Gene Drive Mosquitoes from Islamic Perspective: A Preliminary Discussion

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Abstract

Gene drive mosquitoes could spread desired trait, such as female infertility within a wild population at a rate higher than the normal inheritance rate and could eventually wipe out the population. Consequently, this makes gene drive mosquitoes one of the promising approaches in controlling mosquito-borne diseases, such as malaria and dengue. Despite its potentials, the development of gene drive mosquitoes has raised ethical concerns, mainly on the issues of safety and efficacy, as well as tampering with nature. Little research has been conducted to explore religious perspectives on this new advancement. This article aims to fill that gap by exploring the ethics of gene drive mosquitoes from Islamic perspectives. This article outlines three aspects, namely the purposes, the potential benefits and harms, and the need of the technology that should be considered when discussing whether gene drive mosquitoes should be allowed from Islamic perspectives.

Keywords: Gene drive, CRISPR-Cas9, mosquito-borne diseases, ethics, Islam

Introduction

Mosquito-borne diseases, such as dengue and malaria, are among the global public health concerns. Millions of people worldwide have been infected by these diseases yearly. Dengue, a viral disease that infects humans mainly through the female biting Aedes aegypti mosquito, has become a common disease in many countries, with approximately three billion people that are presently at risk (Centers for Disease Control and Prevention, 2020). Malaria, on the other hand, is caused by Plasmodium parasite that is spread among the human population through female Anopheles mosquito. In 2021, approximately 241 million malaria cases were reported in 85 malaria endemic countries in 2020 (World Health Organization, 2021).

Existing mosquito control strategies include the removal of mosquito breeding sites, installation of mosquito screens, and use of insecticides (Jones et al., 2021). Insecticides have been widely used in controlling mosquitoes, especially in indoor residual spray or insecticide-treated net, which have successfully reduced the global malaria incidence in the past decade (Tizifa et al., 2018; Jones et al., 2021). However, for some reason, these insecticide-dependent strategies are not effective enough to control the mosquitoes and eliminate the diseases subsequently. Apart from the fact that insecticides may bring harm to human health and environment, they have also become less effective over time, as mosquitoes may have developed resistance against them (Tizifa et al., 2018).

Among the novel techniques that have great potentials to eliminate mosquito-borne diseases is the gene drive technology. Inspired by naturally occurring selfish genetic elements, scientists have been developing synthetic gene drive system that can ensure the spread of genetic modification in the target species population at higher-than-normal rate of inheritance. One of the genetic elements is
homing endonuclease genes (HEG). The endonucleases can be re-engineered to change genes that encode specific traits in a mosquito (Hammond and Galizi, 2017). The development of the CRISPR-Cas9 has expedited the gene drive research, as it makes the nuclease engineering and genome editing of the target species much easier (Hammond et al., 2016). Several types of gene drives have been developed so far. First, the nonlocalized suppression gene drive that reduces the number of female biting mosquitoes and eventually eliminates the mosquito population. Second, the nonlocalized replacement gene drive that would prevent mosquitoes from transmitting the malaria-causing parasites. Third, the localized gene drives that are designed to function within certain limitation that are after large number of modified organisms are released or only within specific time limitation. Fourth, the reversal gene drive that would be released to the environment to remove the previously introduced gene drive organisms (Friedman et al., 2020). Apart from its ability to spread the modified trait within the target mosquito population faster than the normal rate, the gene drive approach can be considered as more environmental-friendly than insecticides and other broad spectrum prevention strategies, as it targets specific species (Hammond and Galizi, 2017; Nolan, 2021).

