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

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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 employed in five study areas, collected a total of 3120 beetles belonging to 55 species (29 Buprestidae and 26 Cerambycidae). 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's level. One genus (Agriulus) and the following five species were the dominant species: Acmaeodera rafoguttata 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; Hanks1999) 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 forms of degraded wood and volume loss. Therefore, most of these beetles are dangerous pests of forest and fruit trees, shrubs and herbaceous plants, with an important biological role 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 dead wood 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 dead wood (Siitonen 1994). However, these methods have proved unsatisfactory in many respects (Bouger et al. 2008).

The use of traps for the capture of flying insects, especially beetles, has long been an integral part of many entomological field investigations (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 (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, including 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 ha) containing Quercus castanifolia and Parotia persicae. Pahneh-Kola (53° 03' 06" E, 36° 27' 14" N; 218 m): This site is located in 13 km south of Sari City in a forestry nursery. It was surrounded by dominant trees such as Q. castanifolia. 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 in 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): Posht Koh 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): Type of this forest is Fago-carpino forest and is located 90 km of Sari City.

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, 120-150 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 (Figure 2). Sticky trap - The trap dimensions refer to Figure 2, 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.

Figure 1. The geographical situations of the study sites in Sari City, Mazandaran Province, Iran
The space between each of the trap was 100 cm (Figure 4). Besides, 12 other color sticky traps (red, white and yellow) were set up in Alamdardeh and Posht Koh (two traps from each color). 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 3, 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) (Figure 5). Malaise trap-The trap dimensions refer to Figure 4, according to Townes (1962). Malaise traps were placed in Dashte-Naz and Pahneh Kola only (one Malaise trap in each mentioned site) (Figure 3). 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 Alilkola 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 window 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 (χ²) 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 type 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 species belonging to 23 genera were Cerambycidae, (Tables 1 and 2). 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 tape 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; Table S3, 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 (Figure 6). No significant differences in the catch was 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. Wood-boring beetles (Buprestidae and Cerambycidae), by species, taken in different traps in 2008

