The 2nd International Conference on Biological Engineering and Medical Science
DOI: 10.54254/2753-8818/4/20220604

The Impact of Environment Situation on Fireflies and the Contribution of Fireflies on Environment Situation

Muyao Shen[1], Zijun Qing[2] and Siyu Lin[3]

122 Jiangyao Rd phase 2 BLDG.3 RM.1005, Pudong new district Shanghai China 200126

[1]twade@study.coastalbend.edu
[2]johnny35832@outlook.com
[3]1340612774@qq.com

Abstract. Firefly is an adorable insect which is often seen in our daily life as virtual characters or mascots due to its beautiful appearance. It is famous for its glowing abdomen. It can be colorful but mostly yellow and green. The biological light is rare which attracts lots of scholars and artists to study. However, after taking research on this specie, people start to ignore it. With the technology developing and land extension, they are suffering from land losing and different kind of pollution. There are countable studies on firefly protecting that lead the population of this cute creature decline steeply. The topic of this paper is about the factors which influence a lot on the population of firefly. There concentrates information from some papers related to firefly, environment pollution and bioindicator. Wishfully, this paper will be helpful to those who want to protect fireflies and those who can explore the application of fireflies. After researching, the results are about the impact of environment situation on fireflies and the contribution of fireflies on environment situation. Firefly is threatened by three aspects which are land loss, light pollution and water pollution. Land loss is due to the commercial district and residential district building of urbanization. Light pollution will disturb fireflies to find their companion and mate. Water pollution and land pollution such as insecticide will kill firefly larvae and adults directly in chemical ways. Those above are about how people gradually pushing fireflies to distinct. It's not fair of the way people treat wild fireflies. They have a lot of contribution down for people. They have controlled the number of ampullaria gigas which is a horribly threatening invasive species that confuses people for long. It is also a bioindicator which can test the level of light pollution with a relatively low cost. The biological fluorescence is pretty in the night. It has enlightened quite a few literature and art composers to create many excellent works. It is used to educate children and to witness love when wedding. Thus, the value of fireflies can be seen from this paper and how significant it is to protect wild fireflies.

Keywords: fireflies, environment situation, bioindicator, pollution, human behavior

1. Introduction

Firefly is the sum of all the gleamy insects which belongs to Lampyridae in Insecta Pterygota Coleoptera. There's more than 2000 species in the world that generally distribute in temperate zone, subtropical zone and tropics. According to the law of adult activity, it can be divided into diurnal,

DOI: 10.54254/2753-8818/4/20220604

diurnal and nocturnal. According to the living region of their larvae, fireflies are divided into aquatic and terrestrial species. Fireflies are beautiful luminous insects that emit yellow, orange, red, yellow-green and green fluorescence. Most fireflies can fluoresce whatever they are in the period of eggs, larvae, pupas and adults. The luminescence of firefly larvae is thought to have the function of warning and intimidating enemies, while the adults are thought to use the luminescence for species identification, mating and trapping. The fluorescence is mostly for them to find fellow-creatures and their mates. The luciferase in their abdomen is highly toxic which can kill small reptiles easily.

The level of pollution affects a lot on the survival rate of fireflies. A clean and secure environment is vital for fireflies to live. Fireflies prefer to live in moist area with humidity of about 90% both for larvae and adults. Their somatic function is relatively fragile. Common water pollution can lead them to die. Firefly feeds on mollusks include earthworm, escargots, slugs, snails and so on. These mollusks also require a high-quality habitat. In addition, light pollution influence fireflies as well. Although firefly glows on their own, they themselves are negative phototropic insects, which means that they have a high avoidance of other light except for the fluorescence of their own kind. With the improvement of people's living standard, the use of artificial light becomes more and more widespread. Even this is very convenient for us, it is fatal for fireflies. Other light source prevents them from identifying the location of their companions which is the only way for male fireflies to find female fireflies. All in all, the impact of environment situation on fireflies is prominent.

Due to that firefly is extremely sensitive to environment situation and pollution, it is one of the most useful bioindicator which can show the ecology condition of some certain region in detail. It's also an indispensable species in the food chain. In every lonely night, gleamy insects can always please passing people. Fireflies have made a great contribution on environment situation.

2. The impact of environment situation on fireflies

Firefly populations are thought to be declining worldwide. Although monitored data for many regions are scarce, some published studies from Europe and Asia, suggest that fireflies are in trouble. Recent IUCN Red List assessments for North American fireflies have identified species with heightened extinction risk in the US. 18 taxa categorized as threatened to be extinct. The impact of environment situation on fireflies is prominent. All in all, fireflies are in danger nowadays. As shown in Figure 1, about one fifth of the wild fireflies are in danger which is considerably serious. The three most serious factor which led the population of fireflies to decline are habitat lost, artificial light at night and water pollution.

