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Comparative effectiveness of packaging design pheromone product to sustainable pest management of rhinoceros beetle in oil palm plantation

Perbandingan efektivitas desain kemasan produk feromon terhadap strategi pengelolaan hama kumbang badak yang berkelanjutan di perkebunan kelapa sawit

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ABSTRAK

Kumbang badak (*Oryctes rhinoceros* L.) merupakan hama utama kelapa sawit. Serangan hama kumbang badak menyebabkan kerusakan parah pada tanaman belum menghasilkan dan tanaman menghasilkan. Mereka menghasilkan feromon agregasi yang diidentifikasi sebagai etil-4-metiloktanoat (E4-MO). Kumbang badak menggunakan feromon ini untuk menemukan habitat yang cocok dalam mencari makan dan berkembang biak di lanskap perkebunan kelapa sawit. Penggunaan perangkap feromon secara massal telah digunakan untuk memantau dan menangkap stadia imago *O. rhinoceros* dalam penerapan pengendalian hama terpadu. Banyak produk feromon E4-MO komersial telah dikembangkan di pasaran dengan desain kemasan yang berbeda. Penelitian ini bertujuan untuk mengetahui desain kemasan yang meningkatkan daya tarik dan efektivitas dalam menangkap kumbang badak. Penelitian dilakukan di perkebunan kelapa sawit di Kabupaten Indragiri Hulu, Riau. Penelitian ini menggunakan metode eksperimen. Empat desain feromon (*permeable sachet, micropore sachet, tube dispenser* dan *double dispenser*) dipasang disetiap blok penanaman kelapa sawit (luas tanam ± 30 ha/blok). Jumlah pemasangan setiap desain sebanyak 3 unit/blok dengan lima replikasi (blok). Penilaian hasil tangkapan kumbang badak dilakukan selama empat bulan. Hasil penelitian menunjukkan adanya perbedaan yang signifikan pada hasil tangkapan kumbang badak. Pengamatan bulan ke 4 menunjukkan bahwa desain kemasan double dispenser menghasilkan total tangkapan kumbang badak yang lebih tinggi yaitu dengan rata-rata 161,40 kumbang. Sedangkan pada *permeable sachet, micropore sachet*, dan *tube dispenser* masing-masing sebanyak 139,20, 138,80 dan 91,00 kumbang. Penentuan desain kemasan feromon sangat penting untuk menyediakan strategi pengelolaan hama yang efektif dan efisien.

Kata kunci: etil 4-metiloktanoat, mikrokapiler plastik, oryctes rhinoceros, poliprofilena, polietilena

ABSTRACT

The rhinoceros beetle (*Oryctes rhinoceros* L.) is the primary pest of oil palm plants. Rhinoceros beetle pest attacks cause severe damage to immature and mature plants. They produce an aggregation pheromone identified as ethyl-4-methyloctanoate (E4-MO). Rhinoceros beetles use this pheromone to find suitable habitats for foraging and breeding in the landscape of oil palm plantations. The mass use of pheromone traps has been used to monitor and capture imago stages of *O. rhinoceros* in the implementation of integrated pest management. Many commercial E4-MO pheromone products have been developed on the market with different packaging designs. The research aimed to determine packaging designs that increase attractiveness and effectiveness in catching rhinoceros beetles. The research was conducted at an oil palm plantation in Indragiri Hulu Regency, Riau. This research was an experimental method. The four design pheromone (permeable sachet, micropore sachet, tube dispenser and double dispenser) were installed in each oil palm planting block (planting area ± 30 ha/block). The number of installations for each design is three units/block with five replications. The assessment of rhinoceros beetle catches was carried out over four months. The results showed significant differences in the catch of rhinoceros beetles. The 4th month of observations showed that the double dispenser packaging design resulted in a higher total catch of rhinoceros beetles, with an average of 161.40. Meanwhile, permeable sachets, microporous sachets, and tube dispensers were 138.20, 139.80 and 91.00 beetles, respectively. Determining the pheromone packaging design is crucial to providing an effective and efficient pest management strategy.