Even though gene drive mosquitoes have yet to be released into the wild population, the said technology has received considerable attention from researchers and policy makers. Efforts have been made to study the ethics of gene drive mosquitoes including the main questions of whether it should be allowed and under what condition it can be allowed. A study by de Graeff et al. (2021) found that scholars have divided opinions dependent on their stands on the relationship between human and nature; the moral status, values and interests of both entities and how these should be balanced. While some people are supportive because of the great potentials of the gene drive mosquitoes, some people are against the modification as they believe that each species has its values and should be protected (Annoni and Pievani, 2021). Unlike genetically modified organisms, the genome of the mosquitoes is manipulated directly and the gene drive mosquitoes are intended to be released into the wild population. This has raised great concerns about the unintended effect of suppression or replacement of the mosquito population on the ecosystem (Pugh, 2016; Neves and Druml, 2017; de Graeff et al., 2019; Annoni and Pievani, 2021).

Apart from the ecological and technological aspects, Hartley et al. (2021) emphasized that decision on whether or not to release gene drive mosquitoes should also consider social and political contexts. This includes understanding the values and their influence on public attitude that may help in communication and formulation of policy related to the gene drive technology (Kofler et al., 2018; Wilson, 2019). One of the main resources of the social values is religion that teaches about the moral status, values of animals and how humans should treat them. Therefore, religion may shape the opinion of an individual towards the gene drive technology. Previous research, however, has not given much attention to explore religious perspectives on the gene drive mosquitoes.

Islam is one of the world’s major religions with approximately 1.8 billion followers. (Diamant, 2019). Many of them stay in the countries where mosquito-borne diseases occur. There is yet a ruling on gene drive technology issued by Muslim scholars or fatwa institutions. This could be because the technology is still at the early stage of development. Many scholars may not be aware about the gene drive technology yet,
as Al-Delaimy et al. (2019) found that half of the Islamic scholars in the study had not heard about the technology. Therefore, this article attempts to fill the research gap by exploring Islamic perspectives on the gene drive technology to control mosquito-borne diseases. It explains the fundamental teachings of Islam regarding animals and their relationship with humans, as well as opinions of the Muslim scholars regarding animal genetic engineering. This article also outlines aspects that should be considered when deliberating the issue of whether to allow the use of gene drive mosquitoes. It is hoped that this article draws more scholarly discussion on the ethics of gene drive from Islamic perspectives.

To begin with, the following subtopic briefly explains the fundamental teachings of Islam regarding animals and their relationship with humans that are derived from the main references in Islam namely the Quran and Sunna. The teachings inform Muslims about the moral status and values of animals that may shape their attitudes towards the gene drive mosquitoes.

**Human-Animal Relationship in Islamic Perspective**

Islam teaches that both humans and animals are Allah’s creation. Both are created to be different not only physically, but also in terms of purpose of creation and function in this orderly and balanced universe. Humans are created in the best molds who, unlike animals, are considered as dignified beings who have the capacity to think and make the best decision for themselves. This has been clearly stated in many Quranic verses, among them are Chapter al-Isra’ verse 70 and Chapter ash-Shams verse 8. Animals have specific roles in the universe without which humans would not live prosperously. Even though certain animals may seem insignificant to the human eye, Islam argues that all of them are created for a reason. This is explained in many verses of the Quran, one of them is Chapter Ali ‘Imran verses 190 and 191, which may be translated as follows:

“...Behold! In the creation of the heavens and the earth, and the alternation of Night and Day, there are indeed signs for men of understanding. Men who celebrate the praises of Allah, standing, sitting, and lying down on their sides, and contemplate the (wonders) of creation in the heavens and the earth, (with the thought)” “Our Lord! Not for naught have You created (all) this! Glory to You!...” (Ali, 2007)

