Comparative study of cocoa black ants temporal population distribution utilizing geospatial analysis

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Abstract. Cocoa plantation also subjected to diseases and pests infestation. Some pests not only reduced the yield but also inhibit the growth of trees. Therefore, the Malaysia Cocoa Board (MCB) has explored Cocoa Black Ants (CBA) as one of their biological control mechanism to reduce the pest infestation of the Cocoa Pod Borer (CPB). CPB is capable to cause damage to cocoa beans, and later on will reduce the quality of dried cocoa beans. This study tries to integrate the use of geospatial analysis in understanding population distribution pattern of CBA to enhance its capability in controlling CPB infestation. Two objectives of the study are i) to generate temporal CBA distribution of cocoa plantation for two different blocks, and ii) to compare visually the CBA population distribution pattern with the aid of geospatial technique. This study managed to find the CBA population pattern which indicated spatially modest amount of low pattern distribution in February of 2007 until reaching the highest levels of ant populations in September 2007 and decreasing by the end of the year in 2009 for two different blocks (i.e 10B and 18A). Therefore, the usage of GIS is important to explain the CBA pattern population in the mature cocoa field. This finding might to be used as an indicator to examine the optimum distribution of CBA, which needed as a biological control agent against the CPB in the future.

1. Introduction

Cocoa crop is one of the national commodities and plays an important role for the economy in Malaysia. These plants can bear fruit throughout the year, so it can be a source of daily or weekly income to growers [1]. Cocoa like other plants also has problems with diseases and pests wherever it is grown. Some pests are not only reducing the yield but also inhibit the growth of trees. In the South East Asian region, the Cocoa Pod Borer (CPB), *Conopomorpha Cramerella* Snellen is well-known as the most devastating pest of cocoa. CPB infestation may produce low quality of dried cocoa beans, which resulted from clumped and unusable beans. The whole pod must be discarded when the infestation is severe [2]. Yield losses may up to 100% if the pest if left untreated [3]. As CPB persisted, smallholders have no choice either to adapt strategies in combating this pest or to suffer with a dramatic loss of cocoa income [4]. Various control approaches had been implemented including combination of recommended agronomic practices, chemical control, resistant planting materials, fertilizer programming and Integrated Pest Management [5]. Unfortunately, no unilateral technique was proven successful in managing CPB; even chemical

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control is the most preferable technique by the cocoa growers. As an alternative towards heavy reliance on chemical, the use of biological control in the management of CPB, particularly using ant species had been previously studied in Malaysia. Ants are insects which is abundance on the earth's surface, with more than 12,000 species. Among that, 7600 species from 250 genera have been named and described scientifically [6]. Few ant species were observed to have potential in controlling cocoa pests, especially the Cocoa black ants (CBA), *Dolichoderus thoracicus* Smith (Hymenoptera: Formicidae).

CBA is an endemic species and is feasible where cocoa is inter-planted under coconut [3]. CBA may thrive well due to the availability of nesting sites on the coconut crown. CBA is less hazardous due to their non-stinging behaviour, which given no harmful effects to cocoa growers. CBA have the ability to spread their population in the block with favourable condition. The population of the CBA can be enhanced by augmentation of artificial ant nests made from a plastic bag and stuffed with dry cocoa leaves. Nests were hung on the cocoa trees attended by CBA, and by increasing the numbers of artificial nests, the populations of CBA were enhanced [7]. CBA was able to reduce CPB infestation, in term of increasing the percentage of good cocoa pods and reducing the damage severity. CBA having potential as oviposition deterrence and may hinder CPB from laying their eggs on the pod surface. The use of CBA shows great potential as an alternative approach in controlling CPB, which produce almost similar results provided by insecticide application [8]. However, the CBA must be distributed evenly on every tree and can cover almost all pods for better protection against CPB. Hence, augmentation of CBA artificial nests should be encouraged for an alternative control of CPB.