Keywords: ethyl 4-methyl octanoate, oryctes rhinoceros, plastic micro-capillary, polypropylene, polyethylene

INTRODUCTION

Efforts to control rhinoceros beetles can be carried out using technical culture by planting legume cover crops (LCC), which can suppress the development of rhinoceros beetles. Cover crop vegetation in immature plantation areas (TBM) is higher than in mature plantation areas (TM). Planting LCC in oil palm replantig areas is carried out when the stacks of oil palm stems have yet to experience weathering. Biological control is carried out through the application of entomopathogens such as the fungus *Metarhizium anisopliae* and nematodes from the genera Steinernema (Rhabditida: Steinernematidae) and Heterorhabditis (Rhabditida: Heterorhabditidae) which are pathogenic in the pre-imago breeding stage of *Oryctes rhinoceros* (Hendarjanti, 2021), application of *Oryctes rhinoceros* nudivirus isolates (OrNV) (Rahayuwati et al., 2020; Hall et al., 2021). Control using chemical pesticides such as spraying lambda-cyhalothrin and sowing carbosulfan is the last alternative. According to Alouw et al. (2020), the use of pesticides is considered to have an impact on environmental pollution, killing non-target organisms and continuous application of pesticides will cause resistance to *O. rhinoceros* (Kumara & Mubarak, 2022; Ong & Sajap, 2022). Therefore, it is necessary to carry out safe control methods for the environment and human health by utilizing synthetic attractant pheromones.

Synthetic attractant pheromones have been developed to control 21%–31% of male *O. rhinoceros* imago and 67%–79% of female *O. rhinoceros* in the field (Pradipta et al., 2020). Synthetic attractant pheromone traps have been successfully used in the past to control and monitor the presence of *O. rhinoceros* in Indonesia (Widyanto et al., 2014), Malaysia (Manjeri et al., 2014), Thailand (Winotai, 2014) and also provides estimates of relative abundance (Nuriyanti et al., 2016; Fauzana et al., 2018; Adi et al., 2023). Pheromones are used in traps to catch beetles effectively. The aggregation pheromone, ethyl-4-methyloctanoate, is produced by male *O. rhinoceros* (Bedford, 2014). Pheromone traps are helpful as monitoring tools and economical control methods, especially in young oil palm rejuvenation areas, by installing one pheromone trap every 2 ha (Winotai, 2014). The objective of this research was to determine and assess packaging designs that can increase the attractiveness and effectiveness of catching rhinoceros beetles. Assessing the distribution and abundance of *O. rhinoceros* in oil palm plantation landscapes.

MATERIALS AND METHODS

Location and Time

The research was conducted in an oil palm plantation in Sungai Sagu, Lirik sub-district, Indragiri Hulu Regency, Riau. Location of research in Global Positioning System (GPS) coordinates -0.3123966, 102.2646495. Observations on the population of *Oryctes rhindults* trapped in pheromone traps were conducted for four months, from September 2018 to December 2018.

The Installation of Pheromone Trap

Pheromone traps were installed in each block (planting area ± 30 ha), with 12 cone pheromone traps (Figure 2). The research method used was an experimental method of Randomized Block Design; there were five replications of treatment blocks. In each block, pheromone trap installations were given four kinds of synthetic attractant packaging designs (Table 1 & Figure 1), each pheromone packaging design totaling three pheromones/block. Synthetic attractant pheromone contains the compound ethyl-4-methyloctanoate (E4-MO); this compound was identified as an aggregation pheromone of *O. rhinoceros* produced by males and was widely used in rhinoceros beetle pest observation and control programs (Indriyanti et al., 2018). Liquid aggregation pheromone was packaged in porous plastic packaging, which could be used efficiently for approximately 3 – 4 months. The cone pheromone trap was made of zinc; the top part was pyramid-shaped, and the bottom part was cone-shaped, connected to a bottle containing captured *O. rhinoceros* imago (Figure 2). The pheromone sachet was hung inside the cone pheromone traps. The trap was hung in the tree canopy approximately 1.5–1.8 m above the ground. Traps were observed daily, and the number of rhinoceros beetles caught was recorded and separated into males and females. The pheromone attracts both sexes and was a major tool in the management response to the rhinoceros bettle (Paudel et al., 2023). The observation data was compiled into the number of beetles/ha/month for further analysis. The location for installing the trap was in the area of young oil palm plantations (immature plants). Note and write down the design specifications for pheromone packaging and the tools used clearly.