The above verses also explain one of the functions of animals that is as manifestation of the omnipotence and omniscience of Allah (Al-Qurtubi, 1993). By contemplating the animal kingdom that comprises a huge variety of species, humans may acknowledge the existence and power of Allah. Humans would never be able to create new animal ex nihilo, even a less complex one like a fly (Keshani, 2010). Apart from that, some animals are created for human benefits, mainly as for source of food, transportation, or adornment, as explained in the Quran, Chapter an-Nahl verses 5–8. This happens only because Allah has made the animals subservient to humans, otherwise, they, for instance, will not be able to catch fishes in the sea (Al-Razi, 1981). Animals, which are created by Allah, cannot be deemed sacred because it is against the purpose of their creation. Prostrating to creatures including animals is prohibited as it is considered changing the spiritual aspect of the creatures (Al-Fawzan, 2008).
As a theocentric religion, Islam dictates that human-animal relationship should be in line with Allah’s commands and not humans’ desire. Humans, as vicegerents of Allah, have a huge responsibility to treat animals and other creations with due respect according to the shariah. They must be vigilant about their actions towards animal because all their deeds will be accountable on the Day of Judgement (Al-Faruqi, 1992). A hadith narrated by Abu Dawud explains that humans who have mercy to all creatures on earth will guarantee them Allah’s mercy [(see hadith no. 4941 in Al-Sijistani (n.d)]. Another hadith has also become a motivation for Muslims to be good towards animals. It had been narrated that Allah granted His forgiveness upon a prostitute (prostitution is a great sin in Islam) who used her shoe to draw water from a well and gave it to a thirsty dog [(see hadith no. 2245 in Al-Nawawi (1996)].

Humans’ mercifulness towards animals is obligatory in Islam; even when they kill or slaughter the animals, they should kill or slaughter the animals in the best manner prescribed by shariah, such as using a sharp blade [(see hadith no. 17 in Al-Haythami (2008)]. This merciful action is part of ihsan, a virtue that requires Muslims to do things in the right way and best manner, which include minimizing harm (Ahmed Badi, 2019). Even though some animals can be slaughtered for foods, Muslims cannot kill them for fun and throw their limbs away. This is because it defies the function of animals to humans, as set by Allah. This is in line with a hadith narrated by Ahmad, Al-Nasai, and Al-Darimi that a Muslim will be questioned during the Judgement Day if he kills a sparrow or any animal greater than that unnecessarily [(see hadith no. 4094 in Al-Tabrezī (2013)]. Islam prohibits harming animals without reason. Muslims are prohibited to use living animals as target in their shooting practice [(see hadith no. 1958 in Al-Nawawi (1996)]. Cockfighting is also unlawful in Islam [(see hadith no. 2562 in Al-Sijistani (n.d)]. There are also hadiths that prohibit caging animals that are not intended to be slaughtered, overloading an animal, overmilking animals that can harm their babies, and burning insects (Al-Haythami, 2008).

Apart from that, Islam allows killing animals that may bring harm to humans. A hadith narrated by Bukhari and Muslim states five animals that can be killed even in the Haram land, namely, rat, scorpion, crow, kite, and mordacious (biting) dog [(see hadith no. 1198 in Al-Nawawi (1996)]. There is also permission to kill lizards and snakes. The types of animals that can be killed are not restricted to the animals stated in the hadiths. Animals that could bring similar harm can also be killed. For example, animals that cause harm by damaging humans’ properties as what rats do can be killed (Pejabat Mufti Wilayah Persekutuan, 2019). There is also a hadith narrated by Abu Dawud that states list of animals that are not allowed to be killed, namely, ants, bees, hoopoes, and sparrowhawks [(see hadith no. 5267 in Al-Sijistani (n.d)]. This has raised questions among Muslims of whether killing ants or insects in general is permissible. Muslim scholars are divided regarding this, some of them opine that it is unlawful, while some argue that it is lawful under certain conditions. Opinion of the latter can be considered preponderant (Pejabat Mufti Wilayah Persekutuan, 2016). Insects that may cause harm to humans, such as scorpions and mosquitoes, can be killed (Dar al-Ifta’ al-Misriyyah, n.d).

