Tropical Biomedicine 26(1): 73–79 (2009)

The infestation of *Dermestes ater* (De Geer) on a human corpse in Malaysia

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Received 9 January 2009, received in revised form 20 February 2009; accepted 21 February 2009

Abstract. A human corpse at an advanced stage of decomposition was found in a house in the residential area of Bukit Mertajam, Penang, Malaysia. Entomological specimens were collected during the post-mortem and the live specimens were subsequently reared at room temperature. The time of death was estimated to have been 14 days previous to the discovery of the body based on the police investigation. Both adult and larvae of the beetle *Dermestes ater* (De Geer) were found to be infesting the corpse and from the stage of decomposition of the body and the estimated time of death it would appear that infestation may have begun at a relatively early stage of decomposition.

INTRODUCTION

Beetles (Coleoptera) can provide useful forensic entomological evidence particularly with reference to dry human skeletal remains in the later stages of decomposition (Kulshrestha & Satpathy, 2001). Beetles are holometabolous insects and their lifecycle consists of an egg stage, three to five larval stages depending on species and a pupal stage (Gennard, 2007). The family Dermestidae is a commonly known beetle family and it contains about 1300 species or subspecies worldwide (Hava & Kadej, 2006). These are small to moderately sized beetles (3.5-10.0 mm) densely covered with short hairs or scales which are often conspicuously coloured (Smith, 1986). Byrd & Castner (2001) reported that in Europe and North America the genus *Dermestes* are most active during the warmer months. *Dermestes ater* feeds on organic matter of animal origin (Menezes *et al.*, 2006). They are also known as black larder beetle (Robinson, 2005; Byrd & Castner, 2001). In tropical countries, it is found outdoors on dead birds, mammals, fish, and crabs (Robinson, 2005). This species is cosmopolitan in distribution and appears similar to *Dermestes maculatus*, but the elytra are not serrated (Byrd & Castner, 2001). The larvae can be easily distinguished from others by the urogomphi that extend backward and are not strongly curved (Byrd & Castner, 2001). On adults, the underside of the abdomen is golden brown with small black spots at each side and on both side of the mid-line (Figure 1). The dorsal surface of the elytra are brown to black with short intermixed black or yellow pubescence (Hava & Kadej , 2006). The frass of dermestid larvae has a characteristic twisted shape and is white in colour (Gennard, 2007). On a dead body on which no live specimens of dermestids remain, their frass provides evidence of forensic significant; being indicator that this species was formerly present (Gennard, 2007). In a study conducted by Lee *et al.* (2004) with a total of 448 specimens throughout Malaysia between the period 1972 until 2002 showed that only 1 specimen of beetle (Coleoptera) had been received by Institute for Medical Research, Malaysia.

The objectives of this paper were; 1) to report the infestation of the species *D. ater* on human corpse, and 2) to highlight that the infestation of dermestid beetles (adults and larvae) can occur within 2 weeks in the tropical climate of Malaysia.

Case Study

In this case study a 48 years old man was found dead in his bedroom in Bukit Mertajam, Penang (5° 21' North, 100° 28' East). The body was found by the police after complaints from the neighbours of the deceased about the foul smell emitting from the house. The corpse was found on the 8th April 2008 at 8 pm and was brought to the forensic unit of Bukit Mertajam Hospital on the same day. The entomological specimens were collected by the medical staffs during the autopsy on 9th April 2008 at 8.30 am and we received the specimens at 11 pm on the same day. The specimens received were 3 adult beetles, 28 beetle larvae preserved in 70% alcohol, 7 live beetle larvae and beetle faecal matter (frass). The 3 adult beetles were killed using chloroform and pinned for species identification. The live beetle larvae were reared on dry beef meat with fats. The relative humidity and the temperature of the rearing room were measured twice daily. Since the beetle larvae were found indoors, the rearing also was done indoors to simulate the same condition as the scene of death. Unfortunately, the temperature of the scene of death was not recorded. On further inquiry, the corpse was said to be in advance stage decomposition with leathery skin and extremities and the beetle larvae were collected from the abdomen of the corpse. A piece of cloth was found stuffed inside the mouth of the deceased. We requested the photographs of the scene of death and autopsy, and noted the corpse was found on the floor, fully clothed and the adult beetles were crawling around the corpse and a few found on upper part of the corpse. There was beetles frass on the upper cloth and on the mouth and beetle larvae and adults on the face and upper cloth. The floor of death scene was covered with the liquefied fats and this was where most of the adult beetles were roaming around. We noted no infestation of flies and the skin of the corpse was in leathery appearance although not mummified with the flesh still intact and no visible bones. The manner of the death was determined to be suicide based on the police investigation and the presence of burned charcoal inside the room of the deceased. According to the police, the door and the windows of the deceased room were closed but not fully sealed. The cause of death was given as asphyxiation.

