Tropical Biomedicine 40(3): 370-374 (2023)
https://doi.org/10.47665/tb.40.3.015

RESEARCH ARTICLE

First observation of *Afromorgus chinensis* (boheman, 1858) (Coleoptera: Trogidae) on a rabbit (*Oryctolagus cuniculus* L., 1758) carcass and its implications in forensic entomology

Singh, S.[1], Yong, S.K.[2,3], Rahimi, R.[4], Singh, M.K.C.[5], Low, V.L.[6], Pittino, R.[7], Heo, C.C.[1,5]*

[1]Department of Medical Microbiology and Parasitology, Faculty of Medicine, Universiti Teknologi MARA, Selangor, Malaysia
[2]Faculty of Applied Sciences, Universiti Teknologi MARA, Selangor, Malaysia
[3]Soil Assessment and Remediation (SAR) Research Group, Faculty of Applied Sciences, Universiti Teknologi MARA, Selangor, Malaysia
[4]Department of Pathology, Faculty of Medicine, Universiti Teknologi MARA, Selangor, Malaysia
[5]Institute of Pathology, Laboratory & Forensic Medicine (I-PPerForM), Faculty of Medicine, Universiti Teknologi MARA, Selangor, Malaysia
[6]Higher Institution Centre of Excellence (HICoE), Tropical Infectious Diseases Research and Education Centre (TIDREC), Universiti Malaya, Kuala Lumpur, Malaysia
[7]Via Zezon, 10, 20124 Milano, Italy
*Corresponding author: chin@uitm.edu.my

ARTICLE HISTORY

Received: 3 May 2023
Revised: 25 July 2023
Accepted: 25 July 2023
Published: 30 September 2023

ABSTRACT

Beetles (Coleoptera) are known to constitute forensic evidence in medico-legal investigations as their presence can be used to date human remains in almost all decomposition stages. Many forensic studies focus on the successional colonization pattern of flies (Diptera); however, beetles have not so far been studied extensively for this aspect. A beetle of the genus *Afromorgus* Scholtz, 1986, *A. chinensis* (Boheman, 1858) (Scarabaeoidea: Trogidae), was found beneath a late decaying rabbit carcass at Paya Indah Wetland, Dengkil, Malaysia, for the first time. Both genus and species are already known to occur in Malaysia from literature.

Keywords: Forensic entomology; Malaysia; *Afromorgus chinensis;* rabbit carcass; Trogidae.

INTRODUCTION

Studies on insects and arthropods for investigation in legal matters are called forensic entomology (Hall & Doisy, 1993). Carrion decomposition starts immediately after death, and internal decomposition (autolysis) represents the first stage of this process. Insects arrive on the corpse within a few seconds and contribute significantly to the decaying process (Mann *et al*., 1990). Necrophagous flies arrive abundantly during the first stages of decomposition and deposit their eggs on fresh and/or bloated carcasses. Forensically important coleoptera are increasingly attracted in numbers from the beginning to the more advanced and dry stages of the decomposition process (Zhuang *et al*., 2011), either due to an exclusive necrophagous behaviour on carrion (predominant) or predation on larvae and adults of other necrophagous arthropods, and/or both feeding strategies. To date, the majority of forensic entomological studies were conducted on flies, while a few were carried out specifically on necrophagous beetles (Cai *et al*., 2011).

The minimum post-mortem interval (mPMI), which could constitute entomological evidence (Kulshrestha & Satpathy, 2001), can be estimated successfully by means of beetles collected from human remains. Trogid beetles (Coleoptera: Scarabaeoidea: Trogidae: Hide beetles), among others, have a considerable forensic importance (Strümpher *et al*., 2014), as they consist of six extant genera with about 300 species worldwide. All their representatives, both adults and larvae, feed prevalently on various sources of keratin in different kinds of shed, nests, animal remains and excretions (dry skin, feathers, hairs, bones, old wool remnants, dried faeces etc.) after the soft tissue has been almost entirely consumed. Both adults and larvae are usually found on animal carcasses during the late skeletal stage of decomposition (Vaurie, 1962). Several studies, mainly related to the consequences of environmental alterations, have considered trogid beetles as economic and ecosystem health indicators (Spector, 2006; Gardner *et al*., 2008). Some species of the genus *Omorgus* Erichson, 1847 are found obligatorily in nests of owls (Vaurie, 1962), others occur in animal excavations (Scholtz, 1990), and in nests of mammals and sea turtles (Vaurie, 1962; Moron & Deloya, 1991).

