**Distribution and Nest Occupancy Patterns of *Oecophylla smaragdina* (Hymenoptera: Formicidae) Colonies in Oil Palm Plantations**

Moïse Piere Exélis, Rosli Ramli, Azarae Hj Idris, Rabha Wael Ibrahim, Gemma Clemente-Orta

**Supplementary Materials**

**Table 1. Occupied-unoccupied oil palm plantations by Asian weaver ant colonies in Malaysia.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Plantations | Zones\* | Coordinates | Size (ha) | Observation dates |
| Felda Alor Setar | NP, Perlis-Kedah | Combined data | 16,884.18  | 2019 |
| Felda Bukit Merah |  NP, NW Perlis | 6°33’36”N 100°21’05”E | 100 | December 2015 |
| Felda Bukit Kayu Hitam | NP, Kedah | 6°31’49”N 100°24’21”E  | 123  | March 2014 |
| Ladang Sungai Seraya | Kedah | 6°23’39”N 100°42’06”E  | 255 | March 2014 |
| Sime Darby Kuala Kurau | NP, Perak | 4°59’08”N 100°26’57”E  | 2035 | May 2014 |
| Ladang Kg Kalai | EP, Kelantan | 5°47’29”N 101°45’08”E  | 1008 | July 2014 |
| Felda Pantai Timur | EP, Terengganu | Combined data | 35,058.37  | 2011-2012 |
| Felda Kuala Berang | EP, Terengganu | 5°04’13”N 103°05’32”E  | 3234 | September 2014 |
| Felda Belara Jerangau | EP, Terengganu | 5°04’13”N 103°05’32”E  | 1250 | November 2014 |
| TDM Berhad | EP, Terengganu | 4°52’58”N 103°14’01”E | 3050 | February 2015 |
| Felda Sungai Besar | EP, Pahang | 3°18’28”N 103°21’57”E  | 2067 | April 2015 |
| FGV Bera Selatan 3 | EP, Pahang | 2°54’10”N 102°41’23”E  | 1125 | June 2019 |
| \*Felda Keratong  | EP, Pahang | 3°08’23”N101°44’55” | >50,000 (absence) | April-May 2022 |
| MPOB Teluk Intan | NP, Perak  | 3°49’03”N 100°58’52”E  | 600 | 2010-201420152020-2021 |
| Felcra Teluk Intan | NP, Perak |  | 1025 | 2010-2014 |
| SPP Teluk Intan | NP, Perak |  | 2035 | 2010-2014 |
| UPP Sabak Bernam | CP to N, Selangor |  | >3000 | 2010-2014 |
| Ladang Sungai Buloh | CP, Selangor | 3°09’40”N 101°27’40”E  | 1027 | 20122018-2021 |
| Ladang Kapar | CP, Selangor |  | 600 | 2014 |
| Risda Alor Gajah | SP, Malacca | 2°21’59”N 102°13’30”E  | 700 | 2015 |
| Kebung Baru Kupuk | SP, Pontian Johor | 1°19’21”N 103°26’57”E  | - | 2015 |
| Kebung Tanjung Piai | SP, Johor | 1°16’30”N 103°30’41”E  | 400 | 2015 |
| Tanjung Sepang | SP, Johor | 1°22’35”N 104°16’49”E | 1000 | 2015 |
| Desaru | SP, Johor | 1°27’03”N 104°17’15”E | 540 | 2015 |
| Sawit Siang  | SP, Johor | 1°39’45”N 104°13’00”E  | >500 | 2015 |
| Mados Sedili | SP, Johor | 1°43’46”N 104°09’15”E | 1000 | 2016 |
| Pasir Logok | SP, Johor | (2°02’02”N 104°02’50”E | 1000 | 2016 |
| Felda Tenggaroh Timur 2 | SP, Johor | 2°08’05”N 104°00’15”E  | 1267 | 2016 |
| Mersing  | SP, Johor | 2°21’01”N 103°54’20”E  | 2005 | 2014  |
| Felda Gunung Besout  | NP, Perak | 3°50’30” 101°18’08”E  | >50,000  | 2019-2022 |
| Felda Palong 16 | CP, Negeri Sembilan | 2°53’58”N 102°37’20”E  | 1300 | 2021 |
