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The diversity of wood-boring beetles caught by different traps in northern forests of Iran

H. BARIMANI VARANDI[1,♥], M. KALASHIAN[2], H. BARARI[1], S. A. REZAEI TALESHI[1,♥♥]
[1]Mazandaran Agricultural and Natural Resources Research and Education Center, Sari, Iran, PO Box 48175-556, Tel.: +98-11-42552601-2, Fax.: +98-11-42552603, ♥email: hbarimani@yahoo.com, ♥♥ rezaietaleshi@yahoo.com
[2]Institute of Zoology of the National Academy of Sciences of Armenia, P. Sevak Str., 7, Yerevan, 375014, Armenia

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Abstract. *Varandi HB, Kalashian M, Barari H, Rezaei Taleshi SA. 2018. The diversity of wood-boring beetles caught by different traps in northern forests of Iran. Trop Drylands 2: 65-74.* Efficacy of trap types is an important factor for sampling, faunistic survey, evaluation of the population density, seasonal dynamic and monitoring of wood-boring beetles. In the present research, the diversity of Wood-boring beetles (i.e., Buprestidae and Cerambycidae) was studied by using different types of trap (window trap, color pan trap, color sticky trap and Malaise trap) in northern forests of Iran (Mazandaran Province, Iran). Different types of traps were employed in five study areas, collected a total of 3120 beetles belonging to 55 species (29 Buprestidae and 26 Cerambycidae). Window trap was the best one for collecting the beetles both in the case of different species and of individual numbers, while red pan trap collected only a few beetles (during 2008-2009). After a window trap, two color pan traps (white and yellow) were also very suitable for collecting the beetles. The majority of captured specimens were buprestid beetles (79.87%), while only one-fifth of the specimens were Cerambycidae (20.13%). All of the collected beetle specimens were identified to species' level. One genus (*Agrilus* spp) and the following five species were the dominant species: *Acmaeodera rufoguttata* Reitter, *Anthaxia hyrcana* Kiesenwatter et Kirsch, *Anthaxia intermedia* Obenberger, *Chrysobothris affinis* Fabricius and *Stenoprerus rufus* Linnaeus.

Keywords: Buprestidae, Cerambycidae, diversity, forest, Iran, traps

INTRODUCTION

Metallic wood-boring beetles (Buprestidae), comprising of 15,000 species, and longhorn beetles (Cerambycidae), consisting of 35,000 species, are the most important wood-boring insects that occur in every biogeography region (Bellamy 2000; Hanks 1999) and fill particularly an important ecological niche in forest ecosystem (Belyea 1952; Gardines 1957). The larvae of these beetles are xylophagous, feeding in the phloem and xylem tissues of trees, mining deep into the heartwood and consequently causing severe damage to the wood. Concerning the wood industry, a heavy infestation of commercial wood by these pests can cause economic losses in the form of degraded wood and volume loss.

Most of these beetles are dangerous pests of forest and fruit trees, shrubs and herbaceous plants, implying an important biological position in forestry and agricultural entomology (Cerezke 1977; Post 1984; Orbay et al. 1995; Ozdikmen and Okutaner 2006; Costello et al. 2008). Even some species of wood-boring beetles bore into deadwood in the buildings including furniture, causing structural damage if unchecked for a long period. Moreover, many wood-boring beetles tunnel through fallen tree, trunks and branches, which are then exposed to more rapid decay by wood-rotting fungi, bacteria, and other organisms. Thus, these beetles play an essential ecological role in accelerating the process of wood decay and recycling the nutrients of dead trees, and also have a significant nutritional function for many insectivores including woodpeckers (Anderson 2003; Miller and Asaro 2005; Dajoz 2000).

Several different methods are generally used for collecting beetles such as direct active collection (hand collection), rearing larvae to adulthood, sweeping, bait traps and light traps (Borror and Delong 2005). Hand collection methods have the advantage of sampling directly from the woody substrate, plus the samples may be related to the volume and bark area of deadwood (Siitoren 1994). However, these methods have proved unsatisfactory in many respects (Bouger et al. 2008).

The use of traps for capturing flying insects, especially beetles, has long been an integral part of many field investigations in entomology (Hosking and Knightf 1975). The attraction of Buprestidae and/or Cerambycidae to sticky trap (Werner 2002; Oliver et al. 2004), to different color trap (Sakalian and Langourov 2004), to malaise and yellow pan trap (Bellamy 2000), to malaise and window trap (Michael et al. 2004; Bouget 2008), and to yellow pan trap and window trap (Wermelinger et al. 2002) had been previously studied. However, the trapping efficiency for different species depends on a variety of parameters (Adis 1979), which complicate the comparison of data presented by various authors (Topping and Sunderland 1992). Although many entomologists in the world have used different traps, such as color trap, malaise trap, window trap and sticky trap, for catching beetles (e.g., Bellamy 2000; Werner 2002; Oliver et al. 2004; Sakalian and

Langrov 2004; Bouget et al. 2008) but neither an effective trap nor a comparison test for the efficiency of different traps for collecting Buprestidae and Cerambycidae has been previously studied in the forests of Iran.

The objective of the current study was to compare the efficiency of four different kinds of traps (i.e. color, window, Malaise, and sticky trap) in catching the adult wood-boring beetles, and to discuss the behavior of these insects in response to the traps.

MATERIALS AND METHODS

Study area

The study was done in the northern forest of Iran (Mazandaran Province) located in the Hyrcanian forest zone with humid commercial and industrial broadleaves forests (Figure 1). This area stretches out from sea level up to an altitude of 2800 m above sea level. The forest consists of 80 woody species (trees and shrubs).

