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REVIEW OF CLIMATE CHANGE IMPACTS ON URBAN PESTS

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Abstract Urban centres amplify both abiotic and biotic parameters favouring pest life history. In absence of natural enemies in urban areas, these parameters often are directly proportional to growth and population of these pests. Under the influence of climate change and global warming, these centres will act as favourable spots for pests in multiple ways, thus posing far reaching consequences, affecting human lives. Insects are cold-blooded organisms and are unable to regulate their body temperature and it is believed that the effect of temperature on insects largely overwhelms the effects of other environmental factors. Evidence of climate change and its impact are now apparent in many parts of the world, such as reports of insect vectors and vector borne diseases in previously unrecorded elevations, pest damages in uncited latitudes and pest activity in unexpected seasons. Its influence on aspects such as building materials, quality of urban structures, non-vectors, nuisance pests and prevention are now under examination. Increased urbanization and people's choice of urban life has made this a very relevant subject and this article reviews impact of climate change on various aspects of pest dynamics as well as its influence on a number of tools and methodologies which are used to control and manage them.

Key words Climate change, global warming, urban pests, urban heat island.

INTRODUCTION

Consequences of climate change on humans is mostly unknown, but its impact is slowly being realised. Among many, some could be challenges caused purely by urban and public pests (Dhang, 2016). The impact of climate change on vectors for disease pathogens (mosquitoes, ticks, blackflies, fleas, etc.) and other medically important arthropods (stinging insects, spiders, and bed bugs) is a topic of great concern (Sims and Appel, 2016). Climate change can modify pest life history, resulting in increased diversity and density of pests, consequently posing significant risk to humans. It is also notable that climate change impacts could be amplified in urban centres much different from natural areas due to the creation of urban heat island, making most urban areas warmer than surrounding areas (Douglas and James, 2015). This phenomenon in certain latitudes could influence pests, by increasing their activity and also by making non pest species to move into these warmer centres and become pests as evident by examples described by Douglas and James, (2015). A number of comprehensive reports are available discussing the effects of climate change on public pests in both indoor and outdoor conditions (Dhang, 2016; USEPA, 2010; CIEH 2008; Epstein, 2005; Patz et al., 2003).

MATERIALS AND METHODS

Journal articles were retrieved from library, online sources and personal collection using the key words mentioned elsewhere in this article. A relatively small number of studies exist on the topic, so reference list provided in relevant articles were reviewed in detail to find additional articles. The final information was reviewed to check for completeness towards the theme before being written.

RESULTS AND DISCUSSION

Climate Change In Urban Areas

The urban environment is a complex of wholly or partially anthropogenically-influenced habitats created from natural areas, sometimes via the intermediate state of agricultural land (Robinson, 2005). In the context of the urban environment, 'urban' comprises not just the city centre, but also the surrounding suburbs, urban green space, industrial areas, and the rural-urban fringe (Robinson, 2005). Urban areas present unique composition unlike natural. The main driver of an urban ecosystem is human, his activates and behaviour. Urbanity presents concentrated human population, accumulated resources such as food and water, variety of niches such as micro-habitats, diversity of flora and fauna, climate control options, varied ideology etc. to be called unique. However one of the most significant features which is experienced in urban areas is heat island.

An urban heat island (UHI) is an area/city warmer than its surrounding natural areas due to human activities. The main cause of the urban heat island effect is from the modification of land surfaces (Solecki, 2004; USEPA, 2015) and waste heat generated by energy usage is a secondary contributor (LI and Zhao, 2012). Thus urbanization causes regional increases in temperature that exceed those measured on a global scale, which are as much as 12°C warmer than their surroundings (Angilletta et al., 2007). It is obvious, animals and plants living in urban area will deferentially respond to altered conditions in comparison to natural world. This makes urban areas to amplify both abiotic and biotic parameters often favouring pest life history, and in absence of natural enemies, these parameters often are directly proportional to population of these pests (Dhang, 2016).

Urban heat island also bring permanent changes in the physiology of the species when compared to their natural populations, favouring a step towards evolution of a group which can be now be called "truly urban". It is observed that leaf-cutter ants, *Atta sexdens* colonies in urban heat islands have an increased heat tolerance at no cost (Angilletta et al., 2007). It is expected that species that are good at colonizing can invade to utilize favourable conditions provided by urban heat islands to thrive in regions outside of their normal range. Examples of this include *Pteropus poliocephalus*, a flying fox, and the house gecko *Hemidactylus frenatus*, (Warren, 2005).

