UNIVERSITI PUTRA MALAYSIA

DESTRUCTION OF PREDATORS IN THE ECOSYSTEM AND ITS IMPACT ON INCIDENCE OF DENGUE

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By

KAMARUZAMAN KHAN BIN NAWAB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DESTRUCTION OF PREDATORS IN THE ECOSYSTEM AND ITS IMPACT ON INCIDENCE OF DENGUE

By

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October 2017

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Dengue disease in Malaysia is increasing at an alarming rate. The district of Petaling, Selangor contribute more than 50 percent of the total number of Dengue cases in Malaysia. This study was carried out to show the use of Insecticide in Aedes mosquito control is ineffective because they also kill the mosquito predators which deter the breeding of aedes mosquito. It was done by inspecting 85 existing potential breeding points of aedes larvae distributed in 15 localities at hotspots area (where the incidences of dengue outbreak never stop for more than 30 days) with the presence of at least one mosquito predators. Frequency of Aedes larvae breeding, the incidences of dengue in relation to the presence of mosquito predator and the impact of insecticide used in the ecosystem were used to determine the objective. The mosquito predators identified was Gambushia fish, tadpoles, dragonfly nymph, frog and dragonfly. To determine the frequency of mosquito larvae in relation to the presence of predators, inspection was done at 85 existing potential breeding receptacles at 15 localities hotspots daily for 6 month. The use of data from VEKPRO programme under the Ministry of Health Malaysia was accessed to evaluate the amount of insecticide used monthly and in comparative to the number of dengue cases in that area for the year 2014 to 2015. Result: The frequency of larvae breeding and incidence of dengue cases decrease with the presence of mosquito predators. The use of insecticide is directly proportional to the incidence of dengue cases. In conclusion mosquito predators are very vital in controlling the breeding of aedes mosquito but the use of insecticide exterminated and damaged the mosquito predators and their habitat. It is recommended that the use of insecticide in controlling dengue at urban area should be stopped and biological methods to be introduced in curbing dengue.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMUSNAHAN PEMANGSA DALAM EKOSISTEM MEMBERI IMPAK DALAM PENINGKATAN INSIDEN DEMAM DENGGI

Oleh

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Penyakit denggi di Malaysia meningkat pada kadar yang amat membimbangkan. Daerah Petaling, Selangor menyumbang lebih daripada 50 peratus daripada jumlah kes denggi di Malaysia. Kajian ini dijalankan untuk menunjukkan penggunaan racun serangga dalam kawalan nyamuk Aedes tidak berkesan kerana kesannya juga membunuh pemangsa nyamuk yang menghalang pembiakan nyamuk aedes. Ia dilakukan dengan memeriksa 85 tempat pembiakan larva aedes yang berpotensi di 15 lokaliti di kawasan hotspot (di mana kejadian wabak denggi berterusan selama lebih dari 30 hari) dengan kehadiran sekurang-kurangnya satu pemangsa nyamuk. Untuk mencapai matlamat yang dikehendaki, kekerapan pembiakan larva Aedes, kejadian kes denggi dan kehadiran pemangsa nyamuk serta kesan racun serangga yang digunakan dalam ekosistem telah dianalisa. Pemangsa nyamuk yang dikenalpasti adalah ikan Gambushia , berudu, nymph pepatung, katak dan pepatung. Untuk mendapatkan kekerapan larva nyamuk berkaitan dengan kehadiran pemangsa, pemeriksaan dilakukan setiap setiap minggu selama 26 minggu/ 6 bulan. Penggunaan data dari program VEKPRO di bawah Kementerian Kesihatan Malaysia telah diakses untuk mendapatkan jumlah racun serangga yang digunakan setiap bulan dan berbanding dengan jumlah kes denggi di kawasan itu bagi tahun 2014 hingga 2015. Keputusan: Kekerapan pembiakan larva dan kejadian kes denggi berkurangan dengan kehadiran pemangsa nyamuk. Penggunaan racun serangga adalah berkadar terus dengan kejadian denggi. Kesimpulannya, pemangsa nyamuk sangat penting dalam mengawal pembiakan nyamuk aedes tetapi penggunaan racun serangga membunuh pemangsa nyamuk dan merosakkan habitatnya. Adalah disyorkan bahawa penggunaan racun serangga dalam mengawal denggi di kawasan bandar harus dihentikan dan kaedah biologi diperkenalkan dalam membendung denggi.