| Family and species | Colour pan traps | Traps shape | Colour sticky traps | DD |
|--------------------|------------------|-------------|---------------------|----|
|                    | WhP YeP BIP ReP GrP Malaise Window WhS YeS BiS ReS GrS |             |                     |    |
| Buprestidae        |                  |             |                     |    |
| Acmaeodera pilosella (Bonelli, 1812) | 1 1 0 0 0 0 0 5 0 0 0 0 0 0 | SR |
| Acmaeodera rufoguttata (Reitter, 1890) | 26 38 1 9 4 2 61 12 5 0 38 2 0 2 | DO |
| Acmaeodrella flavofaciata (Piller et Mitterpacher, 1783) | 0 5 1 0 0 0 4 0 0 0 0 0 0 0 | SR |
| Acmaeodera melas (Biebien, 1865) | 0 0 1 0 0 0 1 0 0 0 0 0 0 0 | SR |
| Acmaeodera gibbula (Menetries, 1832) | 0 0 1 0 0 0 0 0 0 0 0 0 0 0 | SR |
| Capnodis tenerebrics (Oliver, 1790) | 0 0 0 1 0 0 0 0 0 0 0 0 0 52 0 | RA |
| Dicerca frillitum (Menetries, 1832) | 0 0 0 0 0 2 0 0 0 0 0 0 0 0 0 | SR |
| Dicerca scabida (Marseil, 1865) | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3 0 | SR |
| Lampropila tuerki (Ganglbauer, 1882) | 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 | SR |
| Sphenoptera cauta (Jakovlev, 1904) | 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 | SR |
| Anthaxia hyrcana (Kiesenwetter et Kirsch, 1880) | 97 125 9 0 0 0 0 0 11 6 0 0 0 0 | DO |
| Anthaxia intermedia (Obenberger, 1913) | 1 2 0 4 1 0 0 15 7 5 122 5 0 0 | DO |
| Anthaxia passerina (Peccchioli, 1837) | 0 0 2 0 0 0 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 0 0 0 | SR |
| Anthaxia cichori (Olivier, 1790) | 0 4 1 0 0 0 0 0 0 0 0 0 0 0 0 | SR |
| Anthaxia bicolour (Falderman, 1835) | 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 | SR |
| Chrysobothris affinis (Fabricius, 17940) | 0 0 0 0 0 2 3 2 15 5 6 157 3 0 | DO |
| Agrius viridus (Linneaus, 1758) | 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 | SR |
| Agrius biguttatus (Fabricius, 1777) | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 | SR |
| Agrius derosulfus (Lacordaire, 1835) | 1 1 1 0 0 1 0 2 0 0 0 0 0 0 0 | SR |
| Agrius obscuricolli (Kiesenwetter, 1857) | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | SR |
| Agrius prattensis (Ratzburg, 1837) | 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 | SR |
| Agrius hypericeti (Creutzer, 1799) | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 | SR |
| Agrius graminis (Kiesenwetter, 1857) | 9 7 10 4 48 0 4 0 0 0 0 0 0 0 | SD |
| Coraesia elata (Fabricius, 1787) | 1 1 0 0 3 0 2 0 1 0 0 1 0 0 | SR |
| Coraesia rubi (Linneaus, 1767) | 0 3 0 0 1 0 0 2 1 0 0 0 0 0 | SR |
| Trachys phyctaenoides (Kolenati, 1846) | 0 0 0 0 0 0 0 19 0 43 3 0 0 | SD |
| Cerambycidae        |                  |             |                     |    |
| Rhagium pygmaeum Ganglb,1882) | 0 0 2 0 0 0 0 0 0 0 0 0 0 0 0 | SR |
| Anoplophora rufipes (Shshaler, 1783) | 3 0 0 0 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 0 0 0 SR |
| Paracoryphia tonsa (J. Daniel et K. Daniel, 1891) | 0 0 0 0 0 1 1 0 0 0 0 0 0 0 | SR |
| Cerambyx scopolii (Fusslinis, 1775) | 1 0 0 0 0 5 0 0 0 0 0 0 0 0 | SR |
| Stenopterus rufus (Linneaus, 1767) | 47 35 15 3 4 0 18 0 0 0 0 0 0 0 | RA |
| Callinumm angulatum (Schrank, 1789) | 6 0 5 0 0 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 0 0 | SR |
| Paraplagionotus florialis (Pallas, 1773) | 0 2 0 0 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 0 0 | SR |
| Clytus arietis (Linneaus, 1758) | 1 2 1 0 0 0 0 1 0 0 2 0 0 0 | SR |
| Phytoecia cylindricus (Linneaus, 1758) | 0 0 0 0 0 0 12 2 0 0 0 0 0 0 | RA |
| Agapanthia percisola Rtt. 1894) | 0 0 0 0 0 2 0 0 0 0 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, BIP-blue, ReP-red, GrP-green) and color sticky traps (WhS-white, YeS-yellow, BiS-blue, ReS-red, GrS-green); DD-Degree of dominant (ED-eudominant, DO dominant, SD-subdominant, RA-rare and SR-sub-rare
Table 2. Wood-boring beetles (Buprestidae and Cerambycidae), by species, 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 |
| Acmaeodera flavofasciata (Piller et Mitterpacher, 1783) | 8   | 3   | 1   | 19  | RA |
| Acmaeodera gibulosa (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 (Kiesenwetter 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 (Faldeman, 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 (Linnaeus, 1767) | 0   | 0   | 1   | 2   | SR |
| Trachys phylacteinaeoides (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 (Faldernmann, 1837) | 0   | 0   | 1   | 0   | SR |
| Alosterna scapularis (Hei. 1878) | 11  | 6   | 3   | 4   | RA |
| Anoplolepra rufipes (Schaller, 1783) | 0   | 2   | 0   | 0   | SR |
| Paracorymbia tona (J. Daniel et K. Daniel. 1891) | 14  | 0   | 0   | 4   | SR |
| Molochus monticola (Plavilstshikio, 1933) | 5   | 4   | 1   | 5   | SR |
| Stenoftera 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 |
| Paraplagionous florialis (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 |
| Phytocercus cylindricus (Linnaeus, 1758) | 0   | 1   | 3   | 1   | SR |
| Agapanthia kirbyi (Gellenhall, 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)
Figure 7. The total number of buprestid and cerambycid species and their abundance in color pan traps (WhP-white, YeP-yellow, BIP-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.

Table 3. The χ² 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, BIP-blue, ReP-red, GrP-green), Malaise and Window traps.

| Traps | WhP   | YeP   | BIP   | ReP   | GrP   | Mal   | Win   |
|-------|-------|-------|-------|-------|-------|-------|-------|
| YeP   | 174.716*** |       |       |       |       |       |       |
| BIP   |       | 164.580*** |       |       |       |       |       |
| ReP   | 100.091*** | 104.604*** |       | 62.743*** |       |       |       |
| GrP   | 91.137*** | 67.498*** | 64.606*** |       |       |       |       |
| Mal   | 24.021ns | 26.152ns | 4.8 ns | 20.243ns | 20.243ns | 70.23** | 44.583** |
| Win   | 106.213*** | 132.402*** | 71.437*** | 87.619*** | 70.23** | 44.583** |       |

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

Table 4. The χ² 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.
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 Acmaeoder a 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 Acmaeoder a 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 the tables 1 and 2, the following 15 subrare species were only caught by typical traps: Acaederella 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 fritillium (Col.: Buprestidae) and Teropes gilipes (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 was variable 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 dominate 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).
The results of this study suggested the significant differences of efficacy of different trap types (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 trap 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 the 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 subrame 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 *Anthisa 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 might have 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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