The genus *Afromorgus* Scholtz, 1986 is widespread throughout Africa (Scholtz, 1982) as well as Oriental and South-Eastern Palaearctic Regions (Zidek, 2013; Pittino & Bezdk, 2016). *A. chinensis* is known to occur throughout China, Taiwan and Japan in the Palaearctic Region; Indochina: Vietnam (Annam, Cochinchina, Tonkin), Cambodia, Laos; Thailand, Myanmar, Indonesia (Java, Sumatra), and Malaysia in the Oriental Region (Harold, 1872; Waterhouse, 1875; Balthasar, 1936; Paulian, 1945; Haaf, 1954; Scholtz, 1982; Masumoto *et al*., 2005; Zidek, 2013; Pittino, 2006; Pittino & Bezdk, 2016; Pittino, unpublished data). However, the finding of a single female specimen of *A.chinensis* (Boheman, 1858) beneath a rabbit carcass in Malaysia is hereby recorded for the first time.

MATERIALS AND METHODS

A forensic entomological study was conducted at Paya Indah Wetland, Dengkil, Malaysia (Figure 1; 2.86°N 101.62°E; 266 m above sea level), site dominated by a tropical bamboo species, *Bambusa multiplex* (*buluh pagar* in Malay). The mean temperature and precipitation of the site were measured with a data logger Elitech 32000 (UK), and a rain gauge, respectively. Three rabbit (*Oryctolagus cuniculus* Linnaeus, 1758) carcasses were placed on the ground surface on 9 August 2019 for entomological and soil chemical studies (Figure 2). Each carcass was kept in a cage 90 cm long × 90 cm wide × 45 cm high to prevent scavenging animals, such as monitor lizards and civet cats. 15 field observations were made every two days for 30 days in all: insects and soil samples associated with rabbit carcasses were taken on each sampling day.

We documented the presence of *Afromorgus chinensis* during the decomposition of a rabbit carcass (Figure 1). The mean temperature of the study site was 40°C ± 1°C and the average rainfall recorded was 45 mm throughout the study period. The single female specimen (n = 1) was collected by a forceps beneath a carcass in an advanced stage of decay on the day 18 post-mortem, preserved in 70% ethanol and transferred for identification to the Parasitology Laboratory, Institute of Medical Molecular Biotechnology (IMMB), Universiti Teknologi MARA (UiTM). It was first identified with a stereomicroscope Olympus SZ51 at 5.6x magnification, then the co-author (Pittino, R.) performed dissection of the genitalia confirming sex and determination with a Zeiss DR at 16x / 63x magnification.

Two legs of *A. chinensis* were used for DNA extraction. Genomic DNA was extracted using the i-genomic CTB DNA Extraction Mini Kit (iNtRON Biotechnology Inc., Seongnam, South Korea) following the manufacturer's instructions. The COI gene region of the beetle was amplified using generic invertebrate amplification primers (Folmer *et al*., 1994). The polymerase chain reaction (PCR) amplification was undertaken in a final volume of 25 µL containing 25–50 ng genomic DNA, 12.5 µL of MyTaq Red Mix (BioLine, Australia), and 10 pmol of each forward and reverse primer. The PCR cycling condition was 1 min at 96°C, followed by 35 cycles of denaturation at 94°C for 1 min; annealing at 55°C for 1 min; extension at 72°C for 1 min 30 s, and a final extension at 72°C for 7 min.

The COI sequence of *A chinensis* (OL423437) generated from this study was deposited at the National Center for Biotechnology Information (NCBI) GenBank. The COI sequences of *Omorgus* spp., namely *O. punctatus* (Germat, 1824), *O. monachus* (Herbst, 1790), *O. suberosus* (F.,1775) and *Afromorgus chinensis* were retrieved from the GenBank for phylogenetic tree reconstruction. *Trox aequalis* Say, 1831 (HM433166) was used as an outgroup. A neighbor-joining (NJ) phylogenetic tree of *Omorgus*/*Afromorgus* was traced using MEGA X (Kumar *et al*., 2018). The NJ bootstrap values were estimated using 1,000 replicates with Kimura's two-parameter model of substitution (K2P distance). To determine interspecific variation among species, uncorrected (p) pairwise genetic distances were calculated using PAUP 4.0B10 (Swofford, 2002). Unfortunately, additional COI sequences of *Afromorgus* spp. were not available at GenBank, thus a complete genetical analysis could not be carried out, however, we can equally retain the phylogenetic tree resulting from the present study by virtue of the close phyletically between the two genera.