Trapping experiments were conducted at six altitude ranges of Mazandaran Province (Sari forest areas) (Figure 1) during 2008-2009 as follows: **Dashte-Naz** is located 36 km north of Sari City (53° 12' 36" E, 36° 41' 36" N; 20 m asl). The dominant vegetations in this area were citrus (*Citrus* sp.), peach (*Prunus persica*), wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), oilseed rape (Brassica *campestris*), rice (*Oryza sativa*) as well as a protected park (ca 55 hr) containing *Quercus castaneifolia* and *Parotia persicae*. **Pahneh-Kola** (53° 03' 06" E, 36° 27' 14" N; 218 m als) is located in 13 km south of Sari City in a forestry nursery. It was surrounded by dominant trees such as *Q. castaneifolia. Carpinus betula, Zelkova carpinifolia, Acer velatinum, Alnus subcordata, Cratagus* spp. and some conifers trees: *Cupressus sempervirence* and *Pinus radiata*. **Alamdardeh** (53° 15' 60" E, 36° 21' 21"; 396 m asl): Alamdardeh is located 35 km south of Sari City in an oak forest. **Haftkhal** (53° 23' 43" E, 36° 17' 16" N, 855 m asl): Type of this forest is Fago-Carpino forest and is located 60 km of Sari City. **Posht Koh** (53° 46' 52" E, 36° 14' 58" N, 1501 m asl) is located in a rangeland region, 110 km south-east of Sari City. **Alikola** (53˚ 39′ 45″ E, 36˚ 13′ 00″ N, 1640 m asl) is located 90 km of Sari City and has Fago-carpino forest type.

Methods

In 2008, color, sticky, window and Malaise traps were used. *Color pan trap*-The trap dimensions refer to Figure 2, based on Sakalian and Langourov (2004). Thirty-five color pan traps (blue, green, red, white and yellow) were arranged in a completely randomized design (5 treatments in 7 replications) and set up in Dashte-Naz, Pahneh Kola, Alamdardeh, Haftkhal and Posht Koh. Each trap was placed in 7 rows, with 100 cm spacing between each row, 120-1500 cm above ground, the space between each of the traps was 30 cm. They were fixed to a wire, which was stretched between rods. Each trap was half-filled with 50% water solution of ethylene glycol.

Sticky trap-The trap dimensions refer to Figure 3, according to Oliver et al. (2004). Thirty-five sticky color traps (blue, green, red, white, and yellow) were arranged in a completely randomized design (5 treatments in 7 replications) in Pahneh Kola region. Each trap was placed in 7 rows, with 100 cm spacing between each row. The space between each of the traps was 100 cm. Besides, 12 other color sticky traps (red, white, and yellow) were set up in Alamdardeh and Posht Koh (two traps from each color).

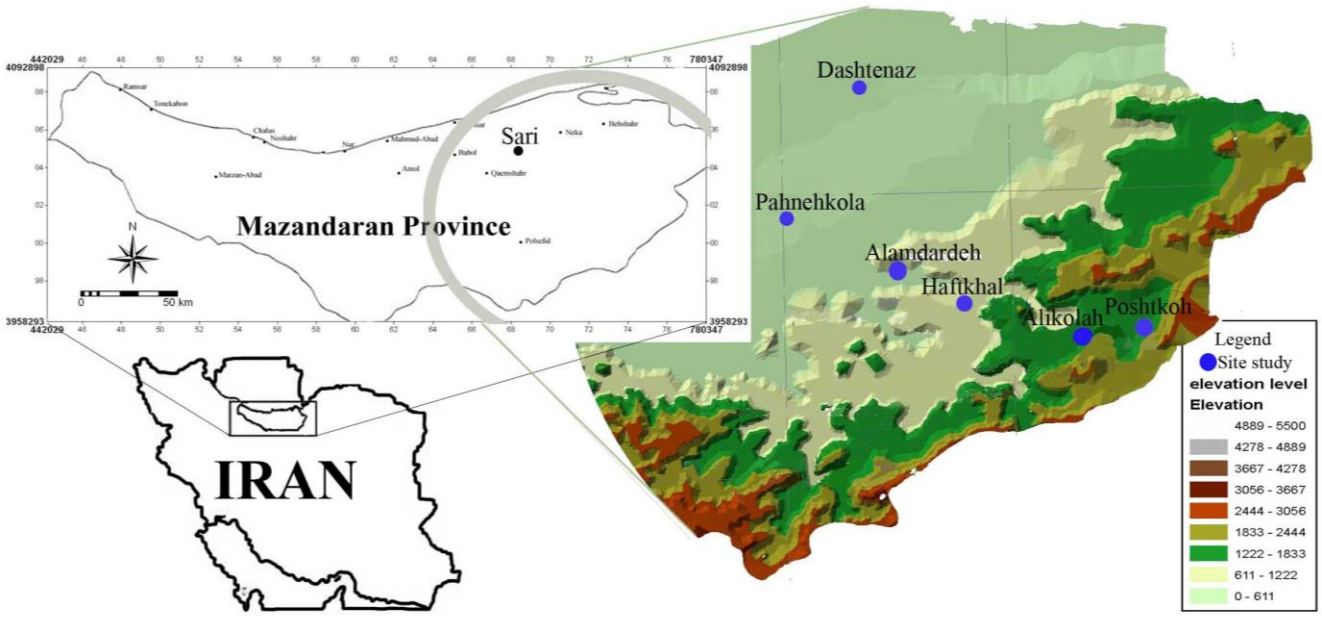

Figure 1. Map of the study sites in Sari City, Mazandaran Province, Iran

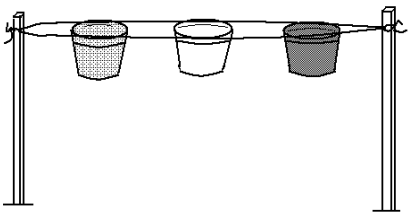

Figure 2. Design and construction of color pan traps (Sakalian and Langourov 2004). Each trap consisted of a plastic tray (with 80 mm and 105 mm diameter at the bottom and the top, respectively, and with 120 mm deep).