Urban areas around the world are known to harbour common pests due to their close dependence on humans. Roy et al. (2009) predicted the effect of climate change on nuisance insect species in the United Kingdom. The report highlights the nuisance insect species that are unlikely to be affected by environmental warming are *Blattella germanica* (German cockroach), *Cimex lectularius* (bed bug), *Monomorium pharaonis* (Pharaoh ant), *Anobium punctatum* (wood-worm), *Ctenocephalides felis* (cat fleas*), Lyctus brunneus* (powderpost beetle), *Hylotrupes bajulus* (house longhorn), *Tineola bisselliella* (common clothes moth), *Dolichovespula media* (media wasp) and *Vespa crabro* (European hornet). The ten species most likely to increase with climate warming are *Tinea riaalternata* (moth fly), *Lasius neglectus* (invasive garden ant), *Thaumetopoea processionea* (oak processionary moth), *Linepithema humile* (Argentine ant), *Reticulitermes grassei* (Mediterranean termite), *Culex pipiens molestus* (urban mosquito), *Culex pipiens pipiens* (mosquito), *Aedes vexans* (mosquito – wetland), *Ochlerotatus cantans* (mosquito – woodland) and *Musca domestica* (house fly). The study further predicted that the ten species most likely to increase with changes in precipitation patters are the same as for increasing temperature with the exception of *Musca domestica*, but included *Phlebotomus mascittii* (sand fly).

Evidence of Climate Change Impacts on Urban Pests

Evidence of climate change and its impact are now visible in many parts of the world. Examples of this can be had from changes in distribution, density or behavioural patterns of pests. Reports of new pest occurrence, such as reports of insect vectors and vector borne diseases in previously unrecorded elevations in eastern and central Africa, Latin America, and Asia are now attributed to climate change

(Dhang, 2016). In addition to mosquitoes, other pest species such as flies, lice, ticks, fleas, bats, rodents, snails and termites could significantly increase their distribution range and contribute to spread of diseases and damages to humans, influenced by changes in climate. This is evident in one of the WHO reports which highlights the linking of climatic factors such as temperature, precipitation, and sea level rise, to the lifecycles of infectious diseases, including both direct and indirect associations via ecological processes (Patz et al., 2003).

Mosquito and its link to climate change has recently under close scrutiny with the increased incidence of malaria in highland urban cities, such as Nairobi, and rural highland areas of Papua New Guinea (Reiter, 2008). Similarly vector of Dengue, Chikungunia and other zoonotic disease *Aedes aegypti*, once limited by temperature to approximately 1000 m in elevation, has recently been found at 1700 m in Mexico and 2200 m in the Colombian Andes (Epstein, 2004). A study conducted by Culler (2015) on artic mosquitoes *Aedes nigripes* conclusively show that warmer spring temperatures caused the mosquitos to emerge two weeks earlier and shortened their development time through the larval and pupal stages by about 10 percent for every 1°C increase in temperature. Warming increased the number of mosquitoes being eaten by diving beetles, but the mosquitoes accelerated growth in their vulnerable juvenile stages lessened their time with aquatic predators, which ultimately increased their chance of surviving to adulthood. With a 2°C warming scenario, the model predicted the mosquito's probability of survival will increase by 53 percent.

A number of studies such as by Easterling et al., 2000; Greenough et al., 2001; Pall et al., 2011, also link climate change to mosquito outbreaks. The studies point out that mosquitoes belonging to the species, *Culex tritaeniorhynchus* and *Culex tarsalis*, vectors for the Japanese and Western Equine Encephalitis viruses respectively, are floodwater species and may increase in abundance in the urban environment during and after flooding events, which are predicted to increase with climate change. Increase in geographic range of mosquitoes following warm temperature gradients into previously unknown territories in USA (Rochlin et al, 2013), serves as another good example how temperature can influence urban pest dynamics.

Evidence of other species showing influence of climate are being increasingly reported. Sims and Appel (2013) reported weather-influenced effects on pests from St. Louis area of USA. They reported termite swarming unusually early in the year, following the extremely mild winter of 2011-12. The mild winter was followed by a very warm and dry summer and this was also associated with a significant increase in houses invaded by brown recluse spiders that normally reside outdoors. Quarles (2007) suggested temperature increases in the USA to favour warm weather pests such as ants, termite pests, clothes moths, flies, mosquitoes, fleas, stored product moths, wood boring beetles, and bed bugs. It is observed that termite distribution and abundance is closely linked to distribution and abundance of rainfall gradient (Wood and Johnson, 1986), temperature and relative humidity (Cabrerra, 1994). Termite foraging patterns are linked to key abiotic parameters (Haagsma and Rust 1995; Mesenger and Su 2005; Moura et al., 2006). Evidence of termites in previously unrecorded latitudes are also coming to light now. Reports of tropical species, such as *Coptotermes gestroi,* becoming established in the subtropics (Grace, 2006); and subtropical species *Coptotermes formosanus* expanding their range northwards into more temperate areas (Jenkins et al., 2002) substantiate the role climate could play in pest distribution.