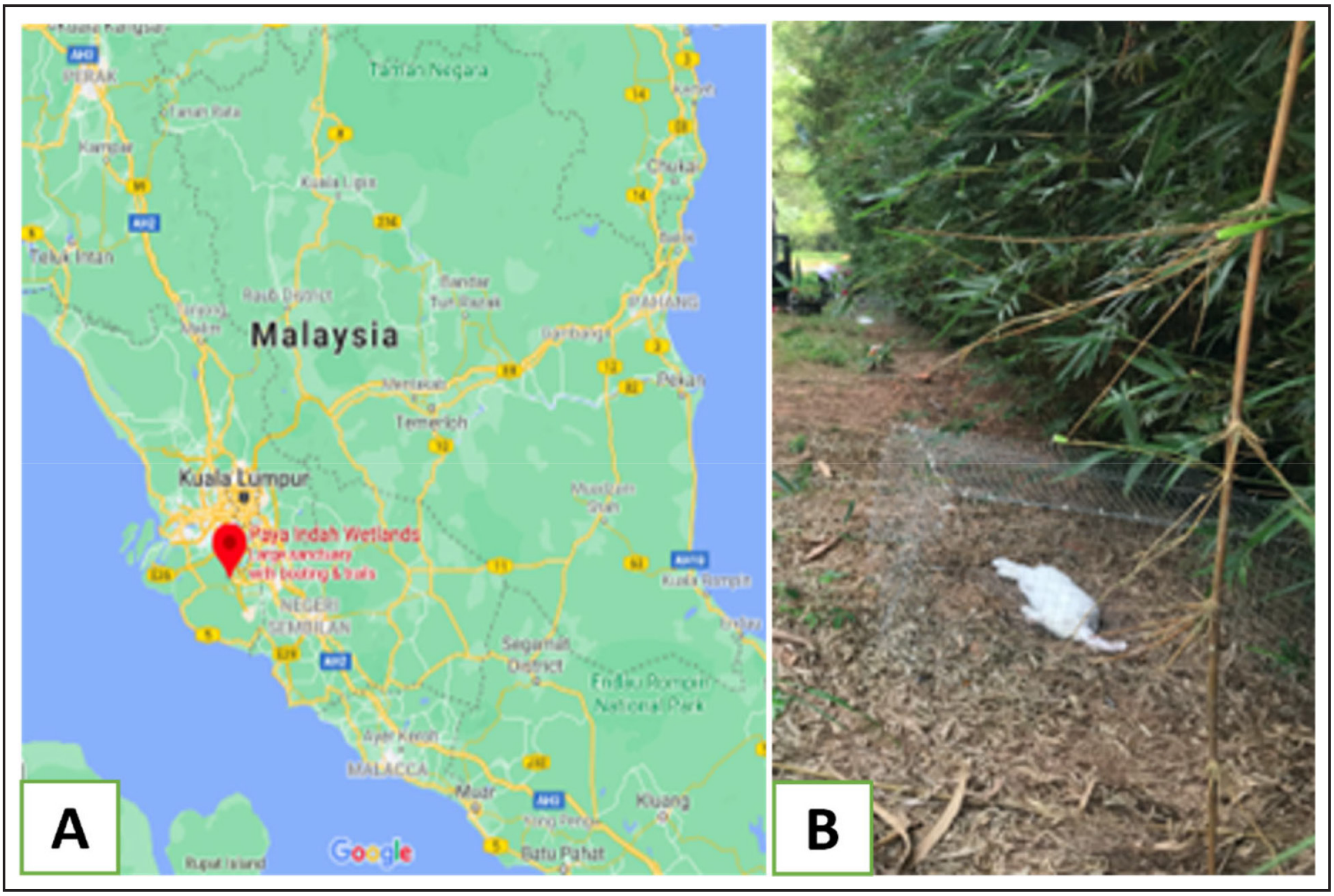

Figure 1. (A). A map showing the study location at Paya Indah Wetlands located in Dengkil, Selangor, Peninsular Malaysia (source: www.google.com.my/maps). (B). A rabbit carcass placed on the soil surface at the study site. A cage was set up around the carcass to prevent vertebrate scavengers.

