Biological control of mosquito pdf

Culex , Aedes, Anopheles, etc. - Diptera, Culicidae (Contacts) -----Please CLICK on the desired category; Depression Ctrl /F to find the subject: Introduction detailed biological control measures Links PEREITI to all: Bio-control cases Please refer also to related studies #1, #2, #3 - The introduction of interest in the biological control of medical pests and vectors had its humble beginnings until the beginning of the last century (Lamborn 1890). At the time, the possible use of dragonflies as natural enemies for mosquito control was clearly recognized. However, as today, the enormous difficulties associated with colonization and management of these insects quickly extinguished any idea of the practical use of these predators to control mosquitoes. Shortly after the beginning of the century, the mosquito fish, Gambusia Affinis (Baird and Girard), came to the forefront of biological control. This small fish, much easier to fight against than dragonflies, was quickly used and transported around the world in the first decades of this century in an attempt to fight mosquitoes. Mosquitofish, G. affinis, along with several other natural controls, was used with some enthusiasm during the first 40 years of the century. All these controls were drastically reduced with the introduction of synthetic organic insecticides after World War II. The convenience and rapid force of killing these chemicals was so dramatic for insects such as mosquitoes, flies and lice that other control tactics were quickly reduced to a minor role. However, interest in alternative control methods, especially biological ones, had to re-emerge when a series of chemicals developed in the 1940s and 1950s began to work because of the development of widespread genetic resistance in vector and pest populations. Although biological control of medically important pests and vectors has made some progress since its resurgence, it has been slow and still lags far behind what has happened in agricultural systems (Service 1983). This discrepancy is partly due to the problems of fixing the level of tolerance to pests, but more importantly due to the temporary unstable habitat exploited by important pests from medical attention (Legner s Sjogren 1984, Legner and Warkentin 1989). As noted by the Service (1983), the successful widespread use of biological controls against mosquitoes will require a much better understanding of the ecology of the relationship between predators/victims and pathogens/hosts. The opportunistic characteristics of many species (i.e. their ability to exploit temporary habitats combined with their short generation time, high natural mortality, greater scattering potential and other R-strategic characteristics) create problems for any biotic regulatory mechanism. Mosquitoes, in the zlt/PHOTO exploit a wide range of different aquatic habitats. Consequently, under many conditions, the biological control agent will have a much narrower range of environmental activity than the target species. Thus, many situations will require a number of different biological control agents and/or appropriate methods if we expect to control even one species of mosquito in a wide range of exploited breeding sources. Studies of the fungal genus Lagenidium, which is able to infect and kill several genus of mosquito larvae (e.g. Anopheles, Culex, Aedes and Psorophora), encourage the continued search for biological control agents as an alternative to pesticides (McCray et al. 1973, Christensen et al. 1977, Glenn and Chapman 1978, Vasino and Fukushima 1978, Vasino 1981, Axtell et al. 1982, Domnas et al. 1982, Yaronski and Axtell 1982, 1983a,b). The potential of such fungi for rapid mosquito control, however, is no greater than for some flatworms or hydra. This recent switch in attention to fungi is probably due to the existence of more mycologists in research power than experts in other groups. The problems of mass production, the spread of acceptable fungal stage and adaptation to contaminated water habitats have called into question their immediate deployment. Similar problems were either non-existent or minimal with Dugesia worms, so their integrity as effective and accessible biological control agents does not wane. The successful widespread use of biological controls against mosquitoes will require a much better understanding of the ecology of the relationship between predator/prey and pathogens/hosts (Service 1983). The opportunistic characteristics of many species (i.e. their ability to exploit temporary habitats combined with their short generation time, high natural mortality, greater scattering potential and other R-strategic characteristics) pose complex challenges for any biological control agent. Mosquitoes usually exploit many aquatic habitats. Often the biological control agent will have a much narrower range of environmental activity than the target species. Thus, in many situations, a number of different biological controls and/or appropriate methods will be required to control even one species of mosquito in different breeding sources. Fish.-Several species of fish are used for biological control of mosquitoes, and these species together form major advances in biological control. Unfortunately, their usefulness is limited to more permanent bodies of water, and even in such situations their impact on target species has only been partially successful. Bay et al (1976) note that many species of fish consume mosquito larvae, but few species have been manipulated to control mosquitoes (Please see the research) Mosquito Fish, G. affinis, is the most famous mosquito control agent. The fish, which hails from the southeastern United States, eastern Mexico and the Caribbean, was first used as an injected mosquito control agent when it was transported from North Carolina to New Jersey in 1905 (Lloyd 1987). Shortly thereafter it was introduced to Hawaii to fight the mosquitoes that were introduced during the 19th century. Over the next 70 years, mosquito fish was transported to more than 50 countries and is now the most widely used biological control agent (Bay 1969, Lloyd 1987). Many of these introductions were directed at the species of anopheles that transmitted malaria. Hackett (1937) described his usefulness in malaria control programs in Europe. He noted that its effects alone are insufficient, but that fish has some effect on the suppression of the disease. Tabibzadeh et al. (1970) reported a fairly extensive production programme in Iran and concluded that this fish was an important component in eradicating malaria. Sasa and Kurihara (1981) and the Service (1983) believed that fish had little effect on the disease and that most of the evidence was circumstantial. Gambusia is no longer recommended by the World Health Organization for malaria control programmes, mainly because of its harmful effects on local fish species (Service 1983, Lloyd 1987). The biological characteristics