| Risda Palong | CP, Negeri Sembilan | 2°53’04”N 102°34’09”E  | >1000 | 2021 |
| Felda Pasir Besar Gemas | CP to SP, Negeri Sembilan | 2°39’02”N 102°34’12”E  | >3000 | 2021 |
| Felda Bukit Rokan Gemencheh | CP, Negeri Sembilan | 2°35’11”N 102°24’03”E  | >2000 | 2021 |
| Felcra Berhad Bukit Jelai | CP, Negeri Sembilan | 2°37’51”N 102°31’41”E  | >1000 | 2021 |
| Felda Sungai Kelamah | CP, Negeri Sembilan | 2°34’45”N 102°30’17”E  | >1000 | 2021 |
| MPOB, Lahad Datu | MB, Sabah | 5°01'48"N 118°25'02"E  | 1000 (high abundance ) | June-July 20122013December 2019 |
| IOI Corporation Lahad Datu | MB, Sabah | 5°02’32”N 118°19’14”E  | >30000 (High abundance) | 20122013 |
| MPOB, Saratok | MB, Sarawak | 1°44'44"N 111°19’00"E | 1000 (High abundance) | July-August 2012 |
| MARDI Saratok | MB, Sarawak | 1°55’11”N 111°13’41”E | 1000  | 2012 |
| Marmahal | MB, Sabah | 6°34’04”N 117°30’29”E  | >5000 | Personal communication |
| IJM Sabang | MB, Sabah | 6°22’12”N 117°29’32”E  | >5000 | Personal communication |
| Felda Sahabat Tambisan | MB, Sabah | 5°27’32”N 119°08’30”E | 12,721.42  | Personal communication |
| FGV Indera Bakti | MB, Sabah | 5°25’39”N 119°04’53”E  |  >10,000 | Personal communication |
| Kampung Dundulit | MB, Sabah | 6°59’28”N 117°09’41”E | >10,000 | Personal communication |
| Ladang Boustead Sandakan | MB, Sabah | 5°54’18”N 117°50’51”E  | >20,000 | Personal communication |
| THP Bukit Belian Estate | MB, Sabah | 5°42’01”N 117°50’20”E  | > | Personal communication |
| Sime Darby Tawau | MB, Sabah | 4°20’03”N 117°49’35”E  | >30,000 | Personal communication |
| Top Victory plantations Sdn.Bhd | MB, Kudat Sabah | 6°49’12”N 117°50’51”E | >20,000 | Personal communication  |
| Felda Trolak  | Perak –Selangor  |  Combined data | 37,219.19  | 2019-2020 |
| Felda Raja Alias | CP, Negeri Sembilan | Combined data | 76,590.56 | 2022 |
| Felda Kuantan | EP, Pahang | Combined data | 69,750.95  | 2020-2021 |
| Felda Jengka | EP, Pahang | Combined data | 69,684.65  | 2019 |
| Felda Mengapa | EP, Pahang |  | 63,577.04 | 2019 |
| Felda Johor Bahru | SP, Johor | Combined data | 79.023.74  | 2019 |
| Felda Segamat | SP, Melacca-Johor | Combined data | 50,884.14  | 2019 |
| Felda Gua Musang | EP, Kelantan | Combined data | 17,092.15 | 2019 |
| Felcra Kuala Pilah | SP, Negeri Sembilan | Combined data | >15,000 | 2022 |
| Pekan Bandar Di Raja | EP, Pahang | Combined data3°30’5”N 103°22’9”E | Urban & plantations | 10/01-21/02/2023 |
| Ladang Lampung Metro Barat | Lampung Indonesia | 2°56’11”N 101°40’43”E  | Isolated patches  | 23/08-10/10/2023 |
| Astra Agro Lestari | Kalimantan Centre, Indonesia | 2°23'10.2"S 111°47'57.7"E | 5, 352  | 1/10-3/10/2023 |

\**O. smaragdina* colonies were absent from the large plantations. Colonies occupied alternative host plants beside the plantations described in supplemental table 5.

