

Edge effect on beetles (Insecta: Coleoptera) species abundance and richness in Tai Om

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1 Introduction

Forest fragmentation is the process of creating isolated forest area by removal of certain forest parts for anthropogenic activity (Murcia, 1995). Fragmentation of forest causes biodiversity loss through reduction of habitat, loss of connectivity between populations, and changing of microclimate near the forest edge (Haddad et al., 2015; Murcia, 1995). The last impact, which is termed "edge effect", have been a prevalent area in research to determine its effect on biodiversity in fragmented habitat.

Temperature, ultra-violet light intensity, and different climate of forest edge differs from forest interior, which causes change of ecological niche near the forest edge (Murcia, 1995). Not only does this causes niche of native organisms to be smaller than the actual forest fragments, where resources will be reduced. The newly altered edge may allow introduction of pest, causing higher probability of competitions between pest and original animal. Therefore, both abundance and richness of original species are lowered by edge effect. Edge effect have numerous effects on abiotic factor and biotic factor. For leaf litter depth and diameter at breast height (DBH), it has been shown that different tree composition and forest would

have difference relationships between the aforementioned variables and distance from edge. (Chen, Franklin, & Spies, 1992; Didham, 1998; Sandoval & Cancino, 2008; Yu, Luo, Zhou, & Yang, 2007). For temperature, it has been shown to be increasing towards edge due to increasing exposure of sunlight (Didham, Hammond, Lawton, Eggleton, & Stork, 1998). For tree density, it has been shown that tree density will be high at recent forest edge due to favourable microclimate condition in recently form edge, and the tree density gradient along the edge will shift towards forest interior after 100 years (Matlack, 1994).

Beetles can potentially be used as one of the indicators of edge effect as they are sensitive to disturbances, abundant, well-recorded and morphologically distinct (Pearce & Venier, 2006; Henle, Davies, Kleyer, Margules, & Settele, 2004). difference families reactions towards forest edge have been investigated by many researchers. For ground beetles (Carabidae), they use litter for foraging ground and protection, and they prefer cooler temperature, and they use fallen wood debris for oviposition (Pearce & Venier, 2006). It has been found that most carabids prefer forest edges due to their foraging strategy (Tóthmérész, Nagy, Mizser, Bogyó, & Magura, 2014; Yu et al., 2007). For longhorn beetles (Cerambycidae), the relationships between species and distance from edge depends on the species (Allison, Strom, Sweeney, & Mayo, 2019). For bark beetles (Scolytinae), their outbreak usually occurs at forest edges with high temperature and high tree density (Kautz, Schopf, & Ohser, 2013). For rove beetles (Staphylinidae), it was found that there significant difference in species number between forest edge and interior (Tóthmérész et al., 2014), but it was also found that forest species in the edge were being replaced by exterior species, altering the species composition in the edge (Pohl, Langor, & Spence, 2007). Therefore, relationship between beetles species abundance, richness and forest edge is highly contextual, and would require taxa specific knowledge of beetles and surrounding trees to predict the outcome. In Hong Kong, some of the common examples of ground and litter-swelling beetles are Carabidae, Curculionidae (including Scolytinae), and Staphylinidae (Bing-Lan et al., 2004).

Tai Om is an old village in Tai Po district, it has a Feng shui woodland which is a plantation forest to bring luck to the village residents. As the village is estimated to be larger than 300 years old, it is safe to assume that the forest is more than 100 years old, however the age of forest edge is not known (Marafa, 2003). Nevertheless, edge forest pattern could persisted after 100 years, so it could potentially still be observed nowadays (Matlack, 1994).

Therefore, in this report, it is hypothesised that temperature, tree density, and potentially leaf litter depth and DBH decrease from the edge to the forest interior. Secondly, leaf litter depth, DBH and tree density would have a positive correlation with beetles species abundance and richness, while temperature have a negative correlation with beetles species abundance and richness.