of G. affinis, namely high reproductive capacity, high survival, small size, omnivorous food in shallow water, relatively high tolerance for fluctuations in temperature, salinity and organic waste, would seem to make this species an excellent biological control agent (Bay et al. 1976, Moyle 1976). However, the question of whether this fish will lead to effective mosquito control at practical cost in many situations is still under discussion. Kligler's (1930) statement that ... their usefulness as destroyer larvae in local environments, where vegetation is abundant and micro fauna is rich enough to meet their needs without any problems, is limited. On the other hand, in moderately clean canals or in pools with limited food supply, they produced excellent results... is probably one of the most accurate. In California, this fish was widely used to control mosquitoes in various habitats (Bay et al. 1976). Mosquito-borne cultivation, harvesting and winter mosquito storage systems have been developed in many areas of the state to accommodate mosquitoes in early spring (Coykendall 1980). This is especially important in rice growing areas in California, where early stocks appear to be critical to increasing fish populations to fight mosquitoes конце лета. Результаты использования G. affinis в </PHOTO> </PHOTO> rice fields will be summarized below as an illustrative example of the mixed gains made on the ground. Growing rice in California is constantly one of the most difficult control problems for the anopheles and Culex species. Hoy and Reed (1970) showed that good very good control of Culex tarsalis Coquillett can be achieved by stocking rates of about 480 or more women per hectare, and Stewart et al (1983) reported excellent control with similar stocking rates against this species in the San Joaquin Valley. While Cx. tarsalis appears to be effectively controlled by G. affinis, control of its frequent companion in northern California rice fields, Anopheles freeborni Aitken, is less obvious. Hoy et al. (1971) showed a decline in An populations. Freeborni at different stocking levels at about 120-720 fish per hectare, but the reduction was not as striking as for Cx. tarsalis. These workers speculated that improved control could be achieved through an earlier stocking season, perhaps multiple release points on the margins and a reliable source of healthy fish for stockings. Despite extensive research in mass culture, management and storage for G. affinis in California (Hoy and Reed 1971), the mass production method was not satisfactorily achieved (Downs et al. 1986, Cech and Linden 1987). G. affinis studies to control mosquitoes in wild rice show that relatively high stocking rates can effectively reduce An populations. freeborni and Cx. tarsalis for three months (Kramer et al. 1987a). Commercial production of wild rice, which is a more reliable and toler plant than white rice and requires only 90 instead of 150 days to mature, has been growing over the past few years in California (Kramer et al. 1987). In the above-mentioned study, stockings of 1.7 kg/ha (about 2,400 fish/kg) released in areas of wild rice weighing 1/10 hectares showed no significant difference in reducing mosquitoes from fish-free areas. Just before the harvest, there was a decrease in the number of larvae, indicating that fish are beginning to affect the number of mosquitoes (Kramer et al. 1987). The number of fish in these sites, based on drainage recovery, was about 100,000 individuals per hectare (about 32 kg/ha) or a density of about 10 fish per square metre. However, no significant control was achieved. In 1987, this study was repeated at a rate of 1.7 and 3.4 kg/ha of fish. The results showed an average suppression of larvae (primarily An. freeborni) and 0.5 per per' dip' for the low and high rate, respectively, compared to the control of plots, which is averaged qgt;4.5 per dive. The fish density in the 1987 study exceeded the fish density in 1986 by about twice that of 1.7 kg/ha and three times at 3.4 kg/ha. the number of fishes made up the control differences. in the second year, although the mosquitoes were not eliminated. Differences between test sites and control sites were observed for the first time eight weeks after the fish was planted and the mosquitoes remained under control until the drainage of the fields (Kramer et al. 1988). Davey and Meish (1977a,b) showed that mosquito fish with flooded emissions of 4,800 fish per hectare, was effective for controlling psorophora columbiae (Dyar and Knab) in the rice fields of Arkansas. The fish, poured on the water, quickly dissipated in the fields. This is an important attribute for the control of the species Psorophora and Ades, whose development of hatches and larvae are completed in a few days. The combination of 1200 G. affinis and about 300 sunfish (Lepomis cyanellus Rafinesque) gave better control than four times the amount of G. affinis or L. cyanellus used separately. This synergistic effect reduces the logistical problems associated with having enough fish at a time when the fields are flooded. Blaustein (1986) found enhanced control of An. freeborni mosquito fish in California rice fields after adding green solar fish. He suggested that increased control was the result of mosquito fish spending more time in protected areas where mosquitoes are larger and green sunfish are avoided. Having fish to stock up fields either inundatively, such as in Arkansas or for control at the end of the season, as is practiced in California, was the main reason why fish were not used more widely in rice fields. The unique use of mosquito fish through flooding release was reported by Farley and Caton (1982). The fish was released into underground urban storm drains to control Culex quinquefasciatus Say breeding in trapped water at low points in the system. Fish releases were made after recent heavy rains to avoid them being washed out of the system. The fish survived for more than three months during the summer and were found throughout the system. Gravid women produced offspring. However, no mating occurred, and after the initial increase in the population of fish decreased as the summer developed. The decrease in the number of mosquitoes from 75 to 94% was observed within three months compared to untreated areas (Mulligan et al. 1983). This control practice is currently conducted on a regular basis by the Fresno Mosquito Abatement District (J. R. Caton 1987, pers. comm.).   