A B S T R A C T

Scarbaceaeni dung beetles are globally distributed group of insects that are scavengers, primarily feeding on animal excrement, but may also feed on carrion, and decomposing fruits. Through their feeding behavior, they perform important ecosystem services. Dung beetle communities respond rapidly to habitat disturbance, specifically tropical forest disturbance, hence they are recognized as ideal ecological indicators to study effects of habitat disturbance on biodiversity. Western Ghats in India is one of the biodiversity hotspots of the world. However, its forests face tremendous population pressure due to agricultural expansion, infrastructure development and non-timber forest product harvest. This has contributed to loss of biodiversity and forest cover in the Western Ghats. There is limited information on ecologically important insects such as dung beetles of South Western Ghats. In the present study, dung baited pitfall traps were used to collect dung beetles across a forest-agriculture habitat ecotone in Nelliampathi South Western Ghats. Thirty four species, belonging to 11 genera and seven tribes were collected from Nelliampathi. Three first reports for South India and nine endemics to Western Ghats were recorded. A species list with pictorial key for dung beetles of Nelliampathi in South Western Ghats is compiled. Such a species list with pictorial key will provide baseline information and enable rapid identification of dung beetles of the region in future studies.

INTRODUCTION

Scarbaceaeni dung beetles are globally distributed group of insects that are scavengers, primarily feeding on animal excrement, but may also feed on carrion, and decomposing fruits (Halfpeter and Mathews, 1966). Through their feeding behavior, they perform important ecosystem services such as nutrient recycling, biological pest control and secondary seed dispersal (Hanski and Cambefort, 1991; Nichols et al., 2008). Dung beetle communities respond rapidly to habitat disturbance, specifically tropical forest disturbance, hence they are recognized as ideal ecological indicators to study effects of habitat disturbance on biodiversity (Davis et al., 2001; Gardner et al., 2008; Nichols et al., 2007).

Western Ghats in India is one of the biodiversity hotspots of the world. However, its forests face tremendous population pressure. Over the last century, agricultural expansion, infrastructure development and non-timber forest product harvest has contributed to loss of biodiversity and forest cover in Western Ghats (Jha et al., 2000; Kumar, 1993; Menon and Bawa, 1997; Shahabuddin and Prasad, 2004).

MATERIALS AND METHOD

Study Site

Nelliampathi is located on the “edge” of Palghat gap in South Western Ghats (Pearson and Ghopade, 1989). The collection site, Kaikatty in Nelliampathi is located at 10° 31’ N longitude and 76° 40’ E latitude, at an elevation of 960msl (Fig. 1). Though extensive in area, Nelliampathi forests presents a fragmented landscape interspersed by large number of plantations, dams, and roads. It is an ecologically high sensitive area forming a corridor for the movement of long ranging species such as Panthera tigris Linnaeus, 1758 (tiger), Panthera pardus Linnaeus, 1758 (leopard), Bos gaurus Smith, 1827 (wild gaur), and is also a crucial migratory route for Elephas maximus Linnaeus, 1758 (elephant) (Sukumar and Easa, 2006).
The vegetation in the forest habitat is characterized by west coast semi-evergreen forest consisting of a mixture of evergreen and deciduous trees (Kerala Forests and Wildlife Department, 2004). Dung beetles were collected across a forest-agriculture habitat ecotone in Nelliampathi. The study sites consisted of a 971 hectare reserve forest, 372 hectare agriculture habitat of banana and orange plantations and a well-defined ecotone characterized by scattered trees and less undergrowth that separates the two habitats (Fig. 2). Traps were placed in the reserve forest, ecotone and in the portion of the agriculture habitat with banana plantation.

Sampling

Dung beetles were collected using dung baited pit fall traps in the year 2007-08. Three collections were made during the study period (monsoon, presummer, summer). The collected beetles were preserved in 70% alcohol and brought to the laboratory of St. Joseph’s College, Devagiri, Kozhikode. The beetles were identified to species levels using taxonomic keys available in Arrow (1931) and Balthasar (1963a, b) and also by verifying with type specimens available in the Coleoptera collections of St. Joseph’s College, Devagiri, Kozhikode. Photographs were taken using Nikon D50 digital camera attached to a trinocular stereo zoom microscope (Labomed ASZ-99TR). All species are listed with their valid names, authority, and the year of description. The specimens are all deposited in the coleopteran collection of St. Joseph’s College, Devagiri, Kozhikode.