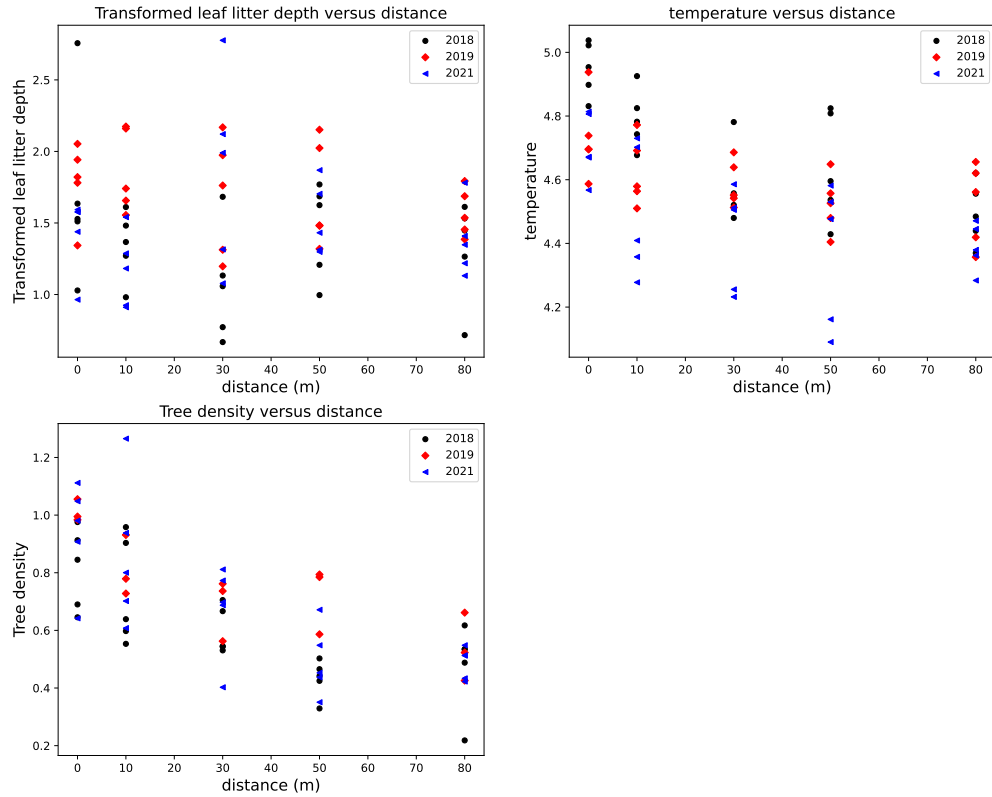


Figure 1: Leaf Litter Depth, Temperature, and Tree Density against distance

2 Methods

Dataset of 2018, 2019, 2021 were used for comparison between variables. Tree density was calculated by separating the amount of trees into 5 quantile by distance, then divided the abundance of tree by the length of the quantile. Square-root transformation were performed on non-uniform distribution, and if normality or homogeneity of variance was not fulfilled, non-parametric test like Kruskal–Wallis test (KW Test) and Spearman correlation test were used instead of analysis of variance and Pearson correlation. Linear regression (LR) was used in computing relationship between DBH and distance from edge.

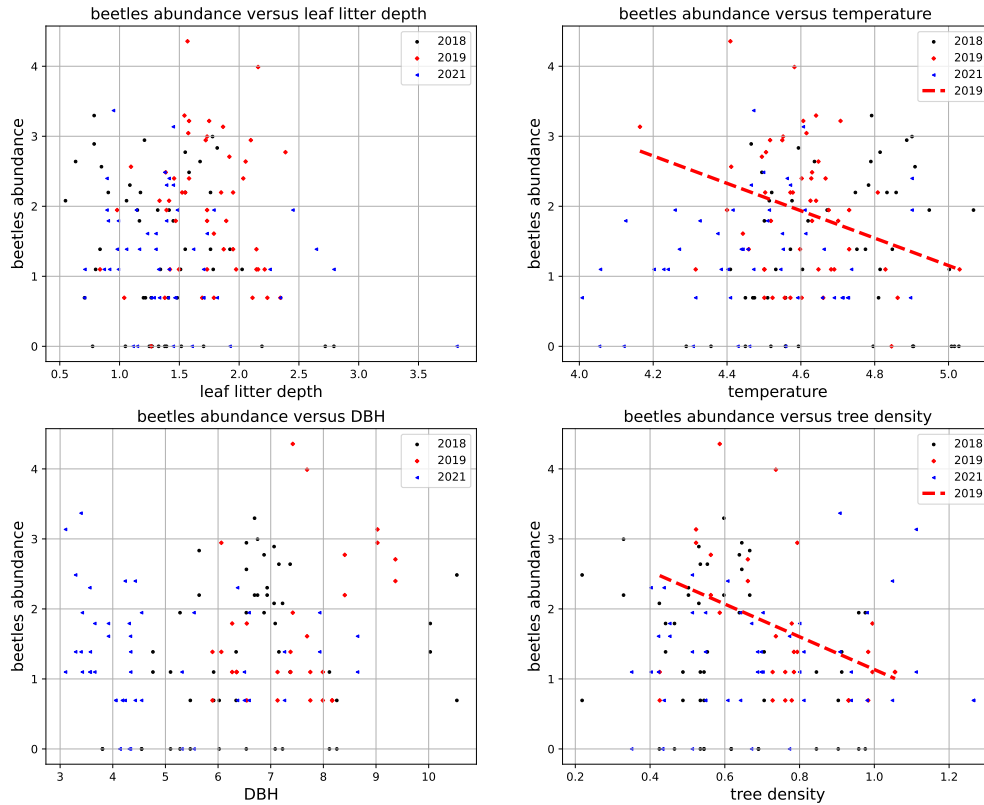


Figure 2: Beetles abundance against Leaf Litter Depth, Temperature, DBH, and Tree Density

