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Aquatic predators(insects) and Mosquito control

Author name: Pratik Gajanan Nagpure

University name: School of Agriculture,Department of Agricultural Entomology,

Lovely Professional University, Phagwara, Punjab, India

Abstract: Our biosphere consists of many ecosystem and these ecosystems contributed by different living individuals and each individual play it's important role in Ecosystem. In this review mosquito which is major issue for us also get cleared through aquatic predators we are going to get information about different individuals specially aquatic individual which play Dynamic role in Food chain. Aquatic predators are the group of insects having dynamic role in Food chain, food web, Ecosystem.Aquatic predators play major role in aquatic ecosystems and related disciplines.

Key words: Aquatic, predators,planktons, zooplankton,Copepod

Introduction

The following are the objectives from which here the review is based

- The biology of aquatic predators
- Characteristics and feeding habits of aquatic predators.
- Major role in Ecosystem
- Predator Prey interaction
- Aquatic insects predators and mosquito control.

, aquatic insect predators here some predators example which are becoming helpful for studying itself the aquatic predators having order is Odanata in which Dragonfly and Damselfly,In order Ephemeroptera Mayfly is there aftrrwards have some look on order plecoptera i.e. Stoneflies then in coleoptera there are some water beetle , whirling beetles and there are some aquatic scavenger also further in Hemiptera there is bug i.e. water striaders, also there is major predator i.e. Giant water bugs. In aquatic life as predators are there that means there are prey also like mosquitoes and flies belonging to Diptera , Trichopteran Caddisfly , Scorpion fly of order mecoptera.Hymenopteran ants and wasps are also playing as a predator in aquatic ecosystem.(Anon Wikipedia)

The insects from orders Hemiptera, coleoptera,odonata,Ditera, Ephemeroptera, Plecoptera these insects order are dominantly found in stream,pond, ecosystem there prey predator interaction,biomass, abundant, density, diversity are found in aquatic ecosystems.(Yapo.,L.M.,et.al.,2013).

1. Biology of Aquatic predators

1.1 May fly (Ephemeroptera:*Ephemera sp.)*

The life cycle of may fly is incomplete metamorphosis the stages of life cycle consists eggs,Nymphs and adult but there is intermediate stage between end of last nymphal stage and adult called subimago or premature stage eggs are laid by fertilization from air and laid in water incubtation period is upto 1-2 weeks then Nymphs arises and this is the most prominent stage and Nymphs survive from 2 months to 2-3 years and it feed on aquatic lives like algae and and some little organisms they act as a aquatic predators after that adult arises after 24 moulting and adult longevity is upto 1 - 7 days (C.Balchandran,et.al,2012)

The mayfly have unique stage i.e. subimago stage this is the preadult stage and this may differed the mayfly from other insect species.(Edmunds G.F.,and McCafferty,W.P.,1988.)

Nymphs of may fly were active at night or darkness Nymphs were positively thigmotactic and negatively phototactic in flowing water.(JM Elliott,1968)some species of may fly Nymphs have flattened body structure and these body structure is useful them to hide in crevices of stones and these Nymphs observed stay inside the waterbody and below the rocks also not on upper side because it has flattened body shape(Dodds G., And Hissaw F.,1924)

The nymphal stage have gills and these gills are act as a accessory oxygen intakings and act as accessory respiratory things at certain species showed these mechanism.(Wingfield CA.,1939).The new species was reported from new Missouri State the found species is Homoeoneuria ammophila.(Sarver,R.J.,and Rachel.L.S.,2020).

The biodiversity is checked from certain studies held in Brazilian Savana inthis study it is seen that the eighter Waterfall is barrier for aquatic insects or not but it is proven that there no problem for the aquatic insect.and biodiversity recorded for Ephemeropteran, Plecopteran and Trichopteran.as researcher found these insects from 33 grnera.(Andrade,ICP.,et.al.,2020).