The reared beetle larvae developmental hours were 178.5 hours (7.4 days) to reach pupa stage from the time of the specimen collection. Pupal development took a further 167.5 developmental hours (7 days). Among the 7 beetle larvae reared, only five were found in the pupa stage which indicates that the other 2 of the larvae were probably cannibalized. One beetle pupa was preserved for the reference purposes. The length of this pupa was 10.8 mm. The other four pupae were allowed to develop to adulthood without any disturbance that might alter their development. The emerged beetles were light brown in colour and turned dark black a couple of hours later. The mean temperature of the rearing room was 30 ± 1.0 °C while the relative humidity was within the range of 76 ± 10%. At the time the specimens collected, the mean length of the beetles larvae were 12.5 ± 4.5mm. The adult beetles were 7.6 ± 0.6 mm in length and were identified by using taxonomic key provided by Hava & Kadej (2006). The confirmation of the species was done based on the illustration of the band pattern (Figure 1) underside the abdomen of the adult *D. ater* provided by Robinson (2005) and also by Andreas Herrmann, a leading authority in Dermestidae beetles.

As for the manner of death, the police found burned charcoals at the scene of death. Whether the deceased asphyxiated due to the cloth stuffed in his mouth or due to the carbon monoxide fumes was not ascertained. If it is assumed that the deceased died because of the carbon monoxide poisoning, the period of carbon monoxide present in the room should last as long as the charcoals burnt. However, how long the carbon monoxide remained in the

Figure 1: Ventral view of adult *D. ater*. The arrows show the golden brown abdomen with small black spots in the middle and laterally on each abdominal sternite.

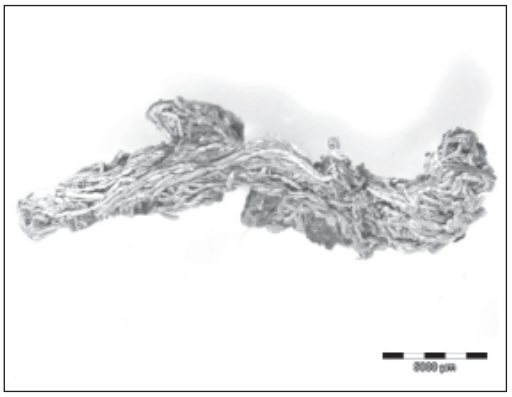

Figure 2: Frass (feacal material) of the *D. ater* collected from the corpse.

room after the burning stopped and thereby caused a delay of infestation is not known. Bergh *et al.* (2003) studied the effect of anoxic treatment towards six species of dermestids and concluded that there are great differences in tolerance to low oxygen levels among the dermestid species, however, *D. ater* was not one of the six species studied. The room temperature also should be higher if the burning had taken place and the dermestid was reported to tolerate temperature between 29ºC – 42ºC with the relative humidity 40-70% (Gennard, 2007).

DISCUSSION

Previous workers have found few adult dermestid beetles on bodies as early as 3 - 10 days after death but larvae were not reported (Early & Goff, 1987). Byrd & Castner (2001) mentioned the presence of dermestid frass (Figure 2) has been found associated with remains from as little as 4 months to 10 years. According to Smith (1986), *Dermestes* first appears about 3 to 6 months post-mortem. Anderson & Vanlaerhoven (1996) reported that dermestid larvae were first found on a dead human body 21 days after death when it was in the early stages of advance decay although flesh still remained and more were collected after 43 days post-mortem interval. Various workers mention different time periods in the infestation of the dermestid but all workers found that the infestation of dermestid beetles occurred at the advance stage of decomposition. However, the length of stages of decomposition and the PMI estimation differs by geographical region and depends on the climate of respective country.