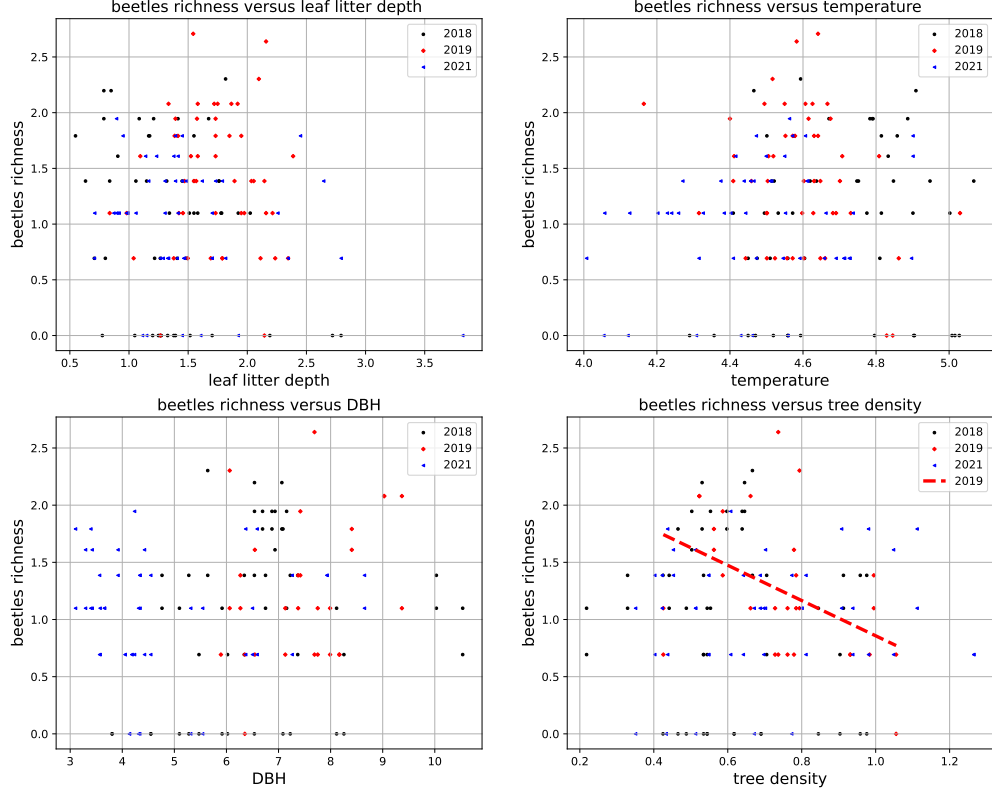


Figure 3: Beetles richness against Leaf Litter Depth, Temperature, DBH, and Tree Density

3 Results

271, 511, and 203 specimens were collected respectively in 2018, 2019, and 2021. High variation of patterns of beetles species abundance and richness were observed among transects over 2018, 2019, and 2021, which abundance ranged from 1 to 77 along 1 transect in 2019.

Firstly, for leaf litter depth, it shows negative relationship with distance in the dataset of 2018 ($F = 2.694, p = 0.043$). A Tukey Test was significant between 0m and 30m ($p = 0.02$). There is only a weak evidence that leaf litter depth have a negative relationship with species abundance in the dataset of 2021 ($r = -0.240, p = 0.093$).

For temperature, there were strong evidences that temperature decreases with distance from edge in 2018 ($F = 22.240, p = 0.000$) and 2019 ($F = 4.611, p = 0.003$). A Tukey Test were significant between 0m and 10m ($p = 0.042$), 0m and 30m ($p = 0.001$), 0m and 50m ($p =$

0.001), 0m and 50m ($p = 0.001$), 0m and 80m ($p = 0.001$), 10m and 30m ($p = 0.003$), 10m and 80m ($p = 0.001$) in 2018, and also 0m and 50m ($p = 0.006$), 0m and 80m ($p = 0.006$) in 2019. There was a strong evidence that temperature have a negative relationship with species abundance in 2019 ($r = -0.292, p = 0.039$), and it had a weak evidence that temperature have a negative relationship with species richness in 2019 ($r = -0.277, p = 0.053$).

