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Some Behavioral Observations on Larvae of Antlion, *Myrmeleon formicarius* Linnaeus, 1767 (Neuroptera: Myrmeleontidae) in Forest and Non-Forest Areas of Kahramanmaras Province, Turkey

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Abstract.- Kahramanmaraş (K. Maraş), located on C6 square by grid system, has a great deal of endemic biodiversity and worthwhile environmental features for both animal and plant species. The study was conducted in the months of May to August in 2009, 2010 and 2011 with a view to determining certain behavioral features in the larvae of antlion *Myrmeleon formicarius* Linnaeus, 1767 in forest and non-forest (including sandy, grassland, scrub, and rangeland) areas 28 localities of Kahramanmaraş. The species was reported for the first time in the west and south of Turkey. The effects of some physical parameters such as temperature, altitude, sand particle size, weather conditions, plant species and locality features were examined on the antlion pit size. Vegetation of the area was also studied. It was inferred that the sand particle size and locality features had a noteworthy effect on the pit size, whereas soil temperature, altitude and weather conditions had no effect. *M. formicarius* larvae in habitats other than forests had larger pit size than forest areas in Kahramanmaraş. Additionaly it was observed that *Fagus* sp., *Pinus halepensis*, *P. pinea*, *Picea abies*, *Quercus infectoria*, and *Myrtus communis* were abundant in the forest area. Besides, presence of *Geranium glaberrimum*, *Ricoata sinua*, *Papaver* sp., *Delphinum cilicium*, *Corydalis solida* and *Rubus sanctus* were the dominant species in the non-forest area.

Key words: Antlion behaviour, *Myrmeleon formicarius*, pit size, Neuroptera.

INTRODUCTION

Forest landscape comprises numerous mosaic units of various types including arable orchards, gardens, meadows and forest stands. Suitable habitat types for lacewings may be scattered over a large landscape. The forests harbour rich biodiversity. Neuroptera are generally accepted by Entomologists to be arboreal (Aspöck *et al*., 1980). Kahramanmaraş in the Mediterranean of Turkey is rich in broad leaved forest resources. Varol and Tatli (2003) reported 1336 plant species from Irano-Turanian, Euro-Siberian and Mediterranean phytogeographical regions out of which 68 species were endemic to Kahramanmaraş province. The flora of Engizek Mountains (located along the boundary of Kahramanmaraş) includes 1036 species (including sub species and varieties). Duman (1990) reported 207 species for the first time from C6 square.

Antlions (Myrmeleontidae) is the biggest and cosmopolitan family of Neuroptera whose larvae have adopted a diversity of predatory strategies. The antlions are known for their unique pitfall or catching method of hunting. Naturalists have been interested in their highly specialized way of life since early twentieth century (Wheeler, 1930). They generally inhabit the warmer and tropical parts of the world (Devetak and Devetak, 2004). They have not been studied in Kahramanmaraş, Turkey the area located in the C6 square by grid system. The area has a great deal of endemism. Antlions of the species *Myrmeleon formicarius* are best known for the ability of their larvae to build inverted conical pits in dry, loose, fine grained soil. Antlion pits provide the antlion larvae with an effective means of capturing prey (Turner, 1915; Akman, 1973; Topoff, 1977). They construct a conical pit in the sand and wait for the prey. The soft-bodied arthropod that accidentally slips down the pit is seized and pierced by the mandibles and the entire body sucked almost immediately (Corner and Eisner, 1983).

Sand particle size has a considerable effect on arthropod locomation especially the ants (Botz *et*

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al., 2003). Antlion pits are usually made in shaded areas such as under ledges of rock, under logs which do not touch the ground at all points or under man made sources of shade (Turner, 1915; Haub, 1942; Green, 1955; Topoff, 1977). Weather conditions also affect the species. Physical factors of the environment like soil temperature of the habitat and the altitude may also play a role in determining the process of pit construction by antlion larvae (Klein, 1982).

There is little previous work on the physical determinants of pit size considering the physical and ecological parameters in Turkey. The paper focuses on the micro distribution of *Myrmeleon formicarius* larvae and some behavioral parameters of the biology of this species in forests and non-forest areas in K. Maraş. The paper also discusses the releationship between the behaviour of *M. formicarius* larvae based on different physical parameters (temperature and altitude) and pertaining to climate factors and different plant species in the study areas.

MATERIALS AND METHODS

Instar determination

Head width, jaw length and total body length with and without jaws, total body length including the jaws of second instar larvae were measured using eyepiece micrometer in a Stereomicroscope, Soif mark.

Temperature

In the surveyed area, temperature of the habitat was measured using digital thermometers WHM 110 Weewell Mark Digital Higro Thermometer.

Sand particle size

Sand samples were collected by using twenty-eight eppendorf tubes (170 mm length, 120 mm width, 60 mm height) from all the surveyed areas and carried to laboratory for investigating. The sand was seperated into nine size classes by sieving, resulting in particle diameter ranges of 0.10 mm, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.50 and 0.60 mm.