Based on the above discussion, it can be concluded that Islam views that mosquitoes, like other animals, are created by God and have specific roles in the universe. By contemplating on creation and the role of mosquitoes, a Muslim may
increase his faith in Allah. Nevertheless, this does not mean that humans cannot kill mosquitoes that harm them. The questions one may ask are that whether a technique or technology and to what extent can one use to kill mosquitoes. These questions are important, as the principle of *ihsan* demands humans to do things in the right way. Before exploring the gene drive technology from Islamic perspective, the following subtopic briefly reviews the principle of *maslahah* in Islam that is often used to determine whether a technology is permissible in Islam.

**Maslahah-Based Ethical Assessment of Technology**

As explained in the previous subtopic, the Quran and Sunna mention mainly about creation of animals, their roles and benefits to humans, and encouragement for Muslims to treat animals humanely. Issues related to modern technologies such as gene drive, however, do not have specific evidences in these references. Therefore, to answer the question of whether the technology should be allowed from Islamic perspectives, Islamic tradition has a distinguished mechanism called *ijithad* (intellectual reasoning) through which Muslim scholars try their best to deduce a ruling by analyzing related evidence in the sources of shariah (Islamic law) and applying shariah legal tools (Kamali, 1996; Isa et al., 2015). Apart from scholarly writings, the output of the *ijithad* especially by a mufti would be issued as fatwa (Islamic legal opinion). The fatwa may later inform the policy makers and Muslim society about the permissibility of the technology. Deliberation of the issue among Muslim scholars may also consider opinions from the experts from science field.

One of the Islamic legal tools that are commonly used in solving ethical dilemmas of allowing a new technology is *maslahah mursalah* (often simply called as *maslahah*). *Maslahah mursalah* is a category of benefits that has no direct reference in the Quran and Sunna. Assessment of whether or not to allow a technology will be based on benefits that it may bring (Al-Zuhaili, 1986). Nevertheless, the decision made is not only based on the analysis of how many benefit and who will benefit from the technology. Rather, the assessment is much more complex, as explained in the following paragraphs.

A technology can only be considered permissible based on *maslahah mursalah* if the permissibility does not in conflict with the principles of *maqasid al-shariah*, namely, the principles of preservation of religion, life, intellect, lineage, and property. The permissibility should not contradict with the rulings that have evidence in the Quran and Sunna, and qiyas (analogical reasoning). The permissibility should also preserve greater *maslahah* (benefit) (al-Buti, 1986). *Maslahah*, according to Islam, has three different categories based on its importance: *daruriyyat* (essentials), *hajjiyyat* (exigencies), and *tahsiniyah* (embellishments). The most important *maslahah* is the category of *daruriyyat* that includes things humans should preserve the most, otherwise their lives would be ruined in aspects of religion, life, intellect, lineage, and property. *Hajjiyyat* is less important than *daruriyyat* because its absence would not damage humans’ life. *Tahsiniyat* category is the least important, as it consists of things that would make humans’ life perfect (Al-Raysuni, 2006).

When assessing a technology, Muslim scholars would determine which category of *maslahah* the technology may bring. Given that a technology may bring both benefits and harms, they will balance the
benefits against the harms. If it brings benefits in daruriyyat category and the harms are only under hajiyyat or tahsiniyyat, the technology could be considered permissible. Conversely, if a technology brings harms in daruriyyat category and the benefits are only under hajiyyat or tahsiniyyat, the technology could not be considered permissible. Moreover, if both benefits and harms of a technology fall under the same category of maslahah, the technology may not be allowed because in Islam prevention of harms takes precedence over gaining benefits. There are also Islamic legal maxims that are used as references when balancing the benefits against the harms such as ‘harm cannot be eliminated by harm of the same or higher category’ and ‘the lesser harm will be allowed to prevent greater harm’ [(for more details about this, see for example Isa and Man (2014)].