For DBH, there are strong evidence that there is a positive relationship between DBH and distance from edge in 2019 ($F = 9.200, p = 0.003, adjusted R^2 = 0.079$). There is a weak evidence that there is a positive relationship between DBH and species abundance ($r = -0.270, p = 0.058$).

For tree density, all datasets showed strong evidences that is a negative relationship between tree density and distance from edge ($F = 17.382, p = 0.002; F = 14.871, p = 0.005; F = 10.433, p = 0.033$). For dataset of 2018, pairwise post-hoc Dunn test revealed significant differences between 0m and 50m ($p = 0.000$), 0m and 80m ($p = 0.006$), 10m and 50m ($p = 0.003$), 10m and 80m ($p = 0.04$), 30m and 50m ($p = 0.03$). For dataset of 2019, Dunn test was significant between 0m and 50m ($p = 0.004$), 0m and 80m ($p = 0.003$), 10m and 50m ($p = 0.014$), 10m and 80m ($p = 0.011$). Surprisingly, there was a strong evidence that tree density have a negative relationship with species abundance ($r = -0.374, p = 0.041$) and a negative relationship with species richness ($r = -0.413, p = 0.026$) in the dataset of 2019.

Table 1: P values of different variables in forest edge of Tai Om, **bold text** indicates significant result

Variables	LR/ANOVA/KW Test			Pearson/Spearman Correlation Test					
	Distance from edge			Species Abundance			Species Richness		
	18	19	21	18	19	21	18	19	21
Leaf litter depth	0.043	0.46	0.178	0.278	0.892	0.093	0.143	0.940	0.305
Temperature	0.000	0.003	0.060	0.300	0.039	0.192	0.300	0.053	0.270
DBH	0.311	0.003	0.922	0.058	0.174	0.422	0.149	0.190	0.565
Tree density	0.002	0.034	0.005	0.155	0.041	0.511	0.619	0.026	0.600

4 Discussion

Forest fragmentation causes reduction of biodiversity due to smaller habitats, resources, and edge effect. In this report, relationship between leaf litter depth, temperature, DBH, tree density with distance from edge, beetles species abundance and richness were investigated.

For tree density, the negative relationship between tree density and distance from edge is in well accordance to the prediction of the result in Matlack (1994). The result in 2019 showed that beetles species abundance and richness would be negatively affected by tree density. The result have contradictions with the prediction and previous literatures (Sarmiento-Garces & Hernández, 2021; Windsor, 2014). Result using dataset of 2019 needed to treated with caution because only data of 3 transects can be used, due to absence of DBH data for the first 2 transects, therefore there are even fewer data point compared to dataset in 2018 or 2021. Apart from this, it is suspected that vegetation composition plays an important role, as more generalist tree species are attracted to the forest edge, which may not be favourable towards some beetles (Normann, 2016).

For leaf litter depth, the negative relationship between leaf litter depth and distance from edge is in line with the prediction. The weak evidence on negative relationship with species abundance is also contradictory towards the prediction and previous literatures (Pearce & Venier, 2006; Tóthmérész et al., 2014; Yu et al., 2007).

For DBH, the positive relationship between DBH and distance from edge in 2019 also contradicted the prediction, and null hypothesis of no relationship between DBH and beetles species abundance and richness cannot be rejected.

For temperature, the negative relationship between temperature and distance from edge in 2018 and 2019 and also the negative relationship between temperature and beetles abundance are in well accordance with the prediction and previous literatures (Murcia, 1995; Pearce & Venier, 2006).

Apart from the above factors, seasonality and phenology of beetles may also be at play here. The data was measured in February where there is not an obvious temperature dif-

ference between forest edge and interior, so the edge effect on beetles distribution may not be as prevalent comparing to Summer. Apart from this, the population of different beetles fluctuates throughout the year due to the life cycle of beetles, most families in Hong Kong would start to increase their population in February and there is a peak around June or July (Bing-Lan et al., 2004). Therefore, the data should be measured monthly to account for the seasonal difference of edge effect and the phenology of beetles.

Overall, edge effect is demonstrated by the relationships between of leaf litter depth, temperature, DBH, tree density and distance from edge. It was unable to fully determine edge effect on all ground-dwelling beetles species abundance and richness, which shows the complex nature of the problem due to varying edge effects on different vegetation and beetles species. Further investigation is needed to include tree species composition, beetles species composition, and forest slope to determine the reason of the contradiction (Normann, 2016; Yu, Luo, & Zhou, 2010).

