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List of Scolytinae and Platypodinae (COLEOPTERA: Curculionidae) captured by ethanol-baited traps in a tropical rainforest in southern Sabah, Malaysia

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マレーシア国サバ州南部の熱帯雨林においてエタノール誘引トラップに捕獲されたキクイムシ亜科とナガキクイムシ亜科（甲虫目：キクイムシ科）のリスト

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Introduction

Bark beetles (*sensu lato*) are found in the two subfamilies (Scolytinae and Platypodinae) of the family Curculionidae (Coleoptera) and ecologically diverse and economically important groups. The subfamily Platypodinae includes c. 1,500 species and almost all of these are ambrosia beetles (Peris *et al*., 2021). On the other hand, c. 6,100 species have been recorded for the subfamily Scolytinae (Cognato *et al*., 2021), which includes many feeding guilds such as phloem feeders (bark beetles (*sensu stricto*)), fungal feeders (ambrosia beetles), pith feeders, fruit and seed feeders, and others.

With over 7,600 species worldwide, bark (*sensu stricto*) and ambrosia beetles play crucial roles in forest ecosystems from tree mortality to early stages of decomposition: Majority of the species are secondary attacker infesting unhealthy or weakened hosts, followed by saprophytic insects. Kajimura (2006) listed 38 species belonging to the subfamily Platypodinae and 26 species from the subfamily Scolytinae as primary insects that infest healthy trees. However, only eight of the 64 species primarily infest healthy hosts (six from Platypodinae and two from Scolytinae). The remaining species, such as the mountain pine beetle (Carroll *et al*., 2005), southern pine beetle (Clarke, 2012), and European spruce beetle (Gregoire, 1988), typically infest unhealthy trees but can attack and kill healthy trees in association with symbiotic fungi

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when their density becomes high, facilitated by an abundant supply of susceptible host trees (Weed *et al.*, 2015). For more than three decades, new records of some secondary ambrosia beetles infesting seemingly healthy trees and killing them have been increasing (Kuhnholz *et al*., 2001), which includes the Japanese oak wilt vectored by *Platypus quercivorus* in Japan (Kamata *et al*., 2002), Korean oak wilt by *Platypus koryoensis* in Korea (Kim *et al*., 2009), laurel wilt by *Xyleborus glabratus* in SE US (Fraedrich *et al*., 2008), and wilting disease by *Euwallacea fornicatus* complex in California (Eskalen *et al*., 2012) and many other countries (Umeda et al., 2016), and by *Euplatypus parallelus* in SE Asia (Beaver, 2013). Among these *X. glabratus* and *E. fornicatus* have caused enormous economic loss in avocado plantations in US (Carrillo *et al*., 2016).

Among the fruit and seed feeders, the coffee berry borer (*Hypothenemus hampei*) has caused enormous economic loss in coffee plantations all over the world (Vega *et al*., 2015). The congeneric species, *Hypothenemus obscurus*, also causes damage to macadamia in Australia and Hawaii (Jones, 1992; Delate, 1994; Mitchell and Maddox, 2010).

Despite their economic importance, there is a lack of information about bark beetles (*sensu lato*) in Sabah, Malaysia. This knowledge gap is particularly concerning considering the region's rich biodiversity and the potential impacts these insects may have on plantation forests, agricultural systems, and native forests.

Under these circumstances, a long-term monitoring of the two subfamilies using ethanol-baited traps has been conducted for three years in a tropical rainforest in southern Sabah, Malaysia. The data obtained from this study provides valuable long-term monitoring insights, facilitating future comparisons of beetle assemblages across different geographical ranges.

Materials and Methods

Study site

This study was conducted in the Ulu Padas Forest Reserve (UPFR) (4° 23′ -27′ N, 115° 42′ -47′ E) (Fig. 1(a)), a tropical rainforest located in southern Sabah, Malaysia. According to Loh *et al*. (2020), the Ulu Padas region encompasses state land covering approximately 16,935 hectares, along with managed forests, which include Maligan Virgin Jungle Reserve (9,055 ha), Sipitang Forest Reserve (99,573 ha), and UPFR (30,605 ha). The UPFR is classified as Class II Forest of the "Heart of Borneo" by World Wildlife Fund and predominantly composed of upper dipterocarp and oak-laurel forests, with elevations ranging from 1,000 to 1,700 m a.s.l. The climate of the region is influenced by the inter-tropical convergence zone between the northeast and southeast trade winds (Naidin *et al*., 2024). Our study sites were all located in Long Miau village in Sipitang, Sabah. The study focused on three forest types: primary forest (PF), disturbed forest