In agriculture, GIS products are very useful for predicting the area and production of agricultural commodities, determination central agriculture, mapping of land resource potential, development of agro-industry and the prediction of the spread of pests and diseases of plants. In general, the map is a means to get some idea of scientific data contained on the surface of the earth by describing the various signs and descriptions, making it easy to read and understand. There are several interpolation method are often used in GIS, each method has its characteristics and advantages and disadvantages of each. Interpolation methods in GIS are Inverse Distance Weighted (IDW), Natural Neighbor, Kriging and Spline. Kriging interpolation method is the spatial interpolation method that utilizes spatial values at sample locations to produce value at another location that is not a sample. Stochastic estimation kriging method is similar to IDW [9]. Kriging interpolation normally estimates of the core surface by a weighted normal of the information, with weights declining with separation between the point when the surface is being evaluated and the areas of the information points [10]. In this study only Kriging interpolation method was utilised to produce CBA distribution map.

A current, most of the study of CBA population [3, 7, 8, 11] were analyzed using conventional methods such as utilizing the Microsoft Excel coupled with appropriate statistical analysis. However the data density of CBA distribution is not clearly seen and unable to reveal any distribution pattern of CBA distribution [3]. Therefore, with the advancement of technology such as Geographical Information System (GIS), the existing data can be mapped and analysed any pattern inherent in the data spatially. The aim of this project is to study the CBA population density formed within two different blocks of cocoa plantation. Hence the objectives of this study are to i) to generate temporal CBA distribution of cocoa plantation for two different blocks ii) to compare visually the CBA population distribution pattern with the aid of geospatial analysis.

2. Materials and Methods

The study was conducted at the Cocoa Research and Development Center (CRDC), Malaysian Cocoa Board Hilir Bagan Datuk, Malaysia (Longitude E.100 M, 52’ 0’, Latitude N3 53’ 42). Two different blocks known as Block 18A high existing block of CBA population and 10B is categorized as medium existing block of CBA population [11]. Both blocks harbored almost similar conditions in term of tree number, tree age, shade trees as well as control and agronomic practices. Age of mature trees at these blocks ranging between 16 to 18 years during the data. CBA data were collected for 30 months starting in February 2007 through July 2009. All the data were recorded manually and saved in the tabular data format without information of x and y location for each tree sampling data.

Position of each sampling cocoa tree within these two blocks were also collected to make it compatible to be analyse in GIS environment. Global Positioning System (GPS) handheld receiver was used to obtain the position of each of the cocoa tree. GPS receivers use the World Geodetic System 1984. In this study, WGS84 projection was then transform to Malaysia Rectified Skew Orthomorphic (MRSO) to combine with other base map of study area GIS data. The coordinate of tree combine with related attribute such as number of ants counted for each trees was converted into shapefile in GIS system. The data divided into 4 different plots to become one block, known as Plot A, B, C and D in Block 18A and similar plotting were implemented at Block 10B. The total sample of cocoa tree is 50 for one plot with overall 200 sample cocoa tree for one block. However only Plot A for each block will be use as an analysis and further presented in the result section later due to data complexity and to present preliminary findings.

Then, GIS geospatial analysis such as interpolation technique is used. The interpolation technique was performed to the CBA population that gathered by the MCB research team for 30 months data (2007 to 2009). Interpolation analysis is a method for producing a prediction surface that is continuous from the group of data samples [12]. Kriging interpolation was used because it able to produce an estimate of the core surface by a weighted normal of the information, with weights declining with separation between the point when the surface is being evaluated and the areas of the information points [10]. Therefore Kriging interpolation will apply to the CBA population and other ant type species. CBA population ranges group as highest population when every trees have more than 500 ants and reach to 1000 ants and however when less than 500 cocoa black ants recorded, it is consider as low population [9].

Methods to identify high, moderate or low CBA distribution through observation visualization was based on quadrants estimation. Four quadrants which any quadrant has a CBA above 500 is considered high and less than 500 is low. When the ratio is ¾ or all quadrants covered by CBA above 500 considered high. While the moderate when the ratio of half or ½ and cocoa black ants are lower at a ratio of ¼ or quarter. The key plan for each of the block as drawn as shown in Figure 1.