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

WHO	World Health Organization
S.W.O.T	Strength, Weaknesses, Opportunities and Threats
CFR	Case Fatality Rate
IVM	Integrated Vector Management
COMBI	Communication for behavioural impact
SOP	Standard Operation Procedure
GDP	Gross domestic product
MOH	Ministry of Health
DDT	Dichlorodiphenyltrichloroethane
CCD	Colony collapsed disorder
DALYS	Disability Adjusted life years
DHF	Dengue Haemorrhagic Fever
DF	Dengue fever
DSS	Dengue shock syndrome
DENV	Dengue Virus
SPSS	Statistical Package for the Social Science
NASA	National Aeronautics and Space Administration
MSDS	Material Safety Data Sheet
CSDS	Chemical Safety Data Sheet

CHAPTER 1

INTRODUCTION

1.1 Background

The escalating invasion of ecosystem with pesticides, constructions, agriculture and industry left a significant impact on the distribution and abundance of insects where some species gain liberty from their natural predators (Garret et al., 2017). One of the repercussions from this impact is the rapid transmission of vector borne disease, dengue which is transmitted by aedes mosquito(WHO, 2016).

This study is done to show that the destruction of mosquito predators in the ecosystem by insecticide has enhanced the increase of aedes mosquito population and thus dengue. Many study and research has been done on mosquito predators but this study exhibit an insight into the effect of mosquito predators on aedes mosquito in a naturally existing environment.

An ecosystem as defined by Longman dictionary as an area of land where all the plants, animals, microorganisms and environment lives as parasite and symbiotically to maintain a perfect balance. In an event if the balance of the ecosystem fails due to increase or decrease of certain species, changes will be inevitable and it will lead to unsustainability of the ecosystem until self-consistency is achieved. Ecosystem is interconnected within each and every insect species (Dreyer et al., 2015).

Insects play a very critical role in ecosystem structure and function. They represent important food resources, predators, parasites, or disease vectors for many other organisms, including human, and they have the capacity to alter rates and directions of energy and matter fluxes as herbivores, pollinators, detritivores and predators in ways that affect global conditions (Schowalter, 2013). They affect, and are affected by environmental issues such as land, water and air pollution including the issue of genetically modified crops, disease epidemiology and climate change. However relatively little attention has been given to the important role of insects as ecosystem engineers, other than to their apparently negative effects on vegetation, human and livestock (Schowalter, 2013).

Insect ecology integrates insect responses to changing and their effects on environmental conditions. These two components represent a feedback loop. The ecosystem constitutes the environment that selects for adapted phenotypes among all individuals. Such natural selection represents evolutionary feedback by the ecosystem. Despite their small size, insects have demonstrated predator, prey capacity to alter ecosystem conditions (Milcu et.al., 2015).

With the introduction of Dichlorodiphenyltrichloroethane(DDT) after the second world war, the source for eradicating both vector borne disease in human and agriculture was pesticide. The use was so vast and overwhelming without control lead to destruction of non-target group of insects and the environment (Kabasenche & Skinner, 2014). Studies show that the killing of mosquito predators is more prominent compared to the mosquito targeted and prolong use lead to the diminishing of predators such as dragonfly, tadpoles, larvivorous fish while the mosquito cultivate resistance.

Some of the chemicals used kill natural mosquito predators more effectively than the target mosquitoes and over time, predators such as fish and insects die out while mosquitoes develop resistance, proliferate to even larger numbers which is referred as "the pesticide treadmill" (Ramsden et.al., 2014).