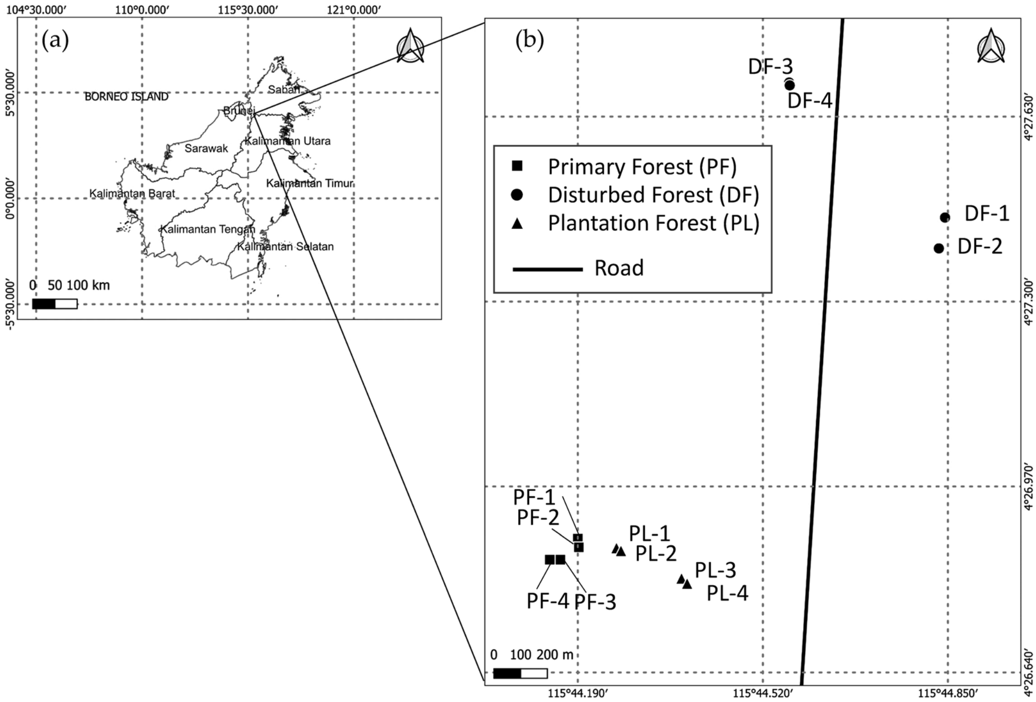

Fig. 1 Location of the study site, Long Miau, Sipitang, Sabah, Malaysia (a) and allocation of the ethanol-baited traps in the three different forest types (b).

(DF), and plantation forest (PL) areas (Fig. 1(b)). The PF remained undisturbed by local people's activities. The DF was a forest area that has been subject to disturbances by development. The PL (rubber plantation) used to be a part of the PF but was recently developed by the local people. The plantation was approximately three to six years old during the sampling period. All traps were set on the territory governed by local people. The PF and PL were situated near to each other with a distance approximately 600 to 700 m. The DF was located approximately two to three km away from the PF and PL.

Ethanol traps

The study utilized ethanol-baited traps for sampling beetles belonging to the subfamilies Scolytinae and Platypodinae, modified from Sanguansub *et al*. (2020). The trap design comprised a 500-ml plastic water bottle, a plastic plate, a 15-ml conical tube, and flexible aluminium wire, as illustrated in Fig. 2. Approximately 20 ml of propylene glycol was put into the water bottle to preserve captured insets. Approximately 15 ml of 90% ethanol (v/v) was put into the conical tube as an attractant. Propylene glycol and 90% ethanol were refilled at each sampling date.