Although G. affinis has been useful for mosquito control in a number of situations, there are obviously drawbacks in its use. In fact, if today's ecological awareness existed at the turn of the century, this fish probably would never have been intentionally introduced in exotic areas (Pelzman 1975, Lloyd 1987). The main objection to this fish was its direct impact on local fish through or its indirect impact as a result of competition (Bay et al. 1976, Schoenherr 1981, Lloyd 1987). The introduction of Gambusia (Schoenherr 1981, Lloyd 1987) negatively affected more than 30 species of native fish. Gambusia, a common predator, can also significantly reduce zooplankton and thus lead to algal blooms in certain situations (Hurlbert et al. 1972). The introduction of Gambusia also reduced the number of other aquatic invertebrates coinhabiting the same waters (Hoy et al 1972, Farley and Younce 1977, Rees 1979, Walters and Legner 1980, Herlbert and Mulla 1981). In California, where local fish pups in the genus Cyprinodon (PHOTO-1, #2) can afford greater potential to control mosquitoes in a wider range of environmental stresses than Gambusia (Walters and Legner 1980), the California Department of Fish and Consumption discourages their use on the grounds that unknown harmful effects can lead to other indigenous fish. There is also concern that some rare species of cyprinodon may be lost as a result of hybridization. The next most widely used mosquito-borne fish is the common guppy, Poecilia reticulata (Peters) It has been successfully deployed in Asia to fight sewage mosquitoes, especially Cx. quinquefasciatus. Like his poeciliid relative Gambusia, he is native to America (tropical South America). But, instead of being deliberately introduced to fight mosquitoes, it was taken to other parts of the world by tropical fish lovers. Sasa et al. (1965) observed the wild populations of this fish breeding in runoff in Bangkok, and concluded from their observations that it controls the mosquitoes common to this habitat. The practical use of guppy is mainly limited to subtropical climate due to the inability to transfer water temperature in the temperate zone (Sasa and Kurihara 1981). However, their most important attribute is tolerance of relatively high levels of organic pollutants, making them ideal for urban water sources rich in organic waste. In Sri Lanka, wild populations have been harvested and used to control mosquitoes in abandoned wells, coconut husk pits and other organic-rich sources (Sasa and Kurihara 1981). The fish is found in India, Indonesia and China and has been deliberately introduced to fight filariasis in Burma (Sasa and Kurihara 1981). Mian et al (1985) evaluated its use for mosquito control in treatment plants in Southern California and concluded that the guppy demonstrated great potential for mosquito control in such situations. Exotic fish are also used to clear aquatic vegetation from waterways, leading to excellent mosquito control. In the irrigation systems of southeastern California, three species of subtropical cichlid, Tilapia (Gervais), Oreochromis mossambica </PHOTO> </PHOTO> Oreochromis hornorum (Trewazas) have been introduced and more than 2,000 hectares of Cx. tarsalis breeding habitat (Legner and Sjogren 1984) have been created. In this situation, mosquito populations are controlled by a combination of direct predator and aquatic plant consumption by these omnivorous fish (Legner and Medved 1973, Legner 1978a, 1983; Legner and Fisher 1980; Legner and Murray 1981, Legner and Pelsew 1983). As Legner s Sjogren (1984) shows, this is a unique example of continuous biological control and is probably applicable only to relatively complex irrigation systems, where a permanent water supply is provided and water conditions are suitable for supporting fish (Legner et al. 1980). The use of these fish three times has three times: (1) clearing vegetation to ensure the openness of waterways, (2) mosquito control and (3) fish large enough to be caught for human consumption. Some sophistication is necessary when stocking these cichlids to combat water districts, which is often not understood by the personnel of irrigation districts (Hauser et al. 1976, 1977; Legner 1978b). В противном случае конкурентное перемещение может привести к ликвидации T. zillii, <PHOTO>наиболее эффективных видов потребления потребления потребления потребления употребления употребления потребления (Legner 1986). Home storage of water in open containers is often the cause of outbreaks of human-borne diseases by Aedes aegypti (Linnaeus) in less developed parts of the world. During the conduct of Ae. In aegypti surveys in Malaysia in the mid-1960s, Dr. Richard Garcia of the University of California, Berkeley, observed that P. reticulata was apparently used by the city's residents to control mosquitoes in bath and drinking water storage containers. The origin of this method of control was not clear, but it appears to have been a custom brought to the area by Chinese immigrants. Not all residents used fish, but those that did not have Ae breeding populations. aegypti. Neng (1987) reported the use of a som, Claris sp., to control Ae. aegypti in water storage tanks in the coastal villages of southern China. This fish was considered suitable because it was local, edible, consumed a large number of mosquito larvae, had a high tolerance for adverse conditions and could be obtained in local markets. One fish was placed in each water source and then checked for larvae by the larvae survey teams approximately every 10-15 days. If the fish was not found during the search, the tenant was ordered to replace the fish or be fined. The study was conducted from 1981 to 1985, and surveys during this period showed a sharp initial decline in Ae. aegypti followed by low mosquitoes during the four-year study period. Dengue outbreaks have been observed in neighbouring provinces in period, but not in the observable fishing villages. The cost of the program was estimated at about 1/15/PHOTO spraying at home (Neng 1987). Alio et al. (1985) described another use of a local fish species to control malaria vector, a similar method reported by Kligler (1930). Oreochromis sp., tilapin, was introduced into human catchments called barkits in semi-arid areas of northern Somalia. These small scattered parking lots served as the only sources of water in the dry season for the large grazing population of the region. Anopheles arabiensis Patton, a malaria vector in this area, is essentially confined to these places. The release of fish into barks quickly reduced both the vector and non-vector mosquito populations. Treatment of the population with antimalarial drugs at the initial stage of this two-part study, combined with a lower vector population, reduced malaria transmission to negligible for 21 months, while control villages remained above 10 per cent. Alio et al. (1985) noted that the local population also recognizes the added benefits of reducing vegetation and insects in water sources. This has led to cooperation with communities and is expected to benefit even more from the control strategy by assisting in the distribution and maintenance of fish as the programme spreads to other areas. The last two examples include the use of indigenous peoples for exotic fish where possible in vector control programmes. There are other examples where local fish have been used in specialized circumstances (Kligler 