According to Marks & Tersigni (2005) the process of decomposition was influenced by temperature and Saukko & Knight, (2004) noted, decomposition may differ from body to body, from environment to environment and even from one part of the same corpse to another. Following death, human body goes through a series of physical and biochemical changes (Gennard, 2007) and insects are attracted to specific stages of decomposition (Benecke, 2004). As it is well known in the field of medico-criminal forensic entomology, different species of arthropods colonize the corpse at different periods after death (Hall & Doisy, 1993; Saukko & Knight, 2004). In dermestid, the differences in the time period of infestation of this species are best explained by comparing the stages of decomposition in Malaysia and outside Malaysia (Table 1). In Malaysia, Azwandi (2005) and Heo *et al.* (2007) observed the advance stage decomposition begin on 5th day till 8th day post-mortem interval. Up in the north, in Thailand, Apichat *et al.* (2007) noted the

advance stage decomposition begin on day 4 till day 6, and reported the presence adult *D. maculatus* on day 4 till day 30 post-mortem interval. Wolff *et al.* (2001) reported the advance stage decomposition begin from day 13 till day 51 in Medellin while Martinez *et al*, (2007) observed the advance decomposition stage only begin from day 31 till day 51 in Paramo though both studies were done in Colombia. Wolff *et al.* (2001) reported the infestation of adults and larvae of dermestid in advance stage decomposition while Martinez *et al.* (2007) did not find this species in their succession pattern.

From Table 1 we can conclude that the length of stages of decomposition varies by geographic region, ambient temperature and the size of animal models used. Though there are variations in days of the infestation of the dermestid species, all workers noted (Smith, 1986; Anderson & Vanlaerhoven, 1996; Wolff *et al.*, 2001; Apichat *et al.*, 2007) the presence of dermestid species in advance stage of decomposition. On the contrary, Azwandi (2005), Heo *et al*. (2007) and Martinez *et al.* (2007) did not observe any beetle species infestation in the advance stage decomposition and it might probably be due to the small size carcasses (animal models weight about 23 kg recommended by Catts & Goff (1992) to approximate the pattern of human corpse decomposition) or to the absence of this species in the study locality. Gennard (2007) mentioned that the rate of development of dermestid depends on the temperature of the habitat and Coombs (1981) found that the rate of development of *D. ater* also increased with the increase in relative humidity. Combining all these factors, the rate of decomposition and the rate of insect development on human corpse would be much faster in Malaysia which is located along the equator, with tropical climate (26.5±5.5°C, mean of day and night temperature), and high relative humidity of 80±10% (Malaysia Meteorological Department, 2008), than in countries with a temperate climate. In our case study, the presence of beetle larvae, adult beetles and frass (Figure 2), suggested that the infestation had been going on for sometime. At the time this paper was submitted, we sampled another corpse in advance stage decomposition with mummified extremities, infested by adult beetles of *D. maculatus* and its larvae (7.0 ± 3.0mm, mean length) with the maximum PMI of 13 days. In this particular case we

Table 1. The variation in the length of decomposition stage (days) using animal carcasses at different temperatures and geographic locations

Stages	Heo *et al*, 2007, Outdoor, Temperature: 31.1±1.5°C Animal : *Sus scrofa (8.5kg)* Location: Tanjung Sepat, Selangor, Malaysia	Apichat *et al*, 2007, Outdoor, Temperature: 28.9±6.6°C Animal : *Sus scrofa (3-4 kg)* Location: Phitsanulok, northern Thailand	Azwandi, 2005, Outdoor, Temperature: 27.0±8.0°C Animal: *Macaca fascicularis (2.45-5.3kg)* Location : Bandar Baharu, Kedah, Malaysia	Wolff *et al*, 2001, Outdoor, Temperature: 21±3.0°C Animal: *Sus scrofa (17.7kg)* Location : Medellin, Colombia	Martinez *et al*, 2007, Outdoor, Temperature: 12.9±8.5°C Animal: *Sus scrofa*, *(10kg)* Location : Paramo, Colombia
Fresh	1–2	0–1	0–1	0–1	0–3
Bloat	3	2	2	2–6	4–16
Active decay	4–5	3	3–4	7–12	17–30
Advance decay	6–8	4–6	5–8	13–51	31–51
Skeletonization	9–14	7–30	7–23	52–207	52–83

personally collected entomological specimens which included *D. maculatus* (adults and larvae), pupa casing of *Chrysomya megacephala* (Diptera: Calliphoridae), larvae of *Piophila casei* (Diptera: Piophilidae), *Megaselia sclaris* (larvae and pupa) (Diptera: Phoridae) and a few unidentified pupa casings.