Four ethanol bait traps were set at each study site (PF-1-4, PL-1-4, and DF-1-4) (Fig. 1(b)). In PF, all the traps were hung on the tree branches (Fig. 2(a)), with trap height ranging from 1.6 to 1.8 meters above the

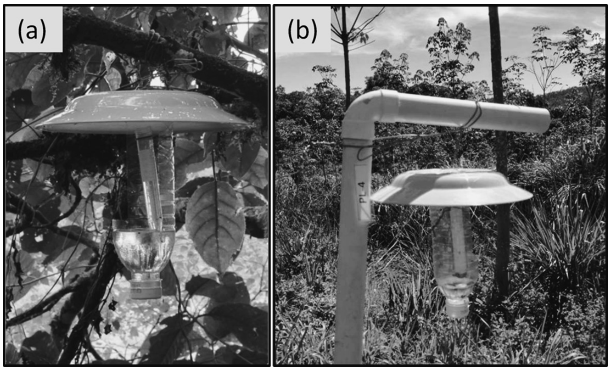

Fig. 2 Ethanol-baited trap used for capturing Scolytine and Platypodine beetles in Long Miau, Sipitang, Sabah, Malaysia.
(a) Trap hung on a tree branch.
(b) Trap installed using an L-shaped PVC pipe.

ground. In contrast, all traps in PL were installed at a similar height (1.7 to 1.8 m) with PF using the L-shaped PVC pipe (Fig. 2(b)), as the tree in this forest were still young and did not provide suitable branch structures for elevated trap placement. The DF featured a mixed trap placement strategy, with three traps hung on tree branches and one trap set on L-shaped PVC pipe. Table 1 shows the elevation and coordinates of each of the 12 traps.

Beetle samples were collected from the traps biweekly over 80 sampling times spanning 160 weeks (≈ three years) from April 2017 to May 2020. The insects captured by each trap were separately transferred to each plastic bag in the field, brought back to the laboratory of Faculty of Science and Natural Resources (at present, Faculty of Tropical Forestry), Universiti Malaysia Sabah. Only Scolytinae and Platypodinae were sorted into morphospecies under the binocular microscope and put separately into microcentrifuge tubes with 95% ethanol for further identification. One to a few individuals of each morphospecies were shipped to RAB for identification.

Results

A total of 154 species belonging to the two subfamilies comprising 7,257 individuals were documented: 20 species (30 individuals) from the subfamily Platypodinae and 134 species (7,227 individuals) from Scolytinae (Table 2).

The raw data for each type of forest and each year are shown in Supplemental Materials (Tables S1-S9).

Acknowledgements

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Table 1 Coordinates and elevation for 12 traps in each land use type.

Forest Types	Traps	Coordinate	Elevation (m.a.s.i)
Primary Forest	PF1	4°26.877′ N, 115°44.190′ E	1082
	PF2	4°26.862′ N, 115°44.192′ E	1078
	PF3	4°26.840′ N, 115°44.159′ E	1098
	PF4	4°26.840′ N, 115°44.140′ E	1104
Plantation Forest	PL1	4°26.861′ N, 115°44.259′ E	1081
	PL2	4°26.856′ N, 115°44.267′ E	1081
	PL3	4°26.807′ N, 115°44.375′ E	1047
	PL4	4°26.798′ N, 115°44.384′ E	1047
Distrubed Forest	DF1	4°27.450′ N, 115°44.845′ E	1024
	DF2	4°27.395′ N, 115°44.834′ E	1016
	DF3	4°27.691′ N, 115°44.567′ E	1065
	DF4	4°27.686′ N, 115°44.568′ E	1064

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Research permission from Sabah Biodiversity Council; JKM/MBS.1000-2/2 JLD.6 (100); JKM/MBS.1000-2/2 JLD.7 (171); JKM/MBS.1000-2/2 JLD.9 (84)

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Table 2 Summary of coleopteran species belonging to the subfamilies Scolytinae and Platypodinae of the family Curculionidae captured using 12 ethanol-baited traps from 2017 to 2020 at the Primary Forest (PF), Disturbed Forest (DF), and Plantation Forest (PL).