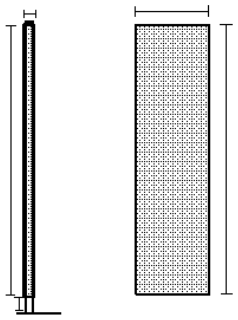

Figure 3. Design and construction of a sticky trap from Oliver et al. 2004). Each trap was a cylindrical tube (with 100 cm long and 2 cm diameter) stapled longitudinally with wallpaper strips (90 cm × 7 cm) and painted with red color. Pestick sticky glue was used to make the trap surface sticky.

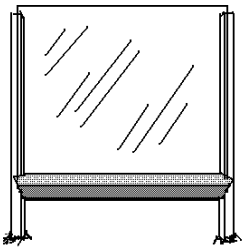

Figure 4. Design and construction of a window trap from (Barari 2005). The trap consisted of a vertically-held, transparent, hard-plastic sheet (window), 81 cm height and 85 cm long, mounted in a metal frame. It had a plastic gutter tray along its bottom edge. The tray was half-filled with water containing 1% detergent. The trap was positioned about 10 cm from the ground

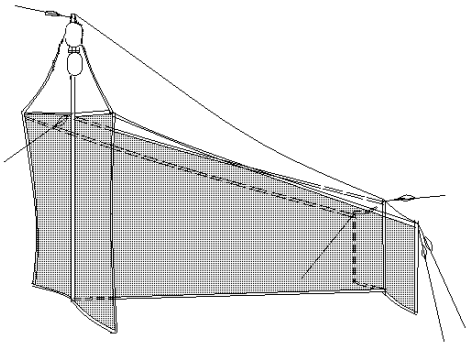

Figure 5. Design and construction of a Malaise trap (Matheus and Matheus 1983). The trap was 160 cm long and 190 cm sloping to 65 cm height. The open sides of the trap were 160 cm long, 95 and 60 cm height on the highest and lowest end, respectively (Barari 2005).

The caught insects were first put into vials containing gas (for cleaning them from glue) and then washed with a mixture of distilled water and detergent, and finally preserved in 75% ethanol in labeled glass vials for later study.

Window trap-The trap dimensions refer to Figure 4, consistent with Wermelinger et al. (2002) and Barari (2005). The gutter tray of each trap was half-filled with 50% ethylene glycol. The trap was positioned about 10 cm from the ground. Three traps were placed in Pahneh Kola, Alamdardeh and Poshtkoh only (one window trap in each site).

Malaise trap-The trap dimensions refer to Figure 5, according to Townes (1962). Malaise traps were placed in Dashte-Naz and Pahneh Kola only (one Malaise trap in each mentioned site).

Hundred color Pan traps (20 traps: 10 white and ten yellow alternately in each location) were set up in Dashte-Naz, Pahneh Kola, Alamdardeh, Haftkhal and Alikola in 2009. The color traps were placed in one row, 120-1500 cm above ground, the space between each of the traps was 30 cm. They were fixed to a wire, which was stretched between rods. Each trap was half-filled with 50% water solution of ethylene glycol. Also, ten window traps and 10 Malaise traps were set up in each mentioned altitude range (two windows and two Malaise traps in each site).

The caught insects were collected once in two weeks from early May to late September, preserved in labeled plastic pots containing 75% alcohol. The insect samples were transferred to the laboratory; removed from alcohol and placed on marked cotton beds for later sorting, counting and identifying the target insects. The target insects were identified to species by using literature and compared with identified materials in Collections of Institute of Zoology NASRA, Yerevan, Armenia. The collected species were kept in the collections of the institute as mentioned earlier and of Agricultural and Natural Resources Research Centre of Mazandaran, Iran.

Data analysis

Data were analyzed and compared using SPSS Ver. 16, at Chi-square (χ^2) manner. The Biodiversity Program Ver. 2.0 (McAleece et al. 1997) was used to calculate the similarity index and to construct the dendrogram. The classification of Heydemann's (Weigmann 1973) was used to evaluate the dominance structure (cited in Sakalin and Langorov 2004). This classification has five degrees of dominance: eudominant (ED), dominant (DO), subdominant (SD), rare (RA) and sub-rare (SR), which are those species making up more than 30%, 10-30%, 5-10%, 1-5% and less than 1% of all the caught specimens, respectively.

RESULTS AND DISCUSSION

The distribution of buprestid and cerambycid species and types of traps are tabulated in Tables 1 and 2. During this study, a total of 3120 specimens were caught by the traps (1292 in 2008 and 1828 in 2009). Among those, 29

species belonging to 12 genera were Buprestidae, and 26 species belonging to 23 genera were Cerambycidae (Tables 1 and 2). The majority of captured specimens were buprestid beetles (79.87%), while only about one-fifth of the specimens were Cerambycidae (20.13%) (Table 2, Figure 6). In 2008, the largest numbers of species were caught by the yellow pan trap (Figure 7), while the smallest numbers of species were caught by blue sticky tap and green sticky trap (Table 1, Figure 8). In 2009, the largest and smallest numbers of species were caught by the window trap and white pan trap, respectively (Table 2, Figure 9). There were significant differences amongst numbers of beetles caught by the traps ($P<0.001$; Tables 3, 4, 5). Regardless of the species, the largest and the smallest numbers of the specimens were caught by window trap (n=759) and red pan trap (n=22), respectively. No significant differences in the catch were observed in Malaise with white pan trap, yellow pan trap, blue pan trap, and red pan trap (Table 3). In 2009, 1828 individuals belonging to 36 species were collected. Of those, 759 individuals (28 species) were caught by window traps, 516 (13 species) by white pan traps, 425 (22 species) by yellow pan traps, and 128 (19 species) by Malaise trap.