References

- Allison, J., Strom, B., Sweeney, J., & Mayo, P. (2019). Trap deployment along linear transects perpendicular to forest edges: impact on capture of longhorned beetles (coleoptera: Cerambycidae). *Journal of Pest Science*, 92(1), 299–308.
- Bing-Lan, Z., Yin, Z., Jie, L., ADES, G. W., SK, L. C., & Wen-Hua, L. (2004). Diversity comparisons of beetles (insecta: Coleoptera) between impact flight trap and ultraviolet light trap in the secondary forest at kadoorie farm, hong kong. *Biodiversity Science*, 12(3), 301.
- Chen, J., Franklin, J. F., & Spies, T. A. (1992). Vegetation responses to edge environments in old-growth douglas-fir forests. *Ecological applications*, 2(4), 387–396.
- Didham, R. K. (1998). Altered leaf-litter decomposition rates in tropical forest fragments. *Oecologia*, 116(3), 397–406.

- Didham, R. K., Hammond, P. M., Lawton, J. H., Eggleton, P., & Stork, N. E. (1998). Beetle species responses to tropical forest fragmentation. *Ecological Monographs*, 68(3), 295–323.
- Haddad, N. M., Brudvig, L. A., Clobert, J., Davies, K. F., Gonzalez, A., Holt, R. D., ... others (2015). Habitat fragmentation and its lasting impact on earth’s ecosystems. *Science advances*, 1(2), e1500052.
- Henle, K., Davies, K. F., Kleyer, M., Margules, C., & Settele, J. (2004). Predictors of species sensitivity to fragmentation. *Biodiversity & Conservation*, 13(1), 207–251.
- Kautz, M., Schopf, R., & Ohser, J. (2013). The “sun-effect”: microclimatic alterations pre-dispose forest edges to bark beetle infestations. *European Journal of Forest Research*, 132(3), 453–465.
- Marafa, L. (2003). Integrating natural and cultural heritage: the advantage of feng shui landscape resources. *International journal of heritage studies : IJHS*, 9(4), 307–323.
- Matlack, G. R. (1994). Vegetation dynamics of the forest edge—trends in space and successional time. *Journal of ecology*, 113–123.
- Murcia, C. (1995). Edge effects in fragmented forests: implications for conservation. *Trends in ecology & evolution*, 10(2), 58–62.
- Normann, C. (2016). *Interacting effects of forest edge, tree diversity and forest stratum on the diversity of plants and arthropods in germany’s largest deciduous forest* (Unpublished master’s thesis).
- Pearce, J. L., & Venier, L. A. (2006). The use of ground beetles (coleoptera: Carabidae) and spiders (araneae) as bioindicators of sustainable forest management: a review. *Ecological indicators*, 6(4), 780–793.
- Pohl, G. R., Langor, D. W., & Spence, J. R. (2007). Rove beetles and ground beetles (coleoptera: Staphylinidae, carabidae) as indicators of harvest and regeneration practices in western canadian foothills forests. *Biological conservation*, 137(2), 294–307.
- Sandoval, S., & Cancino, J. (2008). Modeling the edge effect in even-aged monterrey pine

- (pinus radiata d. don) stands incorporating a competition index. *Forest ecology and management*, 256(1-2), 78–87.
- Sarmiento-Garces, R., & Hernández, M. I. M. (2021). A decrease in taxonomic and functional diversity of dung beetles impacts the ecosystem function of manure removal in altered subtropical habitats. *PloS one*, 16(1), e0244783.
- Tóthmérész, B., Nagy, D., Mizser, S., Bogyó, D., & Magura, T. (2014, 11). Edge effects on ground-dwelling beetles (carabidae and staphylinidae) in oak forest-forest edge-grassland habitats in hungary. *European Journal of Entomology*, 111, 686-691. doi: 10.14411/eje.2014.091
- Windsor, F. (2014). A multi-scalar analysis of habitat characteristics associated with the noble chafer beetle *gnorimus nobilis* in south worcestershire. *Worcestershire Record*, 37, 54–66.
- Yu, X.-D., Luo, T.-H., & Zhou, H.-Z. (2010). Distribution of ground-dwelling beetle assemblages (coleoptera) across ecotones between natural oak forests and mature pine plantations in north china. *Journal of Insect Conservation*, 14(6), 617–626.
- Yu, X.-D., Luo, T.-H., Zhou, H.-Z., & Yang, J. (2007). Distribution of carabid beetles (coleoptera: Carabidae) across a forest-grassland ecotone in southwestern china. *Environmental entomology*, 36(2), 348–355.