The use of pesticides as a strategy in the control of insect especially mosquito ended as a failure due to destruction of ecosystem, predators and the mosquito becoming immune (Kawada et al. 2011, 2014). The insecticide used which is unable to select the type of insect sweeps all insects thus making biological control the best strategy to control mosquito both adult and larvae which benefits both the environment and the ecosystem.

Predation is the interactions in which one organism consumes all or parts of another. This includes predator-prey, herbivore-plant, and parasite-host interactions. These linkages are the prime movers of energy through food chains. They are an important factor in the ecology of populations, determining mortality of prey and birth of new predators. Predation is an important evolutionary force natural selection favors more effective predators and more evasive prey. Predation is widespread and easy to observe. Their existence and importance is the main frame in which ecosystem survive. Logic and mathematical theory suggest that when prey are numerous their predators increase in numbers, reducing the prey population, which in turn causes predator number to decline. The prey population eventually recovers, starting a new cycle (Cortez & Weitz, 2014).

This can be seen in the population of Aedes mosquito, which is a vector for dengue disease, the most important arboviral infections in the world. The occurrence of dengue case is a marker for the abundance of Aedes mosquito. It is found in tropical and sub-tropical climates worldwide, mostly in urban and semi-urban areas. The transmission of dengue illness is associated with the geographic expansion and distribution of mosquito vectors and viruses (Cheong et al., 2013; Halstead, 2008; Hay et al., 2000). Dengue prevention and control solely depends on effective vector control measures.

1.2 Problem Statement

Dengue is one of the major arboviral vector-borne diseases affecting humans today and it is the one that is most prevalent. It is estimated that vector-borne diseases account for approximately 17% of the global burden of infectious illnesses (Bhatt et al., 2013). The female mosquito Aedes aegypti is the most common of its species that produces dengue fever and dengue hemorrhagic fever.

The Aedes mosquito is an urban, day-biting, domestic insect of the tropics and subtropics that has adapted to poor environmental conditions especially in developing countries. Due to climate change, deterioration of the environment from chemicals, rapid and uncontrolled urbanization, has put more than 2.5 billion people in more than 100 countries at risk of acquiring dengue fever including Malaysia (Guzman & Harris, 2015).

In recent years, there are many studies efforts on the prevention of dengue includes various means of vector control, vaccine development, and antiviral drugs. The only link between human infection and dengue virus is the vector Aedes mosquito. Vector control with the use of insecticide started in 1943 when DDT was invented since then vector control and insecticide goes hand in hand. Even though DDT was banned in the year 1972 but the impact was very severe as was mentioned in the book "The Silent Spring" (Lew, Lew, Biedunkiewicz, & Szarek, 2013)(Kabasenche & Skinner, 2014) and with that more insecticide was introduced which caused similar impact and vector borne disease, dengue cases keep on escalating.

This lead to a number of novel methods introduced to reduce mosquito numbers by using mosquito predators including the placement of the guppy fish (Poecilia reticulata) or copepods in standing water to eat the mosquito larvae(Silberbush & Resetarits, 2017). The bacteria of the genus Wolbachia was used to infect the mosquito population which makes the mosquitoes partially resistant to dengue virus(Hughes & Britton, 2013). Dragonfly nymph was placed in water containers to predate on mosquito larvae (Ohba et al., 2016). There are also trials with genetically modified male Aedes aegypti that after release into the wild mate with females, and render their offspring unable to fly.

In Malaysia as like any other countries is facing the same problem with dengue. For the year 2010, the financial burden has rocketed sky high with the district health departments spent RM 21.36 million and the local authorities RM 9.92 million and of this amount 51% was used on purchasing insecticide as residual spray, fogging, and larviciding (Packierisamy et al., 2015). The spending for the control of dengue alone accounts for RM 6045.8 per dengue case reported which amount to 91.2% of the total spent on insecticide annually. This is not including the usage of insecticide by household and construction sites. Cost of insecticide per case estimated RM2580.20 (Lum et al., 2016).