Table 1. List of species of wood-boring beetles (Buprestidae and Cerambycidae) taken in different traps in 2008

Family and species	Colour pan traps					Traps shape		Colour sticky traps					DD
	WhP	YeP	BlP	ReP	GrP	Malaise	Window	WhS	YeS	BlS	ReS	GrS	
Buprestidae													
Acmaeodera pillosella (Bonelli, 1812)	1	1	0	0	0	0	5	0	0	0	0	0	SR
Acmaeodera rufoguttata (Reitter, 1890	26	38	1	9	4	2	61	12	5	0	38	2	DO
Acmaeoderella flavofasciata (Piller et Mitterparcher, 1783	0	5	1	0	0	0	4	0	0	0	0	0	SR
Acmaeoderella mimonti (Bieeldieu, 1865)	0	0	1	0	0	0	1	0	0	0	0	0	SR
Acmaeoderella gibbulosa (Menetries, 1832)	0	0	1	0	0	0	0	0	0	0	0	0	SR
Capnodis tenebricosa (Oliver, 1790)	0	0	0	1	0	0	0	0	0	0	52	0	RA
Dicerca fritillum (Menetries, 1832	0	0	0	0	0	2	0	0	0	0	0	0	SR
Dicerca scabida (Marseul, 1865	0	0	0	0	0	0	0	0	0	0	3	0	SR
Lamprodila tuerki (Ganglbauer, 1882)	0	0	0	0	1	0	0	0	0	0	0	0	SR
Sphenoptera cauta (Jakovlev, 1904	0	0	1	0	0	0	0	0	0	0	0	0	SR
Anthaxia hyrcana (Kiesenwatter et Kirsch, 1880	97	125	9	0	0	0	0	11	6	0	0	0	DO
Anthaxia intermedia (Obenberger, 1913	1	2	0	4	1	0	0	15	7	5	122	5	DO
Anthaxia passerine (Pecchioli, 18370	0	0	2	0	0	0	0	0	0	0	0	0	SR
Anthaxia hungarica (Scopoli, 1772)	0	4	0	0	0	0	0	0	0	0	0	0	SR
Anthaxia cichori (Olivier, 1790)	0	4	1	0	0	0	0	0	0	0	0	0	SR
Anthaxia bicolor (Falderman, 1835	1	0	0	0	0	0	0	1	0	0	0	0	SR
Chrysobothris affinis (Fabricius, 17940	0	0	0	0	0	23	2	15	5	6	157	3	DO
Agrilus viridis (Linneaeus, 1758)	0	1	0	0	0	0	0	0	0	0	0	0	SR
Agrilus biguttatus (Fabricius, 1777)	0	0	0		0	0	0	0	0	0	1	0	SR
Agrilus derasofasciatus (Lacordaire, 1835	1	1	1	0	16	1	0	0	0	2	0	0	RA
Agrilus obscuricollis (Kiesenwatter, 1857	0	0	0	0	0	0	0	0	0	0	1	0	SR
Agrilus pratensis (Ratzeburg, 1837	0	0	0	1	0	0	0	0	0	0	0	0	SR
Agrilus hyperici (Creutzer, 1799)	0	0	0	0	0	0	0	0	0	0	1	0	SR
Agrilus graminis (Kiesenwetter, 1857)	9	7	10	4	48	0	4	0	0	0	0	0	SD
Coraebus elatus (Fabricius, 1787)	1	1	0	0	3	0	2	0	1	0	0	1	SR
Coraebus rubi (Linneaeus, 1767)	0	3	0	0	1	0	0	2	1	0	0	0	SR
Trachys phlyctaenoides (Kolenati, 1846)	0	0	0	0	0	0	0	19	0	43	3	0	SD
Cerambycidae													
Rhagium pygmaeum Ganglb,1882)	0	0	2	0	0	0	0	0	0	0	0	0	SR
Anoplodera rufipes (Sshaller, 1783)	3	0	0	0	0	0	0	0	0	0	0	0	SR
Stictoleptura scutellata (Fabricius,1781)	0	4	1	0	0	0	1	0	0	0	0	0	SR
Paracorymbia tonsa (J. Daniel et K. Daniel, 1891)	0	0	0	0	0	1	1	0	0	0	0	0	SR
Cerambyx scopolii (Fusslins, 1775)	1	0	0	0	0	5	0	0	0	0	0	0	SR
Stenopterus rufus (Linnaeus, 1767)	47	35	15	3	4	0	18	0	0	0	0	0	RA
Callimellum angulatum (Schrank, 1789)	6	0	5	0	0	0	0	0	0	0	0	0	SR
Ropalopus macropus (Germar,1824)	0	0	0	0	2	5	0	0	0	0	5	0	SR
Paraplagionotus floralis (Pallas, 1773)	0	2	0	0	0	0	0	0	0	0	0	0	SR
Xylotrechus sieversi (Ganglbauer, 1890)	0	1	0	0	0	0	0	0	0	0	0	0	SR
Clytus arietis (Linnaeus, 1758)	1	2	1	0	0	0	0	1	0	0	2	0	SR
Phytoecia cylindricus (Linnaeus, 1758)	0	0	0	0	0	12	2	0	0	0	0	0	RA
Agapanthia persicola Rtt. 1894)	0	0	0	0	0	0	2	0	0	0	0	0	SR
Total	195	236	52	22	80	51	103	76	25	56	385	11	1292

Note: color pan traps (WhP: white, YeP: yellow, BlP: blue, ReP: red, GrP: green) and color sticky traps (WhS: white, YeS: yellow, Bls: blue, ReS: red, GrS: green); DD: Degree of dominant (ED: eudominant, DO dominant, SD: subdominant, RA: rare and SR: sub-rare).

