The role of green corridors for wildlife conservation in urban landscape: A literature review

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Abstract. Green corridors are an attempt to mitigate negative effects of the built environment of cities and towns. The corridors act as conservation for rapidly extreme intervention and development of the urban environment. Most importantly, it enables dispersal movement of animals within city areas. Issues relate to wildlife conservation in urban areas has been studied for many years and thus, the research makes a review for how the green corridors contribute to the conservation of urban wildlife. This study reviews groups of articles in disciplines of urban landscape planning and biology conservation to discuss the relationship between elements of green corridors and urban wildlife dispersal movement behaviour in Malaysian context. Accordingly, this research is purposely studied to give understanding on how green corridors contribute to the animals' ability of moving and dispersing within the built-up areas. In advance, it is found that there are three factors contribute to the capability of colonization among urban wildlife which are individual, physical and social factor. Green corridor has been defined as one of the physical factor that influence urban wildlife behaviour movement. Consequently, safety area indicating to animals species for traversing in any time such as at night can be defined as the primary potential corridor.

1. Introduction

A report from Global Conservation Organization, WWF, has suggested that since 1970 the pressure we exert on the planet has almost doubled and the natural resources upon which we depend have declined by more than 33%. Since then, an ever-growing demand for resources by a growing population is putting tremendous pressure on our planet's biodiversity including urban wildlife. This has threatened our future security, health and well-being of urban wildlife in cities area. Regardless, anthropogenic alterations (human interruption) on landscape scale is one of the major wildlife conservation issues facing the world today [1]. The anthropogenic alterations described are including habitat loss and fragmentation, climate change, pollution, over exploitation, unregulated hunting and pesticides [2]. Consequently, the human interruption which lead to loss of habitat and increase in landscape fragmentation are hindering urban wildlife movement and disperse activity. As a result of these big changes on landscape scale, it is common to see animals mortality on road which involving not only mammals but also birds as victim.

Wildlife traditionally refers to animals. Thus, urban wildlife can be defined as animals especially vertebrates that are not domesticated [3], but recent definition encompass "all forms of life that are wild" [4]. Animals including mammals, small mammals, insects, and birds are among the urban wildlife that need attention for conservation. This is because they need time and space to adapt in new environment of built-up areas which totally different from their natural habitat. They have to move and disperse from core area to the other green patches in order to maintain their species development through colonization. Different species may have different ability of disperse. There

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are three different behaviour in dispersal movement among the urban wildlife: 1) direct, long distance movement by a single individual, 2) periodic movement by a single animal, punctuated by pauses and 3) gene flow through a reproduction resident in the corridor [5]. Among the three movement behaviour, the third is the best way of dispersal as it allow colonization through reproducing population resident. Compared to the first, it rely on individual to make full journey straight from one end point to other. Whilst for the second, it could have certain duration of time to rest until it makes other journey in which this kind of behaviour needs space to rest. Thus, they need food supply, cover, water and space provided by the green corridors to survive and have protection from predators.

In recent years there has been a growing discourse regarding green corridors as both a need and right of urban wildlife for their movement and disperse activity. The body of research considering green corridors as a primary mechanism for urban wildlife conservation has raised especially investigation on wildlife dispersal movement behaviour in a city. There are various definition of green corridor which contribute to one appropriate meaning whereby they are networks of linear and linked landscape elements with various width join that provide ecological, recreational, cultural and aesthetical benefits to the community [6,7,8]. In simple meaning, it refers to the natural routes of movement for people, animals, seed and often for water. Green corridors serve multiple functions including habitat, daily and seasonal movement and dispersal capabilities [3], which give good chance for urban wildlife to survive and adapt into the urban environment. As for the green corridors consist of a range of vegetated areas and water body, it gives significance value towards the urban wildlife where they can meet dietary requirement, nesting cavities, movement between vegetation patches, safety to travel and escape from the predators.

2. Methodology
Literature was selected from different disciplines including urban landscape planning, ecology conservation, biological conservation, animal behaviour and animal geographies. Computerized searches were conducted using online databases from Science Direct, Scopus, JSTOR and WILEY Online Library. Combinations of the following keywords were used to guide the search: urban wildlife, urban environments, wildlife conservation, dispersal movement behaviour, green corridor design and elements as well as green corridor development. Papers were drawn primarily from those published between 1990 until 2012 and included theoretical, review, and empirical articles, both quantitative and qualitative. Literature was chosen to illustrate the breadth of knowledge available about the studies on the role of green corridors for wildlife conservation effort in urban landscape. A greater emphasis was placed on literature that addressed the relationship between the characteristics and elements of green corridor, and its impacts on urban wildlife dispersal movement behaviour. The aspects taken into consideration in the review include the potentialities and challenges of green corridors for urban wildlife dispersal movement behaviour.