The stone fly life cycle has been studied by scientists that they are univoltine, as metamorphosis is incomplete we can say as a garadual changes or paurometabolous incubation period is upto 1-2 months while nymphal period is upto 7-8 days (José Manuel Tierno de Figueroa,et.al.2009)

Other major predatory order is odonata that contains Dragonfly and Damselfly they are hemimetabolous active insects predators they have 3 different life stages in which naiads or nymphs are very prolonged and as well as aquatic predators and adults are also aquatic and territorial predators. Eggs are laid by female on aquatic plants and incubation period is upto a week's after nymphs emerged they undergo upto 10 molts and after adult the insect become mature for reproduction and adult longevity upto 1-2 weeks(Cordoba-Aguiler A.,2010).

The life cycle is concerned there is another reference that is taken that in Sierra morena lake data taken from 2 season with 3 consecutive years showed that various and prolonged life stage and adult (*lestes viridis*)dipause upto 3 months.(Aguero-Pelegrin M.,et.al.1999)

Let us see the biology of diving predacious beetle one study has shown us that after hatching of eggs the soft imagine means fresh larvae are seen upto 2-3 months and then larvae gets overwinter and then adult emegerged and die upto next season means this insects show a complete 1 year lifecycle i.e. univoltine.(HAGENLUND G. AND NILSSON A.N.,1985).

Diving beetle,Dytiscus sharpi, adult beetle have preferred Oenanthae javanica plants for egg laying than other plants.(Inoda,2011).The aquatic beetle female lay there eggs in water where predator like fish are ubsent in that area egg laying take place but it is seen that larvae in a fish water are increased than larvae in absent of fish predator having less increase growth(Thomas B.,et.al.2006).

These predacious diving beetle have lot of species but there is proof of occuring of new species which is very similar to hydroporus clairville and the name of species is Hydroporus esseri from southern Turkey (Hans Fery and Lars Hendrich,2011).

From class Insecta as aquatic predators are beetle along with there are predatory bugs also contribute the water striders i.e.Gerris lacustrix (Gereidae : Hemiptera)the life cycle of water striders or pond skaters is upto2-3 months the eggs are laid by female on rocks or plants,then afters imergence of Nymphs it shows four to five juvenile stage these Nymphs look similar to adult on except genitali,wings,oceliia d one less tarasl segment than adult at 4-5 juvenile stage they develop wing pads,adult have wings,And it is mature stage this way pond skaters complete there life cycle.(Yang,C.M.,et.al.,2004).

It is studied that population from 2 habitat show different way of completion of life cycle one water strider species i.e. Gerris lacustrix in field ponds showed bivoltine generation and almost all species from foress ponds showed univoltine life cycle.(Pfenning B., Poethke H.J.,2006).

For better life strategy the Gerris thoracicus shows Wide and better adaptation regarding to food scarcity as this species show high reproduction and less longivity while food sources is available while on other hands this species shows vice versa when there is food scarcity this is the only species showed such type of modification.(Kaitala A., 1987).

For completing life cycle of lethocerus deyrollie (Belostomatidae: Hemiptera).it is foun that these bugs require habitat in rice fields as it is found as the most important habitat for water giant bug for there growth and development.(Mukai Y.,et.al.2005).

There are multihabitual strategy is observed in waterstriders some bugs have marine habitat some are secondarily linked as a terrestrial but major of species are Freshwater habitat/ aquatic habitat.(Spence,J.R.,and Anderson,N.M.,1994).

2. Characteristics of aquatic/feeding habit of aquatic predators

As the adults of may fly are not having specific feeding habit as they do not have well developed mouth parts but the most prominent stage of may fly is the Nymphs as they are active aquatic predators besides there predation they have other qualities like filterers , they are useful for human beings, collect gatherers, scrapers like this they have feeding habit(Jacobus M.,et,al,2019)

In stone fly they are also noticed as predator and specially in Arctoperlaria and Systellognatha have identified as a predator they are predacious on May fly, species of Mayfly ,even case building larvae (Trichoptera).(Tierno J.M.& López-Rodríguez M.J. 2019)