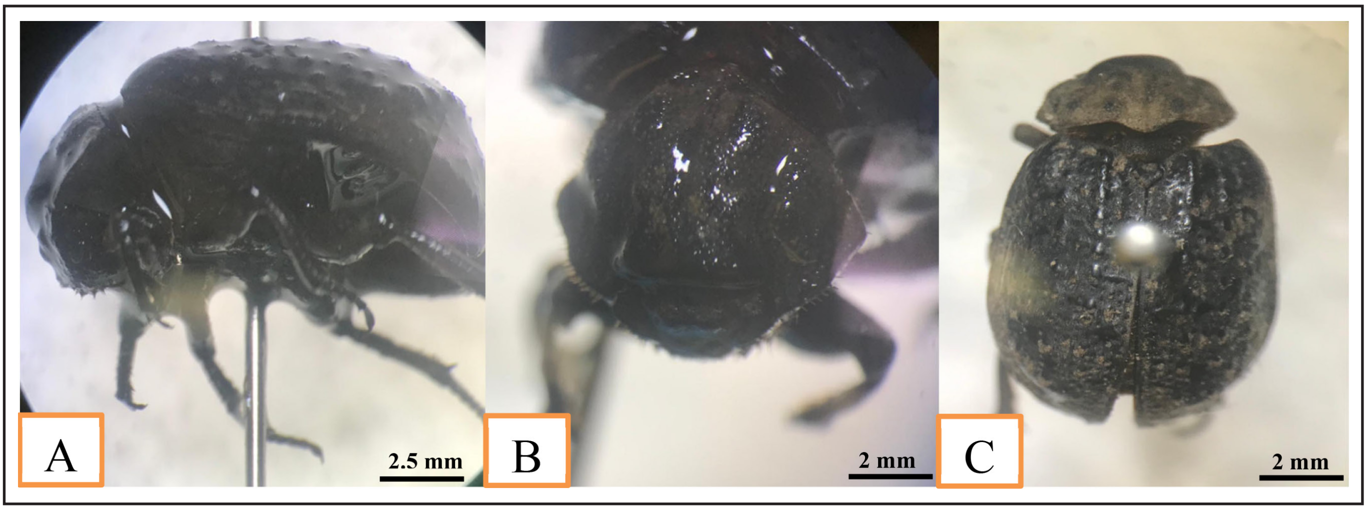

Figure 2. Habitus of the adult *Afromorgus chinensis* (Coleoptera: Trogidae). (A) Lateral view; (B) Forebody; (C) Dorsal view.

RESULTS AND DISCUSSION

As stated above, the determination of *Afromorgus chinensis*, was essentially based on external morphology of a single available female specimen, but it should be confirmed by the study of at least one additional male. The collected specimen is blackish, about 12 mm long and winged with prominent humeral umbones and smooth pronotal and elytral margins. Head and pronotum closely punctate, frons distinctly bituberculate, tubercles suboval, transverse, well separated from each other, vertex with small but distinct short and narrow shiny median area. Pronotum clearly attenuated forward and dilated backward, sides widely explanate with narrowly rounded produced posterior angles, margins slightly sinuate with rather long quite close brownish setae, pronotal disc prominent with distinct anteromedian furrow and deep median basal fovea. Elytral sides broadly explanate with fine short sparse setae along margins, odd intervals (costae) with smooth suboval weakly convex subconfluent tubercles, posterior end of tubercles tomentose with fine short pubescence, the innermost costa (3rd from the suture) more elevated forward, other costae uniformly flattish. Even intervals (intercostae) with small tubercles and intervening shiny glabrous flat sub-square irregular areas; striae ill defined with sparse indistinct coarse punctures. Female genitalia with no distinctive diagnostic characters.

As expected, in our study the genetical analysis conducted on *A. chinensis* proved our sample clearly differs from all examined *Omorgus* spp. (*suberosus*, *monachus*, *punctatus*) by 15.05-15.86%, 16.27%, and 18.37-19.24, respectively, but, quite unexpectedly, showed large discrepancy (by 18.11%, Figure 3) with respect to the sole representative in GenBank (MK937809). However, the origin and details of this strain are unknown, hence further comparative studies could not be carried out. It is uncertain whether this is a matter of a cryptic species complex or because of imperfect taxonomy. The verified great genetic difference would suggest them as separate species, but the morphological characters should rather suggest our sample may fall within the variability range observed in several specimens from the Asian South East (Pittino, unpublished data). Consequently, both specimens providing the respective genetic materials should be verified with certainty having further males from the study site.