3. Result and discussion

3.1 Adaptation and behavioral adjustments of wildlife in the built-up areas
The world have seen changes in which wildlife are now increasing tendency for colonization in the built-up areas like city. This indicates that they have gone through a process of adaptation to specific conditions of the urban environment, in connection with regular existence (often breeding). Consequently, previous research has proved that animals live in the city frequently differ in behavior relative to those from surrounding habitat [9] as animals populations change under anthropogenic disturbances [10]. The anthropogenic disturbances discussed include human activities and interruption that impact on habitat loss and fragmentation of green space such as roads and traffic. Sounds from the roads traffic give distraction to the wildlife whereby it potentially interfere their ability to make biologically important decisions includes food selection, mate selection, and predator detection [11]. As shown in Table 1, there are three main ecological stages deal with colonization in the urban environment: arrival, adjustment and spread [12,9]). Decision to settle in a new environment may be dependent on the risk perceived from the urban environment besides behavioral challenges in themselves.
3.2. *Factors that wildlife dispersal movement behavior in urban environment*

From this review, the influential factors in wildlife dispersal movement behavior can be categorized into individual factors, physical factors and social factors (Table 2). There are unique interactions between individuals, and their physical and social environments that may influence urban wildlife dispersal and movement behavior. For example, an animal who is active in breeding may find difficulties to disperse in a city, even the environment of the city provides a lot of physical quality.

**Table 2.** Main factors influencing wildlife dispersal movement behaviour in urban environment.

| Category            | Main Factors                                      | Descriptions                                                                 |
|---------------------|--------------------------------------------------|------------------------------------------------------------------------------|
| Individual Factors  | • Demographic                                    | • Factors relating to species character and classification of animals         |
|                     | • Ability/attitude to move and disperse           | • Species/Individual preferences and ability to move and disperse from one patch to one patch |
| Physical Factors    | • Design and quality of green corridors/ urban parks | • Provision of green corridors in between urban parks as habitat connectors for wildlife |
|                     | • Environmental factors/urban design/safety       | • Elements of urban design and street design which influence choices of place for disperse activity (planting selection, arrangement and distribution) |
|                     | • Level of habitable (obtain food resources)      | • Availability of environmental elements in providing food resources within the green corridors area to enable inhabitant |
3.2.1. Individual factors. Due to population density, dispersal may relieve pressure for resources in an ecosystem, and competition for these resources may be a selection factor for dispersal mechanisms. Individual factors is crucial in defining the urban wildlife capability of moving and disperse within the urban environment. The dynamic properties of the demography of population, including population size, survival, and birth rates, and genetic factors would influence the level of connectivity maintained by a particular populations [13]. The demographic factors also indicate species preferences and ability to move from one patch to another end of patch because it is vary among urban wildlife who have different species background.

3.2.2. Physical factors. Among all, physical environment is a factor that give motivation for urban wildlife to move and disperse within urban areas. Regardless, physical environment that allow provision of green corridors in between urban parks as habitat connectors give good chances for the urban wildlife to move and disperse under urban pressure. Furthermore, elements of urban and street design including planting species, arrangement and distribution would influence choices of place for disperse activity among the urban wildlife. This is where availability of environmental elements in providing food resources within the green corridors area are needed to enable inhabitant among the urban wildlife species.

In addition, the ability of species colonization would be based on simple differences of habitat area requirement (food resources, space, niche, and water source) and dispersal ability (individual factor) (Table 3). The matrix indicate that lower habitat area requirements and higher dispersal ability lead to good colonization ability. While urban wildlife who need higher habitat area requirement but low in the dispersal ability would perform lowest colonization ability. Thus, this clearly proved that physical character of green corridor to be as urban wildlife habitat would influence their colonization ability.