Family / Subfamily / Tribe		LOCATION			Total Trap Captures
		PF	DF	PL	
Curculionidae					
Platypodinae					
Platypodini	*Baiocis* sp. SB03	0	0	1	1
Platypodini	*Crossotarsus* sp. SB06	0	0	1	1
Platypodini	*Dinoplatypus biuncus* (Blandford)	0	0	1	1
Platypodini	*Dinoplatypus cupulatus* (Chapuis)	0	0	1	1
Platypodini	*Dinoplatypus pseudocupulatus* Schedl	1	0	0	1
Platypodini	*Platypus fraterculus* Schedl	0	0	1	1
Platypodini	*Platypus hirtellus* Schedl	1	0	0	1
Platypodini	*Platypus lunifer* Schedl	0	1	1	2
Platypodini	*Platypus pasaniae* Schedl	3	0	0	3
Platypodini	*Platypus quercinus* Schedl	1	1	0	2
Platypodini	*Platypus semiermis* Schedl	1	0	0	1
Platypodini	*Platypus* sp. SA4	1	0	0	1
Platypodini	*Platypus* sp. SA5	1	0	0	1
Platypodini	*Platypus* sp. SB09	0	1	1	2
Platypodini	*Platypus* sp. SB10	0	1	1	2
Platypodini	*Platypus* sp. SB11	0	0	1	1
Platypodini	*Platypus* sp. SB12	1	0	0	1
Platypodini	*Platypus suffodiens* Sampson	0	1	0	1
Platypodini	*Platypus vetulus* Schedl	3	2	0	5
Tesserocerini	*Diapus quinquespinatus* Chapuis	0	1	0	1
SUBTOTAL (Platypodinae)		**13**	**8**	**9**	**30**
Curculionidae					
Scolytinae					
Coriacephilini	*Coriacephilus* sp. SA1	0	1	0	1
Cryphalini	*Cryphalus* sp. SA1	3	3	0	6
Cryphalini	*Cryphalus* sp. SA2	9	16	32	57
Cryphalini	*Cryphalus* sp. SA3	38	30	11	79
Cryphalini	*Cryphalus* sp. SA4	22	7	8	37
Cryphalini	*Cryphalus* sp. SA5	15	14	7	36
Cryphalini	*Cryphalus* sp. SB02	14	1	18	33
Cryphalini	*Cryphalus* sp. SB03	14	4	7	25
Cryphalini	*Cryphalus* sp. SB04	0	0	2	2
Cryphalini	*Cryphalus* sp. SB05	1	0	1	2
Cryphalini	*Cryphalus* sp. SB06	0	0	2	2
Cryphalini	*Cryphalus* sp. SB11	1	0	0	1
Cryphalini	*Cryphalus* sp. SB12	0	1	0	1
Cryphalini	*Cryphalus?* sp. SB07	15	20	2	37

Table 2 (Continued)