RESULTS

Thirty four species, belonging to 11 genera and seven tribes were collected from Nelliampathi. The genera were Caccobius, Catharsius, Copris, Liatongus, Paracopris, Paragymnopleurus, Ochicanthus, Onitis, Onthophagus, Sisyphus and Tibiodrepanus. The seven tribes were Canthonini, Coprini, Gymnopleurini, Onitini, Onthophagini, Oniticellini and Sisyphini (Table 1).

Three first reports (*) for the South Indian region were recorded from Nelliampathi, they are Onthophagus deflexicollis, O. manipurensis and Tibiodrepanussinicus. Nine species endemic (*) to the Western Ghats were collected from Nelliampathi, they are Caccobius gallinus, Liatongus indicus, Ochicanthus mussardi, Onthophagus amphicoma, O. andrewesi, O. bronzeus, O. Vladimiri, Paracopris davisoni and Sisyphus araneolus.

Key to the tribes and subtribes of subfamily Scarabaenae of Nelliampathi in South Western Ghats

1 Middle and hind tibiae elongate, slender, not or very little widened towards the apex (Fig. 3A) ……………………. 2

Middle and hind tibia short, widened towards the apex and triangular (Fig. 3B) …………………………… 4

2 Middle coxa not widely separated, strongly oblique (Fig. 4A) ………………….. Gymnopleurini

Middle coxa widely separated, parallel or only little converging (Fig. 4B) …………………. 3
Table 1 Dung beetle species collected from a semi-evergreen forest (SEG), ectone (ECO) and agriculture habitat (AGR) of Nelliampathi in South Western Ghats for the 2007-08 study period with distribution records, species endemic to Western Ghats (*), first report from South India (**).