The Data Analysis

The data analysis techniques used were descriptive statistics, hypothesis testing (One-way ANOVA), and further testing using the Tukey test to see significant differences in each population of rhinoceros bettles captured by pheromones.

Table 1. Pheromone packaging design specifications in field trials

Treatment	Packaging Design of Pheromone	Plastic Material of Pheromone	Dimension of Pheromone	Volume of Pheromone
PS	Permeable Sachet	Polypropylene	length 4 cm x width 6 cm	1 ml
MS	Micropore Sachet	Polypropylene	length 4 cm x width 6 cm	1 ml
TD	Tube Dispenser	Polyethylene	length 4 cm x Ø 0.6 cm	1 ml
DD	Double Dispenser	Micro-capillary	length 20 cm x width 0.5 cm	1 ml

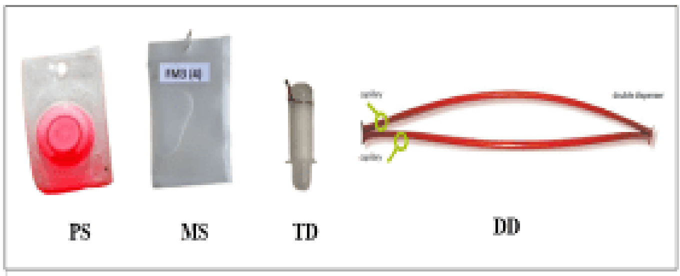

Figure 1. Appearance of Pheromone Packaging Designs in Field Experiments

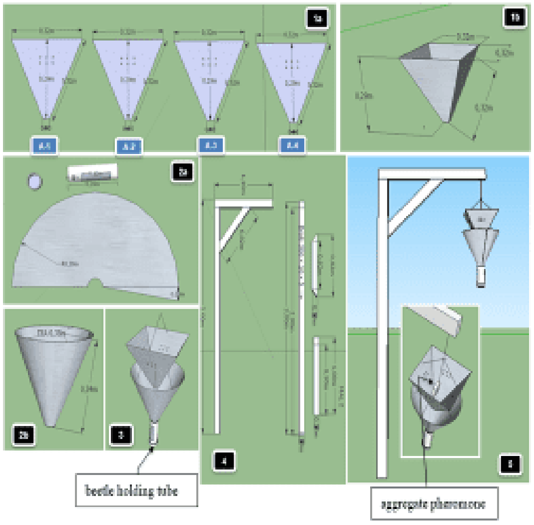

Figure 2. Design of The Cone Pheromone Trap consisting of a pyramid and cone shape: (1a). Mal to form a pyramid, (1b). The Design of a pyramid-shaped pheromone trap (2a). Pattern to form a cone, (2b). Conical pheromone trap design, (3). A series of pyramid and cone pheromone traps, (4) The Design of the pheromone trap support pole, (5). Trap Shape "Cone Pheromone Traps"

RESULTS

The Influence of Pheromone Packaging Design on the Cumulative Population of *Oryctes rhinoceros*

Observations of rhinoceros beetles caught in pheromones for four months showed a fundamental difference between the total cumulative average of rhinoceros beetles caught in pheromone traps installed in four packaging designs (Figure 3). The double dispenser packaging design (plastic micro-capillary) shows an average of 161.40 beetles. Meanwhile, the packaging designs of permeable sachets (plastic polypropylene), micropore sachets (plastic polypropylene), and tube dispensers (plastic polyethene) were able to catch 138.20, 139.80, and 91.00 beetles, respectively.