1930, Legner et al. 1974, Menon and Rajagopalan 1978, Walters and Legner 1980 , Ataur-Rahim 1981 and Lou 1981). Lloyd (1987) argued that only local fish should be used to control mosquitoes because of environmental disturbances caused by exotics such as G. affinis. However, he suggested carefully analyzing local fish's selectivity, reproductive potential and effectiveness in pest control before trying to use them. Lloyd (1987) also noted that an interdisciplinary approach involving biologists and entomologists should be used to develop local mosquito control fish. However, in California, where local puppy fish in the genus Cyprinodon can afford greater potential to control mosquitoes in a wider range of environmental stresses than Gambusia (Walters and Legner 1980), the California Department of Fish and Consumption does not recommend their use on the grounds that unknown harmful effects can lead to other indigenous fish. There is also concern that some rare species of cyprinodon may be lost as a result of hybridization. Perhaps China's example of the multipurpose use of local fish to control mosquitoes and the source of human protein is the most Strategy. This mosquito control app is not new. Kligler used thylapine fish to control Anopheles sp. in citrus irrigation systems in old Palestine, where farmers cared for fish by consuming larger ones. According to Lu (1981), the culture of edible fish in order to control mosquitoes and human food is not widely encouraged in China. The old Chinese peasant custom of growing edible fish in rice fields has recently received more attention because of the benefits made possible by this practice. Common carp, Cyprinus carpio Linnaeus, and herb carp, Ctenopharygodon idella Valenciennes, are most commonly used. The fish is released as fry during planting rice seedlings. The fields are specially prepared with a central fish pit and radiating ditches for shelter when the water level is low. Pisciculture in rice fields, as noted by Lu (1981), has three main advantages: (1) a significant reduction in coulicine and to a lesser extent anofelin larvae, (2) fish are harvested for food and (3) rice yields are increased apparently by reducing competitors and possibly by fertilizing fish plants with excrement. Another group of fish, the so-called Instant or Annual Fish (Cyprinodontidae), which are native to South America and Africa, were considered as possible biological mosquito control agents (Vanderplant 1941, 1967; Hildemann and Woolford 1963; Bay 1965, 1972;

Marcofsky and Mathias 1979). The relatively drought-tolerant eggs of these cyrinodontides, which allow them to use temporary water sources as habitats, seem to make them ideal candidates for mosquito control. There is also some evidence that they affect mosquito populations in their native areas (Vanderplant 1941, Hildemann and Woolford 1963, Marcofski and Mathias 1979). Studies of the biology and ecology of several species have been carried out; however, there are no reports of the successful use of these fish in field situations. In California, the South American species Cynolebias nigripinnis Regan and Cynolebias bellottii (Steindachner) have experienced summers in rice fields, but have not seen breeding over a three-year period (Coykendall 1980). They were supposed to play a future role in California's mosquito control program in temporary pools and possibly in rice fields. C. bellottii was observed to reproduce repeatedly and persist in small periodic dried ponds in Riverside, California for 11 consecutive years, 1968-1979 (Legner and Walters unpubl.). Four flood drying operations within two months were needed to eliminate this species from ponds that were to be used to study local fish (Walters and Legner 1980). It seems logical, given the biological survival opportunities during the annual dry period, that these fish can be successful mosquito control programmes, especially in newly created sources in the geographical geographical area where they naturally meet (Vaz-Ferreira et al. 1963, Anon 1981 and Geberich 1985). Arthropods.-Numerous species of predatory arthropods have been seen to prey on mosquitoes, and in some cases are thought to be important in mosquito control (James 1964, Service 1977, Collins and Vasino 1979, McDonald and Buchanan 1981). However, of the several hundred predatory species observed, only a few have been used in a manipulative way to control mosquitoes. Dragonflies, sometimes referred to as mosquito hawks, were among the first arthropods to be examined. Difficulties in colonization, production and processing limit their use to experimental observation. It is unlikely that they will ever be widely used (Lamborn 1890, Beesley 1974, El Rayah 1975, Riviere et al. 1987a). There are several cases where the difficulties associated with manipulative use of arthropods have been at least partially overcome. More than 50 years ago, with the classical use of biological control, Toxokhinchita mosquitoes, whose larvae are predators of other mosquitoes, were released on several Pacific islands to control natural and artificial container mosquitoes such as Ae. aegypti and Aedes albopictus (Skuse) (Payne 1934, Bonnet and Hu 1951, Petersen 1956). Emissions were not considered successful, but mosquitoes were indeed installed in some areas (Steffan 1975). Several reasons to explain why these releases failed were low egg production, lack of synchronicity between predator and prey life cycle, and choice of only a relatively small number of breeding sites (Muspratt 1951, Nakagawa 1963, Trpis 1973, Bay 1974, Riviere 1985). Although apparently not a suitable predator in the classical sense, there is still interest in the use of different Toxorinchites spp. to flood the release (Gerbert and Visser 1978). Trpis (1981) work with Toxorhynchites brevipalpis (Theobald) showed that the high daily rate of consumption and long survival of larvae without prey made it the main candidate for the use of biological control. Observations of adult females showed that during the 10-week period of survivors there was 50% with a relatively high level of ovity per woman. All of the above attributes suggest that this species will be useful for flooded release programs against container mosquito breeding. Research by Focks et al (1979) in Florida, working with Toxorhynchites rutilis rutilis Coquillett, showed that this species had a high success rate in artificial breeding containers. In a 12.6-hectare residential area, about 70 per cent of the available residences were located within 14 days with two issues of 175 women. Mass cultivation techniques have been developed for this species, as well as amboinensis Toxorhynchites (Focks и Boston 1979, Riviere et al. 1987b). Focks et al (1986), работа с Toxorhynchites amboinensis, amboinensis, that release 100 women on the block in a few weeks, combined with ultra low-volume application malathion, reducing Ae. the population of aegypti is about 96% in