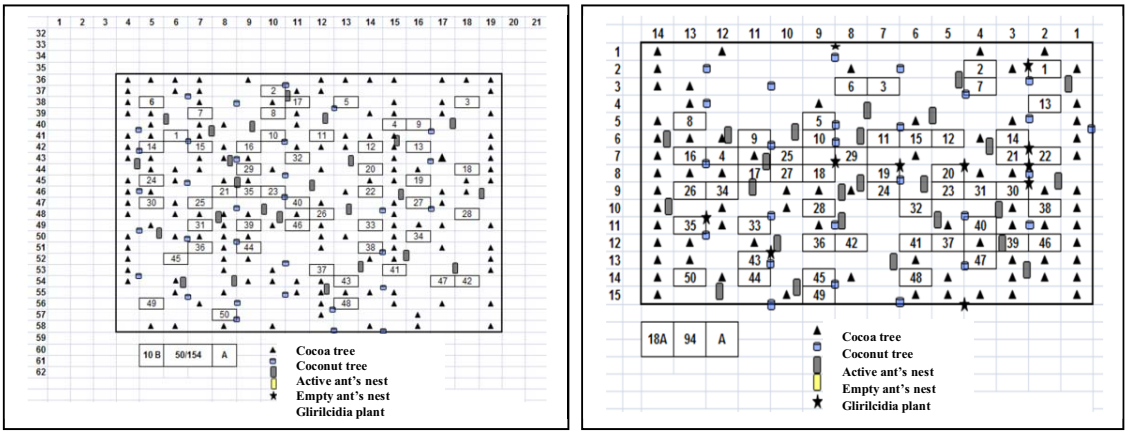


Figure 1. Key plan plot for Block 10B and 18A

3. Result and Discussion

3.1 Spatial CBA population distribution map according plot and year

Kriging Interpolation technique has been used to produce visible images for CBA population in the location plots. Each plot has 50 trees were selected as sample and have been on average the number of ants in the monthly value. Figure 2 and Figure 3 show population pattern of CBA for block 10B and Figures 4 and 5 show population pattern of CBA for block 18A. A total of 21 classes for the population range represented from red orange (zero number of ants) to dark blue (thousand number of ants). A cocoa plot can be grouped as highest population CBA distribution when every tree have more than 500 and reach to 1000 ants and any trees with less than 500 CBA is grouped as low population. Methods to

identify high, moderate or low classes of CBA distribution in the cocoa plot was based on quadrants subdivision analysis. Every plot subdivided into four quadrants as explained in Section 2 above.

The 10B plot is starting from February 2007 until July 2009, the populations of CBA began with a modest low class in February, 2007 until reaching the highest levels of ant populations in September, 2007 and decreasing by the end of the year of 2007 (Figure 2). Two months were found to have the highest rate of CBA in the months of April and October for the year 2008. While in 2009 there was a month that has the highest rate of CBA in June. When viewed in terms of population spots CBA there are deficiencies in plot A for ten months in 2007, eight months in 2008 and four months in 2009. For the three years, plot A has balance numbers of CBA on March and August 2008 also July 2008.