Table 2. List of species of wood-boring beetles (Buprestidae and Cerambycidae) taken in different traps in 2009

Family and species	Color pan traps				DD
	WhP	YeP	Mal	Win	
Buprestidae					
Acmaeodera rufoguttata (Reitter, 1890	28	32	2	320	DO
Acmaeoderella flavofasciata (Piller et Mitterparcher, 1783	8	3	1	19	RA
Acmaeoderella gibbulosa (Menetries, 1832)	0	0	0	1	SR
Capnodis tenebricosa (Oliver, 1790)	0	0	0	3	SR
Lamprodila tuerki (Ganglbauer, 1882)	0	0	0	1	SR
Anthaxia hyrcana (Kiesenwatter et Kirsch, 1880	118	120	1	4	DO
Anthaxia intermedia (Obenberger, 1913	15	27	2	10	RA
Anthaxia hungarica (Scopoli, 1772)	0	5	0	0	SR
Anthaxia cichori (Olivier, 1790)	0	2	0	1	SR
*Anthaxia bicolor (*Falderman, 1835	0	1	0	0	SR
Chrysobothris affinis (Fabricius, 1794)	2	7	5	35	RA
Melanophila decastigma (Fabricius, 1787)	0	0	0	1	SR
Agrilus sp.	195	123	73	249	ED
Coraebus rubi (Linneaeus, 1767)	0	0	1	2	SR
Trachys phlyctaenoides Kolenati, 1846)	0	0	2	41	RA
Cerambycidae					
Prionus coriarius (L., 1757)	0	1	1	0	SR
Rhagium pygmaeum (Ganglb,1882)	0	0	0	1	SR
Fallacia elegans (Faldermann, 1837)	0	0	1	0	SR
Alosterna scapularis (Hey. 1878)	11	6	3	4	RA
Anoplodera rufipes (Sshaller, 1783)	0	2	0	0	SR
Paracorymbia tonsa (J. Daniel et K. Daniel. 1891)	14	0	0	4	SR
Molorchus monticola Plavilstshiko, 1933)	5	4	1	5	SR
Stenopterus rufus (Linnaeus, 1767)	104	64	19	20	DO
Callimellum angulatum (Schrank, 1789)	13	18	0	2	RA
Ropalopus macropus (Germar,1824)	0	2	3	2	SR
Anaglyptus sp.	0	1	0	2	SR
Paraplagionotus floralis (Pallas. 1773)	0	0	3	0	SR
Chlorophorus figuratus (Scop. 1763)	0	2	0	1	SR
Clytus arietis (Linnaeus, 1758)	0	1	1	5	SR
*Acanthocinus elegans (*Ganglb. 1884)	1	0	0	0	SR
Terops gilvipes (Fald. 1837)	0	0	4	0	SR
Phytoecia cylindricus (Linnaeus, 1758)	0	1	3	1	SR
Agapanthia kirbyi (Gellenhal, 1817)	0	0	0	1	SR
Agapanthia walteri (Reitter, 1898	0	1	0	2	SR
Agapanthia subchalybaea (Reitter 1898)	0	0	2	3	SR
Agapanthia persicola (Reitter 1894)	2	2	0	19	RA
Total	516	425	128	759	1828

Note: color pan trap (Wh: white and Ye: yellow), Ma: malaise trap and Win: window trap; DD: Degree of dominant (ED: eudominant, DO dominant, SD: subdominant, RA: rare and SR: subrare)

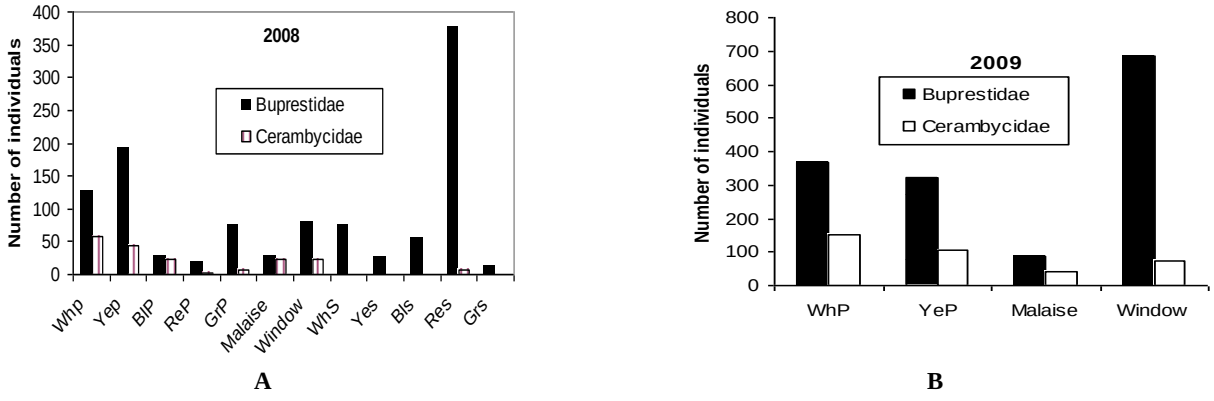

Figure 6. The total number of individuals of Buprestidae and Cerambycidae collected by using different traps: A. Color pan traps (WhP: white, YeP: yellow, BlP: blue, ReP: red, GrP: green); B. Color sticky traps (WhS: white, YeS: yellow, Bls: blue, ReS: red, GrS: green), Malaise and window traps (years 2008 and 2009).

Table 3. The χ^2 test values for the differences in the attractiveness of the traps for wood-boring beetles (Buprestidae and Cerambycidae). Color pan traps (WhP: white, YeP: yellow, BlP: blue, ReP: red, GrP: green), Mal: Malaise and Win: window traps.

Traps	WhP	YeP	BlP	ReP	GrP	Mal	Win
YeP	174.716***						
BlP	164.580***	133.632***					
ReP	100.091***	104.604***	62.743***				
GrP	91.137***	11.332***	67.498***	64.606***			
Mal	24.021*ns*	26.152 *ns*	4.8 *ns*	20.243 *ns*	48.649**		
Win	106.213***	132.402***	71.437***	87.619***	70.23**	44.583**	

Note: ** P<0.001, *** P<0.001

Table 4. The χ^2 test values for the difference in the attractiveness of the traps for wood-boring beetles (Buprestidae and Cerambycidae) in sticky color traps (WhS: white, YeS: yellow, Bls: blue, ReS: red, GrS: green).