the residential area of New Orleans. Toxorites releases rather than insecticide treatment apparently account for much of the reduction. These workers noted that reducing both the number of predators and the use of the disease without reducing effectiveness could further improve the procedure. Mosquitoes such as Ae. aegypti and ae. albopictus, which breeds and whose eggs are dispersed through artificial containers, pose a serious health risk as vectors of human diseases in many of the warmer climatic conditions of the world. The sheer number of container products and rubber tyres, which are then discarded without care or accumulated, have given these mosquito species a huge environmental advantage. The recent creation and widespread distribution of Ae. albopictus in the United States highlights this point (Sprenger and Wuithironyagool 1986). The apparent inability of governments to properly monitor the disposal of these containers and the difficulties in their location after their dumping make flooded toxicity emissions, alone or in combination with other control tactics, a much more plausible approach (Focks et al. 1986, Riviere et al. 1987a). Notonekides are insatiable predators of mosquito larvae in experimental conditions (Ellis and Borden 1970, Garcia et al. 1974, Hazelrig 1974), as well as in waterfowl in the Central Valley of California (Legner s Sjogren, unpub. data). Notonecta undulata Say and Notonecta unifasciata Guerin were colonized in the laboratory. In addition, the collection of large quantities of eggs, nymphs and adults is possible from breeding grounds such as sewage oxidation ponds (Ellis and Borden 1969, Garcia 1973, Hazelrig 1975, Sjogren and Legner 1974, Muira 1986). Some studies have been conducted on the storage of eggs at low temperatures, but vitality has rapidly decreased over time (Sjogren and Legner 1989). Currently, the most possible use of these predators appears to lie in the recovery of eggs from wild populations on artificial egg materials and their redistribution to mosquito breeding sites. Such studies were conducted by Miura in the rice fields of central California (1986). Floating vegetation such as algae and sometimes duck algae (Lemna spp.) form a protective refugia for mosquito larvae, and therefore mosquito populations can be high in the presence of notonocids (Garcia et al. 1974). Colonization and mass production costs, combined with the logistics of distribution, processing and timing of production at the appropriate breeding site, appear to be almost insurmountable problems for the regular use of nontonactids. mosquito control. In addition to predatory insects, several crustaceans feed on mosquitoes Among them are tadpole shrimp, Triops longicaudatus (LeConte), and several species of copepod. Mulla et al. (1986) and Tietze and Mulla (1987), while exploring tadpole shrimp, showed that it was an effective predator in the laboratory and suggested that it could play an important role in the area against the floodwaters of Aedes and Psorophora species in southern California. Drought resistance in predator eggs is an attractive attribute for egg production, storage and manipulation in field situations against these mosquitoes. However, synchronicity in the hatch and development between predator and prey is crucial if it is to be a successful biological control agent for the fast-developing Aedes and Psorophora spp. In addition, tadpole shrimp is considered an important pest in commercial rice fields. Miura and Takahashi (1985) reported that Cyclops Vernalis Fischer was an effective predator on the early larvae of the star Cx. tarsalis in the laboratory. These workers have suggested that they may play an important role in suppressing mosquito populations in rice paddy fields because of their feeding behavior and abundance. Another crustacean that has shown promise for wider use is the cyclopid predator, mesocyclops aspericonnis Dadai (Riviere et al. 1987b). This work showed the abbreviation of Ae. aegypti and ae. Polynesia notes more than 90% after the body is inoculatively released into artificial containers, wells, tree wells and terrestrial crab burrows. Although unable to withstand drying, the fairly small cyclopod predator persists for almost 2.5 years in crabholes and up to five years in wells, tires and tree wells in subtropical conditions. This species may be mass-produced, but its appearance in large quantities in local water sources allows for inexpensive and widespread use of mosquito breeding sites in Polynesia (Riviere et al. 1987a,b). The species is also very tolerant of salinity of more than 50 parts per thousand. The bentic behavior of mesocyclopes makes it an effective predator of lower feeding Aedes, but limits efficiency against surface feeding of mosquitoes. Riviere et al. (1987a,b) believed that efficiency against Aedes was due to a combination of predation and competition for food. Perhaps the greatest usefulness of this mesocyclope will lie in controlling crab rocks such as Ae. polynesysensis in the South Pacific. Further studies may identify additional cyclopods that may affect other mosquito species. The most important non-anthropoude invertebrate predators to draw attention to mosquito control are turbellarian flatworms and coelenterate. Several species of flatworms have been shown to be excellent predators of mosquito larvae in various aquatic habitats (Legner and Bear 1974, Yu and Legner 1976, Collins and Vasino 1978, Vasino 1979, Legner 1977, 1979, Ali and Mullah 1983, George et al 1983). Some of the biological and environmental attributes of flatworms seem to make them ideal candidates for manipulative use. Among them are the simplicity of mass production, embryo overwintering, effective predatory behavior in shallow water with emerging vegetation, on-site exponential reproduction after vaccination (Bear and Legner 1974, Tsai and Legner 1977, Legner Tsai 1978, Legner 1979) and tolerance to environmental pollutants (Bear and Miller 1978, Nelson 1979). Collins and Vasino (1978) and Case and Vasino (1979) hypothesized that flatworms, especially mestomas, could play an important role in the natural regulation of mosquitoes in some California rice fields because of their density and their predatory attack on mosquito larvae in watch cages. Preliminary analysis using an extensive sample showed a significant negative correlation between the presence of flatworms and the levels of the Cx. tarsalis and An populations. freeborni (Case and Washino 1979). However, these workers cautioned that an alternative hypothesis related to the ecology of these species may explain the correlation. More recent studies of Palchik and Vasino (1984), which conducted more restrictive samples, could not confirm the correlation between mesostoma and mosquito populations. However, the enormity of the problem associated with sampling in California rice fields, coupled with the complexity of mining and predator interactions, makes