Various studies of forensic entomology recorded presence of trogid beetles on animal carcasses usually at the latest stages of decomposition across different regions, as from Algeria (Guerroudj & Berchi, 2019; Naima, 2020), Argentina (Horenstein & Linhares, 2011), Brazil (Mise *et al*., 2008; Mayer & Vasconcelos, 2013; Santos *et al*., 2014; Zanetti *et al*., 2015), Ivory Coast (Koffi *et al*., 2017), Poland (Jarmusz, 2020), Thailand (Vitta *et al*., 2007), and the USA (Tabor *et al*., 2004, 2005; Goddard, 2012). Reports of trogids, scarabeids, and dermestids infestations on human corpses at the skeletal stage of decomposition were not uncommon (Rodriguez & Bass, 1983). Philips *et al*. (2003) collected 110 adults and 62 larvae of forensically important mites (Acari) on trogid beetles found on pellets of owl and eagle, and on owl, eagle, falcon, and small-mammal carcasses in different states of the USA. Correa *et al*. (2013) collected 24, 7, and 1 specimen, respectively, of *Omorgus suberosus* (F.,1775), in different traps baited with carrion, cow dung, and pig manure. Our recent observations also confirmed that *O. suberosus* is attracted to decaying animal carcasses. Climatic condition is an important factor affecting the seasonality of *Omorgus* spp.: Lopes *et al*. (2009) observed their highest abundance during the rainy season in Brazil. Trevilla-Rebollar *et al*. (2010) sampled 12 *O. suberosus* individuals from April to December 2007 with carrion-baited traps in Mexico.

Nevertheless**,** the use of these observations in forensic entomology is still underestimated, which would indicate the importance of documenting their occurrence on decaying carrions. This study first reports the presence of *Afromorgus chinensis* on a rabbit carcass in a late decaying stage. Further similar findings should be recorded as they could be useful, mainly in establishing the mPMI or serving as a locality indicator. Thus, we recommend new ecological and behavioural research on trogid beetles in order to better understand their actual role in the process of carrion decomposition and subsequently reveal their actual forensic significance.

Finally, further field research should be conducted in the future on the same environments as the present study in order to collect additional both male and female specimens. This would allow us to complete both morphological and genetic studies hereby started, to definitely confirm the specific identity of the sole female specimen examined, maybe also clarifying origin, details, unknowns, and uncertain phyletic ally of this strain that have emerged from the neighbour-joining tree of our genetic analysis. The apparent genetic difference from the other *A. chinensis* from GenBank (MK937809) actually calls for a valid explanation.