In colder areas of North America such as Wisconsin and southern Canada, populations of *Reticulitermes flavipes* appear to be gradually expanding their range and even swarming under natural outdoor conditions (Arango et al., 2014, Scaduto et al., 2012). However, colony growth and slow dispersal without the need for swarming has been associated with these northern colonies on the fringe of their range (Arango et al., 2014). Swarming events can occur in all months of the year. With increasing temperatures, both the total yearly number of swarms and frequency of swarms in cooler months can be expected to increase.

Range expansion in house fly in response to rising global temperatures and anthropogenic changes has received considerable attention in the last two decades (Parmesan and Yohe, 2003; Crozier 2004; Karban and Strauss, 2004; Hickling et al., 2005). Climate change is predicted to have major effects on flies of public health significance in domestic premises and climate change models predict that populations of the house fly, *Musca domestica*, and blow flies, *Calliphora* spp., could increase up to 244% by 2080 (Goulson et al., 2005).

Climate is one of the most important factors influencing the distribution of ants (Jenkins et al., 2011) and climatic suitability may be the most important factor responsible for the current global distribution of the invasive Argentine ant, *Linepithema humile* (Roura-Pascual, 2011). The Rasberry crazy ant, now positively identified as *Nylanderia fulva* (Gotzek et al., 2012), was introduced into the Southeastern United States and its distribution continues to rapidly expand. It should eventually occupy the entire Gulf Coast but the northern limits of its range are unclear and will be influenced by weather conditions associated with climate change.

Long-term observations on tick fauna in Europe suggested that medically and veterinary important species changed their areas of occurrence. Many authors correlated this phenomenon with climatic changes such as increasing temperatures in winter months, mild and long spring and autumn, changes in snow cover (Gliniewicz et al., 2016). Changes in climate parameters generate changes in environment, particularly the flora and the fauna components. Ticks can be transported also by small and large mammals and birds as their hosts, when they invade new territories. Expansion of ticks to the new areas because of climatic changes is one cause of observed increase in tick-borne disease cases in European countries.

Insects are cold-blooded organisms and cannot regulate their body temperature. The temperature of their body is approximately the same as that of its immediate environment. Therefore, temperature is probably the single most important environmental factor influencing pest behavior, distribution, development, survival, and reproduction (Petzoldt and Seaman, 2010). It has been recognised for many years that climate affects biochemical, physiological and behavioural processes in insects (Thomas and Blanford, 2003). Thus it is inevitable that modest changes to the climate are expected to have a rapid impact on the distribution and abundance of pest insects because of temperature would trigger their physiology, make lifecycles shorte , increase mobility and reproductive potential (Ayres and Lombardero, 2000; Roy et al., 2009).

The effect of climate change is however complex and will be determined by the extent of pest's actual exposure to it. Indoor pests living under continuous air conditioning or in very close proximity to humans may not experience changes as will be faced by outdoor pests. Synanthropic species such as bed bugs, and human-parasitic species such as head lice or pubic lice *Pthirus pubis* are unlikely to experience major, if any, changes in population size or an impact from climate change unless it drives a major change in human behaviour (Comont, 2016). This is very much predicted by Roy et al. (2009).

In addition, a number socioeconomic conditions and human activity will influence pest distribution and density. This complex interlinking further complicates distribution. For example in case of urban mosquitoes, water storage practices, and various intervention methods used to prevent intrusion of mosquitoes into homes affect their distribution and population. Such factors can mix up basic associations between climate parameters and mosquito abundance (Saul Lozano-Fuentes, 2012) and affect prediction models. Close association of *Aedes* mosquitoes to humans is an example where human action can be a determinant factor in deterring pest distribution and density, irrespective of climate.

The impact of climate change on urban pest is a complicated subject knowing that urbanity is a heterogeneous mixture of variables. The review however conclusively shows climate change will affect various aspect of urban pest, most notably their distribution and density. It can be safely concluded that climate change and resulting temperature regimens in particular will have profound influence on urban pests and humans.

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