further studies necessary before the role of this group of flatworms in rice fields can be clearly established. The important attributes of the manipulative use of flatworms mentioned above raise the question of why they were not developed further for use in mosquito control. Perhaps the modern development of Bacillus thuringiensis var. Israelensis DeBarjac (H-14), a highly selective easily used microbial insecticide, may have been at least partially responsible for slowing the further operation and development of these predators. Their mass culture must be continuous and requires qualified technical assistants (Legner and Tsai 1978). Their conservation in habitats may also depend on the presence of other organisms, such as ostracok, which can be used for food during low mosquito abundance (Legner et al. 1976). HHG Coelenterates, like flatworms, have shown great promise for further development and use in individual breeding sites. Chlorohydrra Viridisima (Pallas) is effective in suppressing coulicin larvae in ponds with dense vegetation, and this species can also be mass-produced (Lenhoff and Brown 1970, Yu et al. 1974a,b, 1975). However, like flatworms, work on these predators has weakened, perhaps for the same reasons as for flatworms. Microbial pesticides can be wide range mosquito breeding habitats. In addition, the commercial production of flatworms and coelenterates will be much more expensive, and storing viable crops is all but impossible. Mushrooms.--The most promising fungal pathogen is a very selective and environmentally friendly oomycete, Lagenidium giganteum Couch. First tested for mosquito pathogenicity in the field by McCray et al. (1973), it is used by aircraft in rice fields (Kerwin and Washino 1987). Lagenidium develops asexual and sexually in mosquito larvae, and is capable of recycling in permanent bodies of water. This creates the potential for long-term infection in overlapping generations of mosquitoes. Lagenidium can also remain dormant after the water source dries and then becomes active again when the water returns. Sexually produced oospore offers the most promising stage for commercial production because of its resistance to drying out and long-term stability. However, problems in the production and activation of oospores still remain (Axtell et al. 1982, Merriam and Axtell 1982a,b, 1983; Yaronsky and Axtell 1983a,b,c, Kerwin et et al. 1986, Kerwin and Vasino 1987). Field tests with sexual disputed and asexual zoospor show that this mosquito pathogen is close to the goal of practical use. Kerwin et al (1986) reports that asynchronous germination has a particular advantage in breeding sources where mosquito larvae populations are relatively low, but mosquito recruitment is continuous due to successive and overlapping generations, as in California's rice fields. The germination of oospores for several months provides long-term control for these continuous low-level populations. In addition, asexual zoospores stemming from the disputed infected mosquitoes are available every two to three days to respond according to the density of the way to suppress any growing mosquito population. This stage survives about 48 hours after leaving the infected host. Kerwin et al. (1986) indicate that the laboratory fermentation of Lagenidium's asexual stage for mosquito control in the field is approaching the development requirements and production costs of Bacillus thuringiensis israelensis. The clear advantage of this pathogen over Bacillus is its potential to recycle through subsequent host generations. The downside of the asexual stage is that it is relatively fragile, cannot be dried and has a maximum shelf life of just eight weeks (Kerwin and Washino 1987). Thus, the main focus for commercial production is on oospore, which is resistant to drying and can be easily stored. Axtell and Guzman (1987) recently encapsulated both sexual and asexual stages of calcium alginate and reported activity against mosquito larvae 35 and 75 days, respectively. Further Further in production and encapsulation methods, this approach can be a viable option for future commercial production and application. Restrictions on the use of this pathogen include intolerance to contaminated water, salinity and other environmental factors (Jaronski s Axtell 1982, Lord s Roberts 1985, Kerwin and Washino 1987). However, there are many sources of mosquito breeding where these restrictions do not exist, and therefore it would be expected that this selective and persistent pathogen would be available for routine mosquito control in the near future. The Culicinomyces clavosporus Couch, Romney and Rao fungus, first isolated from laboratory colonies of mosquitoes and then from habitats, has been under research and development for more than a decade (Sweeney et al. 1973, et Couch al. 1974, Russell et al. 1979, Frances et al. 1985). The fungus is active against a wide range of mosquito species and also causes infections in other aquatic Dipter (Knight 1980, Sweeney 1981). The ease of production with relatively inexpensive media in fermentation tanks is an extremely desirable trait. However, storage problems must be overcome if this fungus is to be widely used. It is possible that the drying process currently being studied will solve the storage requirements (Sweeney 1987). Although the fungus showed high infection rates in field trials, dosage rates were high and notable persistence on the site was not demonstrated (Sweeney et al. 1973, Lacey and Undeen 1986, Sweeney 1983, 1987). Different types of coelomomyces have been studied over the past two decades for use in mosquito control. Natural epizootics with infection rates of more than 90% have been recorded. These fungi persist in some habitats for a long time; however, the factors that cause outbreaks in such situations are not well understood (Chapman 1974). Some field tests were done, but the results were very variable (Federici 1981). In general, the difficulties associated with the complex life cycle of these fungi burdened the research on them. Federici (1981) and Lacey and Undin (1986) examined the potential of these fungi to fight mosquitoes. Nematodes.