

## **CONSERVATION OF DUNG BEETLES (SCARABAEIDAE: SCARABAEINAE) IN PENINSULAR MALAYSIA**

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### **ABSTRACT**

Dung beetles (Scarabaeidae: Scarabaeinae) have emerged as useful taxa for biodiversity monitoring due to their close association with mammalian diversity and forest structure. While an estimated 170 species have been found in Peninsular Malaysia thus far and several ecological studies have been conducted, very little has been discussed about the conservation of this subfamily. In this review, we examine the current legal provisions for the protection of dung beetles, identify potential threats to dung beetle diversity, describe challenges that arise from a lack of information about the ecology of most dung beetle species and suggest conservation recommendations to protect the existing dung beetle diversity. Additionally, we provide a species list of common species that were derived from unpublished data and existing literature.

**Keywords:** Dung beetles, Scarabaeidae, Scarabaeinae, conservation

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### **INTRODUCTION**

Dung beetles (Scarabaeidae: Scarabaeinae) are a species-rich group, with the current informal estimate of Peninsular Malaysia at roughly 14 genera and 170 species (Table 1) (J. Huijbregts, pers. comm., 2017). Many of these species are still undescribed. These beetles carry out important ecological functions such as secondary seed dispersal, soil aeration through bioturbation, pest and parasite suppression, plant growth enhancement and pollination of plants (Nichols *et al.*, 2008). Dung beetles are an important indicator species for monitoring forest health and biodiversity, as they are sensitive to habitat alteration and the loss of mammalian biodiversity (Spector, 2006).

Thus far, the need for the conservation of dung beetles has been neglected in Peninsular Malaysia. Within the context of Peninsular Malaysia, we review the current ecological knowledge on dung beetles, identify threats to their conservation, discuss challenges for conserving these species and suggest conservation recommendations to protect the existing dung beetle diversity.

**Table 1** Diversity and breeding behaviour of dung beetles in Peninsular Malaysia

Tribe	Genus	Breeding behaviour	Number of species
Gymnopleurini	<i>Paragymnopleurus</i>	Roller	3
Sisyphini	<i>Sisyphus</i>	Roller	1?
Canthonini	<i>Ochicanthon</i>	Roller	3?
Coprini	<i>Copris</i>	Tunneler	16?
	<i>Catharsius</i>	Tunneler	1
	<i>Synapsis</i>	Tunneler	3
	<i>Heliocopris</i>	Tunneler	3
	<i>Panelus</i>	Roller	>1?
Oniticellini	<i>Liatongus</i>	Tunneler	2?
	<i>Oniticellus</i>	Dweller	2
	<i>Yvescambefortius</i>	Tunneler	1
Onitini	<i>Onitis</i>	Tunneler	>3?
Onthophagini	<i>Onthophagus</i>	Tunneler	>100?
	<i>Caccobius</i>	Tunneler/kleptoparasite	2?

## LEGAL PROTECTION OF BEETLES IN MALAYSIA

Internationally and within Malaysia, there are no Malaysian dung beetle species that are legally protected. No Malaysian dung beetles are listed under CITES (CITES, 2017) or the Wildlife Protection Act 2010 (Akta Pemuliharaan Hidupan Liar 2010). There are only two species of beetle listed under CITES *Dynastes satanus* (Appendix II) and *Colophon* spp (Appendix III) (CITES, 2017), both of which are not dung beetles. Only a single beetle is listed in Schedule 1 of the Wildlife Protection Act 2010 (Akta Pemuliharaan Hidupan Liar 2010): the South African endemic stag beetle *Colophon* sp. (Cape Stage Beetle). There is little to no information regarding the trade of beetles in Malaysia, although large Scarabaeid beetles from the subfamily Dynastinae are often sold as souvenirs.

## THREATS TO DUNG BEETLES

### The Ornamental Insect Trade

Dung beetles are not particularly popular with insect collectors; only a few species are prized for their horns and colouration. The largest and most impressive Peninsular Malaysian dung beetles fetch only a quarter of the price of more popular horned beetles (Dynastinae). Most collectors of dung beetles in the South East Asian Region collect them for scientific purposes and tend to deposit their collections in museums. Beetle breeders for South-East Asian species are non-existent, as most breeders prefer more colourful Central American species such as *Phanaeus vindex* (Barney & McMonigle, 2012).