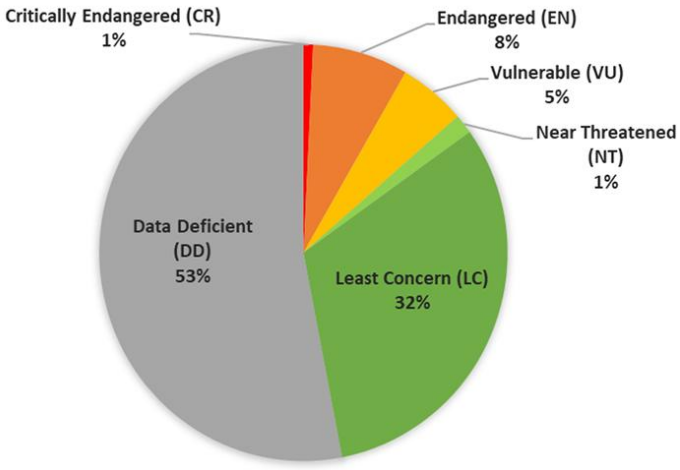

Figure 1. levels and percentage of threatened firefly WORLDWIDE [1].

DOI: 10.54254/2753-8818/4/20220604

2.1. Habitat lost

Habitat lost is defined as the most serious threat to fireflies. Due to the low similarity and liquidity of genes between different subspecies, endangered species can't be saved by migration. Even between two subspecies in the same region, there exists reproductive isolation. It makes habitat lost the most urgent factor to cause some subspecies of fireflies to die out. In the case of urbanization, the area of greenbelt and freshwater lake decreased. Commercial and residential flats developed. They are agricultural conversion, groundwater pumping, waterway modifications, cattle grazing and recreational activities that destroyed the habitat of fireflies [2]. In addition, tourist industry is also a large harm to wild fireflies. The great amount of visitor flow will impact a lot on fireflies' habitat. With the continuous expansion of human activity area, there's less habitat for wild animals to live in. Especially fireflies are influenced a lot because they have a high requirement on the quality of habitat which means they don't have lots of region to migrate to. For rural area, human can live together with fireflies but nowadays rural areas are urbanized gradually. The scene that rural children play with adorable flying insects is disappearing.

2.2. Light pollution

Artificial light at night is the second most terrible threat to fireflies. Due to the popularity of artificial light, streetlights have been erected not only in towns and cities, even remote suburban areas have set street lights up [3]. Most houses are lighted up at night. Light pollution can significantly prevent the courtship ritual because they can't find mate without fluorescence emitted which leads to their rapid extinction because they cannot reproduce [4]. Artificial light at night consists of skyglow, glare and light trespass. Fireflies prefer natural light regimes and are sensitive to light including periodicity, polarization, intensity, source and wavelength [5]. Most fireflies are nocturnal which means they have a highly sensitive visual system. Their superposition compound eyes can be hurt by the three kinds of artificial light at night listed above. The damage will weaken their ability to have activity at night. When fireflies meet artificial night light, they will be attracted, repelled, disoriented or blinded soon which will decrease the number of wild populations. Natural environmental light levels dictate when fireflies will begin to flash. Thus, a night with increased environmental light may have an impact on both the timing of activity and the ability to recognize bioluminescence signals given off by possible sexual partners [5]. Bioluminescence signals are the main method for fireflies to communicate. Light pollution is deadly for their communication system. It's like a curse to make everyone in the region blind, deaf-mute and disable [6]. Obviously, any community with this curse would disappear soon. Nowadays, these adorable creatures are facing this kind of crisis and the situation keeps turning worse and worse. Fireflies are so sensitive to light pollution. Almost half of their body is used to glow in the dark [7]. Because their visual system is designed to function in the dark, nocturnal insects can execute during the night the same visual tasks as nocturnal ones with comparable precision and accuracy. In comparison to apposition eyes of the same size, their superposition compound eyes are 100–1000 times more sensitive [5]. Most species start their activities after sunset and most stop at 20:00 and 21:00 in the evening. Since seeing the bioluminescent flashes is essential for firefly reproduction, the illumination intensity should be low during this time, yet the sky seems like it is daytime due to light pollution, which prevents fireflies from growing and foraging. The amount of ambient natural light determines when fireflies begin to flash [5]. If the illumination intensity stays high for whole day, fireflies can never start their activity.