**Table 2**. **Occupancy study in selected oil palm fields.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| \*Plantations | Zone | Coordinates | Size (ha) | Observation periods |
| MPOB Teluk Intan | NP. Perak | 3°49’03”N 100°58’52”E | 600 | 2010-20152020-2021 |
| UM plantations Sdn.Bhd Sg Ara | SP. Johor | 2°01'40'' N 103°5155” E | 400 | 2012-20152019 |
| Felcra Berhad Sg Ara | SP. Johor | 2°01’47”N 103°51’43”E | 1000 | 2012-20152019 |
| Boustead Ladang Teluk Sengat | SP. Ayer Tawar Johor | 1°34’09”N 104°02’15”E | 1000 | 2012-20152019 |
| Ladang Sungai Buloh | CP. Selangor | 3°09’40”N 101°27’40”E | ±450 | 2018-2020 |
| MPOB Lahad Datu | MB. Sabah | 5°01'48"N 118°25'02"E | 1000 | 2012-20142019 |
| MPOB Saratok | MB. Sarawak | 1°44'44"N 111°19’00"E | 1000 | 2012 |
| Felda Gunung Besout | NP. Perak | 3°50’30” 101°18’08”E | 1064.53 | 2020-2022 |

\**O. smaragdina* colonies were highly abundant with a dense nesting presence except for Felda Gunung Besout Perak.

**Table 3. Colony growth development stage status.**

Some definitions for (i) incipient, (ii) immature, (iii) pre-matured, (iv) matured *Oecophylla smaragdina* colonies:

An incipient is an embryonic colony identified as occupying only 1 palm within 1 to 3 months. The term immature is an innovative description to distinguish among the four determined growth of development stage of the Asian weaver ant. Pre-matured refers to the colonies newly reproductive emergence since the first release corresponding to a not yet acquired population dynamic stability. The matured colony is above 3 years of age with a notified stable population dynamic suitable for manipulation i.e. nest capture and translocation to unoccupied plantation blocks in the case of a sudden defoliator’s infestation outbreak.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Colony status | Range Age (month) | Occupied palm | Nest range number | References |
| Incipient | 1-3 | 1 | 1 | Hölldobler & Wilson, 1990 |
| Immature | 4-16 | 3-5 | ≥ 2-15 | NA\* |
| Pre-matured | 18-24 | 6-10 | ≥ 15-30 | Peng *et al*., 1998a; Peng *et al*., 2013 |
| Matured | 36 | 8-21 | 38-149 | Offenberg *et al*., 2013; Exélis, 2015 |