### Exotic Food

Dung beetles are eaten in rural Thailand (Watanabe & Satrawara, 1984; Hanboonsong, 2010) and Laos (Boulidam, 2010), where they are collectively known as *Kudchi*. Some nutritional studies have been carried out on these species (Raksakantong *et al.*, 2010; Bophimai & Siri, 2010). All the species used in Thai cuisine are open area species that are associated with cow

or buffalo dung. These species are mostly Indochinese species and are less common south of the Isthmus of Kra (Goh T.G., unpublished data). There is no evidence that this entomophagical trend has spread to Peninsular Malaysia.

### **Traditional Chinese Medicine Trade**

The traditional Chinese medicine (TCM) trade is one of the largest threats to wildlife in the region (Still, 2003). Dung beetles are not exempt from being used as traditional medicines. *Catharsius mollosus* is used in Chinese medicine and there are currently efforts to extract active ingredients from this species (Ahn *et al.*, 2003, Jiang *et al.*, 2012). A superficially similar species is present in Peninsular Malaysia, *Catharsius renaudpauliani* (Ochi & Kon, 1996), however traditional Chinese medicine practitioners likely do not care about taxonomic details. As *C. mollosus* is widespread in Southern China and Indochina (Arrow, 1931), the local *Catharsius* species are not exploited for the TCM trade.

### **Habitat Destruction**

Dung beetles are known to be sensitive to changes in habitat and some species have been proposed as indicator species for habitat disturbance (Davis *et al.*, 2001). Comparison of the dung beetle diversity between old-growth logged forests in Johor and secondary forests in Singapore indicates that secondary forests had significantly less dung beetle species and abundance (Lee *et al.*, 2009). Forested islands created by the flooding of the Tasik Kenyir had less diverse species assemblages on smaller islands but there was no clear pattern on community structure, which indicated that random effects played a large role in the dung beetle community of smaller islands (Qie *et al.*, 2011). Comparison between adjacent logged and unlogged forests found no significant difference between the number of species or abundance of beetles; however, there was a difference in species composition of both forests (Hosaka *et al.*, 2014). A comprehensive study of forests within Peninsular Malaysia, comprising primary and secondary forests, suggested that mammalian diversity, which is also a response of forest size and encroachment, might be the actual factor affecting dung beetle diversity (Doll *et al.*, 2014).

### **Mammalian Extinction**

Dung beetles are primarily dependent on mammalian dung and are at risk of going extinct following the removal of the mammals (Nichols *et al.*, 2009). Through the removal of large mammals due to hunting, traffic accidents or poaching, or the poaching of smaller mammals such as monkeys, a case of trophic collapse can occur in the dung ecosystem. Trophic collapses can cause a restructuring of ecosystems, or a total failure of an ecosystem due to changes in the food web (Terborgh & Estes, 2009). While there are no studies regarding this in Peninsular Malaysia, several studies in the Neotropics indicate decreasing mammalian biomass and biodiversity leads to a loss of dung beetle diversity and abundance (Andresen & Laurence 2007; Culot *et al.*, 2013; Feer & Boissier, 2015).

### **Endemism**

Several endemic species or subspecies of dung beetle can be found in Peninsular Malaysia (Table 2). Some are found in isolated habitats such as mountains or islands. Sites with unique conditions like *kerangas* forests and limestone karsts have not been intensively surveyed but reports from Gunung Mulu in Sarawak indicate that they may harbour undescribed endemic

species (Hanski, 1983). Table 2 represents an incomplete list as there is a lack of distributional data on many species and further surveys of isolated or unique localities are required.

**Table 2** Dung beetle species endemic to Peninsular Malaysia. (Note: Endemic to Langkawi= \*, Endemic to Fraser's Hill= \*\*)