<table>
<thead>
<tr>
<th>Species</th>
<th>Habitat</th>
<th>Distribution</th>
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<tbody>
<tr>
<td>Caccobius(Caccobius)galilinus* Arrow, 1907</td>
<td>ECO, AGR</td>
<td>India (Kerala: Nelliampathi, Wayanad; Tamil Nadu: Nilgiri Hills)</td>
</tr>
<tr>
<td>Caccobius(Caccobius)meridionalisBoucomont, 1914</td>
<td>AGR</td>
<td>India (Karnataka; Kerala: Erumaisoor, Mahé, Nilgiri, Nelliampathi, Ranipuram, Shendurney, Silentvalley, Thekkady, Wayanad; Gujarat; Maharashtra; Tamil Nadu: Anaimalai Hills, Nilgiri Hills), Sri Lanka (Haryana: Kannerni; Karnataka: Budipadaga; Kerala: Nelliampathi, Ranipuram, Shendurney, Silent valley, Thekkady, Wayanad; Gujarat; Haryanva; Karnataka: Nelliampathi, Ranipuram, Shendurney, Silent valley, Thekkady, Wayanad; Meghalaya; Mumbai; Orissa; Rajasthan; Sikkim; Tamil Nadu; Uttaranchal; W. Bengal), Laos, Malaysia, Nepal, Sri Lanka, Sunda Islands, Taiwan, Thailand, Vietnam (Annam)</td>
</tr>
<tr>
<td>Caccobius (Caccobius) ulterior Sharp, 1875</td>
<td>AGR</td>
<td>Afghanistan, Cambodia, China, India (Andaman; Arunachal Pradesh; Assam; Bihar; Gujarat; Haryana; Karnataka; Kerala: Kinavellore, Nelliampathi, Thekkady, Wayanad; Meghalaya; Mumbai; Orissa; Rajasthan; Sikkim; Tamil Nadu; Uttaranchal; W. Bengal), Laos, Malaysia, Nepal, Sri Lanka, Sunda Islands, Taiwan, Thailand, Vietnam (Annam)</td>
</tr>
<tr>
<td>Catharusius(s.str.)molossusLinnaeus, 1758</td>
<td>SEG, ECO, AGR</td>
<td>China, India (India (Arunachal Pradesh; Bihar; Chattisgarh; Gujarat; Karnataka; Kerala: Nelliampathi, Palghat, Ranipuram, Shendurney, Silent valley, Taliparamba, Thekkady, Wayanad); Madhya Pradesh; Maharashtra; Mumbai; Pondicherry; Rajasthan; Tamil Nadu: Anaimalai Hills, Nilgiri Hills; Uttar Pradesh), Sri Lanka, Thailand</td>
</tr>
<tr>
<td>Capris (s.str.) repertusWalker, 1858</td>
<td>SEG, ECO, AGR</td>
<td>India (Kerala: Nelliampathi, Wayanad; Tamil Nadu: Anaimalai Hills, Nilgiri Hills)</td>
</tr>
<tr>
<td>Liatorus (s.str.) indica* Arrow, 1908</td>
<td>AGR</td>
<td>India (Kerala: Cardamom Hills, Nilgiri Hills)</td>
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<tr>
<td>Ochicanthomussart* Caccodoro, 2011</td>
<td>ECO</td>
<td>India (Karnataka; Kerala: Kinavellore, Nelliampathi, Thekkady, Wayanad; Meghalaya; Mumbai; Orissa; Rajasthan; Sikkim; Tamil Nadu; Uttaranchal; W. Bengal), Laos, Malaysia, Nepal, Sri Lanka, Sunda Islands, Taiwan, Thailand, Vietnam</td>
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<tr>
<td>Onitissubopacus Arrow, 1931</td>
<td>AGR</td>
<td>China, India (Assam; Bihar; Kashmir; Kerala: Nelliampathi, Wayanad; Madhya Pradesh; Tamil Nadu: Anaimalai Hills; Uttaranchal; W. Bengal), Myanmar, Nepal, Sri Lanka, Sunda Islands, Thailand, Vietnam</td>
</tr>
<tr>
<td>Onthophagus (s.str.) amphicona*Boucomont, 1914</td>
<td>SEG, ECO, AGR</td>
<td>India (Kerala: Mahe, Malabar, Nelliampathi, Travancore; Tamil Nadu: Nilgiri Hills)</td>
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<tr>
<td>Onthophagus (s.str.) tridens* Arrow, 1931</td>
<td>SEG, ECO, AGR</td>
<td>India (Karnataka; Kerala: Kanara; Nelliampathi, Wayanad; Tamil Nadu: Anaimalai Hills, Nilgiri Hills)</td>
</tr>
<tr>
<td>Onthophagus (s.str.) tridens* Arrow, 1907</td>
<td>SEG, ECO, AGR</td>
<td>India (Kerala: Nelliampathi, Wayanad; Tamil Nadu: Nilgiri Hills)</td>
</tr>
<tr>
<td>Onthophagus (s.str.) casteniLamberg, 1867</td>
<td>SEG, ECO</td>
<td>India (Kerala: Nelliampathi, Travancore, Trivandrum, Wayanad; Tamil Nadu: Kodaikanal (Shembaganur), Madura, Palni Hills; Uttar Pradesh)</td>
</tr>
<tr>
<td>Onthophagus (Microonthophagus) caviaBoucomont, 1914</td>
<td>SEG, ECO</td>