Table 3. Matrix indicating the ability of species colonization based on simple differences of habitat area requirement and dispersal ability.

| Dispersal ability | Low colonization ability | Medium colonization ability | Good colonization ability |
|-------------------|--------------------------|-----------------------------|---------------------------|
| Habitat area requirements | High | Extinct species | | |
| | Medium | AREA OF CONSERVATION CONCERN | | |
| | Low | Pest species | | |

3.2.3. Social factors. Social factors described here are including anthropogenic disturbances and alteration as well as predator or domestic animals that influence the urban wildlife disperse activity. Road and traffics are simple example of human intervention towards natural landscape that also impact on the colonization ability as they act as barriers and pressure. Besides, exposure to unfamiliar enemies involving domestic animals like cat and dog also gives intervention to the urban wildlife dispersal behavior.
3.3. Characteristics of habitat and corridor in relation with dispersal activity among urban wildlife in the city.

There are five categories of habitat and corridor involved in the built-up areas which are primary habitat, secondary habitat, primary potential corridor, secondary potential corridor and unsuitable habitat (Table 4). The categorization of habitat and corridor characteristics are based on the quality of the habitat in the patch and corridor.

Table 4. Characteristics of habitat and corridor in relation with dispersal activity among urban wildlife in the city.

| Habitat & Corridor Category | Characteristics                                                                 | Width/Area               | Environmental elements               | Species Presence       |
|-----------------------------|---------------------------------------------------------------------------------|--------------------------|--------------------------------------|------------------------|
| Primary habitat             | Greatest conservation value which include source of water, food, larger size and open access to forage | 100ha-core area          | Primarily forest, water body          | Mammals, birds        |
|                             |                                                                                 | 50m-edge buffer          |                                      |                        |
| Secondary habitat           | One or more requirements are missing                                           | 50ha-core area           | Small forest/city park, water body    | Small mammals, birds  |
|                             | Provide forage and protection for dispersing animals as they are moving to new areas of primary habitat | 30m-edge buffer          |                                      |                        |
| Primary potential corridor  | Safety area indicating to animals species for traversing in any time, such as at night | 30m-edge buffer          | City park, water body                 | Small mammals, birds, insects |
| Secondary potential corridor| Areas that are known to be traversed by the species in question, but which constitute much riskier to the vegetal cover types | 10m-edge buffer          | Vegetated area, water body            | Small mammals, birds, insects |
| Unsuitable                  | Areas that are not suited for habitat and corridor                              | none                     | Lawn/bushes                          | Insects               |

4. Conclusion

It is has been shown that green corridors with more forest cover, wider corridors, greater amount of adjacent natural or semi natural habitat like river, would have greater numbers of species presence. Existence of natural elements in the corridor is important for their survival and developmental needs. The green corridors that offer niche, shelter, food and protection allow the urban wildlife to survive and move from one patch (green space) to another. Thus, many studies generally investigated the corridor attributes in which the urban wildlife engaged in most of their disperse activity and the factors that influences their choice of location and routes to make a move. Finally, green corridors have a potential as routes and way of disperse mechanism for the urban wildlife, however, there are needs to identify the challenges and opportunities in order to totally maximize its potential. Indeed, it is essential to recognize the challenges from all point of view because they are interconnected. The result of this study is focuses on the green corridor character only, but it is found that human activity factors should be taken into consideration when dealing with wildlife conservation study. In advance, it is suggested for the next study to overlap the findings from green corridor character and nature attributes with surrounding human activity as it contribute to urban wildlife disperse performance in the city. Furthermore, management and landscape architect should not only concentrate on planning...
within the corridor, for example, planting of native vegetation, but also should plan to incorporate surrounding landscape features that will eventually enhance the biodiversity value of connectors.

References
[1] MacDonald M A 2003 Hobart: Tasforests 14 41-52
[2] Saunders D A, Hobbs R J and Margules C R 1991 Conservation Biology 5 18-32
[9] Sol D, Lapiedra O and Gonzalez-Lagos C Animal Behaviour 85 1101-12
[10] Luniak M 2004 International Urban Wildlife Symposium 4 50-55
[11] Chan A A Y and Blumstein D 2011 Behavior Science 131 1-7
[13] Rosenberg D K, Noon B R and Meslow E C 1997 BioScience 47 677-87
[14] Vos C C, Verboom J, Opdam P F M and Terbraak C J F 2001 The American Naturalist 157 24-41
[15] Watts K, Humphrey J W, Griffiths M, Quine C and Ray D 2005b Evaluating biodiversity in fragmented landscapes: Principle (Edinburgh:Forestry Comission)