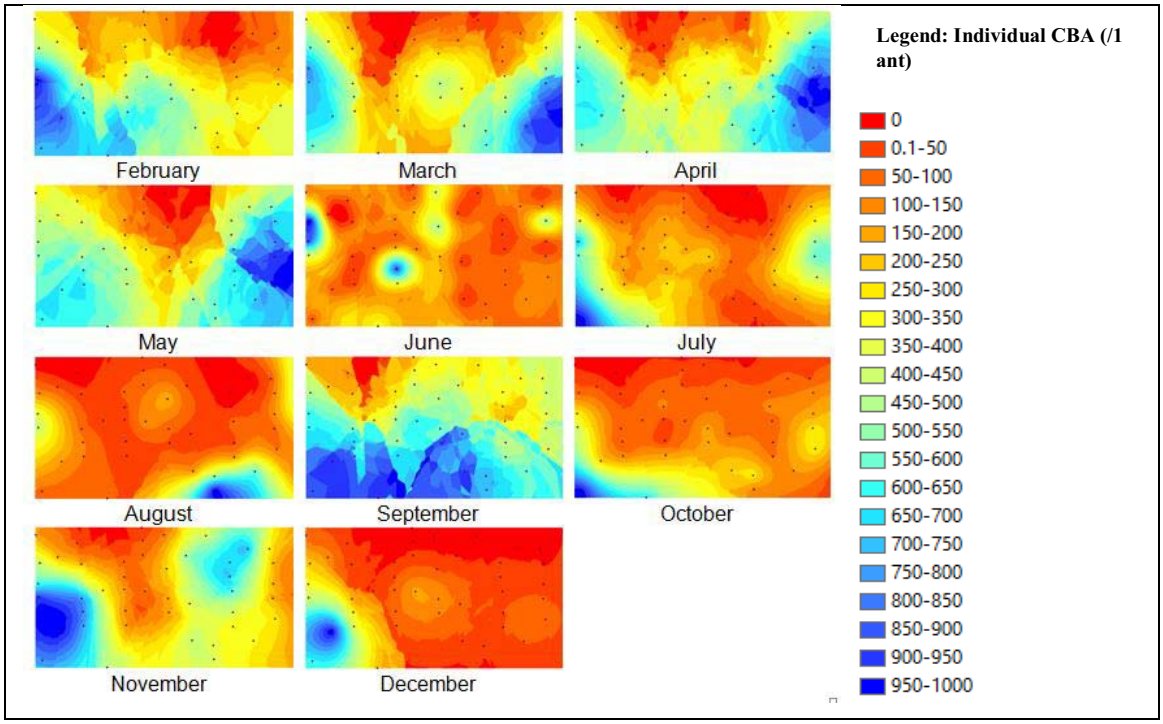


Figure 2. CBA populations at block 10B plot A in year 2007

The block 18A plot A (Figure 3), the dispersion of CBA increment quickly to it is top in the first year (2007), then stay at its low numbers in the second year (2008) and progressively increment in the third year (2009).

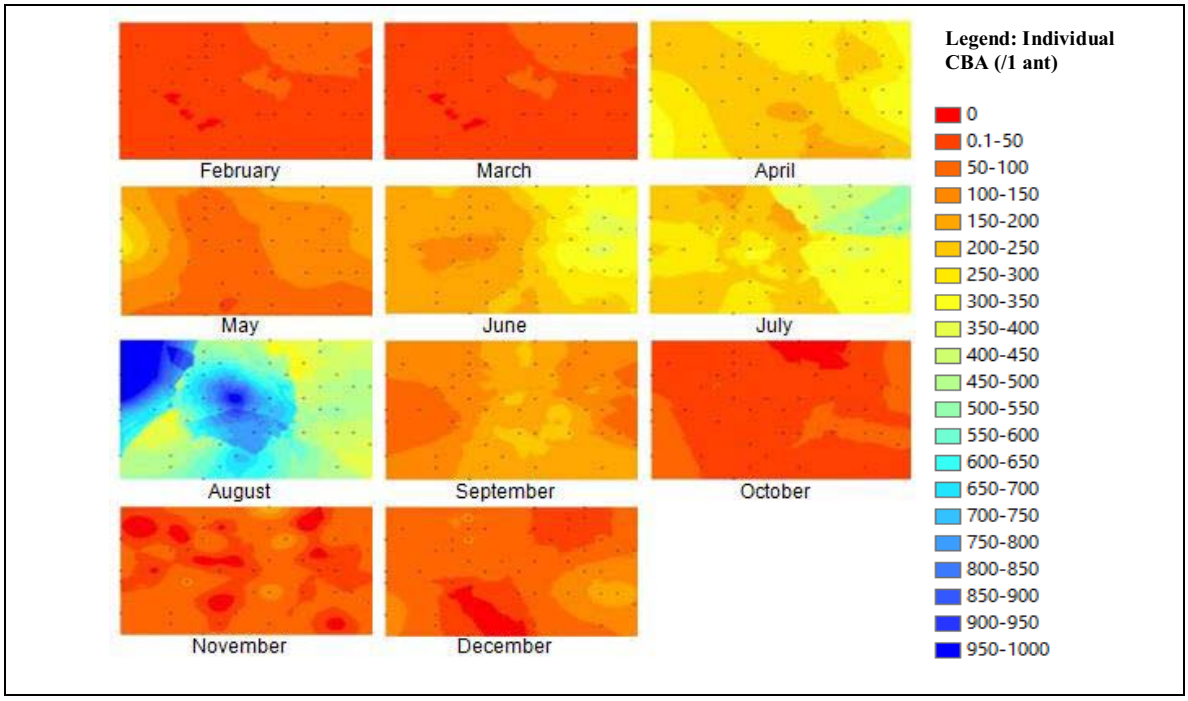


Figure 3. CBA populations at block 18A plot A in year 2007

3.2 Geospatial Comparison of CBA population distribution

The data that used in this study comprised of two different blocks known as Block 10B and 18A with the same data collection activities for the CBA's population. Therefore, to understand better the CBA's pattern according to month, analysis on the differences and similarity of CBA for Plot A was performed. The comparison was done by investigating each plot for the same year starting from 2007 to 2009 (i.e. 30 months). Figure 4 to Figure 6 illustrate the comparison of CBA distribution results from the Kriging interpolation for these plots for monthly data in 2007 to 2009.