Only for the state of Selangor more than RM140 million was spent for the year 2014, this is more than halve the cost used for the whole country. In account of this the amount of chemical or insecticide being injected into the environment is far beyond imagination but the mosquito population is still very rampant (Casida & Durkin, 2013).

1.3 Study Justification

The undeniable fact is that Dengue cases are on the rise in many countries in the world including Malaysia. Figure 1.1 shows the tremendous increase of dengue cases in Malaysia from the year 1995 to 2016. Within a period of 20 years the cases increased from 6,543 to a mind blowing of 120,836 cases which is about 20 fold increase. The dengue mortality rose from 28 deaths in 1995 to 336 in the year 2015 as shown in figure 1.2.

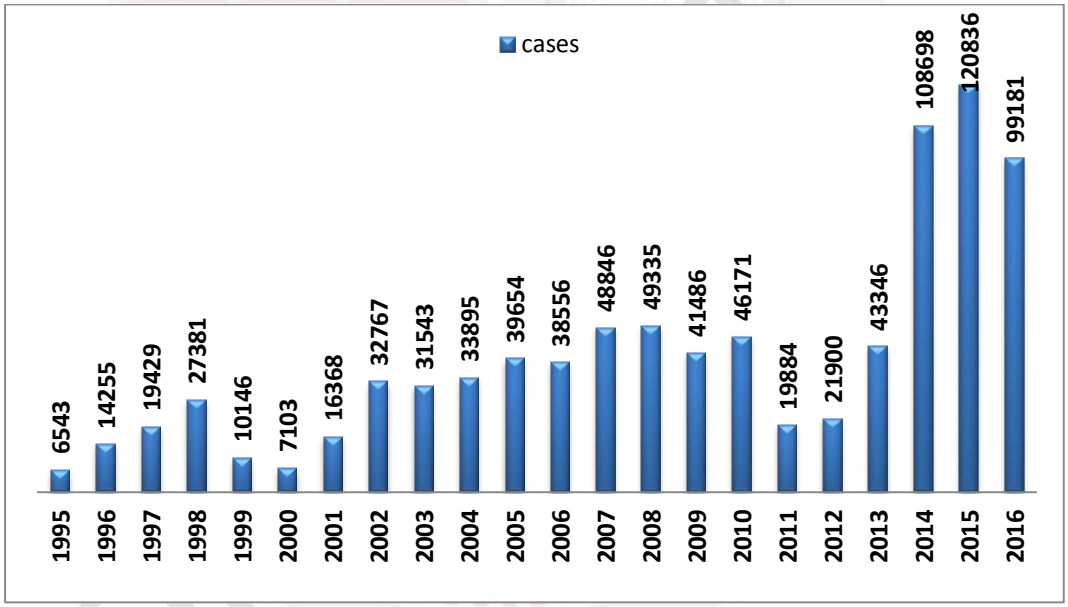

Figure 1.1 : Source : Ministry of Health Malaysia, Number of Dengue cases in Malaysia from the year 1995 to 2016

Mega operations, new specific guidelines based on world health organization to denature dengue diseases end up in a waste(Weaver, 2015). Despite all the action taken with millions of ringgit flowing, man power engulfed, the death cases still on the rise and the time and hours wasted end up to a negative result. Figure 1.2 shows the number of death cases from the year 1995 to 2016.