<td>India (Bombay; Karnataka: Nandidiroog; Kerala: Nelliampathi, Tamil Nadu: Coonor, Nilgiri Hills)</td>
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<tr>
<td>Onthophagus (s.str.) centriornis Fabricius, 1798</td>
<td>SEG</td>
<td>Afghanistan, India (Karnataka; Kerala: Nelliampathi, Wayanad; Maharashtra; Tamil Nadu: Nilgiri Hills)</td>
</tr>
<tr>
<td>Onthophagus (s.str.) deflexicollisLamberg, 1883</td>
<td>ECO</td>
<td>Indonesia (Sumatra), Malay Peninsula, Myanmar, Tonkin</td>
</tr>
<tr>
<td>Onthophagus (s.str.) exsul Boucomont, 1914</td>
<td>SEG, ECO, AGR</td>
<td>India (Arunachal Pradesh; Gujarat; Kerala: Nelliampathi, Ranipuram, Thekkady, Wayanad; Tamil Nadu: Madhura, Nilgiri Hills)</td>
</tr>
<tr>
<td>Onthophagus (s.str.) fasciatusBoucomont, 1914</td>
<td>ECO, AGR</td>
<td>India (Karnataka; Kerala: Nelliampathi, Ranipuram, Thekkady, Wayanad; Madhya Pradesh; Mumbai; Uttaranchal; W. Bengal; Tamil Nadu: Anaimalai Hills, Madhura, Nilgiri Hills)</td>
</tr>
<tr>
<td>Onthophagus (s.str.) favreliBoucomont, 1914</td>
<td>SEG, ECO, AGR</td>
<td>India (Karnataka; Kerala: Nelliampathi, Wayanad; Tamil Nadu: Coimbatore, Nilgiri Hills), Sri Lanka (India (Assam; Kashmir; Kerala: Ranipuram, Thekkady, Wayanad; Punjab; Uttaranchal))</td>
</tr>
<tr>
<td>Onthophagus (s.str.) insignicollisFrey, 1954</td>
<td>SEG, ECO, AGR</td>
<td>India (Bihar; Kerala: Nelliampathi, Wayanad)</td>
</tr>
<tr>
<td>Onthophagus (s.str.) laevir Harold, 1880</td>
<td>SEG, ECO, AGR</td>
<td>Borneo, China (Kerala: Nelliampathi, Wayanad; Sikkim; Uttaranchal, W. Bengal), Indonesia (Java; Sumatra), Myanmar, Thailand</td>
</tr>
<tr>
<td>Onthophagus (Digitionthophagus) manipurenensis* Arrow, 1907</td>
<td>SEG, ECO, AGR</td>
<td>Burma; India (Arunachal Pradesh; Assam; Kerala: Nelliampathi; Manipur)</td>
</tr>
<tr>
<td>Onthophagus (s.str.) pacificusLamberg, 1885</td>
<td>SEG, ECO, AGR</td>
<td>China, Bangladesh, Borneo, India (Assam; Karnataka; Kerala: Wayanad; Nilgiri Hills; Tamil Nadu: Nilgiri Hills; Uttaranchal), Indonesia (Java; Sumatra), Myanmar, Malaysia, Sunda Islands, Thailand, Laos, Vietnam</td>
</tr>
<tr>
<td>Onthophagus (s.str.) porcusArrow, 1931</td>
<td>SEG, ECO, AGR</td>
<td>India (Arunachal Pradesh; Kerala: Nelliampathi, Wayanad; W. Bengal)</td>
</tr>
<tr>
<td>Onthophagus (Seronophorus)rectecornutusLamberg, 1883</td>
<td>AGR</td>
<td>China, India (Assam; Bihar; Karnataka; Kerala: Malabar, Nilgiri, Nelliampathi, Tamil Nadu: Nilgiri Hills; W. Bengal), Sri Lanka, Sunda Islands, Thailand</td>
</tr>
<tr>
<td>Onthophagus (s.str.) turbator Walker, 1858</td>
<td>SEG, ECO, AGR</td>
<td>India (Karnataka; Kerala: Mahe, Malabar, Nilgiri; Mahäashtra; Puducherry; Tamil Nadu: Nilgiri Hills), Sri Lanka</td>
</tr>
<tr>
<td>Onthophagus (s.str.) vladimir*iFrey, 1957</td>
<td>SEG, ECO</td>
<td>India (Kerala: Nelliampathi, Wayanad; Tamil Nadu: Anaimalai Hills)</td>
</tr>
<tr>
<td>Paracoprisschistus Gillet, 1927</td>
<td>SEG, ECO, AGR</td>
<td>India (Gujarat; Karnataka; Kerala: Nelliampathi, Ranipuram, Shendurney, Thekkady; Surat; Tamil Nadu: Anaimalai Hills; Lafayana)</td>
</tr>
<tr>
<td>Paracoprisschistorius Waterhouse, 1891</td>
<td>ECO, AGR</td>
<td>India (Karnataka; Kerala: Nelliampathi, Poremada, Ranipuram, Thekkady, Travancore, Wayanad; Mumbai; Tamil Nadu: Nilgiri Hills, Palni Hills)</td>
</tr>
<tr>
<td>ParacoprisschistusWalker, 1858</td>
<td>ECO</td>
<td>India (Karnataka; Kerala: Nelliampathi, Poremada, Ranipuram, Thekkady, Travancore, Wayanad; Mumbai; Tamil Nadu: Coimbatore)</td>
</tr>
<tr>
<td>Paragamopoleurusannuatus Oliveir, 1789</td>
<td>SEG</td>
<td>Burma, India (Central and Northern India; Kerala: Nelliampathi), Laos, North Vietnam, Southern China</td>
</tr>
</tbody>
</table>