Figure 4 shows that observation plot A 2007 on block 10B with high peak CBA on eighth (September) months and block 18A on seven (August) months from the starting observation. The first months on February for the two blocks are low populations which is less than 500 CBA.

Figure 5 shows that observation plot A 2008 on block 10B there was high peak CBA on seventh (April) and sixth (October) months from the starting observation. However does not have high peak from block 18A.

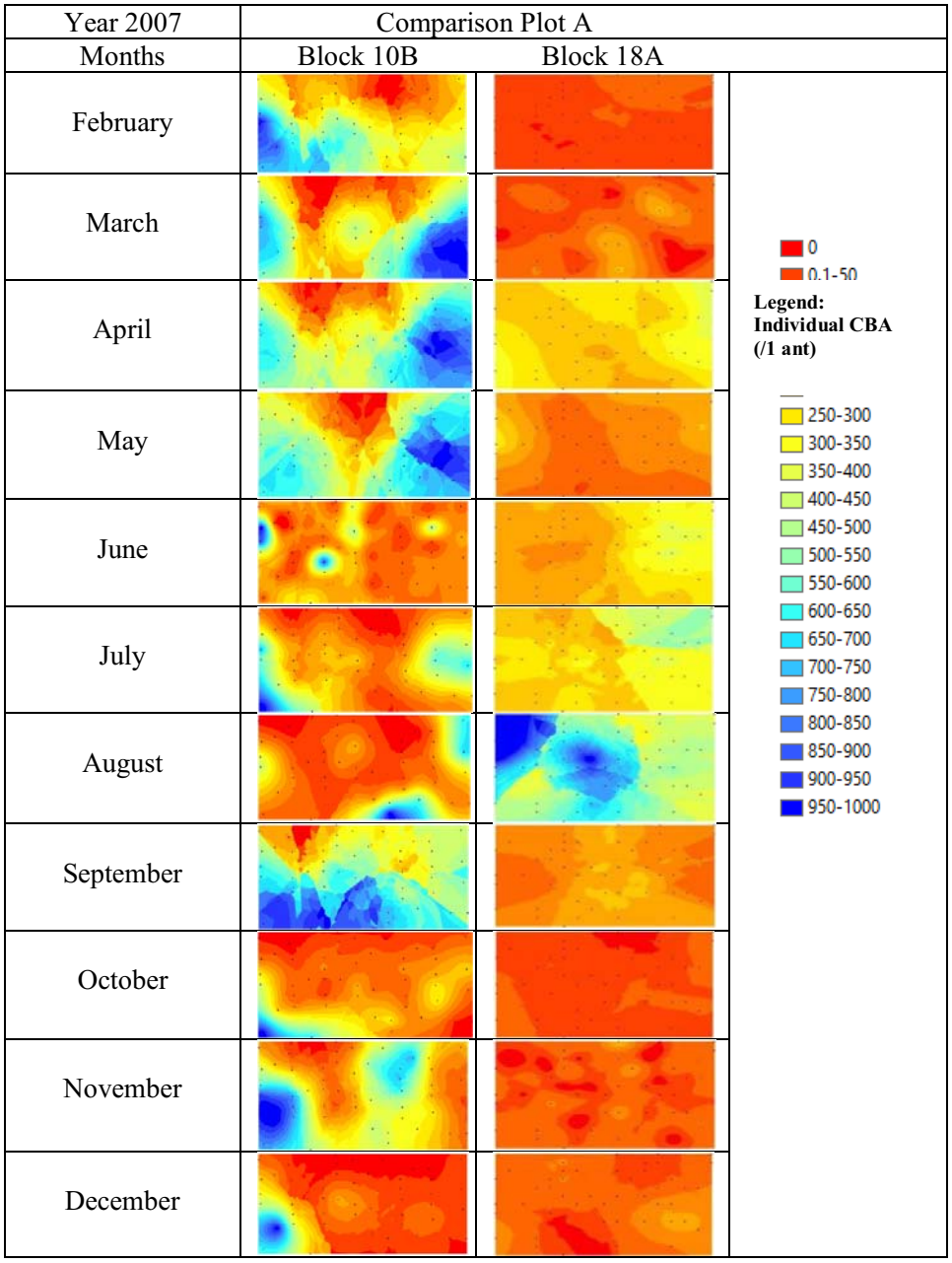


Figure 4. Comparison graphic of CBA's distribution result for 10B and 18A for Plot A in the year 2007