Islamic Perspectives on Animal Biotechnology

Muslim scholars have discussed several advances in animal biotechnology, including animal cloning and genetic engineering from Islamic perspectives. Animal genetic engineering in general is considered permissible in Islam on the condition that preventive measure has been taken to avoid harm from being imposed on humans, animals, and environment (Islamic Fiqh Council, 1998). Similar ruling is also applied to animal cloning, whereby it is also considered lawful if it can bring benefits such as yield increase (Kashim et al., 2021). Using animals in stem cell research is also lawful from Islamic perspective. Nevertheless, researchers are urged to treat them with mercy and minimize exposing them to pain and suffering (Dar al-Ifta’ al-Misriyyah, n.d).

Some Muslims may argue against genetic engineering of organism including animal, as this action is regarded as playing God. However, this argument has been refuted because genetic engineering does not create a new animal ex nihilo (Bouzenita and Mirghani, 2014). Instead, the existing creation is manipulated for the benefits of humankind (Ghareeb, 2011). Some Muslims also view that genetic engineering is not allowed in Islam because it is considered as tampering with God’s creation. This is because Chapter An-Nisa’ verse 119 implies that changing God’s creation follows Satan’s order, hence, its prohibition (Rahman, 2013). However, Muslim scholars are divided over whether humans cannot make change in creation at all. Some scholars opine that humans can make change such as castrating cattle if it can bring benefit to humans (Ibn Atiyah, 2001). Therefore, genetic engineering of organism that can bring benefit may be allowed under certain condition (Safian, 2019).

There are fatwas on genetically modified food (GMF) issued by fatwa committee including from Malaysia. The national fatwa committee of Malaysia had declared that GMF is permissible unless it contains substance from unlawful animals such as pig or from animals that are not slaughtered according to shariah. GMF that may bring harms to humans and environment including unknown harms is also considered unlawful (Jabatan Kemajuan Islam Malaysia, 2015). Nevertheless, there are calls for a more holistic Islamic perspective on GMF. Apart from the use of lawful materials as well as the potential benefits and harms of the food, attention should also be given to socio-economic issues that may arise such as unequal distribution of the products and monopoly of big corporations (Al-Attar, 2017; Bouzenita, 2010). The national fatwa committee of Malaysia had considered the socio-economic issue, but it was only on the question of whether to allow GMF that
contains unlawful substance as it may help resolving the issue of famine. They decided that it cannot be allowed because famine happens due to unequal distribution of food (Isa, 2013). It was not discussed, however, whether the socio-economic issues such as monopoly of big companies can be used to justify the prohibition of lawful GMF.

Given that little research has been done to explore Islamic perspectives on gene drive and no specific fatwa has been issued yet, the following subtopic reviews aspects that should be taken into consideration when discussing the ethics of gene drive from Islamic viewpoint.

Islamic Perspectives on Gene Drive Mosquitoes

Islam allows killing mosquitoes that may cause harm to humans, as explained in the previous subtopic. This permission alone, however, does not simply warrant any means to kill the harmful mosquitoes. The following paragraph explains three aspects that can be considered when discussing the ethics of gene drive from Islamic perspective. Consideration of maslahah and its related principles are highlighted wherever possible.

Firstly, the purposes of developing the gene drive mosquitoes. As explained in the Introduction section of this article, the development of gene drive mosquitoes aims to reduce and eventually eliminate mosquito-borne diseases, such as dengue and malaria. These fatal diseases have caused millions of deaths worldwide. Studies have shown that releasing gene drive mosquitoes into wild population would help in controlling the diseases and save many lives. Obviously the objective of developing this technology is consistent with maqasid al-shariah principle of preservation of life, which is considered as maslahah under the category of daruriyyat (necessities), the highest level of maslahah. Nevertheless, the aim of the development of gene drive mosquitoes alone cannot be the deciding factor of its permissibility.