The Influence of Pheromone Packaging Design on Fluctuations in Catches of *Oryctes rhinoceros*

Observations of the average fluctuation of rhinoceros beetles trapped in pheromone traps for four months in a planting area of ± 30 ha showed significant differences in the 2nd, 3rd, and 4th months (Figure 4). A description of the number of female and male Imago and the sex ratio in each packaging design was presented in Table 2.

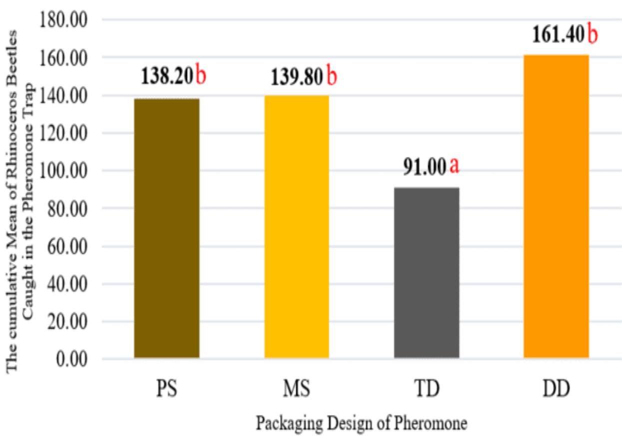

Figure 3. The average cumulative number of rhinoceros beetles trapped in pheromone traps for four months in each pheromone packaging design: permeable sachet (PS), micropore sachet (MS), tube dispenser (TD) and double dispenser (DD)
Note: Means followed with the same letters within bars were not significantly different based on the Tukey at $p < 0.05$

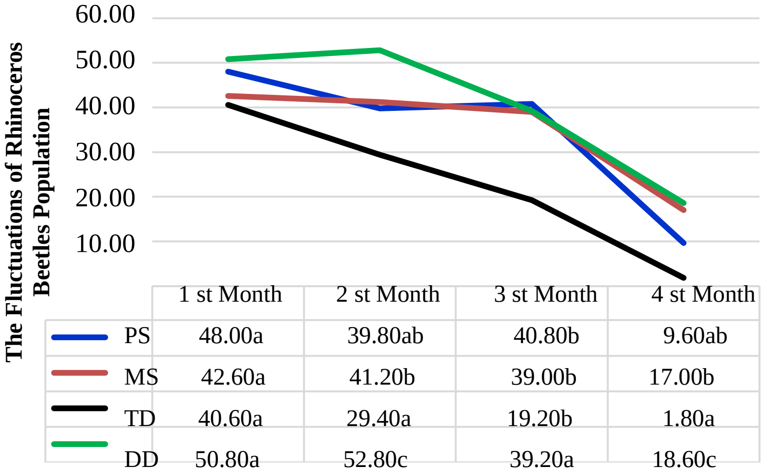

Figure 4. The fluctuations of the rhinoceros beetle population trapped in pheromone traps for four months in each pheromone packaging design: permeable sachet (PS), micropore sachet (MS), tube dispenser (TD) and double dispenser (DD)
Note: Means followed with the same letters within rows were not significantly different based on the Tukey at $p < 0.05$

Table 2. Table of average population fluctuations and sex ratio of rhinoceros beetle trapped in pheromone packaging design

Packaging Design of Pheromone	1st Month September 2018				2nd Month Oktober 2018			
	♂	♀	Total	Sex Ratio	♂	♀	Total	Sex Ratio
PS: Permeable Sachet	16.60	31.40	48.00	1:1.89	13.60	26.20	39.80	1:1.93
MS: Micropore Sachet	10.40	32.30	42.70	1:3.11	15.40	25.80	41.20	1:1.68
TD: Tube Dispenser	12.80	27.80	40.60	1:2.17	10.80	18.60	29.40	1:1.72
DD: Double Dispenser	18.20	32.60	50.80	1:1.79	19.00	33.80	52.80	1:1.78
Packaging Design of Pheromone	**3rd Month Nopember 2018**				**4th Month Desember 2018**			
	♂	♀	Total	Sex Ratio	♂	♀	Total	Sex Ratio
PS: Permeable Sachet	18.20	22.60	40.80	1:1.24	3.80	5.80	9.60	1:1.53
MS: Micropore Sachet	13.20	25.80	39.00	1:1.95	6.40	10.60	17.00	1:1.66
TD: Tube Dispenser	7.40	11.80	19.20	1:1.59	0.80	1.00	1.80	1:1.25
DD: Double Dispenser	15.00	24.20	39.20	1:1.61	8.20	10.40	18.60	1:1.27