2.3. Water pollution

Water pollution is the third most critical factor which led the population of fireflies to drop. In order to prevent desiccation, moisture is fundamentally needed during the entire firefly life cycle. Females without wings and soft-bodied larvae may be especially vulnerable [8]. Fireflies prefer to live in the place with shelter, plants and high humidity. Fireflies cannot grow without water, and their pupal stage is also near water. The cleanliness of water is especially important for fireflies in the pupal stage. Adult fireflies need a high humidity environment with lush grass and trees. Firefly depends on water a

DOI: 10.54254/2753-8818/4/20220604

lot so soluble chemicals will impact them and their food——mollusks [9]. There're many kinds of ways to influence the quality of water such as pesticides, sewage discharge, noxious gas and insecticide. Between them, insecticide affects most. Neonicotinoids, neonicotinoids, and other organochlorines are common agricultural insecticides [10]. By decreasing the availability or raising the toxicity of their larval diet, which includes snails and earthworms, insecticide might indirectly harm fireflies. Since earthworms are the primary food source for firefly larvae, it has been demonstrated that imidacloprid and other neonicotinoids are very hazardous to them [11]. Actually, fireflies can communicate in chemical ways, water pollution can prevent them from communicating with each other to a great extent.

Figure 2 show the distribution of the impact of each kind of harm on fireflies in different region. Different countries damage wild fireflies for different extent. South Asia exploits most of the habitat from firefly. Generally, the situation in Asia is the most pessimistic.

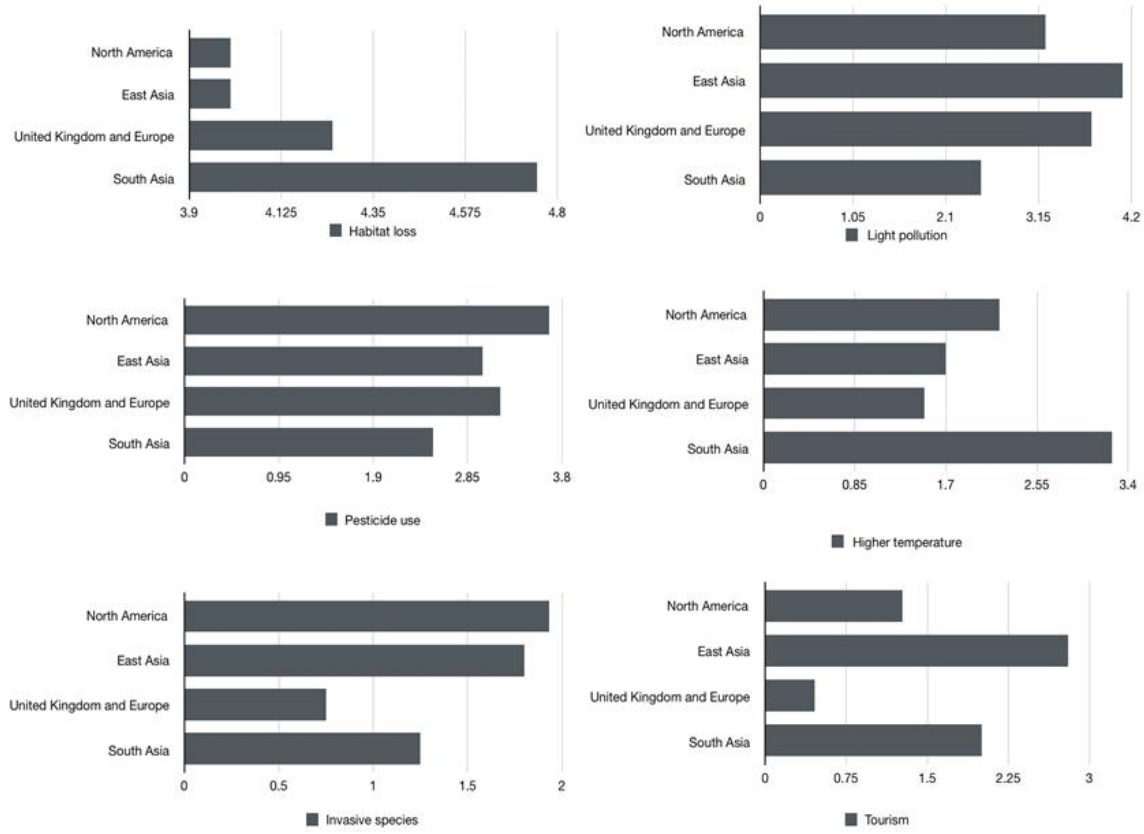

Figure 2. damage taken place in each region on FIREFLY [12].