Secondly, the potential benefits and harms of the gene drive mosquitoes. As previously explained, gene drive mosquitoes have huge potentials in controlling disease-transmitting mosquitoes effectively. This can reduce the incidence of mosquito-borne illnesses, thus reducing the public health cost and consequently improving economy of the affected countries (Mitchell et al., 2018). The gene drive approach, in theory, has more advantages over other mosquito control approaches. Among the advantages are that it is self-sustaining and requires minimal infrastructure. This method would only target specific mosquitoes, thus, it may bring lesser harm to the environment than other broad-spectrum intervention, such as using insecticides (Nolan, 2021).

Nevertheless, scientists are still developing the gene drive and have not yet resolved the issues of safety and efficacy of the gene drive approach. Among the issues are the development of resistance against the gene drive within the wild population of mosquitoes, spill overs to non-targeted species (Courtier-Orgogozo et al., 2020; Greenbaum et al., 2021), and invasion of undesirable organism after suppression and replacement of the mosquitoes (World Health Organization, 13 October 2020). To carefully evaluate the potential benefits and reduce or mitigate potential harms, each gene drive application would undergo a phased testing pathway that includes five phases: research preparation, laboratory-based research, field-based research, staged environmental release, and post-release surveillance (National Academies of Sciences, Engineering, and Medicine, 2016; Santos, 2020). To date, none of the gene drive types have completed the pathway. Currently, the most advanced type
is the nonlocalized, low-threshold gene drive that may enter the field testing soon (Friedman et al., 2020).

Recent studies on gene drive have shown promising results. By using modelling to test the gene drive, North et al. (2019) concluded that repeated releases of suppression gene drive using the driving-Y chromosome over few years would be able to suppress the malaria mosquitoes population in the study area, depending on certain conditions such as seasonality. In another study, it was found that the doublesex gene (dxy)-targeting gene drive that reduces female fertility could suppress the population of malaria mosquitoes within a few years (North et al., 2020). Apart from that, a study by Simoni et al. (2020) indicated that a male-biased sex-distorter gene drive can be used for controlling malaria mosquitoes. It could be the best gene drive for suppressing malaria-transmitting mosquitoes by far because of its efficacy, resistance management, and robustness.

Besides evaluating the great potentials of the gene drive approach, one should also consider the existing alternatives that have been used. According to Islamic teachings, if one were to choose between two methods that may bring benefits, one should choose the method that brings greater benefit and lesser harm. He cannot choose method that causes harm that is similar or greater than the harm that he wants to remove (Isa and Man, 2014). Therefore, the gene drive approach may not be considered permissible if it would bring similar or greater harm than the existing alternatives in controlling the mosquitoes. Harms that are to be considered in the assessment are not uniquely about harm to humans, but also harm to animals and to the environment. Given that the gene drive approach is still at an experimental level and has yet to complete the testing pathway, its safety and efficacy are still uncertain. Hence, its permissibility from Islamic perspective cannot be determined yet. More research is needed not only on the potential effects of the most advanced gene drive but on all types of gene drive and non-gene drive approaches before a proper ethical assessment from Islamic perspectives can be conducted.

Thirdly, the needs for developing the gene drive mosquitoes. Among the questions that need to be answered are whether the technology is necessary and whether there is better alternative(s) available. This is a crucial aspect because in a case where a technology is extremely needed, for example, to save life, and there is no better alternative, the technology may be considered permissible even if it involves unlawful matter (Isa, 2016).

Gene-drive mosquitoes, according to scientists, would serve as a complementary approach to combat the diseases (Hammond and Galizzi, 2017; Nolan, 2021). Existing methods such as using the insecticide-treated mosquito net are not fully successful in eliminating the diseases due to some factors including the access to the distribution center and the development of resistance in mosquitoes (Tizifa et al., 2018). Apart from gene drive mosquitoes, other new preventive strategies have also been developed, for example, using the Wolbachia-infected mosquitoes for dengue control (Flores and O’Neill, 2018; Jones et al., 2021). Having said that, in the case of malaria, it was reported that 40 countries and territories including Australia, Algeria, Uzbekistan, and most recently China have been certified free from malaria. This indicates that it is possible to eliminate the diseases without the gene drive mosquitoes. What is needed the most could be the ‘targeted and sustained action’ as what China did (World Health Organization, 30 June 2021). In addition, poverty and social
inequality in poor countries especially in the African region need to be addressed, as these have been considered the major factors that cause malaria (Ren, 2019). These countries may need financial help and policy advice in managing the mosquito-borne diseases, instead of a new scientific approach.