DISCUSSION

The Influence of Pheromone Packaging Design on the Cumulative Population of *Oryctes rhinoceros*

During field trials, cumulatively for four months, the packaging designs PS: permeable sachets (plastic polypropylene), MS: micropore sachets (plastic polypropylene) and DD: double dispenser (plastic micro-capillary), did not show any real difference to catch of *O. rhinoceros*. Each packaging design can see an average of 161.40, 138.20, and 139.80 beetles. However, the three packaging designs showed significantly different results from the tube dispenser design (plastic polyethylene), which only obtained a cumulative average catch of 91,00 beetles. Double dispenser packaging designs tend to get higher yields than others. The characteristics of the double dispenser are specifically designed to release pheromone molecules into the surroundings using several chemicals. ShinEtsu Chemical (2023), in its publication, stated that the double dispenser pheromone packaging design is a micro-capillary type plastic container. Two factors regulate the release of synthetic pheromones into the environment: (1) the rate of penetration of the pheromone through the dispenser walls and (2) the rate of evaporation of the pheromone into the air. The double dispenser pheromone packaging design ensures that the active ingredients of synthetic pheromone remain actively absorbed even after the contents have been used. The entire area of the double dispenser package continues to fascinate synthetic pheromones continuously. It is constantly released throughout the capture of rhinoceros beetle in the field, and the temperature is also constant.

The cumulative number of rhinoceros beetles caught four months after applying synthetic pheromone ethyl-4-methyl octanoate shows that the pheromone effectively controls rhinoceros beetles. An average of 530.40 beetles (189.80 males and 340.60 females or 1:1.79) were trapped after four months of application in 30 hectare oil palm plantation area. So, the average number of rhinoceros beetles caught was around 4.42 beetles/ha/month. These results are close to those of synthetic pheromones tested by Hosang et al. (2020), which show an average catch of 5.6 beetles/ha/month in areas of young oil palm plantations. The number of female images caught was greater than that of male photos. The same results were also observed by several countries that carried out the same tests, such as the Philippines, Malaysia, and India, using synthetic aggregation pheromones (Kumara et al., 2015). The type of pheromone used as a trap for the rhinoceros beetle is classified as an aggregation pheromone. So, both female and male images can be trapped.

This aggregation pheromone is quite effective because it can catch more female beetles (64.22%) than male beetles (35.78%). Indriyanti et al. (2018) stated that aggregation pheromones attract more female adults than male adults in coconut plantation areas, with percentages of 61% and 39%, respectively. Therefore, pheromones are not only used for monitoring purposes but also for controlling *Oryctes rhinoceros* adults. After the rhinoceros beetle is caught, it is killed or used as a food source for the mass rearing of predatory insects, which are natural enemies of oil palm leaf-eating pests.

The Influence of Pheromone Packaging Design on Fluctuations in Catches of *Oryctes rhinoceros*

In this study, the density of pheromone traps was one trap for every 2.5 ha. It is hoped that the traps installed in the rejuvenation area will help suppress the population of the rhinoceros beetles. Based on the results of observations over four months (Figure 4), it can be seen that the catch of rhinoceros beetles fluctuated from the first month (September) in each packaging design to the third month (November). Furthermore, in the fourth month, catches of rhinoceros beetles tended to decrease. This is because, in the fourth month, some of the pheromone content has begun to evaporate and run out. The average population of rhinoceros beetles showed a decrease in catches after 90 days (3 months) of installing pheromone traps (Hosang et al., 2022). In line with Pertami's statement (2016), the number of rhinoceros beetles decreased because the extended use of pheromones caused more pheromones to evaporate in the air. In its use, synthetic pheromones have a success rate based on the amount of chemicals that evaporate and environmental factors such as temperature, temperature, rainfall and wind speed.