3 Middle and hind legs remarkably long and slender and the hind tibia more or less strongly curved (Fig.5A) ……………………………………………………. Sysiphini

Middle and hind legs not remarkably long, hind tibia not strongly curved (Fig.5B) …………………………………………………….Canthonini

4 Second segment of the labial palpi shorter than the first, third well developed (Fig.6A)………………………………Coprini

Second segment of the labial palpi longer than the first, third very rudimentary or absent (Fig. 6B)……………5
5 Antenna 8 segmented (Fig.7A) ……….. **Oniticellina**
Upper surface smooth or with fine hairs (Fig.7Ai) ……….. **Oniticellina**
Upper surface with coarse erect hairs (Fig.7Aii) ……….. **Drepanocera**
Antenna 9 segmented (Fig.7B) ……….. 6

6 Pronotum with two basal impression in the middle (Fig.8A) ……….. **Onitini**
Pronotum without two basal impression in the middle (Fig.8B) ……….. **Onthophagini**

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**Key to the genera of subfamily scarabaeinae of Nelliampathi in South Western Ghats**

**Gymnopleurini**
Clypeus with two teeth (Fig.9A) ……….. **Paragymnopleurus Shipp**

**Sisyphini**
Body round with dispropotionately large legs, clothed above with short, erect, hooked setae (Fig.9B) ……….. **Sisyphus Laterellii**

**Canthonini**
Elytra with six dorsal striae, seventh stria bordering the edge of elytra (Fig.9C) ……….. **Ochicanthon Vaz-de-Mello**

**Coprini**
1 Elytra with two lateral carina (Fig.10A) ……….. **CatharsiusHope**

Elytra with one lateral carina (Fig.10B) ……….. 2

2 Punctures at the apex and sides of the elytra without hairs (Fig.11A) ……….. **Copris Geoffroy**
2’ Punctures at the apex and sides of the elytra bearing short stiff hairs (Fig.11B) ……….. **Paracopris Balthasar**

**Onthophagini**
1 Terminal margin of the front tibia at right angles to the inner margin and anterior angles of the prothorax hollowed beneath (Fig.12A) ……….. **Caccobius Thomson**
Either one or none of the above characteristics present (Fig.12B) ……….. **Onthophagus Latreille**

**Onitini**
Scutellum very minute, front tarsi absent (Fig 13) ……….. **Onitis Fabricius**

**Oniticellini**
1 Elytra not fringed with hairs before the hind margin (Fig 14 A) ……….. **Liatongus Reitter**
Elytra fringed with hairs before the hind margin (Fig 14B) ……….. **Tibiodrepanus Krikken**
Key to the species of subfamily scarabaeinae of Nelliampathi in South Western Ghats

Paragymnopleurus
Pronotum strongly angulate at the sides (Fig.15A)……
P. sinuatus Olivier, 1789
Sisyphus
Metasternum feebly punctured in front (Fig.15B)……..S. araneolus Arrow, 1927
Ochicanthon
Elytral striae narrow with chains of oval depressions joined by straight sulci (Fig.15C)…………………………O. mussardi Cuccodoro, 2011

Catharsius
Head with small smooth area adjoining each eye (Fig 16A) ……C. molossus (Linnaeus, 1758)

Copris
Pronotum with sharply defined anterior declivity (Fig 16B)……C. repertus Walker, 1858

Paracopris
1 Clypeus strongly punctured (Fig 17A)…………P. cribratus Gillet, 1927
Clypeus rather smooth (Fig 17B)………………………..2

2 Metasternal shield punctured in front (Fig 18A)………..P. davisoni Waterhouse, 1891
Metasternal shield not punctured in front (Fig 18B)
………………P. signatus Boucomont, 1858

