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DETECTIONS OF DAMAGE BY ORYCTES RHINOCEROS L. INFESTATION IN IMMATURE OIL PALM USING MULTISPECTRAL UNMANNED AERIAL VEHICLE IMAGERY

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ABSTRACT

Oryctes rhinoceros L., known as Rhinoceros beetle (RB), is one of the major pests in oil palm. Infestation of the pest can lead to delayed maturity, reduction in oil palm trees morphology and yield loss. Integrated pest management (IPM) such as biological control and insecticide spraying are in place to suppress the infestation. However, determining infested palm trees and the exact localities relies heavily on damage assessment through manual census, which could be labour intensive, time-consuming, and prone to human error. Therefore, this study examines the level of damages of oil palm caused by RB infestation using field measurement (biophysical parameters) and multispectral data (biophysical parameters, vegetation indices and textural features). Rapid Damage Survey was performed to identify the level of damages, which were classified into three: uninfested (L1), damaged (L2), and severely damaged (L3). Field measurements including crown area, perimeter, diameter and height of oil palm were taken from immature oil palm of different levels of damage, from the age of 1 until 2 years old Subsequently, aerial imagery was acquired using Micasence RedEdge-M, a multispectral sensor mounted underneath a DJI Phantom 4, a multi-rotor unmanned aerial vehicle (UAV) with three different flying altitudes: 20 m, 60 m and 80 m above ground level (AGL). Relationships were explored for all collected fields and extracted variables towards the level of damages. Results of field data analysis show that RB infestation does reduce the morphology of oil palm (R^2 = 0.53 - 0.87). Meanwhile, multispectral data analysis shows that only crown variables (crown diameter, perimeter and area) can be explained by the level of damages (R^2 = 0.62 - 0.78). Vegetation indices and textural features show no relationship with the level of damage. Based on the results of the stepwise regression method, this study observed that 60 m altitude data is the best model utilizing the crown diameter as the only variable explaining the level of damages, with the highest R^2 of 0.78. The model produces a substantial Cohen's Kappa value (0.644) and the highest percentage agreement of 75.8% compared to other flying altitudes. In conclusion, the proposed remote sensing techniques are proven to be capable of providing efficient damage assessment compared to the conventional manual census. It demonstrates that extracted variables from UAV imagery are useful in detecting the level of damages in immature oil palm caused by RB infestation. The models can identify hotspots for biological control, such as artificial breeding sites and preclude blanket spraying of biological control agents. The sub-meter accuracy of the model can assist the newly introduced UAV-sprayer system, which aims explicitly to control RB infestation through insecticide spraying. This study shows that remote sensing can facilitate more targeted and effective control measures.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

The oil palm trees had become the most important source of vegetable oil, and the industry played a significant role in the global market. Palm oil has become one of the world's most-produced vegetable oils, with 30% of total global vegetable oil consumption (Chew et al., 2021; Khiabani & Takeuchi, 2020). A century had passed since *Elaeis guineensis* Jacquin's humble beginnings in Malaya, now Malaysia is held responsible for 39% of oil palm production and 44% of the world's palm oil export (Meijaard & Sheil, 2013; Sarkar et al., 2020). Almost 90% of the perennial plant is grown in Southeast Asia, especially in Malaysia and our neighbouring country, despite the controversial carbon storage, ecosystem and biodiversity issues (Danylo et al., 2020; Fawcett et al., 2019). Domestically, the industry plays a vital role in supporting Malaysia's economy by providing job opportunities through cultivation and food industries; improving the lives of millions of rural farmers and plantation workers, reflecting how significant the industry is (Danylo et al., 2020; Gan & Li, 2014). For the year 2021, export revenue for the oil palm sector is expected to be RM 74 billion, increasing 2.4% from the year 2020 (Kwan, 2021). Palm oil is a lucrative industry; however, it is also exposed to various risks that could impede its production to meet the world's demand.

One of the challenges in maintaining oil palm production came from various factors, including pest intervention. In this case, we look into *Orcytes rhinoceros* L., known as Rhinoceros beetle (RB), which emerged as a major pest in oil palm after implementing zero burning concepts in the 90s, providing ample foraging and breeding site (Manjeri et al., 2014). Infestation commonly occurs within the immature stage of oil palm; emerges as early as six months after replanting, pest occurrence is higher in the first 12 months, making the age of one of immature oil palm more susceptible to infestation than the age of two and three (Kamarudin & Wahid, 2004; Manjeri et al., 2014; Zainal Abidin et al., 2014). With the ability to travel more than a 1.6 km radius from the breeding site, RB poses a great deal of harm to a vast area of immature oil palm (Kamarudin & Wahid, 2004; Kumashiro et al., 2014). The damages inflicted is