\*NA: not available

**Table 4**. **Colonies nests distribution patterns in relation to growth maturity status.**

 **Colonie**s  **Matured1 Pre-matured Immature-Incipient**

 **Type**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Colonies | \*Nest/Palmdistribution | Age | Total Nests | Occu-Palms | Nest/Palmdistribution | Age | Total Nests | Occu-Palms | Nest/Palmdistribution | Age  | Total Nests | Occu-Palms |
| 1\* | 1/3/5/7/13 | 39 | 53 | 12 | 1/3/5 | 11 | 14 | 4 | 1 | 3 | 3 | 1 |
| 2\*\* | 3/5/7/11/15 | 63 | 101 | 15 | 2/3/5/7 | 24 | 30 | 6 | 1/3/3 | 6 | 7 | 3 |
| 3 | 1/3/5/7 | 39 | 50 | 12 | 1/3/5 | 11 | 15 | 5 | 1 | 1 | 1 | 1 |
| 4 | 1/3/5/7 | 34 | 44 | 12 | 1/3/5 | 12 | 17 | 5 | 1/2 | 4 | 3 | 2 |
| 5 | 1/3/5/7 | 38 | 50 | 12 | 1/3/5 | 13 | 17 | 5 | 1 | 1 | 1 | 1 |
| 6 | 1/3/5/7 | 36 | 48 | 12 | 3/5 | 9 | 11 | 3 | 1 | 1 | 1 | 1 |
| 7 | 1/3/5/7 | 41 | 50 | 12 | 3/5 | 8 | 11 | 3 | 2 | 3 | 2 | 1 |
| 8 | 1/3/5/7/9/11 | 49 | 77 | 15 | 1/3/5 | 17 | 23 | 7 | 1/2 | 4 | 3 | 2 |
| 9 | 1/3/5/7/9/13 | 47 | 69 | 15 | 1/3/5 | 14 | 19 | 6 | 2/2 | 6 | 4 | 2 |
| Total | - | 386 | 542 | 117 | - |  | 157 | 44 | - | - | 25 | 14 |
| Mean | 1/3/5/7 dominant | 43 | 60.2 | 13 | 1/3/5dominant |  | 15.4 | 4.88 | 1 dominant |  | 2.77 | 1.55 |

\*Colony nest distribution in Lahad Datu, Sabah. \*\*Colony from Saratok, Sarawak. 1/3/5/7 represents an example of nest distribution in various palms within the same matured colony. 1First emergence of sexual forms by an average18- 24 months range. All dataset residuals’ distribution followed a normal distribution by the Shapiro-Wilk test. 1All ages are expressed in months.

**Table 5. *Oecophylla* colonies host plants association in oil palm plantations.**

These below fruiting trees and plants were identified as being among the favorite hosts for the Asian weaver ant colonies. The surveys conducted from January 2018 up to the end of 2022, demonstrated a satisfactory population stability with a high average nest abundance per occupied tree-plant.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Family** | **Colloquial/local names**  | **Scientific botanical names**  | **Number of trees examined** | **Average nests per tree** |
| Rutacea1  | Pomelo/Limau Bali  | *Citrus maxima* | 10 | 3-5 |
| - | Shaddock/Sarawak Pomelo | *Citrus grandis* | 10 | 3-5 |
| - | Mandarin orange/Limau langkat | *Citrus reticulata* | 5 | 3-5 |
| - | Lemon/Limau kerat lintang | *Citrus medica limonum* | 14 | 3-5 |
| - | Key lime/Limau nipis  | *Citrus aurantiifolia* | 30 | 5-9 |
| - | Calamansi-Philippines lime/Limau Kasturi | *Citrofortunella microcarpa* | 100 (orchards – isolated trees) – short trees ± 2.5 m | 1-3 (bigger size nests) |
| Rubiaceae  | Akar Berdara Laut | *Oxyceros longiflorus (Lam.)*  | Few  | 1 |
| Anacardiaceae | Mango/ Mangga | *Mangifera indica* | 106 | 5-10 |
| Malvaceae | Cacao/Pokok Koko  | *Theobroma cacao* | BC treatment | Way & Khoo, 1991 |
| Arecaceae | Coconut palm/Kelapa | *Cocos nucifera* | 45 | 3-7 |
| Clusiaceae | Purple mangosteen/Manggis | *Garcinia mangostana* | 9 | 3 |
| Meliaceae | Langsat/ Duku  | *lancium domesticum* | 20 | 3 |
| Myrtaceae | Watery rose apple/Jambu air | *Syzygium aqueum* | 35 | 7-11 |
| Myrtaceae | Java apple/Jambu merah  | *Syzygium samarangense* | 15 | 7-11 |
| Sapindaceae | Hairy lychee/Rambutan  | *Nephelium lappaceum* | 50 | 7-9 |
| Meliaceae | Langsat/Duku manis | *Lansium parasiticum* | 10 | 3-5 |
| Melastomataceae | Common Sendudok | *Melastoma malabathricum L.* | Few | 1 |
| Malvaceae | Mallow/Durian | *Durio zibethinus* | 35 | 5-7 |
| Lauraceae | Ceylon cinnamon/Kayu manis | *Cinnamomum iners* | 20 | 5-9 |
| Sapotaceae  | Bullet wood-Spanish cherry/Bunga tanjung | *Mimusops elengi*  | 20 (tall trees) | 5-9 |
| Euphorbiaceae  | Pokok Getah | *Hevea braziliensis* | Plantation > 100 | 3 |
| 2Unidentified plant species |  | short plants ≤ 2.5 m high  | 51 | 1-3 nests monodomous/polydomous  |
| 1. Acanthaceae3
2. Piperaceae
3. Melastomataceae
4. Melastomataceae
 | 1. Chinese violet/Rumput Israel
2. Wild pepper/Daun kaduk
3. Common Sendudok
4. Senduduk
 | Short plants of various species ≤ 1.5 m high 1. *Asystasia gangetica*
2. *Piper sarmentosum*
3. *Melastoma malabathricum 'Alba'*
4. *Melastoma malabathricum L.*
 | >100 | Only 1 nestMonodomous nesting  |