3. The contribution of fireflies on environment situation

Why we need to protect firefly is that it also contributes a lot on the nature, technique development and daily life. The sacrificing is noteworthy. It has pried a large number of invasive species which deals a problem that confuse people for long. It is used as an indicator to test the level of pollution of an area and it is sensitive. Even a little pollution will be illustrated. It decorates every boring night as well as it pleasant many rural kids and travelers.

3.1. Restrain invasive species

Globally, ampullaria gigas is one of the severest invasive species. Ampullaria gigas are native to the Americas. After the invasion of the United States, Japan, Philippines and other countries, it has caused serious harm to local nature and agriculture, and the effect of control in various countries is not

DOI: 10.54254/2753-8818/4/20220604

satisfactory. Its population and the area of spread still show an increasing trend [13]. Mean annual temperature is a major influence on the dispersal distribution of the species. Global warming may lead to its further spread northward invasion. Ampullaria gigas have a wide and mixed diet, large food intake, high adaptability, fast reproduction, and resistance to high temperature, drought, cold, starvation, acidity, and water pollution. These characteristics made it troublesome to fix the biological invasion. Biological control refers to the use of natural enemies of invasive organisms to control their growth and reproduction. Fireflies can be used to control the population of ampullaria gigas effectively. In clean and secure environment, fireflies can prey a large number of mollusks including plenty of ampullaria gigas.

3.2. Bioindicator

Bioindicators are those organisms that can indicate the characteristics of the environment or an environmental factor through changes in their characteristics, numbers, species or communities within a certain area. In environmental protection, some sensitive organisms are often used to indicate the environmental pollution status [14]. Firefly is one of the best bioindicator. It can be used to test the level of pollution in the environment by recording data after setting fireflies into the region which is useful when anyone wants to know if some place is safe or not for creatures. It is sensitive to almost every pollution such as water pollution, light pollution, noise pollution, land pollution and so on. Bioindicators ought to be responsive to alterations in the environment. Aside from their sensitivity, fireflies are attractive candidates for environmental artificial night lighting bioindicators since they can be easily seen at night [5]. It is its sensitivity to environment that make it a fantastic bioindicator. The properties of fireflies as environmental indicator organisms illustrate that an area with more fireflies is a better area, an area with fewer or extinct fireflies is a worse area. If an area has a poor environment, the number of fireflies is going to be less. But if an area has a good environment, the fireflies are not necessarily more because if the area has experienced the extinction of fireflies and when the environment is restored after a few decades, the fireflies that are not naturally suited for long-distance flight will not be able to reach here. This is a situation where fireflies as environmental indicator organisms are unable to indicate which means firefly is limited when being used as a bioindicator. It can only illustrate that the region is without pollution ever.

3.3. Aesthetics and culture

Fireflies can decorate the night well. They live in the region with weak light pollution which means that mostly moon and stars are able to be seen. Watch right upward the sky, white moon, twinkling stars, looming clouds and glowing fireflies together decorate the dark blue sky which is one of the prettiest sceneries in the world. When most animals went to sleep, the nature turns silent. It is firefly that having activity to lighten the sleeping world. Not only in ancient time but stile present years, lots of content creators such as poets, writers, music composers and painters even video game makers have created incomputable productions about fireflies. Fireflies enlightened the content creators to make fantastic works and the works inspired many people to be like the fireflies to light the night in the long process of history. Nowadays, people use artificial breeding fireflies to decorate people's wedding. In some kindergarten teachers let students to release fireflies from glass jars to let kids know the significance of protect the environment. When these adorable light spots get out of the glass jars one by one. Children can obviously feel happiness when the nature gets better.

4. Conclusion

In conclusion, this paper does research on how each kind of human behaviors affect fireflies globally and how fireflies contribute to the environment. Habitat lost is the most serious problem affects fireflies' population, it leads to a large proportion of firefly extinct regionally. Light pollution leads fireflies have less offspring. Due to fireflies highly dependence on aqueous environment so water pollution is also a mortal threat to fireflies. As fireflies highly sensitive to surroundings, so it is the optimal bioindicator, moreover due to it is a bioluminescence insect, we can also observe them at night.