Now there is active predatory order which is aquatic and terrestrial pradators that order named Odanata i.e. Dragonfly and Damselfly it is seen that they are very active predators as they have high vision, activity of good flying that is they are active flyers while in adult ,they are morphological made for predation, Odonates are very superior predator (Bomphrey Rj.,2016)

In biological control we can use or rear dragonfly because there nymphs and adult active predators and it is recorded that the dragonfly have more daily consumption capacity and have standing in stock more than their prey so they are good biological controller an have very important role in ecosystem.(Thorp J.H., AND Cothran M.L.,1984

) The main food of dragonfly lara (*Anax Junius)* has different kind of food as they are actively predating on amphipods and *Choborus larvae* and other food is some coleopterans,zygopterans and some i sects from chironomidae showed by study.(Folsom, T. C. and Collins, N. C. 1984.)

In odonata there is also contrary mechanism of Dragonfly and Damselfly research showed that the Damselflies larvae are attacked by Dragonfly as well as some fishes so dselflyies have evolved predation mechanism shows study(Stoks R.,et.al.2003).

Feeding and top predation nature of dragonfly showed that due to there presence near to stream the activity of tadpole species get changed that if some are immobile tadpoles get mobile to avoid predation by dragonfly,the species of tadpole are *bufo bufo,Bombina bombina,Hyla arborea.(*Andreas Chovanec,1992)

The Damselfly are recorded as it made itself evolutionary changes in pond ecosystems and there are seven species are reseached *Enallagma* species out of 2 from Dragonfly as a top predator and 5 from fish predators as have changed their evolution and found as they have attained high speed anti predatory mechanisms and dselflyies have long caudal lamellae also enforce to attain high speed for sweeming to protect Damselfly larvae from predators (Mcpeek M. And Schrott A.,1996)

The Damselfly and Dragonfly are become most active predator because there mouth type and legs,mouth has sharped and pointed mandibles as well as they have basket type of legs which is helpful for holding the prey either on aquatic or terrestrial they have unique characteristics of body structure so that they always proud to active predation.(Stanislav N. Gorb.).

There is also seen that predators that attacks always on small larvae and other organisms while being attacke the larvae of Odonata shows some antipredatory action which is beneficial for larvae to sustain themselves but have bad effects for their growth.(Tomas and Bordin,2005).

By moving forward there are some coleopterans also act as a aquatic predator in which water diving beetle is one of the important insect these creature mainly L. angusticollis juvenile stage are voracious feeder they mainly feed on Boeckella poppei i.e.copepod are preyed by grub stage of beetle and adult mainly predators of benthic ostracods.(Arnold R.,and Convey P.,1998)

The aquatic predators are dependent on prey size they have recorded as feed on tadpoles except the predacious diving beetle (Dysticus verticalis) they prefer not only Hatched tadpoles but handle rather than new hatched larva. Some prey species avoid becoming prey by rapid larval growth of predacious diving beetle.(Brodie E.,et.al.,1983).

The another Predatory bug is water striders,pond skaters are the insects which found on surface of water the insect majorly feeds as a predator on small insects which will fall on water source. They suck the nice from prey and feed on them pond skaters belongs family Gereidae of order Hemiptera some time cannibalism also occur.(Cheng,L.,et.al.,2001.)

Another major aquatic predator that we are going to discuss is water giant bug (Belostoma sp.: Belostomatidae) the water giant bug is found as major aquatic predator and it is seen this insect is predator of cave fish(Tobler M.,et.al.2007).

Water giant bug predacious for snakes,ambhibians,fish,etc but in this study it is clearly observed that this water giant bug predacious for turtle also and this bug belongs to subfamily Lethoceranae and this bug found as largest body size amongst Belostomatidae.(Shin-ya OHBA,2011).

Further studieng the heteropteran superfamily Corixoidae are the bug similar to true bugs the diet and feeding habit of the waterboatman are unclear but most of this superfamily are zoophagy feeding on algae and detritus only

superfamily Cymatiainae bugs are active predators these are organisms and predators of fresh water ecosystem.(Hadicke C.W., et.al.,2017).