Diamerini	*Sphaerotrypes* sp. SA1	1	0	0	1
Dryocoetini	*Coccotrypes* aff. *fallax* (Eggers)	2	1	1	4
Dryocoetini	*Coccotrypes carpophagus* (Hornung)	23	6	13	42
Dryocoetini	*Coccotrypes gedeanus* (Eggers)	0	1	0	1
Dryocoetini	*Coccotrypes longior* (Eggers)	5	9	2	16
Dryocoetini	*Coccotrypes myristicae* (Roepke)	4	2	1	7
Dryocoetini	*Coccotrypes rhizophorae* (Hopkins)	17	4	18	39
Dryocoetini	*Coccotrypes* sp. 1	0	0	1	1
Dryocoetini	*Coccotrypes* sp. 2	0	1	0	1
Dryocoetini	*Coccotrypes* sp. SB01	1	0	0	1
Dryocoetini	*Coccotrypes* sp. SB02	1	0	2	3
Dryocoetini	*Coccotrypes vulgaris* (Eggers)	0	0	1	1
Dryocoetini	*Coccotrypes?* sp.	0	1	0	1
Dryocoetini	*Cyrtogenius* sp.	0	1	0	1
Dryocoetini	*Cyrtogenius* sp. SA1	0	1	0	1
Dryocoetini	*Dryocoetiops moestus* (Blandford)	274	196	190	660
Dryocoetini	*Ozopemon brownei* Schedl	0	0	2	2
Dryocoetini	*Ozopemon regius* Hagedorn	2	0	1	3
Ernoporini	*Eidophelus* (*Ptilopodius*) sp. SA1	0	0	1	1
Ernoporini	*Eidophelus* (*Ptilopodius*) sp. SB01	2	0	0	2
Ernoporini	*Eidophelus* (*Scolytogenes*) sp. SA1	1388	519	834	2741
Ernoporini	*Eidophelus* (*Scolytogenes*) sp. SA2	18	2	1	21
Ernoporini	*Eidophelus* (*Scolytogenes*) sp. SA3	2	2	4	8
Ernoporini	*Eidophelus* (*Scolytogenes*) sp. SB01	0	0	1	1
Ernoporini	*Eidophelus* (*Scolytogenes*) sp. SB02	0	0	2	2
Ernoporini	*Eidophelus* sp. 3	0	1	5	6
Ernoporini	*Eidophelus* sp. SA1	111	7	15	133
Ernoporini	*Eidophelus* sp. SB01	0	2	2	4
Ernoporini	*Eidophelus* sp. SB02	0	0	1	1
Ernoporini	*Eidophelus?* sp.	0	0	1	1
Ernoporini	*Ernoporus* sp. SB01	0	0	2	2
Hylesinini	*Ficicis despectus* (Walker)	36	9	6	51
Hyorrhynchini	*Sueus borneesis* Bright	0	0	2	2
Phloeosinini	*Phloeoditica* sp. SA1	1	2	1	4
Phloeosinini	*Phloeosinus* sp.	0	0	1	1
Phloeosinini	*Phloeosinus?* sp. 2	0	0	1	1
Scolytoplatypodini	*Scolytoplatypus carinatus* Bright	23	6	0	29
Scolytoplatypodini	*Scolytoplatypus glaber* Eggers	2	2	0	4
Scolytoplatypodini	*Scolytoplatypus javanus* Eggers	5	4	1	10
Scolytoplatypodini	*Scolytoplatypus nanus* Schedl	54	46	110	210
Scolytoplatypodini	*Scolytoplatypus parvus* Sampson	0	0	1	1
Trypophloeini	*Cosmoderes* sp. 1	1	0	0	1
Trypophloeini	*Hypothenemus areccae* cx (Hornung)	39	36	229	304
Trypophloeini	*Hypothenemus birmanus* (Eichhoff)	4	2	68	74
Trypophloeini	*Hypothenemus eruditus* cx Westwood	64	35	619	718
Trypophloeini	*Hypothenemus* sp.	3	1	2	6

Table 2 (Continued)

Trypophloeini	*Hypothenemus* sp. SA1	33	12	44	89
Trypophloeini	*Hypothenemus* sp. SA2	1	0	2	3
Trypophloeini	*Hypothenemus* sp. SA3	4	3	4	11
Trypophloeini	*Hypothenemus* sp. SA4	0	0	1	1
Trypophloeini	*Hypothenemus* sp. SA5	1	0	0	1
Trypophloeini	*Hypothenemus* sp. SA7	1	0	2	3
Trypophloeini	*Hypothenemus* sp. SA8	0	1	0	1
Trypophloeini	*Hypothenemus* sp. SB03	5	1	6	12
Trypophloeini	*Hypothenemus* sp. SB04	4	0	3	7
Trypophloeini	*Hypothenemus* sp. SB05	1	0	1	2
Trypophloeini	*Hypothenemus* sp. SB06	3	2	124	129
Trypophloeini	*Hypothenemus* sp. SB07	0	1	14	15
Xyleborini	*Amasa resecta* (Eggers)	3	1	1	5
Xyleborini	*Ambrosiodmus asperatus* (Blandford)	89	170	182	441
Xyleborini	*Ambrosiophilus consimilis* (Eggers)	0	1	1	2
Xyleborini	*Ambrosiophilus* sp. SA1	0	0	1	1
Xyleborini	*Ancipitis puer* (Eggers)	3	0	0	3
Xyleborini	*Ancipitis scabrior* (Schedl)	0	1	0	1
Xyleborini	*Arixyleborus castaneae* Schedl	1	1	0	2
Xyleborini	*Arixyleborus granifer* (Eichhoff)	1	0	5	6
Xyleborini	*Arixyleborus leprosulus* Schedl	4	1	7	12
Xyleborini	*Arixyleborus puberulus* (Blandford)	3	2	0	5
Xyleborini	*Arixyleborus* sp. 2	2	0	0	2
Xyleborini	*Arixyleborus* sp. 3	1	0	0	1
Xyleborini	*Arixyleborus suturalis* (Eggers)	2	0	1	3
Xyleborini	*Cnestus bicornioides* (Schedl)	11	2	11	24
Xyleborini	*Cnestus nitidipennis* (Schedl)	3	3	5	11
Xyleborini	*Cnestus suturalis* (Eggers)	8	5	8	21
Xyleborini	*Coptodryas confusa* Hopkins	2	1	0	3
Xyleborini	*Cryptoxyleborus cuneatus* Beaver & Hulcr	0	2	0	2
Xyleborini	*Cyclorhipidion circumcisum* (Sampson)	0	3	0	3
Xyleborini	*Cyclorhipidion perpilosellum* (Schedl)	1	1	1	3
Xyleborini	*Cyclorhipidion repositum* (Schedl)	1	1	0	2
Xyleborini	*Cyclorhipidion* sp. SA1	1	0	0	1
Xyleborini	*Cyclorhipidion* sp. SB02	1	0	0	1
Xyleborini	*Debus amphicranoides* (Hagedorn)	1	0	0	1
Xyleborini	*Debus emarginatus* (Eichhoff)	1	1	1	3
Xyleborini	*Debus pumilus* (Eggers)	2	3	3	8
Xyleborini	*Debus quadrispinus* (Motschulsky)	0	1	1	2
Xyleborini	*Debus* sp. 2	0	1	0	1
Xyleborini	*Debus spinatus* (Eggers)	0	0	1	1
Xyleborini	*Diuncus haberkorni* (Eggers)	8	6	26	40
Xyleborini	*Diuncus javanus* (Eggers)	9	9	29	47
Xyleborini	*Diuncus mucronatus* (Eggers)	4	3	0	7
Xyleborini	*Diuncus quadrispinosulus* (Eggers)	2	10	16	28
Xyleborini	*Eccoptopterus limbus* Sampson	2	0	14	16