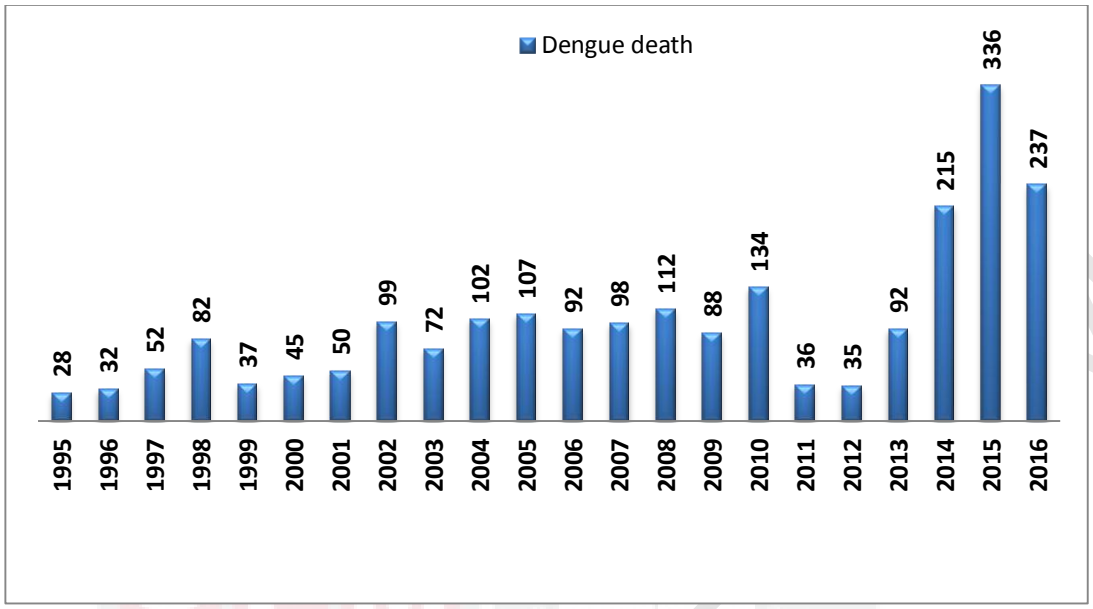

Figure 1.2 : Source : Ministry of Health Malaysia, the number of dengue mortality from the year 1995 to 2016 in Malaysia

Of the number of cases shown in figure 1.1, the state of Selangor contribute more than 50% of the total number of cases yearly in Malaysia which is shown in table 1.1 from the year 2008 to 2016. Within a period of 8 years the cases increased from 21,262 to 51,652 cases an increase by almost 2.5 fold. In detailing further table 1.2 shows that from the year 2013 to 2015 highest number of cases comes from Petaling district in the state of Selangor.

Table 1.1 : Source : Ministry of Health Malaysia, Number of dengue cases in the state of Malaysia from the year 2008 to 2016

State	2008	2009	2010	2011	2012	2013	2014	2015	2016
Perlis	184	191	215	110	172	226	317	258	179
Kedah	1678	750	782	514	817	813	1014	1000	942
Pulau Pinang	2324	2444	1834	1579	791	1053	3141	5830	2458
Perak	4219	2734	2288	1411	1716	2519	7525	9466	3549
Selangor	21262	18676	16367	7758	9113	23852	54290	63198	51652
WPKL/ Putrajaya	5446	3746	4205	2038	1814	2570	7185	8332	8325
Negeri Sembilan	1405	1057	1501	737	552	1198	3781	2454	2693
Melaka	830	769	1485	450	449	1549	2770	2420	2167
Johor	3908	2528	4406	1583	1650	4977	6323	15743	10332
Pahang	1327	907	1688	894	641	744	2170	3001	2880
Trengganu	1721	968	1472	675	739	621	1688	1445	1986
Kelantan	2399	1031	3578	743	1245	1454	14456	2850	5869
Sarawak	1517	4490	4240	974	1519	1311	2571	1923	2639
Sabah	1045	1170	2091	402	672	744	1456	2904	3497
W.P. Labuan	70	25	19	0	10	14	11	2	13

Table 1.2 : Source : Ministry of Health Malaysia, Number of dengue cases at the district in Selangor from the year 2013 to 2015

District	No of dengue cases by Year		
	2013	2014	2015
Gombak	3326	7266	7915
Hulu Langat	6371	11748	14919
Hulu Selangor	480	1301	1204
Klang	2645	7443	8404
Kuala Langat	288	861	1294
Kuala Selangor	304	799	905
Petaling	9600	24094	25477
Sabak Bernam	175	250	323
Sepang	663	527	2757
Total	23852	54289	63198

Thus this study is carried out at the district of Petaling for the very reason that it has the highest number of case to obtain a better perspective and understanding on protecting the ecosystem which is being exterminated gradually and to regain the natural predators for mosquito back in the ecosystem(Crowder & Harwood, 2014). In return the reduction of the vector which is the link for dengue and human.