In addition, high temperatures will accelerate the release of compounds and reduce the ability of pheromones to spread odours (Anggini et al., 2022). Pheromone traps to capture *Oryctes rhinoceros* imago are widely used in oil palm plantations because they are effective (Santi et al., 2022). The trapped rhinoceros beetles consist of males and females. The monthly catch of rhinoceros beetles tends to be higher in the double dispenser packaging design. In each pheromone packaging design, three traps were installed for every 7.5 ha of oil palm plantations, so that the results of catching rhinoceros beetles in the double dispenser packaging design in the 1st, 2nd, 3rd, and 4th months were 6.77, 7.04, 5.23 and 2.48 beetles/ha/month. Synthetic pheromones reduce insect pest populations by 5-27 beetles/ha/month. This pheromone can also suppress pest insect populations from reproducing or producing new offspring (Ivan et al., 2018; Lestari et al., 2020).

Table 2 showed that the catch of female imago was higher in each pheromone packaging design and catch period (month) than male imago. The sex ratio of *O. rhinoceros* imago in each pheromone packaging design and catch period (month) varied between 1.79 to 3.11 (in the first month), 1.68 to 1.93 (in the second month), 1.24 to 1.95 (in the second month). 3) and 1.25 to 1.66 (in the fourth month). This data shows that the microphone sachet packaging design in the first month of observation captured more female rhinoceros beetles than other pheromone packaging designs. Faleiro et al. (2003) stated that around 85% of female beetles caught with pheromone traps were fertile and produced viable eggs, indicating that the beetles had mated before entering the trap. Therefore, pheromone-based traps are very effective in breaking the pest cycle in the field. Synthetic aggregate pheromones can attract and capture rhinoceros beetles, so that pheromone traps can be used as a pest monitoring tool and an economical control method. Placing pheromone traps between 20 rows at a distance of 30 m from the collection road into the block is the most effective treatment for catching rhinoceros beetles (Sinaga & Santi, 2021).

CONCLUSION

During four months of observation, the double dispenser (plastic micro-capillary) pheromone packaging design showed high catches of *Oryctes rhinoceros* imago with a cumulative average of 161.40 beetles. Meanwhile, packaging designs for permeable sachet (plastic polypropylene), micropore sachet (polypropylene), and tube dispenser (polyethylene) are respectively, 138.20, 139.80, and 91.00 individuals. In general, the sex ratio of *O. rhinoceros* imago trapped in pheromone traps is between 1:1.24 and 1:3.11 (male: female). In general, during the capture period, the population of trapped rhinoceros beetles tends to decrease, along with the length of time the pheromone is used and the influence of abiotic factors. Determining the pheromone packaging design is very important to obtain adequate and efficient catches to support sustainable rhinoceros beetle pest management strategies.

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REFERENCES

Adi, H., Hidayat Soesilohadi, R. C., Nugroho, A. P., Hadisusanto, S., Sudaryatno, Aldawood, A. S., Sukirno, S. 2023. Distribution Analysis of Asiatic Palm Weevil Rhynchophorus vulneratus Panzer (*Coleoptera: Dryphthoridae*) using GIS Technique and the Interaction with Coconut Beetle *Oryctes rhinoceros* L. (*Coleoptera: Scarabaeidae*). *HAYATI Journal Bioscience*, *30*(5), 918-926. https://doi.org/10.4308/hjb.30.5.918-926OI:10.4308/hjb.30.5.918-926

Alouw, J. C., Hosang, M. L. A., Nguyen, Q. 2020. Biotechnology contributing to integrated pest management: The example of two major coconut pests, *Oryctes rhinoceros* and *Brontispa longissima*. *Coconut Biotechnology: Towards the Sustainability of the 'Tree of Life,* 151–168. https://doi.org/10.1007/978-3-030-44988-9_8

Anggini, P. S., Wahyudi, L, Mantir, F. R. 2022. The Effectiveness of Pheromones against Interest Horn Beetle (*Oryctes rhinoceros*) on Coconut Plants (*Cocos nucifera* L.). *Bios Logos Journal*, *12* (1), 71-79. DOI: https://doi.org/10.35799/jbl.v12i1.40116

Bedford, G. O. 2014. Advances in the control of rhinoceros beetle, Oryctes rhinoceros in oil palm. *Journal of Oil Palm Research*, *26*(3), 183–194.