Table 2 (Continued)

Xyleborini	*Eccoptopterus spinosus* (Olivier)	64	66	241	371
Xyleborini	*Euwallacea fornicatus* cx (Eichhoff)	4	2	14	20
Xyleborini	*Euwallacea minutus* (Blandford)	0	1	0	1
Xyleborini	*Euwallacea semirudis* (Blandford)	2	0	5	7
Xyleborini	*Euwallacea* sp. SA2	0	1	0	1
Xyleborini	*Immanus* sp. SA1	1	0	0	1
Xyleborini	*Microperus parvus* (Sampson)	0	1	0	1
Xyleborini	*Microperus recidents* (Sampson)	0	1	0	1
Xyleborini	*Microperus* sp. SA1	0	1	0	1
Xyleborini	*Microperus* sp. SC01	0	1	0	1
Xyleborini	*Planiculus* aff. *limatus*	1	0	0	1
Xyleborini	*Streptocranus bicolor* Browne	0	1	1	2
Xyleborini	*Streptocranus fragilis?* Browne	4	10	4	18
Xyleborini	*Tricosa metacuneola* (Eggers)	0	1	1	2
Xyleborini	*Truncaudum agnatum* (Eggers)	0	2	0	2
Xyleborini	*Webbia* sp. SA3	0	0	1	1
Xyleborini	*Xyleborinus andrewesi* (Blandford)	77	52	26	155
Xyleborini	*Xyleborinus exiguus* (Walker)	15	13	19	47
Xyleborini	*Xyleborinus horridulus* (Browne)	6	2	4	12
Xyleborini	*Xyleborinus* sp. SA1	1	4	0	5
Xyleborini	*Xyleborinus* sp. SA6	7	5	0	12
Xyleborini	*Xyleborus affinis* Eichhoff	1	0	2	
Xyleborini	*Xylosandrus compactus* (Eichhoff)	3	1	3	7
Xyleborini	*Xylosandrus crassiusculus* (Motschulsky)	0	12	4	16
Xyleborini	*Xylosandrus morigerus* (Eichhoff)	62	37	10	109
Xyleborini	*Xylosandrus* sp. SB02	0	0	1	1
Xyloterini	*Indocryphalus* sp. SA1	1	0	0	1
Xyloterini	*Indocryphalus tropicus* (Browne)	1	1	0	2
SUBTOTAL (Scolytinae)		**2684**	**1460**	**3083**	**7227**
TOTAL		**2697**	**1468**	**3092**	**7257**

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