3. Major role in ecosystem

The aquatic insects are most important fauna for ecosystem and at various environmental variable of water diversity and density of aquatic insects were studied by standard method.these aquatic insects are useful for estimating as a pollution indicator and they have significant role in bioindicators.(Dalal,A.,and Gupta,S.,2018).

May fly are most dynamic Creature as it also contribute it's own life in pond ecosystem, it play a very essential role in transfering the energy flow,may fly act as a clear water indicator means it lives in clear water may fly also play vital role in process of fine particulate organic matter .(Balchanndran C.,et.al.2017)

Comparison of plecopteran and ephemeropteran has shown by here like there are variety of both orders are having little difference like they are having cold and tropical water stream habitat respectively also these orders have different mating habits that is plecopteran mating carry on ground while may fly in air. Plecopteran has evolved brachyptery and Ephemeropteran has not brachyptery.(John E. Brittain, University of Oslo)

Now we have an iconic insect creature that is Dragonfly of odonata order dragonfly is most iconi insect aquatic as well as aerial predators it has major role in ecosystem these insects are sensitive to the environmental conditions,it has significance role in conservation at all special scale very effective species of our ecosystem (samways M. 2008)

Odonata is the order of hexapods that have evolutionary ecology as well as genomic issues that makes this order extraordinary because this order have variety of features likes sexual dimorphism,bioindicators of pollution as well as climate change.(Bybee S.,et.al.,2016)

There is study of influence of biotic and abiotic factors it is shown that some species of odonata are found drastically low population than the fish free ponds or other species found which are different from those species which is affected by fish population and only water acidity is the only one abiotic factors for dragonfly larvae or dragonfly life stages that were affected.(Johansson F.& Brodin T.,2003).

Like Damselfly dragonfly larvae also get affected by the presence of fish in ponds and there are fixed and reactive predator behavior shown by odonata larvae fixed behaviour is shown when there is only presence of predator and reactive behaviour shown by taking sense of predator presence and move away this evolutionary behaviour noticed and essential for ecosystem and its role itself in pond ecosystem(C.L.Pierce,1988).

Here for developing countries the fresh water ecosystem is less known and lack of awareness about knowledge of freshwater some project from South Africa,Japan and Tanzania, these countries promoted the project on Dragonfly as freshwater identifiers, Dragonfly is an easy to learn tool in environmental education system and these helpful for making life ecosystem more healthier(Clausnitzer,V.,et.al.2017.).

The dragonfly and dselflyies are colourful and conspicuous Species of insects fauna and we have to take action for conserving this fauna as they are Clear atmosphere bioindicators and clear water indicators.(Butler,R.G.,and deMaynadier,P.G.,2008.).

For water diving beetles it is seen that in auatic ecosystems the larvae are active predators and also shown effect in presence or absence of aquatic plants among some species there are *Dysticus s*howed 'sit and watch' tactics,*Graphiderus* showed that as engaging in active predation while *Rhantus* showed above both behaviour combinely it is observed that how active predators they are!(Donald A.,2009).

Examined the study reported the predatory beetle,Dysticus verticalis and tadpole (Rana clamitans) from semi permanent ponds these tadpoles are being preyed by predacious aquatic beetle size getting bigger is seen as a antipredatory mechanism for beetle.(Farmanowicz D.R.,1986.)

Coleoptera is the largest order of insects that contains beetle and such aquatic beetles also here the information has put that the aquatic beetle have preyed by major organisms but they have developed defence mechanism against there predator like types of behavior, mimetic, cryptic, or aposematic appearances, etc. And these may be multifunctional like repellent,toxicants,etc.(Konrad Dettner,1987.)

Water giant bug is also an very active predators and it is endangered species.feeding of this bug is in rice field feed on frogs for this conservation of bug there should be frogs for maintaining the ecosystem and biodiversity.(Toshiaki Hirai, Kazumasa Hidaka,2002).

These Lethoceranae is the subfamily of largest body sized water giant bugs these bugs diet contain main aquatic plants, terrestrial and aquatic invertebrates, small fish, tadpoles, adult anurans and less feed on snakes and turtles.here the study showed these bugs like feed on Drndropsopus minutus an adult frogs as these frogs are main dietary component of These bugs.(Rocha R.,2014).