\*All nests were constituted with only young leaves with old leaves nests being abandoned (N=300). 1Fruits trees ≥ 3 m. 2Short occupied plants (average height ≤ 2.5 m) inside oil palm at close distance of few meters at Felda Gunung Besout Perak. 3These diverse host small size plants species (average height ≤ 1 m) are located at oil palm blocks outskirt within close distance (average 100 m) or inside the plantations.

**Table 6.** **Descriptive analysis of barrack and brood nests of *O. smaragdina.***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | All nests (26 nests) | Barrack nest (8 nests) |  | Brood nest (18 nests) |
| Min | Max | Mean1 | Min | Max | Mean1 |  | Min | Max | Mean1 |
| Number of leaflets | 4 | 29 | 11 ± 6 | 11 | 29 | 16 ± 7a |  | 5 | 21 | 10 ± 5b |
| Nest length | 28.0 | 64.0 | 45.9 ± 10.4 | 30.0 | 63.0 | 41.8 ± 12.9a |  | 30.0 | 60.0 | 46.9 ± 9.6a |
| Nest width | 6.0 | 32.0 | 14.6 ± 6.1 | 9.0 | 23.0 | 15.6 ± 6.0a |  | 7.0 | 30.0 | 14.4 ± 6.2a |
| Nest height | 3.0 | 23.0 | 10.8 ± 4.3 | 7.0 | 13.0 | 9.2 ± 2.5a |  | 2.0 | 23.0 | 11.1 ± 4.5a |
| Nest volume | 827.4 | 16621.5 | 4300.7± 3753.2 | 989.6 | 7289.9 | 3661.6 ± 2535.6a |  | 829.4 | 16618.5 | 4452.8 ± 3998.5a |
| Height from the ground | 4.0 | 10.0 | 7.2 ± 2.0 | 4.0 | 4.0 | 4.0 ± 0.0b |  | 6.0 | 10.0 | 8.0 ± 1.3a |
| Total workers | 11 | 64761 | 6333 ± 12419 | 11 | 1390 | 708 ± 544a |  | 43 | 64761 | 7672 ± 13499a |
| Number of major workers | 11 | 60873 | 5490 ± 11731 | 11 | 1390 | 706 ± 543a |  | 43 | 60873 | 6629 ± 12814a |
| Number of minor workers | 0 | 3888 | 842 ± 864 | 0 | 6 | 2 ± 3b |  | 0 | 3888 | 1043 ± 846a |
| Number of winged queens | 0 | 139 | 18 ± 36 | 0 | 0 | 0 ± 0b |  | 0 | 139 | 22 ± 39a |
| Number of worker pupae | 0 | 3650 | 630 ± 876 | 0 | 0 | 0 ± 0b |  | 0 | 3650 | 780 ± 914a |
| Number of larvae | 0 | 6509 | 979 ± 1557 | 0 | 0 | 0 ± 0b |  | 0 | 6509 | 1212 ± 1652a |
| Egg volume | 0 | 21.2 | 1.4 ± 4.3 | 0 | 0 | 0 ± 0a |  | 0 | 21.2 | 1.7 ± 4.8a |

 Note: 1Variable with the different superscript alphabet had significantly different mean value at p < 0.05.