Also, fireflies may help solving invasive species—mollusks including ampullaria gigas which is the most harmful one. In addition, the ornamental value is also noteworthy. The pleasant glow in the night has a positive impact on human activity. To defend the value that fireflies provide to human, it's undoubtable to protect them. In order to protect fireflies, there are three aspects generally which are keep population of wild fireflies, water pollution and light pollution. To keep even increase the population of wild fireflies, hunting and selling fireflies should be banned. Sanctuary should be set. The construction of urbanization needs to avoid fireflies' habitat. To control water pollution, it is prohibited to discharge sewage, domestic water and other polluting substances into river courses. Vegetation in its habitat ought to be protected. Using of pesticides need to decrease. To control light pollution, government should decline unnecessary artificial night light. In the future, the value of firefly will be found gradually and the population of wild fireflies will receive attention soon.

Reference

[1] Fallon CE, Walker AC, Lewis S, Cicero J, Faust L, Heckscher CM, et al. (2021) Evaluating Firefly Extinction Risk: Initial Red List Assessments for North America. Plos ONE 16(11): E0259379.Page5 Https://Doi.Org/10.1371/Journal.Pone.0259379.G001

[2] Meilin Li,Jun He. Firefly Living Status and Ecological Environment Protection in Shanghai.Middle School Biology 2019 **Vol.35** No.4.

[3] Hagen. Investigation Of the Artificial Night Lighting Influence in Firefly (Coleoptera: Lampyridae) Occurrence in The Urban Areas of Campinas and Sorocaba Municipalities.

[4] Ariel Firebaugh · Kyle J. Haynes. Experimental Tests of Light - Pollution Impacts on Nocturnal Insect Courtship and Dispersal.

[5] Hagen, O., Santos, R.M., Schlindwein, M.N. And Viviani, V.R. (2015) Artificial Night Lighting Reduces Firefly (Coleoptera: Lampyridae) Occurrence in Sorocaba, Brazil. Advances In Entomology, 3, 24-32.

[6] Owens ACS, Lewis SM. 2022 Artificial Light Impacts the Mate Success of Female Fireflies. R. Soc. Open Sci. 9: 220468.

[7] Stephanie Vaz, Stella Manes, Danielle Gama-Maia, Luiz Silveira, Gustavo Mattos, Paulo C. Paiva, Marcos Figueiredo5 and Maria Lucia Lorini. Light Pollution Is the Fastest Growing Potential Threat to Firefly Conservation in The Atlantic Forest Hotspot.

[8] Fallon CE, Walker AC, Lewis S, Cicero J, Faust L, Heckscher CM, et al. (2021) Evaluating Firefly Extinction Risk: Initial Red List Assessments for North America. Plos ONE 16(11): E0259379.

[9] JIANG Qian-Wen, LIU Feng, PENG Ying-Xiang, WANG Hua,YAO Ran,LI Hong-Fang, LUO Pei, LIU Xin-Liang, WU Jin-Shui. Nitrogen And Phosphorus Removal by Integrated Ecological Engineering Treatment System in A Small Agricultural Watershed.

[10] Ramdan Faudzi, Azlan Abas*, Nurul Wahida Othman and Sytty Mazian Mazlan. Effect Of Water Quality on The Abundance of Firefly Populations at Cherating River, Pahang, Malaysia.

[11] Sara M. Lewis, Choong Hay Wong, Avalon C.S. Owens, Candace Fallon, Sarina Jepsen, Anchana Thancharoen, Chiahsiung Wu, Raphael De Cock, Martin NovÁK, Tania LÓPez-Palafox, Veronica Khoo, And J. Michael Reed. A Global Perspective on Firefly Extinction Threats.

[12] Sara M Lewis, Choong Hay Wong, Avalon C S Owens, Candace Fallon, Sarina Jepsen, Anchana Thancharoen, Chiahsiung Wu, Raphael De Cock, Martin NovÁK, Tania LÓPez-Palafox, Veronica Khoo, J Michael Reed, Corrigendum: A Global Perspective on Firefly Extinction Threats, Bioscience, **Volume 70**, Issue 5, May 2020, Page 440.

[13] YIN Ying-Xuan1, WU Yin-Juan1, HE Qing1, HE Yong-Xin2, GAO Ruo-Xi2, LIU Qi-Yong3, LI Xue-Rong1. Status, Hazards, And Control Strategy of Primary Invasive Snails in China.

[14] XU Zhi,MA Jing,WANG Hao,ZHAO Jianshi ,HU Yajie,YANG Guiyu. Key Indicator and Critical Condition for The Water Resource Carying Capacity in The Yangtze River Estuary.