3 Elytra very shining (Fig 19A)………………..C. gallinus Arrow, 1907
Elytra not shining (Fig 19B)……………………………..4
4 Elytra variegated (Fig 19C) …………………………C. meridionalis, Boucomont, 1914
Elytra entirely black (Fig 19D)………………..C. ultor Sharp, 1875

Onthophagus
1 Eyes large separated by distinctly less than three times their length (Fig. 20A)………………O. cavia Boucomont, 1914
Eyes small separated by at least three times their length (Fig. 20B)……………………………..2

2 Hind tibia extremely short, triangular, as broad at the end as metatarsus is long (Fig. 21A)………………………..3
Hind tibia not extremely short, triangular, not as broad at the end as metatarsus is long (Fig 21B)…………………..5

3 Pronotum grooved (Fig. 22A)………………..O. laevis Harold, 1880
Pronotum not grooved (Fig 22B)………………………..4
4 Pronotum with 4 tubercles (Fig. 23A) .................O. insignicollis Frey, 1954

Pronotum without 4 tubercles (Fig 23B) ..................O. pacificus Lansberge, 1885

5 Pronotum wholly or partly granular or rugose (Fig 24A) ...............6

Pronotum punctured without granules, asperities, or rugosity (Fig 24B) ...............9

6 Pronotum entirely granular or rugose without distinct punctures (Fig 25A) .............O. bronzeus Arrow, 1907

Pronotum partly granular or rugose with some punctures or smooth areas (Fig 25B) ...............7

7 Front angles of pronotum not produced, very blunt (Fig 26A) ..................O. castetsi Lansberge, 1867

Front angles of pronotum more or less produced (Fig 26B) ..................8

8 Pronotum light brown (Fig 27A) ...........O. rectecornutus Lansberge, 1883

Pronotum black (Fig 27B) ..................O. manipurensis Arrow, 1907

9 7th elytral stria indistinct (Fig 28A) ..................O. amphicoma Boucomont, 1914

7th elytral stria distinct (Fig 28B) ...............9

10 Punctures of the pronotum, large, close, umbilicate (Fig 29A) ............O. furcillifer Bates, 1891

Punctures of the pronotum, not large close umbilicate (Fig 29B) ..................10

11 Pronotum pale at the sides (Fig 30A) ..................12

Pronotum uniformly colored (Fig 30B) ..................13

12 Pronotum with an elongated process (Fig 31 A) .............O. vladimiri Frey, 1957

Pronotum without an elongated process (Fig 31 B) ..................12

13 Base, apex and sides of the elytra pale (Fig 32A)  ..................O. fasciatus Boucomont, 1914

Base, apex and sides of the elytra not entirely pale (Fig 32B) ..................O. favrei Boucomont, 1914
DISCUSSION

Comparison of dung beetles collected in the present study with collections of Arrow (1931), Balthasar (1963, 1974), Paulian (1980, 1983) and the checklist of dungbeetles of the moist western slope of the South Western Ghats (Sabu et al., 2011) revealed that several species belonging to genus Ochicanthon and Panelus which were earlier well represented in the Nelliampathi region was not recorded in the present study. Genus Ochicanthon was represented by only Ochicanthonmussardi in the present study while earlier collections had reported the presence of O. gauricola (Latha et al., 2011), O. laetus (Arrow, 1931) and O. nitidus (Paulian, 1980). Genus Panelus was not recorded in the present study but earlier, Panelusmussardi (Paulian, 1980) and P. keralai (Paulian, 1980) were recorded. The absence of the above mentioned species in the collection could be due to habitat degradation in the region which could possibly result in species loss (Sabu et al., 2011) and affect the dung beetle fauna of the region.

CONCLUSION

This study gains significance in the context of present deterioration of forests in the Western Ghats region due to anthropogenic pressures. Documenting the biodiversity of such threatened habitats is important as adequate information on biodiversity of a region is essential for planning conservation strategy for a region.

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Balthasar, V. 1963a. Monographic der Scarabaeidae und Aphodiidae der Palaearktischen und Orientalischen
Species List With Pictorial Key For Dung Beetles (Coleoptera: Scarabaeidae: Scarabaeinae) of Nelliampathi In South Western Ghats, India

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16128