1.4 Research Objectives

1.4.1 General Objective

To evaluate the impact of mosquito predators on Dengue cases using Aedes index in a Dengue hotspot area in relation to the presence of mosquito predators.

1.4.2 Specific Objectives

i. To determine the Aedes larvae breeding in relation to the type of mosquito predators frequency at 15 hotspot locality.
ii. To determine the number of dengue cases in relation to the type of frequency of mosquito predators at 15 hotspot locality.
iii. To determine the impact of insecticide used in the ecosystem in relation to the presence of mosquito predators and incidence of dengue cases.

1.5 Study hypothesis

i. There is a significant association of Aedes larvae breeding to mosquito predator frequency at the 15 hotspot locality
ii. There is a significant association of dengue cases and the frequency of mosquito predators.
iii. There is a significant impact of insecticide used in relation to mosquito predators and dengue cases

1.6 Conceptual framework

The increasing number of dengue cases and the spreading of the disease to new geographical areas are solely because the number of adult aedes mosquito breeding is massive and increasing. The high usage of chemicals both in addressing pest and insect in agriculture and vector control has destroyed the ecosystem and the unbalanced in the food web(Reid & McKenzie, 2016).

Prolong used of chemical as further reduce the predators not to mention the encroachment of high rise buildings, infrastructure which occupies acres of land which destroy the habitat where the predators breed and pollution of the rivers, streams, drainage system, lakes and ponds(Hunt, Galatowitsch, & McIntosh, 2017).

The construction of high rise building of unique patterns and design has in fact an advantage for the breeding of mosquito thus the increase of dengue cases in urbanised area(Who, 2001). Figure 1.3 shows the conceptual framework which relates the

variable which act as a catalyst in enhancing the increasing of adult aedes mosquito and also increase in the number of dengue cases which is the dependent variables.