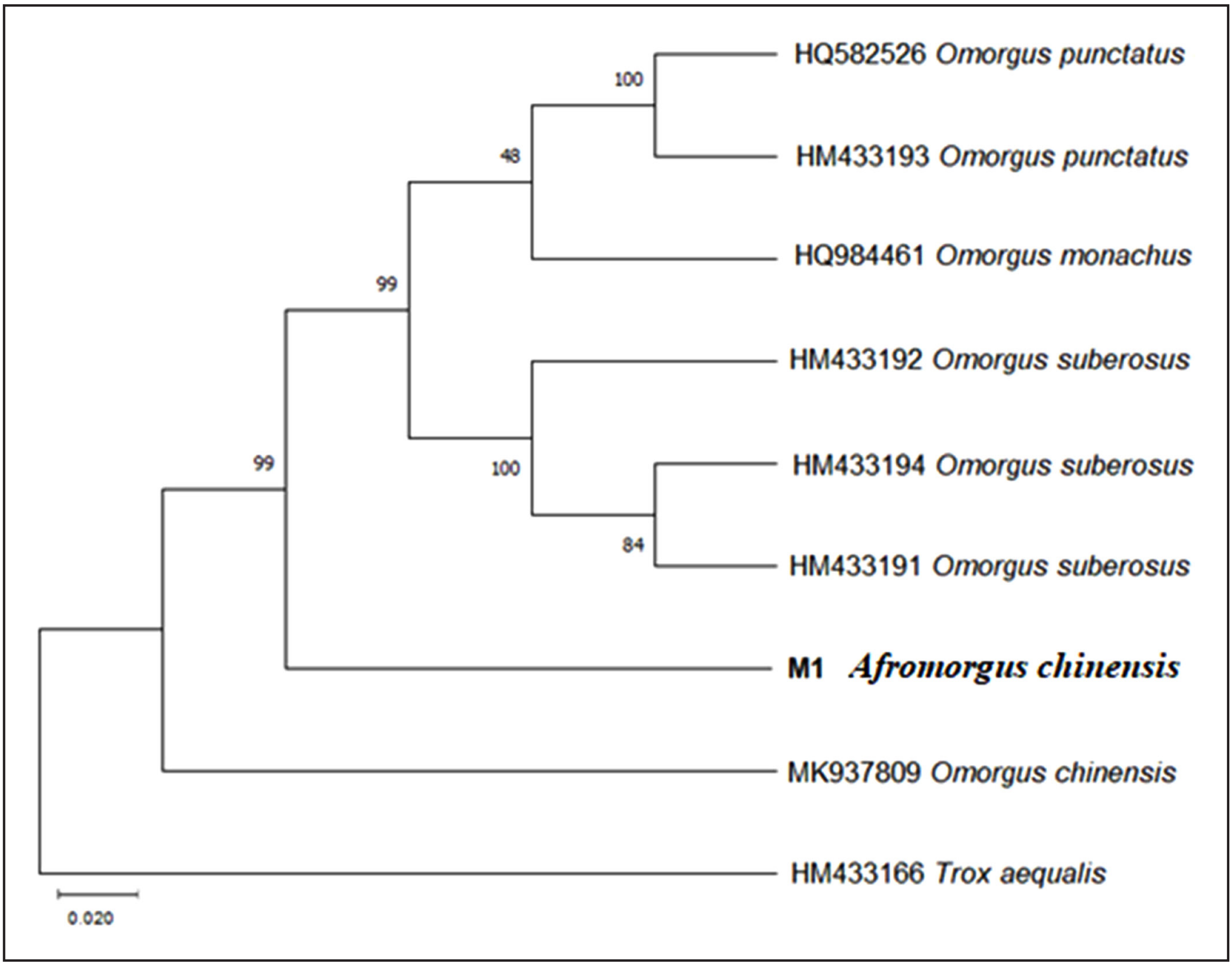

Figure 3. Neighbor-joining tree of *Omorgu*s and *Afromorgus* species (Coleoptera: Trogidae) based on the mitochondrial COI gene sequences. Scale bar represents 0.020 substitutions per nucleotide position.

ACKNOWLEDGEMENTS

We thank the Wildlife and National Parks Department for permission to conduct experiments at the Paya Indah Wetlands. Our sincere appreciation to the Institute for Medical Molecular Biotechnology (IMMB), Faculty of Medicine, Universiti Teknologi MARA, for providing the laboratory facility. Last but not least, we would like to acknowledge the Higher Institution Centre of Excellence (HICoE) program (MO002-2019) for supporting this study.

Conflict of interests

The authors declare that they have no conflict of interests.

Ethical consideration

The Research Ethics Committee (UITM CARE) has approved the study protocol of Universiti Teknologi MARA [262/2019 (15/02/2019)]

REFERENCES

Balthasar, V. (1936). Monographie der Subfam. Troginae der palaearktischen Region. *Festschrift für Prof. Dr. Embrik Strand* **1**: 407-459.

Boheman, C.H. (1858). Coleoptera. Species novas descripsit. In: Kongliga Svenska Fregatten Eugeniesresa omkring Jorden, Norstedt, P.A. & Soner A.B (Editors). Stockholm: Norstedt, pp. 1-112.

Cai, J., Wen, J., Chang, Y., Meng, F., Guo, Y., Yang, L. & Liang, L. (2011). Identification of forensically significant beetles (Coleoptera: Staphylinoidae) based on COI gene in China. *Romanian Journal of Legal Medicine* **19**: 211-218. https://doi.org/10.4323/rjlm.2011.211

Correa, C.M.A., Puker, A., Korasaki, V. & Ferreira, K.R. (2013). *Omorgus suberosus* and *Polynoncus bifurcatus* (Coleoptera: Scarabaeoidea: Trogidae) in exotic and native environments of Brazil. *Zoologia* **30**: https://doi.org/10.1590/S1984-46702013000200015

Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrijenhoek, R. (1994). DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology* **3**: 294-299.

Gardner, T.A., Hernández, M.I., Barlow, J. & Peres, C.A. (2008). Understanding the biodiversity consequences of habitat change: the value of secondary and plantation forests for neotropical dung beetles. *Journal of Applied Ecology* **45**: 883-893. https://doi.org/10.1111/j.1365-2664.2008.01454.x

Goddard, J., Fleming, D., Seltzer, J.L., Anderson, S., Chesnut, C., Cook, M., Davis, E.L., Lyle, B., Miller, S., Sansevere, A. *et al*. (2012). Insect succession on pig carrion in North-Central Mississippi. *Midsouth Entomologist* **5**: 39-53.

Guerroudj, F.Z. & Berchi, S. (2019). Composition of the necrophagous fauna on a rabbit corpse in Constantine, Northeastern Algeria. *Energy Procedia.* **157**: 1083-1088. https://doi.org/10.1016/j.egypro.2018.11.275

Haaf, E. (1954). Die afrikanischen un orientalischen Arten der Gattung Trox (Col. Scarab.). 1. Beitragzur Kenntnis der Subfam.Troginae. *Entomologische Arbeiten aus dem Museum Georg Frey* **5**: 326-393

Hall, R.D. & Doisy, K.E. (1993). Length of time after death: effect on attraction and oviposition or larviposition of midsummer blow flies (Diptera: Calliphoridae) and flesh flies (Diptera:Sarcophagidae) of medicolegal importance in Missouri. *Annals of the Entomological Society of America* **86**: 589-593. https://doi.org/10.1093/aesa/86.5.589

Harold, E. von (1872). Monographie der Gattung Trox. *Coleopterologische Hefte* **9**: 1-192.