Color sticky trap	WhS	YeS	BlS	ReS	GrS
YeS	109.485***				
BlS	80.114***	59.706***			
ReS	119.461***	80.974***	99.751***		
GrS	80.174***	99.444***	80.123***	120.307***	

Note: *** P<0.001

Species similarity and abundance in different traps

The dendrogram of the similarity of the species composition and abundance in different traps are shown in Figures 5 and 6. The highest similarity (~ 79%) was between wood-boring beetles caught in the white and yellow pan traps during 2008 (Figure 10) and 2009 (Figure 11) samplings. Yellow and green sticky traps showed more than 60% similarity.

Table 5. The χ^2 test values for the difference in the attractiveness of the traps for wood-boring beetles (Buprestidae and Cerambycidae). WhP: white pan trap, YeP: yellow pan trap, Mal: Malaise trap and Win.: window trap

	WhP	YeP	Mal
Ye	346.87***		
Mal	129.63***	152.28***	
Win	251.29***	259.05***	157.06***

Note: *** P<0.001

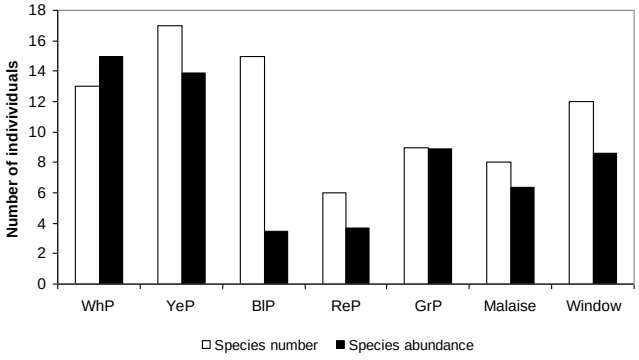

Figure 7. The total number of buprestid and cerambycid species and their abundance in color pan traps (WhP: white, YeP: yellow, BlP: blue, ReP: red, GrP: green), Malaise and window traps in 2008

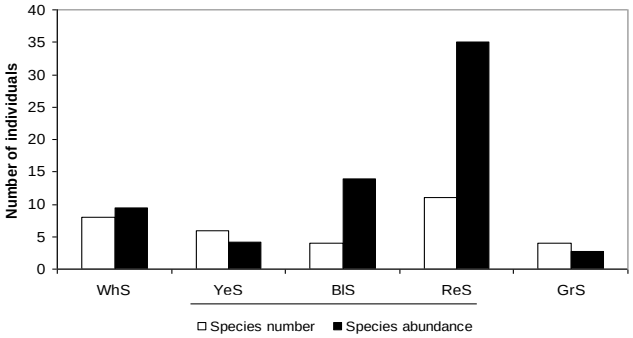

Figure 8. The total number of buprestid and cerambycid species and their abundance in sticky color traps (WhS: white, YeS: yellow, BlS: blue, ReS: red, GrS: green) in 2008

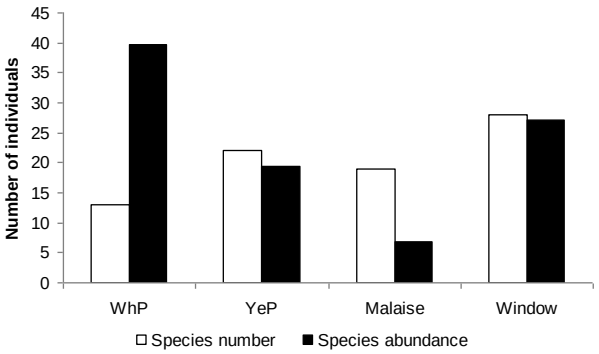

Figure 9. The total number of buprestid and cerambycid species and their abundance in color pan traps (WhP: white and YeP: yellow), Malaise and window traps in 2009

The attractiveness of the traps to different species

The results also indicated differences in the attractiveness of the traps for different species of Cerambycidae and Buprestidae (Tables 3-5). Among those 55 caught species, five species (mostly Buprestidae) and one genus were dominant (Figures 12-14). According to Figure 11, window trap was the most attractive trap for *Acmaeodera rufogutata* (Col.: Buprestidae) and *Agrilus* spp (Col.: Buprestidae), but not for *Anthaxia hyrcana* (Col.: Buprestidae) and *Stenopterus rufus* (Col.: Cerambycidae). White pan trap was the most attractive trap for *Agrilus* spp. It was also attractive for *Anthaxia hyrcana* and *S. rufus* but to a less degree. Yellow pan trap was attractive to *Agrilus* spp. and *Anthaxia hyrcana* but with a less degree for *Acmaeodera rufogutata* and *S. rufus*. Malaise trap was only attractive for *Agrilus* spp and S. *rufus* in small numbers. Red sticky traps were the best ones for collecting *Chrysobothris affinis* (Figure 13) and *Anthaxia intermedia* (Figures 14).

According to Tables 1 and 2, the following 15 subrare species were only caught by typical traps: *Acmaeoderella gibbulosa*, *Anthaxia passerine* and *Sphenoptera cauta* (all Col.: Buprestidae) by blue pan traps; *Lamprodila tuerki* (Col.: Buprestidae) by green pan traps; *Agrilus pratensis* (Col.: Buprestidae) by red pan trap; two buprestids (*Anthaxia hangarica*, *Agrilus viridis*) and two cerambycids *(Paraplagionotus floralis*, *Xyloterechus sieversi*) by yellow pan traps; *Dicerca fritillum* (Col.: Buprestidae) and *Teropes gilvipes* (Col.: Cerambycidae) by Malaise trap and four Buprestids (*Dicerca scabida*, *Agrilus biguttatus*, *Agrilus obscuricollis* and *Agrilus hyperici*) by red sticky traps. *Anthaxia bicolor* (Col.: Buprestidae) was only found in white color traps.