--Among the various nematodes pathogens for mosquitoes, Romanomermis culicivorax Ross and Smith, received the most attention (Petersen and Willis 1970, 1972a, b, 1975; Brown et al. 1977, Brown s Platzer 1977, Poinar 1979, Petersen 1980a,b, Brown-Westerdahl et al. 1982, Kerwin and Washino 1984). This memirtide, which is active against a wide range of mosquito species, has been mass-produced (Petersen and Willis 1972a) and has been used in a number of field trials. The nematode was produced and sold commercially under the name Skeeter Doom TMR, but according to Service (1983), the eggs showed a decline in vitality in transport and is no longer for sale. However, the ability of nematodes to recycle through mosquitoes and wintering in a variety of habitats, including drained, collected, burnt stubble, cultivated and transplanted rice fields, are strong attributes, conducive to its further research and development for biological control (Petersen and Willis 1975, Brown-Westerdahl et al. 1982). Several field applications performed well and included both pre-parasitic stages and post-parasitic phases with the first, more applicable to rapid destruction, and the second for longer-term continuous control, for example, in the rice fields of California (Petersen et al. 1978a,b, Levy et al. 1979, Brown-Westerdahl et al. 1982). Some drawbacks of its widespread use include intolerance to low levels of salinity, contaminated water and low oxygen levels, the predation of aquatic organisms and the potential for the development of resistance on the part of the host (Petersen and Willis 1970, Brown and Platzer 1977, Brown et al. 1977, Petersen 1978, Brown-Westerdahl 1982). However, these environmental problems are generally not a problem for controlling the anomaly. To control these species, the cost of mass production in vivo is clearly the main drawback of this pathogen. Perhaps its most plausible use will be in specialized habitats integrated with other control strategies (Brown-Westerdahl et al. 1982). Bacteria.-Controversy forming a bacterial pathogen, Bacillus thuringiensis var. Israelensis (H-14), was isolated by Goldberg and Margalit (1977) and produced by a toxin has been shown numerous studies to be an effective and environmentally friendly microbial insecticide against mosquitoes and blacks. Its high degree of specificity and toxicity, combined with its relative simplicity of production, has made it the most widely used microbial product to date for mosquito control and black fly. Currently, there are several formulations from commercial firms around the world. Their effectiveness in various environmental conditions and problems associated with its use were considered by Garcia (1986, 1987) and Lacey and Undeen (1986). Another spore-forming bacterium, Bacillus sphaericus Neide, also showed great promise as a larvacide against some mosquito species (Mulla et al. 1984). In general, several strains of this pathogen show a much higher degree of toxic variability among mosquito species. Culex spp. seems to be very susceptible, while other species such as Ae. aegypti is very fireproof. Unlike the ephemeral larkakidal activity of Bacillus t. i. toxin, some strains of B. sphaericus have shown persistence and apparent recycling in some aquatic habitats (DesRochers and Garcia 1984). For more information, see a recent review of Lacey and Undeen (1986). the number of protozoa were isolated from mosquitoes and other medically important arthropods (Roberts et al. 1983, Lacey and Undeen 1986). From this assembly, microsporidians are microsporidians studied quite intensively. Because of their complex life cycle and the in vivo production methods needed to sustain them, studies of their practical usefulness have been limited. However, as Lacey and Nemin (1986) note, if more information is available about their life cycle, it can be found that they may play a role in suppressing mosquitoes through non-carbon and additional emissions in certain habitats. Among the other simplest that show the promise of endoparastic ciliate, Lambornella clarki Corliss and coat, the natural pathogen of mosquitoes, Aedes sierrensis Ludlow. This pathogen has received considerable attention over the past few years as a potential biological control agent for container mosquito breeding (Egeter et al. 1986, Washburn and Anderson 1986). Decication of resistant cysts allow the preservation of the cylit from one year to the next. In vitro production methods are being developed and small field tests are being carried out to determine its effectiveness and practicality for local use (Anderson et al. 1986a,b). Viruses.-- Numerous pathogenic viruses have been isolated from mosquitoes and black flour. However, to date, no one looks promising for practical use in management (Lacey and Undeen 1986). For more information on biological mosquito control, please refer to the Reviews. RELATED: Detailed zlt.medvet.ref.htm'gt; Additional links can be found at: MELVYL Library Ali, A.I.M.S. Mullah. 1983. Assessment of The Planarian Dugesia dorothephalia as a predator of chironomids and mosquitoes in experimental ponds. Komarov News 43: 46-49. Axtell, R.K., S.T. Yaronski and T. L. Merriam. 1982. The effectiveness of fungal pathogen mosquitoes, Lagenidium giganteum (Oomycetes: Lagenidiales). It's a good time. Calif. Assoc control vector. 50: 41-2. Case, T.J. and R.K. Vasino. 1979. Control of mosquito larvae in rice fields. Science 206: 1412-14. Christensen, J.B., J.L. Fetter-Lasco, R.C. Vasino, R.C. Husbands I. E. Kaufman. 1977. Preliminary field study using the Lagenidium giganteum fungus as a possible biological means of controlling the Aedes nigromaculis grazing mosquito. It's a good time. Calif. Assoc control vector. 45: 105. Collins, F.H. and R.C. Vasino. 1978. Microturbellaria as natural predators of mosquito larvae in the rice fields of northern California. It's a good time. Calif. Vect. Contr. Assoc. 46: 91. Collins, F.H. and R.C. Vasino. 1979. Factors influencing the density of Culex and Anopheles freeborni resins in the rice fields of northern California. It's a good time. Calif. Control assoc. 47: 97-98. Domnas, A.J., S.M. Fagan and S.T. Yaronski. 1982. Factors influencing the production of zoospor in liquid cultures of the pathogen Lagenidium giganteum (Oomycetes: Lagenidiales). Mycology 75: 1999 Garcia. R. and Legner, E.F. </medvet.ref.htm> </medvet.ref.htm> Biological control of medical and veterinary pests. In: Fisher, T.W.and T.S. Bellows Jr. (eds) Biological Control Handbook: Principles and Applications. Academic Press, San Diego, CA 1046 George, J. A. 1978. The potential of local planner Dugesia tiger (Tricladida, Turbellaria) to fight mosquitoes in Ontario. It's a good time. Ent. Soc. Ont. 109: 65-9. George, J.A., B.A.L. Nagy and J.W. Stewart. 1983. The effectiveness of Tricladida: Turbellaria in reducing the number of kalex in both the field and the laboratory. Mosk. News 43: 281-87. Glenn, F. E. and H. E. Chapman. 1978. Natural epizootic water fungus Lagenidium giganteum in Culex territans mosquitoes. Mosk. News 38: 522-24. 158. Hauser, W.J., E.F. Legner, R.A. Medved and S. Platt. 1976. Tilapia is a tool for managing the biological control of aquatic animals and insects. Bull. Amer. Fishing Soc. 1(2): 15-16. 160. Hauser, W.J. 1976. Simple, inexpensive fish labelling technique. Progressive Fish Bodybuilder 38 (1): 18-19. 168. Hauser, W.J., E. F. Legner and F. E. Robinson. 1977. Biological control of aquatic animals by fish in irrigation canals. Proc. Water management for irrigation and drainage. ASCE/Reno, Nevada, July 20-22. 139-145. Yaronsky, S.T. and R.K. Axtell. 1982. Effect of organic water pollution on the infectiousness of the Lagenidium giganteum fungus (Oomycetes; Lagenidiales) for mosquito larvae (Culex quinquefasciatus): Field and laboratory assessment. J.Med. Ent. 19: 255-62. Yaronsky, S.T. and R.K. Axtell. 