Faleiro, J. R., Rangnekar, P. A., Satarkar, V. R. 2003. Age and fecundity of female red palm weevils *Rhynchophorus ferrugineus* (Olivier) (*Coleoptera: Rhynchophoridae*) trapped by pheromone traps in coconut plantations of India. *Crop Protection*, *22*(7), 999–1002. https://doi.org/10.1016/S0261-2194(03)00114-5

Fauzana, H., Agus, S., Desita, S. 2018. Population fluctuation of *Oryctes rhinoceros* L. beetle in Plant Oil Palm (*Elaeis guinensis* Jacq.) Given Mulching Oil Palm Empty Bunch. *Jurnal Corpsaver*, *1*(1), 42-47. https://doi.org/10.24198/cs.v1i1.16998

Hall, D. R., Harte, S. J., Farman, D. I., Ero, M., Pokana, A. 2021. Identification of Components of the Aggregation Pheromone of the Guam Strain of Coconut Rhinoceros Beetle, *Oryctes rhinoceros*, and Determination of Stereochemistry *Journal of Chemical Ecology*, 48, 289-301. https://doi.org/10.1007/s10886-021-01329-z

Hendarjanti, H. 2021. The potential and efforts to maintain the effectiveness of several entomopathogens in controlling O*ryctes rhinoceros* larvae in oil palm plantations. *In*: *Proceedings of the 9th National Seminar Sub Optimal Land*. Sriwijaya University, Palembang p. 411-425.

Hosang, M, L, A., Rahma, Maskromo, I., Alouw, J, C. 2022. Comparative effectiveness of three types of pheromones against Rhynchophorus vulneratus (Panzer) and *Oryctes rhinoceros* (L.) in Indonesia. The 2nd International Conference on Sustainable Plantation. *IOP Conf. Series: Earth and Environmental Science* 974 (2022) 012090: 1-8. https://doi.org/10.1088/1755-1315/974/1/012090

Indriyanti, D. R., Lutfiana, J. E., Widiyaningrum, P., Susilowati, E., Slamet, M. 2018. Aggregation pheromones for monitoring the coconut rhinoceros beetle (*Oryctes rhinoceros*) in Jerukwangi Village Jepara, Indonesia International Conference on Mathematics, Science and Education 2017 (ICMSE2017). *IOP Publishing. IOP Conf. Series: Journal of Physics: Conf. Series*, *983* (2018) 012177, 1-4. https://doi.org/10.1088/1742-6596/983/1/012177

Ivan, Idum, S. S., Elisabeth, N. K. 2018. Comparison of The Effectiveness of Some Types of Trap Pheromones Against Pest *Oryctes rhinoceros. Journal of Agromast*, 3(1).

Kumara, A, D, N, T., Chandrashekharaiah, M., Kandakoor, S, B., Chakravarthy, A, K. 2015. Status and Management of Three Major Insect Pest of Coconut in the Tropics and Subtropics. *New Horizons in Insect Science: Towards Sustainable Pest Management*, 359-381. https://doi.org/10.1007/978-81-322-2089-3_32

Kumara, A., Mubarak, A. N. M. 2022. Advances, Prospects and Limitations of Genetic Tools for Pest Management Strategies in Sri Lanka. In *Genetic Methods and Tools for Managing Crop Pests*, 285–302. Springer. https://doi.org/10.1007/978-981-19-0264-2_9

Lestari, W., Saragih, S. H. Y., Harahap, H. 2020. Effect of Height of Pheromone Trap in Control Horn Beetle (*Oryctes rhinoceros* L.) at PT. Herfinta Plantations. *Journal of Agroplasma, 7*(2), 80-84