In southern maexica there is cave and water and relative ecosystem there is hydrogen sulphide which is toxic although these Belostomatids found as a top predator and in water there found larvae of Giant bugs and feed on specially cave fish and other organisms and these play vital role for ecosystem and found various ecological function.(Tobler M.,et.al.,2013).

PREDATOR-PREY INTERACTION:

Aquatic insects have various prey Predator relationship as predator have also wide range of tactis of search,capture and consumption,while prey also have some morphological modification,mimicry against predator this concept known as predator prey relationship.(Peckarsky B.,1982).

Here prey Predator relationship between Mayfly and stonefly has observed that there are some species of Mayfly from Family Haptageniidae show effective crawling evaded, some species show scorpion like behaviour to avoid Stoneflies,some Mayfly species show swam or drifted against Stoneflies these tactics are observed from 'Mayfly Stoneflies'.(Peckarsky B.,1980).

The experiment showed that there are interaction between prey and predators and most of of aquatic predators have better interaction like capture, encounter,attack, ingestion the macro invertebrate predator which are active exhibit stronger prey than the sit and watch predators and it is shown that sit and watch predator have better ability of interaction with prey than mobile predators.(Cooper S.,et.al.,1985).

Odonates larvae starved and found much active for predation of some zooplanktons. Active prey also captured by sit and watch technique the predators require high vision for prey capture.and prey ingestion depends on predator prey frequency.(Crowley P.H and Moragan T.H.,1979).

Dragonfly larvae capture prey by rapid protraction of labium and these larvae ha e two types one is 'climbers' and other one is sprawlers, climbers detect there prey by staying amongts plants and with the help of there compound eyes while Sprawlers remains at bottom and capture prey by tactile stimulation.(pitchard G.,1965)

There are some noticeable changes observed in rice field the study showed here the rice field were dominated by some organisms like tubificids,chironomids,baetids,ceratopogonids population observed in different rice cultivation

phenomenon. And Dragonfly population i.e. Agriochnimus femina requires these organisms for successful emergence.these are active predator for rice pests.(Salmah C.,et.al.,2017).

Among Other ecosystem the paddy ecosystem were observed as best ecosystem where prey and there predators occurs and prey Predator relationship occurs for ex. Larvae of mosquitoes and other odonates, some coleopterans, Bugs,etc are occured.(Das,P.K.,et.al.2006).

The prey predator relationship showed that the activities of prey reduced when there is free living predator because of having predation of itself study was done with Damselfly larvae as it showed reduced movement while present of free predator.(Schaffner AK., Anholt BR., 1998).

Predatory aquatic insects group is a diverse group, knowledge of there food is fragmentary.which are little difficult to find of there mechanism of maintaining high local diversity and effects on local food web structure and dynamics.(Klecka J.,and Boukal D.S.,2012)

The relationship between the aquatic insects and insectivores birds in riparian habitat observed as directly proportional to imergence of stream insects and insectivores birds have major food contents in there feeding criteria as it is the relationship between insectivores birds to emerging aquatic insects.(Gray L.J.,1993).

The linkage between terrestrial and aquatic habitat the predators on terrestrial like some arachnids like spider and other invertebrate along with insectivores birds,bats,lizards with aquatic insects predators it is seen that some arachnids and other invertebrate are preyed by aquatic insect but insectivores birds,bats,lizards are not readily preyed by aquatic insect this relationship may lead assymetry in the strength of food web linkage between aquatic and terrestrial habitats.(Burden J.F. and Harding J.S.,2008)

The relationship with bugs and blood sucking Diptera,Bugs and fish,Bugs and some amphibians and water birds may be water bugs be a predator or prey but these relationships are considered as a important to economic point of view sometimes these bugs are saprobity bioindicators.(Miroslav PAPÁČEK,2013).

Predatory prey relationship is detected by the releasing of kairomones by predators present in aquatic habitat where mosquitoes are going to laid eggs or not if kairomones detected by mosquitoes it doesn't lay eggs in the such habitat said study.(Silberbush,A.and Blaustein L.,2007).