1983a. The effect of temperature on the growth of infection and zoosporogenesus Of Lagendium gianteum, a fungal pathogen of mosquito larvae. Mosk. News 43: 42-5. Yaronsky, S.T. and R.K. Axtell. 1983b. Preservation of the mosquitoes fungal pathogen Lagenidium giganteum (Oomycetes; Lagenidiales) after introduction to the natural habitat. Mosquito News 43: 332-37. Yaronski, S.T., R.K. Axtell, S.M. Fagan and A.D. Domnas. 1983. Production of zoospores by Lagenidium giganteum mosquitoes (Oomycetes: Lagenidiales) on solid media. J. Invert. Way. 41: 305-09. Kenk, R. 1972. Turbellaria Planarium of North America. Biota Freshwater Ecosystems, Identification Guide No. 1, Smithsonian Institution, Washington, D.C. 81. Lambourn, R.H. 1890. The dragon flies against mosquitoes. D. Appleton Co., New York. 202 p. Legner, E. F. 1977. Reaction of Culex spp larvae. and their natural insect predators are two indicators of vaccination with dugesia dorotocephala (Woodworth) in shallow ponds. Mosk. News 37: 435-40. 1984 Legner, E.F.I. R.D. Shogren. 1984. Biological mosquito control is moving forward with advances in technology and research. D. Amer Mosk. Contr. Assoc. 44(4): 1974 Legner, E.F., R.D. Shogren and I.M. Hall. 1974. Biological control of medically important arthropods. Critical Environmental Control Reviews 4(1): 85-113. 1975 Legner, E.F., R.A. Bear and W. J. Hauser. 1975. Predator of a desert puppy, cypriinodon maculars on Coulex mosquitoes and bent het chironoid midges. Entomophaga 20 (1): 23-30. 1978a Legner, E. F. 1978a. Efforts to combat Hydrilla verticillata Royle with herbivorous Tilapia zillii (Gervais) in the Imperial County irrigation channels. It's a good time. Calif. Vector Contr. Assoc., Inc. 46: 103-104. 1978b Legner, E. F. 1978b. The mass culture of Tilapia (Cichlidae) in the ecosystems of ponds. Entomophaga 23 (1): 51-56. 1978c Legner, E. F. Part I: Parasites and predators introduced against pests of arthropods. Deepter. In: Introduced parasites and predators of arthropods and sorators: World Review (C. P. Clausen, ed.), p. 335-39; 346-55. Agrick. Herdbk. No 480, ARS, Usda, U. S. Govt. Printing Off., Washington, D.C. 545 p.m. 1979 Legner, E. F. 1979. Improvements in the use of flatworms for biological mosquito control. It's a good time. Calif. Vector Contr. Assoc., Inc. 47: 42-43. 1973 Legner, E.F.I. R.A. Bear. 1973. Influence of Tilapia Mossambik (Peters), T. Sillius (Herveis) (Cihlida) and Mollienesia Latipinna LeSuor (Pocilida) on populations of pond populations of crippled mosquitoes and hetomids. D. Amer Mosk. Counter. Asshak. 33(3): 354-364. 1974 Legner, E.F.I. R.A. Bear. 1974. Laboratory and small-scale field experiments with planaria (Tricladida, Turbellaria) as biological mosquito control agents. It's a good time. Calif. Contr. Assoc., Inc. 42: 79-80. 1984 Legner, E.F.I. R.D. Shogren. 1984. Biological mosquito control is moving forward with advances in technology and research. D. Amer Mosk. Contr. Assoc. 44(4): 449-456. 1978 Legner, E.F.I. S.-S. Cai. 1978. Increase the rate at which the Dugesia dorotocephala mosquito is divided by biological filtration. Entomophaga 23 (3): 293-298. 1990 Legner, E.F.I. R. W. Warkentin. 1990. The rationale for the desert puppy, Cyprinodon macularius, as an addition to Gambusia in the fight against mosquitoes. Calif. Vector Contr. Assoc., Inc. 57: 142-145. 1976 Legner, E. F., T.-C. Tsai and R.A. Bear. 1976. Environmental stimulants for asexual reproduction in planarian, Dugesia dorotocephala. Entomophaga 21 (4): 415-423. Lenhoff, M. H. and R.D. Brown. 1970. Mass culture of hydra: improved method and application to other invertebrates. Anime Laboratory 4: 139-54. Levy, R. and T.W. Miller Jr. 1978. Tolerance to The Planning Dugesia high concentrations of pesticides and growth regulators. Entomophaga 23: 31-34. McKay, E. M., D. J. Womeldorf, R.C. Husbands and D.A. Eliason. 1973. Laboratory observations and field tests using lagenidia against California mosquitoes. It's a good time. Calif. Managing Assoc. 41: 123-28. Bear, R.A. and E.F. Legner. 1974. Feeding and reproducing a planarian, Dugesia dorotocephala (Woodworth), in the presence of Culex peus Speiser. Environ. Ent. 3: 637-41. J. J. Meyer 1981a. Laboratory research on the potential of Dugesia tigrina for mosquito predators. Mosk. News 41: 760-64. J. J. Meyer 1981b. A field test of the potential of local flatworm Dugesia tigrina for biological control of mosquitoes in temporary pools. North Dakota Farm Res. 39 (2): 19-24. Nelson, F.R.S. 1979. Comparative predatory potential and asexual reproduction of Dugesia's separate dorotocephaly in terms of biological control of mosquito vectors. Environ. Ent. 8: 679-81. Palchik, S.I.K. Vasino. Factors affecting the abundance of mosquito larvae in northern California's rice fields. It's a good time. Calif. Management 52: 144-47. Service, MV 1983. Biological control of mosquitoes - does it have a future? Mosk. News 43: 113-20. 1977 Tsai, S.-K. E. F. Legner. 1977. The exponential growth of the culture of the Plannede Predator mosquito Dugesia dorotocephala (Woodworth). D. Amer Mosk. Contr. Assoc. 37(3): 474-478. 1980 Walters, L.L. and E. F. Legner. 1980. The influence of desert puppies, cypriinodon maculars and gambusia affinis on fauna in the ecosystems of ponds. Hilgardia 48 (3): 1-18. Vasino, R.K. 1981. Biocontrol of mosquitoes associated with California rice fields, with a particular reference to the recycling of The Lagenidium gianteum Couch and other microbial agents. 122-39. In: M. Laird, Biocontrol of medical and veterinary pests. Prager Pable., New York. Vasino, R.K. and C.K. Fukushima. Evaluation of biological controls on mosquito larvae in Northern California: progress report. It's a good time. Calif. Assoc control vector. 46: 89. Yu, H.-S. E. F. Legner. 1976. Regulation of water dipters by planaria. Entomophaga 21: 31-12. Yu, H.-S., E. F. Legner and R. D. Sjogren. 1974a. Mosquito control with European green hydra on irrigated pastures, river seepage and duck club ponds in Kern County. It's a good time. Calif. Contr. Assoc. 42: 77-78. Yu, H.-S., E. F. Legner and R. D. Sjogren. 1974b. Effects of mass release of chloroidrate viridisima (Coelenterata) on populations of Aedes nigromaculis and Culex tarsalis in Kern County, California. Entomophaga 19: 409-20. Yu, H.-S., E. F. Legner and F. Pelsue. 1975. Control of Culex mosquitoes in the habitats of Lake Usx in Los with chlorohydrate viridisima. It's a good time. Calif. Contr. Assoc. 43: 123-26. 123-26. biological control of mosquitoes. biological control of mosquitoes pdf. biological control of mosquitoes is done by using. biological control of mosquito larva. biological control of mosquitoes in ponds is done by using. biological control of mosquito larvae by guppy fish. biological control of mosquito larvae ppt. biological control of mosquito larvae slideshare