Therefore, careful and deep consideration about the need of gene drive approach for a country is crucial. This includes reviewing the existing alternatives that have been used and considering the need of a particular country, as different countries may need different approach. Critical scrutiny on the cause of ineffectiveness of existing strategies used in a particular country is imperative before a decision on whether to allow the gene drive approach from an Islamic perspective can be made. If the technology is the main factor, the gene drive approach may be allowed after it has been proven as safe and efficient, given that preventing serious diseases and saving lives fall under category of daruriyyat (necessity). Nevertheless, if the ineffectiveness of strategy used in eliminating the diseases in a country is due to the non-scientific factors such as lack of political and social commitment, and not the technology that have been used, it could be a better decision from Islamic perspective not to use the gene drive approach. This is because it has uncertainties, while the success stories from countries that have been certified free from malaria have proven that the existing method(s) is reliable and efficient. According to Islam, the assured maslahah (benefit) takes precedence over uncertain maslahah (Al-Qaradawi, 1996). Implementing a new approach without proper investigation into the ineffectiveness of the previous strategies may only lead to another problem and consequently increase the burden of the country. This is also against the principle of ihsan in Islam that urges humans to do things in the right way and best manner.

Conclusion

Mosquitoes according to Islamic teachings are God’s creation that have specific role in this universe. It cannot be killed unless it causes harm to humans, like the disease-transmitting mosquitoes. With the advance of modern science and technology, the matter arising is that whether a technology is permitted to be used to eliminate the mosquitoes. One of the technologies that have been actively researched is the gene drive technology. Despite the great potentials, the development of gene drive mosquitoes raises concerns about its safety and efficacy, including its impacts on the ecosystem.

Given that the technology is relatively new and still at the early stage of development, many may not know about it. The discussion from Islamic perspectives is also scarce. Decision on whether to allow the release of the mosquitoes from Islamic perspectives cannot be made yet due to the uncertainties. Having said that, given the fast pace of the gene drive research in recent years, it is timely to discuss the Islamic perspectives so that stakeholders including policy makers can make an informed and timely decision when required.

This article discusses the three aspects of gene drive mosquitoes that should be considered when assessing its permissibility from Islamic perspectives, namely, the purposes, the potential benefits and harms and the need of the technology. This should be done on a case-by-case basis because each type of gene drive may be developed based on specific context and to resolve specific problems. In general it can be concluded that the aim of developing gene drive mosquitoes, which is to reduce and consequently eliminate mosquito-
borne diseases, is consistent with the *maqasid al-shari`ah* principle of preservation of human life. Nevertheless, evaluation on its potential benefits and harms is required, and comparison should be made against the existing alternatives. Among the principles in Islam that could be considered when evaluating the gene drive and other approaches are ‘preserving greater benefit’, ‘choosing the lesser harm’ and ‘harm cannot be removed by harm of the same or higher degree’.

Even though some scientists consider the development of gene drive as necessary because it is a complementary approach that can help in global elimination of mosquito-borne diseases, careful investigation on the causes of ineffectiveness of existing strategies in eliminating the diseases is needed. Lessons should also be learnt from the countries that have successfully managed to be free from the diseases. In this regard, inputs from science and non-science experts are crucial in deliberating the Islamic perspectives on the gene drive mosquitoes. This is to get a holistic view of the issue and to conduct a sound ethical assessment on whether the gene drive approach is necessary for a particular country.

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