterjee & Chandra,[5] G. *affinis* consumed per day 48, 51 and 31 larvae of *An. subpictus*, *Cx. quinquefasciatus* and *Ar. subalbatus* respectively. The fish was more active during 04.00 - 10.00 h. Feeding rate increased with the increase in prey and predator densities. Feeding rate decreased with the increase in water volume; i.e. its feeding rate is directly proportional to the prey. Thus the biocontrol efficacy of *G. affinis* is seen. Hackett[6] described the usefulness of the mosquito predatory fish in malaria control programmes in Europe. According to him, *G. affinis*, when employed in an area of about 21 km^2 on Istrain peninsula, resulted in the

reduction in malaria rates from 98 per cent in 1924 to 10 per cent in 1980. Alike, Menon & Rajagopalan [7] studied on the habitat predation rate and larvivorous potentiality of 14 species of fish found in Puducherry. Each *Gambusia* fish showed an average predation rate of 65.7 per day on larvae of *An. subpictus.* In an experiment the predatory efficiency of *G. affinis* on the larvae of *Ae. aegypti* was found to be dependent on prey density (Singaravelu *et al)* [8]. Malaria[9] was also successful in combated by *G. affinis holbrooki* which were introduced from Italy into the Ghazian marshes during 1922. In Hyderabad an operational release of *G. affinis holbrooki* in 1967 controlled the breeding of *An. stephensi* in hundreds of wells in about 2 years[10]. Rajnikant *et al,* [11] through a series of experiments, showed that *G. affinis* was the best predator of the larvae of *An. stephensi* breeding in overhead tanks. *G. affinis* is the most widely used species in anti-malarial programmes in the world and is known as mosquito fish. *G. affinis,* when introduced at a rate of 46 fish/m^2 water surface in the rice fields, brought about a sharp reduction in the anopheline larval densities and vector biting rates[12]. The Kunder valley of Afghanistan was its trial ground. According to the report of Tabibzadeh *et al,*[13] *Gambusia* sp. substantially reduced anopheline larvae in habitats in Iran and contributed in malaria eradication. When rice fields had been stocked with 250 to 750 *G. affinis* per hectare, there was a 95 per cent and a 40 per cent reduction in the immature density of *An. freeborni* and *An.Pulcherrimus respectively.* Das & Prasad[14] evaluated the mosquito control potential of *G. affinis* in the rice fields in Shahjahanpur district of Uttar Pradesh, India. At a stocking rate of 5 fish/m^2, *G. affinis* significantly reduced the larval and pupal densities in experimental fields as compared to control fields during the entire observation period of 42 days. Rao *et al,* [15] carried out a study to assess the feasibility of controlling mosquito breeding in casuarina pits in four coastal villages of Puducherry using *G. affinis. An. subpictus* is the predominant species breeding in the casuarinas pits. A tremendous reduction was noted in the number of pit breeding mosquitoes and the maximum control achieved was about 96 per cent. *G. affinis* survived well in submerged rice fields and provided 87.8 per cent mosquito larval control in Shahajahanpur district, Uttar Pradesh, during 1991 Prasad *et al* [16]. Rajnikant *et al* [11] showed that *G. affinis* was the best predator of the larvae of *An. subpictus* and *An. culicifacies* breeding in rice fields.

Poecilia reticulata

Poecilia reticulata is a native species of South America. Commonly known as the guppy fish, it was introduced to British India (now Bangladesh, India and Pakistan) from South America in 1908 for mosquito control and is now found in ponds, canals, tanks and ditches in rural and urban areas throughout Bangladesh, India and Pakistan. It is also found in The Netherlands, West Indies, and from Western Venezuela to Guyana. It was imported to India more than once, and restricted to South India and some other parts of the country. It is an efficient mosquito control agent with characteristics similar to *Gambusia.*

Ecology and behaviour: *Poecilia* is a prolific breeder in tropical waters requiring a temperature between 22 and 24°C, *Poecilia* lives on artificial food and prefers mosquito larvae and can tolerate toxic pollutants more than *Gambusia.* An adult and a fingerling of *P. reticulata* can consume 32 and 18 IV stage *An. subpictus* larvae in 24 h Chatterjee & Chandra [17]. According to Menon & Rajagopalan[7] average predation of *P. reticulata* per day was 53.1 and range of consumption was from 15 to100. (Study based on the habitat, predation rate and larvivorous potentiality of 14 species of fish found in Puducherry). *P. reticulata* through community participation effectively control *An. aconitus* in rice fields of central Java. A sharp decline in the number of malarial cases was noticed (Nalim & Tribuwono)[18]. *P. reticulata,* effectively suppressed larval and adult population of *An.gambiae* in washbasins, and cisterns by 85 per cent in a single year using

3-5 fish in a water surface of 1 m^2 in Grand Comoro Island Sabatinelli *et al* [19]. Gupta *et al* [20] reported that in India, *P. reticulata* effectively reduced the breeding of *An. stephensi* and *An. subpictus* population breeding in containers, by 86 per cent using 5-10 fish in a water surface of 1 m^2. *P. reticulate* was used to control *Cx. Quinquefasciatus* in the surface drains of Kolkata (Bhattacharya S *et al*,1981) [21]. Saha *et al* [22] studied on the use of guppy (*P. reticulata*) as a powerful biocontrol agent in the field of mosquito eradication. The fish also controlled mosquito breeding in Ghaziabad district villages near Delhi. It was found effectively controlled in wells provided the fish did not die or were not prevented from feeding on larvae due to debris. Guppies survived and multiplied in wells over the twenty two week period of observations[23]. Larvivorous fish in wells targeted the malaria vector sibling species of An. *Culicifacies* complex in villages of Karnataka (Subarao *et al*, 2005) [24]. *P. reticulata* fish were introduced into all wells and streams in the villages in Karnataka. After one year no vectors were found in Puram, a village with 22 wells. No malaria cases were detected in the villages over one year after release of fish from 1998 until 2003.

RESULT AND DISCUSION

Since the beginning of the 20th century reports began pouring in on the larvivorous potentiality of various fishes[58]. Fish have their greatest potential as biocontrol agents against the aquatic stages of mosquitoes and are used as a major component of the integrated vector control programme. Many countries in Asia including India have used mosquito larvivorous fish for the containment of mosquito borne diseases, especially malaria. Moreover this method is economically viable and sustainable. In order to make this method ecologically sustainable, use of local mosquito fish in natural habitats, adapted to local conditions is recommended. In India, exotic fishes viz, *Gambusia* and *Poecelia* have been used widely in malaria control programme and the results are encouraging. However its impact on local biodiversity has not been studied adequately (Ghosh et al, 2006)[59]. Naturally before and after releasing exotic and non local indigenous fishes in any natural water bodies, an impact assessment of the aquatic ecosystem is necessary. *Aplocheilus panchax* an indigenous fish is found to be effective in controlling mosquito larval population. Long-term sustainability of this biocontrol programme requires that fish resources be developed locally. Different fish can be used cost-effectively, particularly when there is also community participation. For example in the maintenance of fish stocks and hatcheries, distribution of fish, etc. Proper evaluation of each candidates larvivorous fish is required before introducing in a particular bio-geographical situation so as to avoid any harmful effect on non-target organisms, thereby maintaining an ecological homeostasis. In the strictest sense, biological control alone, however, is considered inadequate in controlling the mosquito population and has to be coupled with other available control programmes to yield a cumulative and meaningful effect.

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