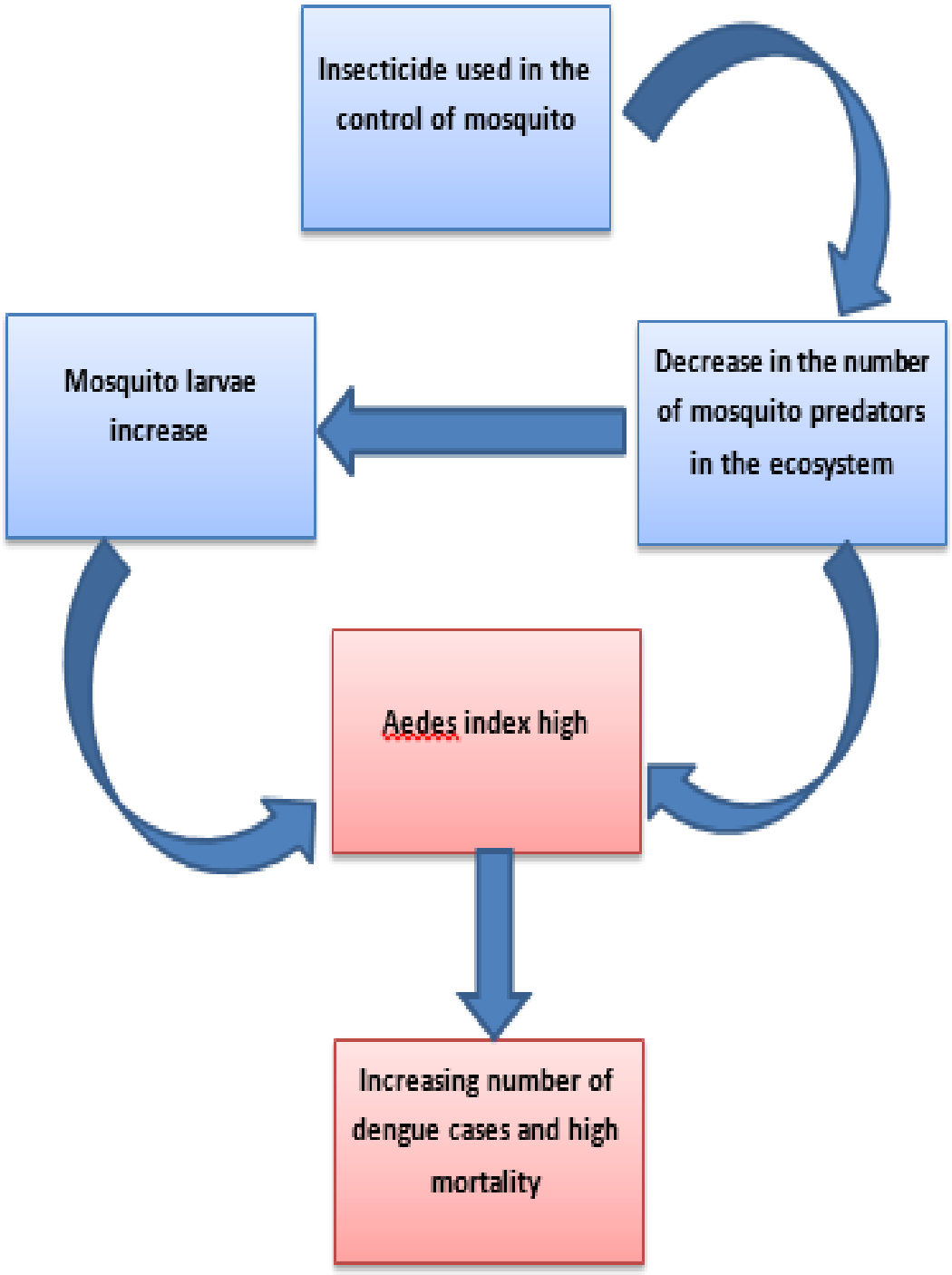

Figure 1.3 : Conceptual framework

1.7 Definition of term

Dengue: It is an acutely infectious mosquito borne viral disease (namely arbo virus). It is a life threatening fever and is transmitted through the bite of infected Aedes mosquito (World Health Organization (WHO), 2016).

Dengue Fever: Is an acute febrile illness with sudden onset of fever (39^0C and 40^0C) followed by a remission of a few hours to 2 days. (biphasic curve). The rash may be diffuse flushing , mottling or fleeting pin – point eruption on the face, neck and chest during the first half of the febrile period and a conspicuous rash that may be maculopapular or scarlatiniform on 3rd or 4th day. It may be accompanied by itching and hyperaesthesia (World Health Organization (WHO), 2016).

Dengue Haemorrhagic Fever: DHF is a severe form of dengue fever caused by infection with more than one dengue virus. Anorexia, vomiting, epigastric discomfort, tenderness at the right costal margin and generalized abdominal pain are common. The major pathophysiologic changes are thrombocytopenia, increased vascular permeability and haemorrhagic manifestations(World Health Organization (WHO), 2016).

Dengue outbreak: Is where more than 1 case of dengue occurs in an area of 200 meters radius within 14 days (Plan of action Ministry of Health Malaysia 2009).

Dengue Hotspot: Is a locality where the outbreak is continuous for more than 30 days from the day the dengue outbreak started (Plan of action Ministry of Health Malaysia 2009).

Check point: Existing potential breeding area for mosquito larvae at the hotspot location.

Aedes larvae index: Is the number of aedes larvae breeding found in a container divided to the number of container found multiply by 100. Index more than 10 shows high transmission risk and below 10 low transmission risked of dengue cases (Hasnan, Dom, Rosly, & Tiong, 2016).

Predator: An organism that preys upon other organisms(Belgrad & Griffen, 2016)

Predation: A symbiotic relationship between two organisms of unlike species in which one of them acts as predator that captures and feeds on the other organism that serves as the prey(Belgrad & Griffen, 2016).

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