Measuring pit size

Diameter of all pits was measured by a ruler consistenced to conical formed areas in the surveyed areas.

Determining locality coordinate(s)

GPS coordinates (dd° mm' sss) of survey locations were determined by using Garmin 1410 Navigation Device.

Sample collection

Plant species and sand samples were collected from 28 different locations in K. Maraş (Turkey) for three years

RESULTS

M. formicarius larvae pit sizes in relation to several physical factors and plant species are shown in Tables I, II. The pit of *M. formicarius* is shown in Figure 1 and the larvae in Figure 2. Locations where *M. formicarius* larvae were observed are shown in Figure 3.

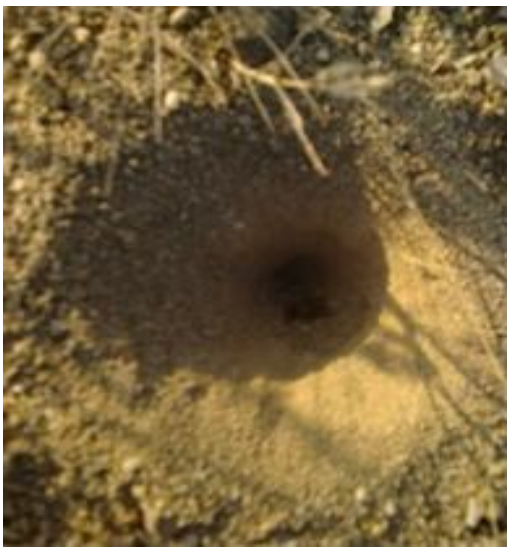

Fig. 1. The view of *M. formicarius* larvae pit in Ekinözü, Kahramanmaraş

Relationship between sand particle size and pit diameter

The pit size increased with an increase in sand particle size, registering a positive correlation between the sand particle size and *M. formicarius*

Table I.- Physical environment features (air temperature, weather conditions and sand particle size) in relation to pit diameter of *M. formicarius* recorded from forest and non-forest areas of Kahramanmaras Province, Turkey

Loc. number	Locality	Altitude (m)	Date/Time	Air temp (°C)	Sand particle size (mm)	Pit diameter (mm)	Weather conditions
Forest areas							
1	Afşin	1352	09/07/2009	29	0.20	21	Cloudy
3	Andırın	1109	12/07/2009	28	0.15	19	Light windy
11	Ekinözü	1674	20/09/2009	33	0.20	24	Sunny
13	Ekinözü	1219	28/09/2009	34	0.30	25	Sunny
15	Elbistan	1510	15/05/2010	32	0.20	21	Sunny
17	Elbistan	1341	18/05/2010	29	0.25	25	Cloudy
19	Göksun	1612	04/06/2010	30	0.25	24	Sunny
20	Göksun	1388	04/06/2010	31	0.10	20	Light rainy
21	Nurhak	1432	05/06/2010	33	0.15	20	Sunny
23	Nurhak	685	05/07/2011	34	0.25	24	Sunny
26	Türkoğlu	653	09/07/2011	33	0.15	21	Sunny
Non-forest areas							
2	Afşin	1214	11/07/2009	30	0.40	27	Partly cloudy
4	Andırın	924	18/07/2009	32	0.30	28	Light windy
5	Andırın	1059	21/07/2009	32	0.40	33	Light windy
6	Andırın	1391	25/08/2009	31	0.35	40	Sunny/ligt windy
7	Andırın	1085	02/08/2009	34	0.60	40	Partly cloudy
8	Çağlayancerit	1320	09/08/2009	28	0.50	39	Sunny
9	Çağlayancerit	1484	15/08/2009	28	0.25	32	Sunny/ligt windy
10	Çağlayancerit	1503	19/09/2009	32	0.50	31	Sunny
12	Ekinözü	1674	20/09/2009	29	0.40	35	Sunny
14	Elbistan	1219	14/05/2010	30	0.50	39	Sunny
16	Elbistan	1510	12/05/2010	27	0.30	26	Light rainy
18	Göksun	1341	01/06/2010	34	0.40	29	Sunny
22	Nurhak	1432	05/06/2010	29	0.30	26	Sunny/light windy
24	Türkoğlu	574	07/07/2011	30	0.50	29	Sunny
25	Türkoğlu	685	08/07/2011	29	0.35	27	Light rainy
27	Türkoğlu	823	10/07/2011	30	0.50	36	Cloudy
28	Türkoğlu	615	11/07/2011	32	0.60	36	Cloudy

pit size. The minimum and maximum pit size was respectively 19 mm (range: 19 to 25 mm) in forest areas, and 40 mm (range: 26 to 40 mm) in non-forest areas. The sand particle size ranged between 0.15 and 0.30 mm in the forest area and 0.25 and 0.60 mm in the non-forest areas. It was inferred that i) the pit size increase depended on the size of sand particles collected around the pit and that ii) the pit and sand particle size in non-forest areas were higher than those in forest areas.