Species	Reference
<i>Anoctus laevis</i>	Balthasar (1963)
<i>Copris (Microcopris) hosakai</i>	Ochi and Kon (2014b)
<i>Copris johkii</i>	Ochi and Kon (2014c)
<i>Copris novaki*</i>	Zelenka (1992)
<i>Copris hatayamai**</i>	Ochi and Araya, 1992
<i>Haroldius maruyamai</i>	Utsunomiya and Masumoto (2005)
<i>Haroldius pahangensis</i>	Kral (2003)
<i>Larhodium maruyamai</i>	Masumoto and Utsunomiya (2003)
<i>Larhodium hashimi</i>	Masumoto and Utsunomiya (2003)
<i>Onthophagus horii</i>	Ochi, Kon and Tsubaki (2009)
<i>O. semipersonatus</i>	Ochi, Kon and Tsubaki (2009)
<i>O. paracentricornis</i>	Ochi and Kon (2014d)
<i>O. uenoi</i>	Ochi (1995)
<i>O. tsubakii</i>	Ochi and Kon (2009)
<i>O. (Gibbonthophagus) viridicervicapra</i>	Ochi, Kon and Tsubaki (2009)
<i>O. (Gibbonthophagus) rufiobscurior</i>	Ochi, Kon and Tsubaki (2009)
<i>O. (Gibbonthophagus) nigriobscurior</i>	Ochi, Kon and Tsubaki (2009)
<i>O. (Indachorius) semiwaroae</i>	Ochi, Kon and Masumoto (2014a)
<i>O. (Indachorius) maruyamai</i>	Ochi, Kon and Masumoto (2014a)
<i>O. (Indachorius) ulugombakensis</i>	Ochi, Kon and Masumoto (2014a)
<i>O. (Indachorius) perakensis</i>	Ochi, Kon and Masumoto (2014a)
<i>O. (Indachorius) semiperakensis</i>	Ochi, Kon and Masumoto (2014a)
<i>O. (Indachorius) viridiperakensis</i>	Ochi, Kon and Masumoto (2014a)
<i>O. (Onthophagialus) suginokoichii</i>	Ochi and Kon (2008)
<i>O. (Parascatonomus) pseudoriekoae</i>	Ochi, Kon and Masumoto (2012)
<i>O. (Parascatonomus) satoi</i>	Ochi, Shimada and Kon (2003)
<i>O. (Pseudophanaeomorphus) parachandrai</i>	Ochi, Kon and Tsubaki (2009)
<i>Ochicanthon peninsularis</i>	Krikken and Huijbregts (2007)
<i>Ochicanthon niinoi</i>	Ochi and Kon (2014b)
<i>Ochicanthon okudai</i>	Ochi and Kon (2014b)
<i>Synapsis roslihashimi</i>	Ochi, Kon and Kawahara (2008)
<i>Synapsis punctatus</i>	Ochi, Kon and Kawahara (2008)

## CHALLENGES

### Incomplete Biogeographic Distribution Information

At the moment distribution information of many species of dung beetles is rather incomplete, and the political boundaries of Peninsular Malaysia do not reflect the biogeographical zone of the Malay Peninsula, which also includes parts of Thailand south of the Isthmus of Kra. Grossly the biogeography of dung beetles on the Malay Peninsula mirrors that of mammalian fauna, with the Kedawi region being a transitional zone between Sundaland beetles and Asiatic mainland species (Goh, T.G., unpublished data). This leads to problems identifying ‘rare’ species, as some species that are considered ‘rare’ on the Malay Peninsula are actually common in Thailand. For example, *Copris nevinsoni* is considered to be rare in the Malay Peninsula (Goh *et al.*, 2014b) but it is commonly found in Thailand markets (Hanboonsong, 2010). Future biogeographical studies that include the Asiatic mainland can help to identify and categorise these species.

### Unknown Ecology

If the bait of a species is not known, it can be mistaken as a ‘rare’ species due to non-detection. Some species rarely occur in baited traps; however, this may not be representative of the actual population sizes of certain species as many species of dung beetle may not be attracted to the standard baits. Species such as *Onthophagus tsubakii* appear to be rare when monkey or human dung is used, but relatively easy to collect using elephant dung (Goh, T.G., unpublished data).

Despite being dung beetles, many species of Scarabaeinae do not feed entirely on dung. Other diets include saprophagy, frugivory, necrophagy and parasitism (Hanski & Cambefort, 1991). Without using a variety of baits, some of these beetles are not detected or collected as singletons during conventional sampling. An example would be *Onthophagus rudis*, which is listed as a rarely occurring species in Arrow (1931) but it can be collected in quite large numbers with flight interception traps (Davis *et al.*, 2001) or rotten fish baited pitfalls traps (Goh, 2014a).

Due to the lack of ecological information on both ‘rare’ and uncommon species, very little is known about many species aside from the localities and forest types that they are collected from. The lack of population-based studies and the unknown geographical ranges of most species prevent the proper classification of these beetles under the criteria of the IUCN Red List (IUCN, 2017).

### Lack of Charisma

Perhaps the most obvious problem with the protection of dung beetles is the question of “Why bother?” Dung beetles are small uncharismatic animals that do not elicit any sympathy with the public. Instead of being directly targeted by poaching, dung beetles are more threatened by indirect means such as deforestation and loss of mammalian diversity. Perhaps the most pragmatic approach is to practice an umbrella species concept by using large charismatic animals to protect the habitat that less charismatic animals depend on. Another alternative is to emphasise the utility of these beetles as indicators of environmental health (Spector, 2006). A forest with a healthy dung beetle community is indirectly a forest with higher mammalian diversity.