Horenstein, M.B. & Linhares, A.X. (2011). Seasonal composition and temporal succession of necrophagous and predator beetles on pig carrion in central Argentina. *Medical and Veterinary Entomology* **25**: 395-401. https://doi.org/10.1111/j.1365-2915.2011.00969.x

Jarmusz, M., Grzywacz, A. & Bajerlein, D. (2020). A comparative study of the entomofauna (Coleoptera, Diptera) associated with hanging and ground pig carcasses in a forest habitat of Poland. *Forensic Science International* **309**: 110212. https://doi.org/10.1016/j.forsciint.2020.110212

Krell, F.T., Korb, J. & Walter, P. (2003). The beetle fauna of hyaena latrines: coprocenoses consisting of necrophagous beetles (Coleoptera Trogidae Scarabaeidae). *Tropical Zoology* **16**: 145-152. https://doi.org/10.1080/03946975.2003.10531191

Koffi, A.F., Aboua, L.R.N., Djodjo, M., Dao, H., Koffi-Tebele, J.D.E. & Yapoc, C.Y.E. (2017). Contribution of different groups of necrophagous insects, in the process of decomposition of a pig corpse (Sus scrofa domesticus L.) exposed to the open air, in the guinean zone of Côte d'Ivoire. *International Journal of Scientific Engineering and Applied Science* **3**: 14-22.

Kulshrestha, P. & Satpathy, D.K. (2001). Use of beetles in forensic entomology. *Forensic Science International* **120**: 15-17. https://doi.org/10.1016/S0379-0738(01)00410-8

Kumar, S., Stecher, G., Li, M., Knyaz, C. & Tamura, K. (2018). MEGA X: Molecular Evolutionary Genetics Analysis across Computing Platforms. *Molecular Biology and Evolution* **35**: 1547-1549. https://doi.org/10.1093/molbev/msy096

Lopes, W.D.Z., Costa, F.H., Lopes, W.C.Z., Balieiro, J.C.C., Soares, V.E. & Prado, A.P. (2009). *Omorgus* (*Omorgus*) *suberosus* (Fabricius) (Coleoptera: Trogidae) em esterco de galinhas poedeiras de São João da Boa Vista, SP, Brasil. *Arquivos do Instituto Biologico* **74**: 227- 232. https://doi.org/10.1590/1808-1657v74p2272007

Mann, R.W., Bass, M.A. & Meadows, L. (1990). Time since death and decomposition of human body: Variables and observation in case and experimental field studies. *Journal of Forensic Science* **35**: 103-111.

Masumoto, K., Ochi, T. & Li, C.-L. (2005). A Revision of the Taiwanese species of the Family Trogidae (Coleoptera Scarabaeoidea). *Elytra*, *Tokyo* **33**: 229-243.

Mayer, A.C.G. & Vasconcelos, S.D. 2013. Necrophagous beetles associated with carcasses in a semi- arid environment in Northeastern Brazil: implications for forensic entomology. *Forensic Science International* **226**: 41-45. https://doi.org/10.1016/j.forsciint.2012.11.019

Mise, K.M., Martins, C.B.C., Kob, E.L. & Almeida, L.M. (2008). Longer decomposition process and the influence on Coleoptera fauna associated with carcasses. *Brazilian Journal of Biology* **68**: 907-908.

Moron, M.A. & Deloya, C. (1991). Los Coleoptera Lamellicornia de la reserva de la biosfera "La Michilía", Durango, México. *Folia Entomologica Mexicana* **81**: 209-283.

Naima, B. (2020). Insects involved in decomposing corpses in the Constantine region-Algeria. *Jornal of Trauma* **4**: 022-024. https://doi.org/10.17352/ojt.000026

Paulian, R. (1945). Coléoptères Scarabéides de l'Indochine. Première partie. *Faune de l'Empire Frannais. III.* Paris: Librairie Larose: 1-225.

Philips, J.R. (2009). The mite (acarina) fauna of trogid beetles (Coleoptera: Trogidae). *International Journal of Acarology* **35**: 1-17. https://doi.org/10.1080/01647950802709843

Pittino, R. (2006). Family Trogidae MacLeay, 1819. In: Catalogue of Palaearctic Coleoptera. Vol. 3. Scarabaeoidea - Scirtoidea - Dascilloidea - Buprestoidea - Byrroidea, Löbl, I & Smetana, A. (editors). Stenstrup: Apollo Books: **26**: 79-81.