**Table 7.** **Normality test of Shapiro-Wilk after dataset transformations and Kaiser-Meyer-Olkin (KMO) value**

|  |  |  |
| --- | --- | --- |
| Variables | KMO value (Average: 0.6039) | p-value of Shapiro-Wilk1,2 |
| No transformation | Standardize (n-1) | Standardise (n) | Centre | Standard deviation-1 (n-1) | Standard deviation-1 (n) | Pareto | Log |
| Number of leaflets | 0.6828 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0221** |
| Nest length | 0.4375 | **0.0017** | **0.0017** | **0.0017** | **0.0017** | **0.0017** | **0.0017** | **0.0017** | **0.0002** |
| Nest width | 0.4565 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0329** |
| Nest height | 0.4697 | **0.0218** | **0.0218** | **0.0218** | **0.0218** | **0.0218** | **0.0218** | **0.0218** | **0.0001** |
| Nest volume | 0.4884 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0061** |
| Height from the ground | 0.6369 | **0.0003** | **0.0003** | **0.0003** | **0.0003** | **0.0003** | **0.0003** | **0.0003** | **< 0.0001** |
| Total workers | 0.6441 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** |
| Number of major workers | 0.6270 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0002** |
| Number of minor workers | 0.8642 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** |
| Number of winged queens | 0.3988 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0044** |
| Number of worker pupae | 0.7263 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0024** |
| Number of larvae | 0.7445 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0030** |
| Egg volume | 0.5534 | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **< 0.0001** | **0.0416** |

Note: 1Null hypothesis (H0) = The dataset variables followed a normal distribution and alternative hypothesis (Ha) = The dataset variables did not follow a normal distribution.

 2Bold p-value indicated p-value < 0.05, thus this study accepted the Ha, indicated that the dataset variables did not follow a normal distribution.

**Table 8**. **Correlation matrix for Pearson moment.**

|  |  |
| --- | --- |
| Variables | Correlation matrix1,2 |
| Total nests per colony  |   | Total occupied palm |   | Average colony age3 |  |
| Total number of nests/colony  | **1**  |  | **0.831**  |  | **0.991** |  |
| Total number of occupied palms  | **0.831** |  | **1** |  | **0.845** |  |
| Average colony age | **0.991** |  | **0.845** |  |  **1** |  |
|  |  |  |  |  |  |  |

Note: 1|0.000| < R < |0.300| = weak correlation, |0.300| < R < |0.700| = moderate correlation, and |0.700| < R < |1.000| = strong correlation. 2Values in bold indicated a significant correlation between two variables at α = 0.05. Since the p-value < α, H0 is rejected. 3Newly unstable matured colony average of 24 months to reach maturity stability by 36 months (3 years). Covariance = 76.5 & 11.05 for nests and occupied palms respectively.



**Figure 1 a.** **Felda map in Peninsular Malaysia.** By Derkommander0916 - Karya sendiri, CC BY-SA 4.0. <https://commons.wikimedia.org/w/index.php?curid=102743261>



**Figure 1 b**. **Oil palm plantations closed canopy and tropical peat lands distribution.**

 The distribution covers the lowlands of Peninsular Malaysia (PM), Borneo (SB: Sabah; SW: Sarawak) and Sumatra. Source: Butler, 2011. <https://photos.mongabay.com/11/0307Koh_PNAS_Figure1.jpg>. <https://news.mongabay.com/2011/03/first-large-scale-map-of-oil-palm-plantations-reveals-big-environmental-toll/>.

**Figure 2: Boxplot of (a) barrack nest and (b) brood nests.**

**Figure 3.** **Discriminant analysis centroids graph.**

**Figure 4 A-C. *O. smaragdina* nests, palm trees distribution in function of the age in months**