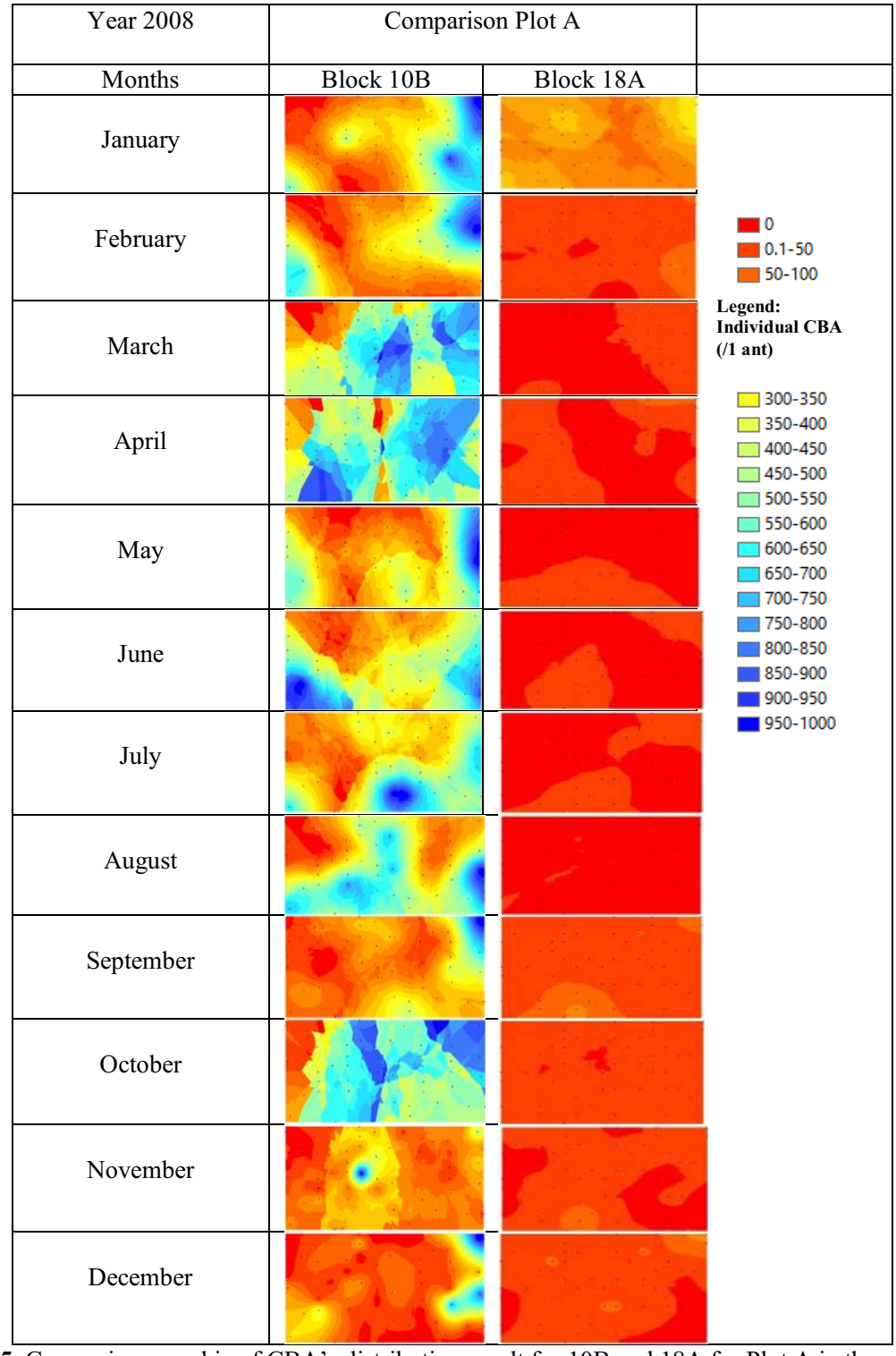


Figure 5. Comparison graphic of CBA's distribution result for 10B and 18A for Plot A in the year 2008