Smith (1986) indicated that the length of the pupal stage of *Dermestes* sp. can last between 2 weeks and 2 months depending on the temperature. On the contrary, our beetle larvae pupal stage only took 7 days at 30 ± 1.0ºC and the development taken by the beetle larvae from the time the specimens were collected to the emergence of adults was 14.4 days. According to developmental study on *D. ater* done by Coombs (1981) in the United Kingdom, at a constant temperature and relative humidity of 30ºC and 65% respectively, the larval period was 34.5±1.0 days. If the PMI estimation done using this developmental data, the PMI estimation would has been overestimated. In real practical casework, the ambient temperature and relative humidity fluctuates. Studies of the effect of fluctuating temperature on insect development often show that given the same mean temperature, insects appear to develop at different rates in fluctuating conditions than they do at constant temperatures (Worner, 1992). It should be kept in mind that most of the developmental data found in the literature were done at the constant temperature or more accurately said, reared in controlled environment. These developmental data might be accurate for the respective localities where the studies were done but the practical use of these data in local casework, across the geographic region should be used with caution.

Our studies indicate that the infestation of dermestid larvae on human corpse can occur within 2 weeks in Malaysia. However the exact time of oviposition of this species on human corpse in Malaysia is not known unless the developmental data on the instar stages of *D. ater* is available. This is because after the pupation of *D. ater*, we sieved the soil that was used for rearing and found five larval cast skins which represents the last molted skin before pupation. In blowflies, the instar stages can be used to estimate the PMI, however, though we knew the beetle larvae completed its last molt, we failed to retrieve any reference material regarding the morphology of the instar stages of *D. ater* and its developmental time which might give us the possibility to estimate the exact oviposition period of this species on the corpse. Similar problem regarding the lack of morphological distinction between the instars was mentioned by Gennard (2007). According to Roth & Willis (1950) the fastest development of this species was 21 days at the temperature 27.5ºC ± 0.5ºC while Hinton (1945) reported the completion of the dermestid life cycle within 22 days at 29ºC ± 1ºC. Based on the findings of Hinton (1945) and Roth & Willis (1950) we estimate the time of oviposition that could have occurred in this case would be around 6-8 days after death and by this time we doubt carbon monoxide fumes would still be present in the room of the deceased if he asphyxiated by it. As based on the history of this case, the time of death of the deceased was estimated 14 days based on the police investigation as they found the daily subscription of newspapers were left uncollected in front of the deceased house for 14 days. The adult beetles that were collected from the corpse were hard to be identified since the liquefied fats of the corpse made the bristle and the band pattern under the abdomen not visible. The confirmation of the species had been done using the adults that emerged from rearing. Another point to be considered is that the three adult beetles collected from the corpse could have been attracted to the corpse to predate other beetle larvae as its known to cannibalized (Byrd & Castner, 2001) or it also could have attracted to the corpse to lay another batch of eggs. The latter statement could be ruled out by dissecting the abdomen to identify the genitalia of the beetles and in the case of the females the development stage of their ovaries. It is considered highly unlikely that the adult beetles found associated with the body originated from eggs laid upon it because the fastest development of dermestid so far reported in the literature

was 21 days (Roth & Willis, 1950) while the maximum PMI of the corpse was only 14 days. Relating to our experiences of collecting entomological evidence from 40 cases (unpublished data), we noted the infestation of the flies first occur on the head (if the corpse were fully clothed and no external injuries) where the orifices (eyes, mouth and ears) located. In this case, though the deceased fully clothed with no external injuries, the face and the head was not skeletonised and we observed no sign of flies infestation from the photographs given to us. Even if there is infestation of the blow flies, it does not affect the presence of the *D. ater* since the beetle are well known predators (Menezes *et al*, 2006) and they (flies and beetles) are attracted to corpses according to different stage of decomposition (Smith, 1986). We also would like to highlight here that the real circumstances of a case will not be known unless the collections of entomological evidence were done thoroughly by an entomologist which is not a standard practice in Malaysia (Institute for Medical Research, 2003; Lee *et al.*, 2004). For an accurate estimation of post-mortem interval using this beetle larvae in Malaysia, further research into the life cycle of the beetle *D. ater* in tropical environment will be helpful.

Acknowledgements. We would like to thank Mr. Chan Kok Cheng, Mr. Mahashim Mahamud and Mr. Abdullah Shaari from Bukit Mertajam Hospital for their help during the period of sample collection. We also grateful and thankful to Andreas Herrmann for his time and assistance in the species identification and providing the list of references materials. This research was funded by Universiti Sains Malaysia RU grant 1001/PBiology/815009.

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