The ecologists said that there is cues are released by predators for prey it is captured by prey that cues known as chemical alarm signals eighther released by predator or prey if captured by predator they released chemical alarm signal this is the part of prey predator relationship.(Chivers,D.P.,and Smith,R.F.,1998).

Aquatic Insect Predators and Mosquito Control

Mosquitoes are very dangerous insect as there biting can cause various vector born diseases to mammals so it is found that they can be preyed by various aquatic predators like odanates, some dipterans which are primarily predators, true bugs,etc.they act as a effective biological control for mosquitoes larvae and pupa also the kairomones released by the predators can avoid female mosquitoes to lay there eggs for a week as it can be produced commercially for control mosquitoes.(Shaalan S. and Canyon D.V.,2009).

There is found that Anopheles and culex mosquitoes are found in the aquatic habitat where the predator of mosquitoes are also found like water beetle, water giant bug and it's larvae were found and can be use against to mosquitoes control.(Yasuoka J.and Levins R.,2007).

The further study of Culex quinquefasciatus mosquitoes have major dominant active predator noticed that is predatory water bugs Sphaeroderma annulum is acted as a biological control of larvae and pupae of mosquitoes and selectively there is lower emergence of mosquitoes adult.(Aditya G., et.al.,2004).

The water bug Sigara hogarroca found that it has potential of bioefficacy is more and active predator and great potential agaist for control of mosquitoes larvae in aquatic and semi aquatic habitat.(Ahmad A.M.,et.al.2009).

The 2nd instar larvae of Toxorhynchites splendens have more Predatory behaviour than other instar these T.splendens feeding on larvae of mosquitoes which are smaller in size than bigger one predation has taken place in high water at high temperature. (Amalraj D., And Das P.K.,1998).

There is also a predatory diperoid larvae Chaoborus cookie(Diptera: Chaoboridae)which is actively predacious on the larvae of mosquitoes and act as a biological control for mosquitoes larvae.(A Borkent,1980).

The main predator were detected for culex albifasciatus were coleopteran beetle out of which Liodessus sp. Were observed the best predator of larva and pupa of C.albifasciatus,and Rhanthus signature signatus, (Dysticidae: Coleoptera),Lancetus marginatus and the Predatory dipteran Psorophora ciliata more prominent predator for pupal stages of C.albifasciatus.(Campos R.E.,et.al.,2004).

The mosquitos can be controlled by biological method is again proved that the larvae Acilius sulcatus (Dysticidae: Coleoptera) is most prominent biological control for Culix subfasciatus as by feeding on larvae of mosquitoes mostly of 4 th instar larvae. This beetle is important for medical important mosquitoes.(Chandra,G., et.al., 2008).

The Damselfly naiads are also play an important role for controlling the larvae of mosquitoes.(JN Collins, VH Resh,1985).

The larvae of odonata was found on the tree hole near water surface and at that same place the larvae of Chironomids and Culicidae observed as they are prey of odonata and helps in biological control of mosquitoes.(Copand R.S.,et.al.,1996).

The shorefly larva (Ochthera chalybescens) preyed on mosquitoes at all stages except eggs and mosquitoes larva size and type of water could not affect on the feeding habit of this fly this fly has ability to consume 18

larvae per day and it is also one of the best biological control for Anopheles gambiae.which is the vector of African malaria disease.(Minakawa,N.,2007).

For contolling mosquitoes Not only insect pradators are present but parasitic fungii**(Coelomomyces sp**.) and nematodes(**Romanomermis sp.)** were observed in field of rice these these mosquitophagous fungii and nematodes are effectively biological control of anophelins and culicines larvae of mosquitoes(Chandrahas,R.K.,and Rajagopalan,P.K.,1979.)

.The study of combination of **Mesocyclops thermocyclopoides** i.e.copepod (Thai-strain) and **Bacillus thurengiensis var.israelensis** are more effective control of larvae of **Aedes aegypti.(**Chansang,U.,R.,et.al.,2004).

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