Figure 6 shows that observation of Plot A 2009 on block 10B represented high peak of CBA population on the 8th months (May) from the starting month of observation. However conversely, Block 18A not represented by any high peak of CBA populations. The differences obviously identified with 10B

represented by the medium and high classed range the Block 18A dominated by the very low class of CBA population. Therefore, this type of analysis can serve as managing tool to enhance CBA population in any block with lower numbers of CBA population. This analysis able to indicated precision site specific biological input to any cocoa trees and a artificial nest to enhance CBA population can easily been identified.

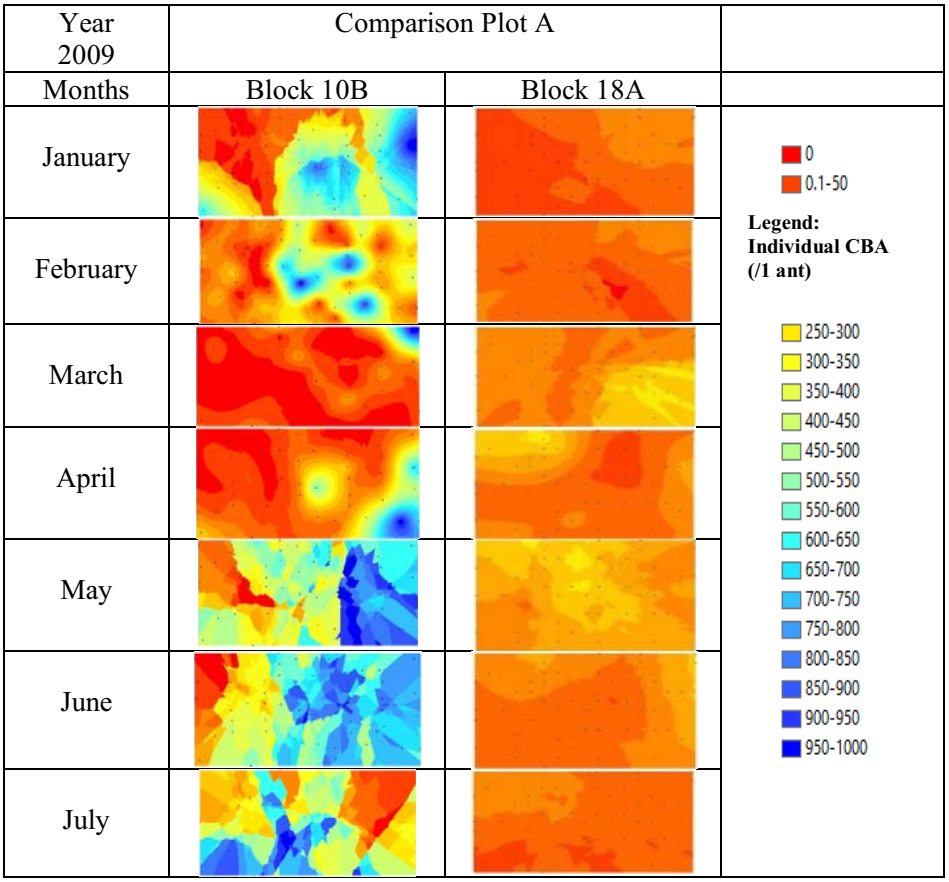


Figure 6. Comparison graphic of CBA's distribution result for 10B and 18A for Plot A in the year 2009

4. Conclusion

In conclusion the method for implementation of CBA as an effective biological control can be site specifically study for each cocoa tree. Hanging of artificial nest on the trees with appropriate amounts can be proposed to enhance CBA population and distributions. The study able to visually map the CBA population density formed within two different blocks in the cocoa plantation area. The CBA has its own unique pattern in which their population will peak in a particular month of the 7th and 8th months and declined in most of other months. Therefore, the usage of GIS able to explained the CBA pattern population and might able to be used to lessen the impact of pest infestation from CPB for further studies.

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