Pittino, R. & Bezděk (2016). Family Trogidae MacLeay, 1819. In: Catalogue of Palaearctic Coleoptera. Vol. 3. Scarabaeoidea - Scirtoidea - Dascilloidea - Buprestoidea - Byrroidea. Revised and updated edition (I. Löbl, D. Löbl eds). Leiden: Boston: Brill: **1**: 53-58.

Rodriguez, W. & Bass, W. (1983). Insect activity and its relationship to decay rate of human cadavers in East Tennessee. *Journal of Forensic Science* **28**: 423-432.

Santos, W.E., Alves, A.C.F. & Creao-Duarte, A.J. (2014). Beetles (Insecta, Coleoptera) associated with pig carcasses exposed in a Caatinga area, Northeastern Brazil. *Brazilian Journal of Biology* **74**: 649-655. https://doi.org/10.1590/bjb.2014.0072

Scholtz, C.H. (1982). Catalogue of World Trogidae (Coleoptera: Scarabaeoidea). *Entomology Memoir Department of Agriculture and Fisheries* **54**: 1-27.

Scholtz, C.H. (1986). Phylogeny and systematics of the Trogidae (Coleoptera: Scarabaeoidea). *Systematic Entomology* **11**: 355-363.

Scholtz, C.H. (1990). Revision of the Trogidae of South America. *Journal of Natural History* **24**: 1391-1456.

Spector, S. (2006). Scarabaeine dung beetles (coleoptera: Scarabaeidae: Scarabaeinae): An Invertebrate focal taxon for biodiversity research and conservation. *Coleopterists Bulletin* **60**: 71-83. https://doi.org/10.1649/0010-065X(2006)60[71:SDBCSS]2.0.CO;2

Strümpher, W.S., Farrell, J. & Scholtz, C.H. (2014). Trogidae (Coleoptera Scarabaeoidea) in forensic entomology: occurrence of known and new species in Queensland, Australia. *Austral Entomology* **53**: 368-372. https://doi.org/10.1111/aen.12084

Swofford, D.L. (2002). PAUP*. Phylogenetic Analysis Using Parsimony (*and other Methods). USA: Sinauer Associates.

Tabor, K.L., Brewster, C.C. & Fell, R.D. (2004). Analysis of the successional patterns of insects on carrion in Southwest Virginia. *Journal of Medical Entomology* **41**: 785-795. https://doi.org/10.1603/0022-2585-41.4.785

Tabor, K.L., Fell, R.D. & Brewster, C.C. (2005). Insect fauna visiting carrion in Southwest Virginia. *Forensic Science International* **150**: 73-80. https://doi.org/10.1016/j.forsciint.2004.06.041

Trevilla-Rebollar, A., Deloya, C. & Padilla-Ramírez, J. (2010). Coleópteros necrófilos (Scarabaeidae, Silphidae y Trogidae) de Malinalco, Estado de México, México. *Neotropical Entomology* **39**: 486-495. https://doi.org/10.1590/S1519-566X2010000400005

Vaurie, P. (1962). A revision of the genus *Trox* in South America (Coleoptera, Scarabaeidae). *Bulletin of the American Museum of Natural History* **124**: 101-168.

Vitta, A., Pumidonming, W., Tangchaisuriya, U., Poodendean, C. & Nateeworanart, S. (2007). A preliminary study on insects associated with pig (*Sus scrofa*) carcasses in Philsanulok, northern Thailand. *Tropical Biomedicine* **24**: 1-5.

Waterhouse, C.O. (1875). On the Lamellicorn Coleoptera of Japan. *Transactions of the Royal Entomological Society of London* **1875**: 71-116.

Zidek, J. (2013). Checklist and bibliography of the Trogidae (Coleoptera: Scarabaeoidea). *Insecta Mundi* **0314**: 1-38.

Zanetti, N.I., Visciarelli, E.C. & Centeno, N.D. (2015). Trophic roles of scavenger beetles in relation to decomposition stages and seasons. *Revista Brasileira de Etomologia* **59**: 132-137. https://doi.org/10.1016/j.rbe.2015.03.009

Zhuang, Q., Cai, J., Zhang, M., Feng, H., Guo, Y., Lan, L. & Chen, Y. (2011). Molecular identification of forensically significant beetles (Coleoptera) in China based on COI gene. *Revista Colombiana de Entomologia* **37**: 110-114.