A rare buprestid species (*Capnodis tenebricosa*) was only attracted to red color (mostly red sticky traps).

Flight activity of dominant species

The seasonal activity of many caught species varied during sampling periods. A maximum number of wood-boring beetles (Cerambycidae and Buprestidae) were trapped in late May to early July (Figure 15). However, most of the dominant species were captured throughout the spring, with peak catches of *Ch. affinis* and *Anth. intermedia* on 25 April, *A. rufigutata* on 21 April, *Anth. hyrcana* on 5 May, *Agrillus* spp on 22 May and *S. rufus* on 9 April (Figures 16 and 17).

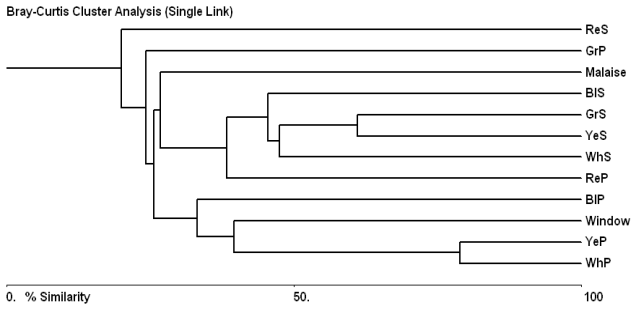

Figure 10. Similarity dendrogram of species composition and abundance in different traps: color pan traps (WhP: white, YeP: yellow, BlP: blue, ReP: red, GrP: green), color sticky traps (WhS: white, YeS: yellow, Bls: blue, ReS: red, GrS: green), Malaise and window traps (year 2008)

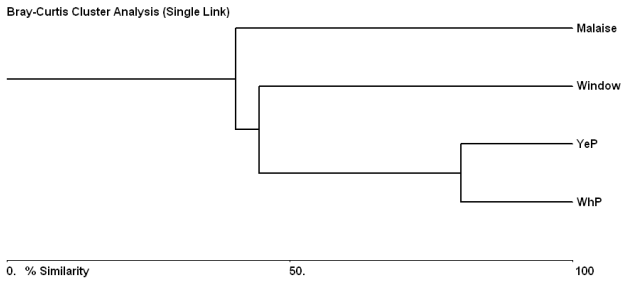

Figure 11. Similarity dendrogram of species composition and abundance in different traps: color pan traps (WhP: white, YeP: yellow), malaise and window traps (the Year 2009)

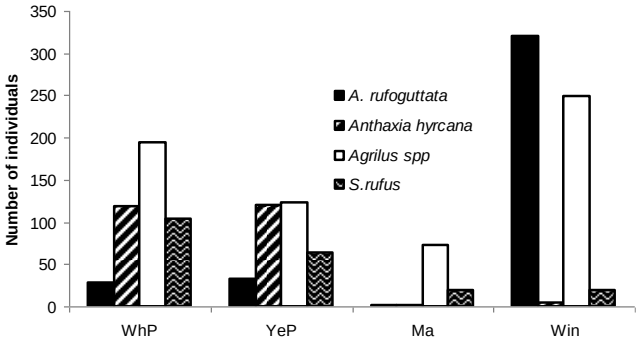

Figure 12. The dominant taxa caught by the various traps in 2009. WhP: white pan trap, YeP: yellow pan trap and Mal: Malaise trap and Win: Window trap

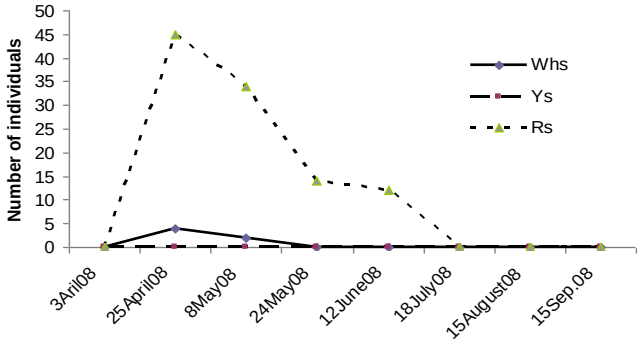

Figure 13. The dominant species (*Chrysobothris affinis*) caught by the various color sticky traps (Whs: white, Ys: yellow and Rs: red) during 2008 sampling

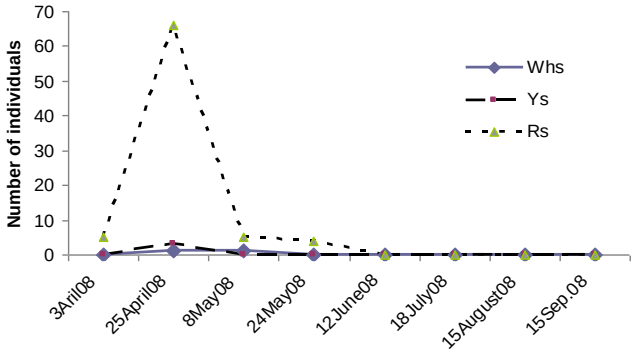

Figure 14. The dominant species (*Anthaxia intermedia*) caught by the various color sticky traps (Whs: white, Ys: yellow and Rs: red) during 2008 sampling