## RECOMMENDATIONS

### Continue With Current Conservation Strategies

As previously mentioned, the umbrella species concept is a practical approach to conserving the current diversity of dung beetles. As such, the National Tiger Action Plan (DWNP, 2008) and the Elephant Management Plan (DWNP, 2006), as well as the Central Forest Spine (CFS) plan, seem to be good strategies for the conservation of dung beetle species. As large mammals require a large habitat range, protecting large mammal habitats has the ‘trickle-down effect’ of also preserving dung beetle diversity. Ensuring that the mammals on the current Department of Wildlife and National Parks (DWNP) red list (DWNP, 2010) are protected also prevents the occurrence of a trophic collapse that may harm dung beetle populations. Additionally, the gazettement of geoparks and Environmentally Sensitive Areas (ESA) (DTCP, 2010) may protect yet undiscovered endemic species.

### Least Concern Species

Perhaps the first step to protecting dung beetle species is to define what is not “data deficient”. Table 3 is a list of common beetles derived from species records from the Museum of Zoology, University of Malaya and species lists of Boonrotpong *et al.* (2004), Lee *et al.* (2009), Qie *et al.*, (2011), Hosaka *et al.* (2014), Doll *et al.* (2014) and Goh (2014a). These are species that are common, widespread and adaptable to human encroachment. We suggest the following list of species as meeting the criteria for least concern under the IUCN Red List (IUCN, 2017).

**Table 3** Proposed Least Concern (LC) species of dung beetles for Peninsular Malaysia

Tribe	Species	Habitat
Sisyphini	<i>Sisyphus thoracicus</i>	Primary forests, secondary forests, forest edges, oil palm estates.
Gymnopleurini	<i>Paragymnopleurus maurus</i>	Primary forests, secondary forests
Canthonini	<i>Ochicanthon peninsularis</i>	Primary forests, secondary forests
Oniticeleini	<i>Liatongus femoratus</i>	Primary forests, secondary forests, forest edges
	<i>Oniticelellus cinctus</i>	Cow farms
	<i>Oniticelellus tessellatus</i>	Primary forests, secondary forests, forest edges
	<i>Yvescambefortius sarawacus</i>	Primary forests, secondary forests
Coprini	<i>Copris (Microcopris) doriae</i>	Oil palm estates
	<i>Copris (Microcopris) reflexus</i>	Cow farms, secondary forests, forest edges
	<i>Copris (Paracopris) punctulatus</i>	Cow farms, forest edges
	<i>Copris (Paracopris) ramosiceps</i>	Primary forests, secondary forests
	<i>Copris spinator</i>	Primary forests, secondary forests
	<i>Catharsius renaudpauliani</i>	Primary forests, secondary forests, oil palm estates
Onthophagini	<i>Onthophagus (Parascatonomus) peninsulocupreus</i>	Primary forests, secondary forests, oil palm estates
	<i>Onthophagus (Parascatonomus) rudis</i>	Primary forests, secondary forests, oil palm estates
	<i>Onthophagus (Parascatonomus) semifex</i>	Primary forests, secondary forests, oil palm estates
	<i>Onthophagus aphodiodes</i>	Primary forests, secondary forests, forest edges, oil palm estates

Tribe	Species	Habitat
	<i>Onthophagus babirusa</i>	Primary forests, secondary forests, oil palm estates
	<i>Onthophagus crassicollis</i>	Forest edge, open areas.
	<i>Onthophagus deflexicollis</i>	Primary forests, secondary forests.
	<i>Onthophagus leusermontis</i>	Primary forests, secondary forests, forest edges, oil palm estates.
	<i>Onthophagus orientalis</i>	Primary forests, secondary forests, forest edges, oil palm estates, open areas
	<i>Onthophagus proletarius</i>	Secondary forests, open areas, cow farms.
	<i>Onthophagus pacificus</i>	Primary forests, secondary forests, forest edges, oil palm estates
	<i>Onthophagus rugicollis</i>	Primary forests, secondary forests,
	<i>Onthophagus saggitarius</i>	Cow farms
	<i>Onthophagus rectecornutus</i>	Cow farms
	<i>Onthophagus viridicervicapra</i>	Primary forests, secondary forests
	<i>Onthophagus vulpes</i>	Primary forests, secondary forests, oil palm estates
	<i>Onthophagus waterstradti</i>	Primary forests, secondary forests, forest edges, oil palm estates.

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