Manjeri, G., Muhamad, R., Tan, S. G. 2014. *Oryctes rhinoceros* beetles, an oil palm pest in Malaysia. *Annual Research and Review in Biology*. 4, 3429-3439. https://doi.org/10.9734/ARRB/2014/11023

Nuriyanti, D. D., Widhiono, I., Suyanto, A. 2016. Ecological Factors That Affect Population Structure of The Rhino Beetle (*Oryctes rhinoceros* L.). *Biosfera*, 33(1): 13-21. DOI: 10.20884/1.mib.2016.33.1.310

Ong, S. P., Sajap, A. S. 2022. Insect Pests of Tropical Malaysian Urban Trees. In *Urban Forestry and Arboriculture in Malaysia: An Interdisciplinary Research Perspective*, 135–150.

Paudel, S., Marshall, S. D. G., Tsatsia, F., Crispus Fanai, Kolubalona, M., Mansfield, S., Jackson, T. A. 2021. Monitoring an invasive coconut rhinoceros beetle population using pheromone traps in Honiara, Solomon Islands. *New Zealand Plant Protection, 74*(1), 37–41. https://doi.org/10.30843/nzpp.2021.74.11742

Paudel, S., Jackson, T. A., Mansfield, S., Ero, M., Moore, A., Marshall, S. D. G. 2023. Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle (*Oryctes rhinoceros*): A review. *Crop Protection, 174* (2023), 106400, 1-10.

Pertami, A. P. P. 2016. Intensity of *Oryctes rhinoceros* Attacks on Coconut Plants in Three Villages in Jepara District. Thesis. FMIPAUNNES. Semarang

Pradipta, A. P., Wagiman, F., Witjaksono, W. 2020. The Coexistence of *Oryctes rhinoceros* L. and *Xylotrupes gideon* L. (*Coleoptera: Scarabaeidae*) on Immature Plant in Oil Palm Plantation. *Jurnal Perlindungan Tanaman Indonesia*, *24*(1), 82–88. https://doi.org/10.22146/jpti.52582

Rahayuwati, S., Kusuah, Y. M., Prawirosukarto, S., Dadang, Santoso, T. 2020. The Status of *Oryctes rhinoceros* Nudivirus (OrNV) Infection in *Oryctes rhinoceros* (Coleoptera: Scarabidae) in Indonesia. *Journal of Oil Palm Research*, *32*(4), 582-589. https://doi.org/10.21894/jopr.2020.0041

Santi, I. S., Prayoga, A., Setyawan, H., Atmaka Aji, W. 2022. Implementation of integrated pest control to reduce rhino beetle (*Oryctes rhinoceros*) attacks in oil palm plantations. *Tropical Plantation Journal*, *1*(2), 68–74. https://doi.org/10.56125/tpj.v1i2.10

ShinEtsu Chemical Co. Ltd. (2023). *Pheromones and mating Distruption*. Milan: CBC (Europe) Ltd, 17p. http://www.biogard.it/images/CATALOGHI/guide-EN.pdf Accessed on October 6, 2023

Sinaga, W. V., Santi, I. S. 2021. Effectiveness of Ferotrap Placement to Control Horn Beetle Pests (*Oryctes rhinoceros*) in Oil Palm Plantations. *Journal of Agroista*, *5* (1), 47-59.

Widyanto, H., Saputra, S., Suryati. 2014. The Control of Horned Beetle Pests (*Oryctes rhinoceros* Linn.) Using Pheromone Traps on Oil Palm Plants (*Elaeis guineensis* Jacq) in the Peatlands of Riau Province. *In: Proceedings of The National Seminar on Sustainable Management of Degraded Peatlands to Mitigate GHG Emissions and Increase Economic Value*. Jakarta, Indonesia, August 18-19, 2014.

Winotai, A. 2014. Integrated Pest Management of Important Insect Pests of Coconut. *Cord, 30* (1), 18-36. https://doi.org/10.37833/cord.v30i1.82