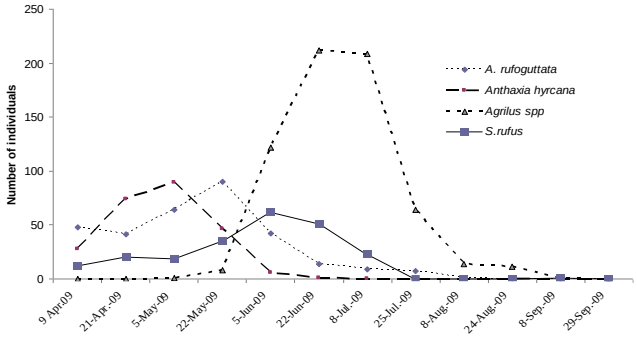

Figure 16. Seasonal dynamics of the dominant species (*A. rufoguttata*, *Anth. hyrcana* and *S. rufus*) and *Agrilus* spp caught by color pan traps (yellow and white), Malaise and window trap during 2009 samplings

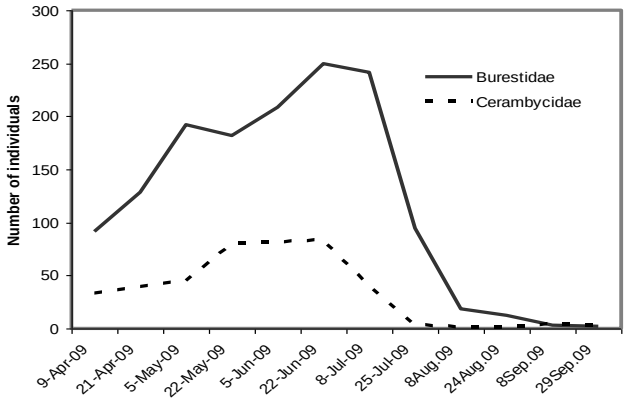

Figure 15. Seasonal dynamics of all number of wood-boring beetles (Cerambycidae and Buprestidae) caught by different tarps (yellow pan trap, white pan tap, Malaise and window trap) in 2009

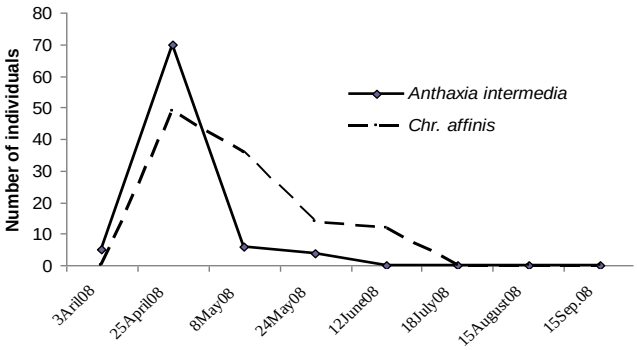

Figure 17. Seasonal dynamics of the two dominant species (*Anthaxia Intermedia* and *chr. affinis*) caught by color sticky traps during 2008 samplings

The results of this study suggested the significant differences in efficacy of different trap types (i.e. color pan traps, sticky color traps, Malaise and window traps) for collecting the members of the two important families of wood-boring beetles of Mazandaran forests (i.e., Buprestidae and Cerambycidae). Our findings are similar to those from Sakalin and Langourov (2004) (color taps), Olivier et al. (2004) (sticky color traps) and Michael et al. (2004) (window and Malaise traps). In 2008, window traps and malaise traps were set up in small number as monitoring action, but in 2009 our experiment was very comprehensive with setting more different traps in different areas which resulted in very reliable findings (Table 2). Window trap was the best one for collecting the beetles both in the case of different species and of individual numbers, while red pan trap collected only a few beetles (during 2008-2009) (Figure 6). After a window trap, two-color pan traps (white and yellow) were also very suitable for collecting the beetles. Wermelinger et al. (2002) used window traps and yellow pan traps as suitable collecting methods for capturing Scolytidae, Cerambycidae, and Buprestidae. Differences in the performance of the trap types can partly be explained by several factors that can influence the efficacy of the traps; trap shape, color and design might play an important role (Lindgren et al. 1983, Borden et al. 1986; Flechtmann et al. 2000).

According to our results in 2009, 28 of the total 36 species were caught by window traps. These suggested that the window trap is the most suitable trap for collecting different species in high numbers of individuals. It seems that species landing on the ground are fairly easily sampled by window trap. According to McIntosh et al. (2001), landing behavior is also likely to play a role in catching efficacy. Characteristic of landing behavior was also observed in other insects (Goodman 1960).

The high number of individuals caught by white and yellow pan traps (Table 2) is similar to what has been documented for buprestid species by Sakalin and Langarov (2004). They believed that the jewel beetles show a preference for white and yellow color traps.

As Tables 1 and 2 showed, 15 sub-rare species and one rare species were only caught by typical traps, and these species were not found in any other kinds of traps. Among all kinds of traps employed in the present study, yellow pan trap and red sticky trap were more effective. It might be concluded that these kinds of traps are more suitable for

monitoring subrare and rare species in the forests; however, catching single specimens by some traps may not be considered as indicative of trap performance.

The results also revealed that *Capnodis tenebricosa* and *Anthaxia bicolor* were only collected by red and white color traps, respectively. In this case, visual cues may play a role, because in many species, visual orientation may play a role in host location and selection (Schonherr 1977; Mathieu et al. 1997; Flechtmann et al. 2000), and an interaction between host attractants and visual stimuli might occur (Vite and Bakke 1979; Borden et al. 1982).

In our 2-year study, the majority of caught specimens were Buprestidae (~80%), while only 20% were Cerambycidae (Figure 6). This difference migh had been caused by the different duration of larval development stages of these beetles, which often take several years. Therefore, a more extended period of field study is needed. We found that maximum flight activity of the wood-boring beetles occurred in June and early July, which concurs with Wermelinger et al. (2002).

In conclusion, this study was the first comprehensive field study in Iran using different traps for a faunistic survey of Buprestidae and Cerambycidae, which introduced the suitable traps for sampling, monitoring, evaluation of the population density and seasonal dynamic of Mazandaran forest wood-boring beetles.

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