Effect of altitude and temperature on pit diameter

The altitude had no impact on the construction of the pit or the pit size (data given in Table I). Larvae built 36 mm sized pit at 823 m altitude (Locality No. 27); at 1616 m elevation the pit size was 25 mm (Loc. No. 13) and 36 mm at 615 m (Loc. No 28). The inconsistent results indicated that there was no difference or releationship between the larvae habitat altitude and the pit size. During three years study period temperatures fluctuated from 27°C to 34°C in the habitats.

Changing of locality features in pit diameter

The larvae were living in pits of bigger size in non-forest areas (min-max: 26-40 mm) than those living in pits located in forest areas (min-max 19-25 mm) in 28 different localities (Table I).

Table II.- Plant species related to Neuroptera collected from forest (including edges) and non-forest areas (including areas outside forest) in K. Maraş.

Locality Number	Plant species
Forest areas (including edges)	
1	*Q. infectoria, Picea abies, Taraxacum revertens*
3	*P. nigra, Orcho palustris*
11	*P. halepensis.*
13	*P. pinea, Abies cilicia, Fagus orientalis, Sanicula europea*
15	*Fagus sp.*
17	*Salvia pilifera, F. orientalis,P. nigra*
19	*Q. infectoria, Picea abies, Salix sp.*
20	*P. nigra, Myrtus communis, Arbutus andrachne*
21	*P. halepensis, Myrtus communis*
23	*P. pinea,*
26	*Fagus sp., P. pinea*
Non forest areas (including areas outside forest)	
2	*Rosa canina*
4	*Rubus sanctus, Delphinium cilicium*
5	*Elaeagnus angustifolia*
6	*Paliurus spina-christi, Veronica macrostachya*
7	*Cerasus microcarpa*
8	*Ranunculus sp., Rubus sanctus*
9	*Astragalus gummifer*
10	*Orlaya daucoides, Papaver sp.*
12	*Delphinium cilicium, Papaver rhoeas*
14	*Polygonum amphibium Chenopodium album*
16	*Corydalis solida subsp. Tauricola*
18	*Ricotia sinuata, Orchis morio, Arrhenatherum elathus.*
22	*Geranium glaberrimum*
24	*Ricotia sinuata*
25	*Papaver sp., Rubus sanctus*
27	*Coronilla scorpioides*
28	*Lathyrus inconspicuus*

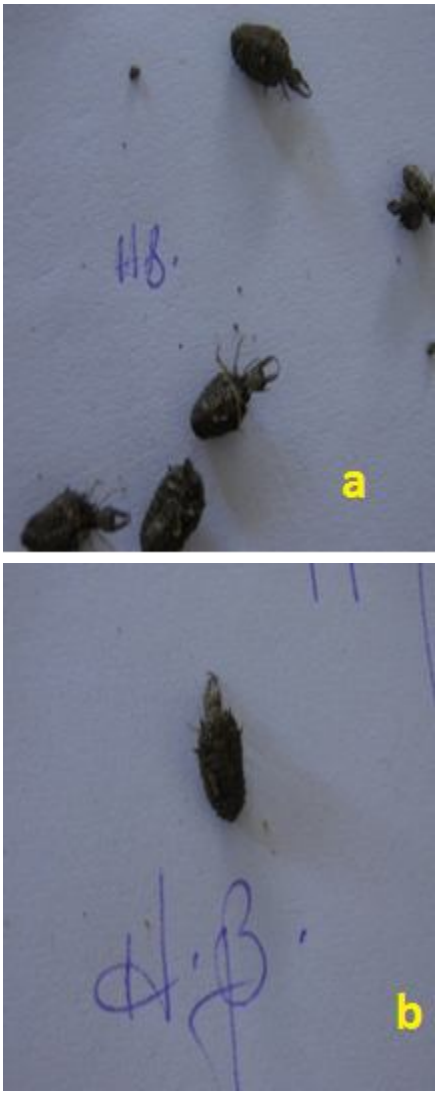

Fig. 2. The view of *M. formicarius* larvae
a: dorsal and ventral view, b: dorsal view

Weather conditions

Weather conditions varied during 3 years study period; partly cloudy, light windy, sunny/ light windy, sunny, light rainy, and cloudy. Different pit diameter dimensions were recorded at localities 1 (pit size: 21 mm) and 17 (pit size: 25 mm) under similar weather conditions (cloudy, air temp. 29°C, Table I). Similarly pit size was different in localities 2 (pit size: 27 mm) and 7 (pit size: 40 mm) under the same weather conditions (Table I). Weather conditions therefore, did not have any impact on the antlion larvae pit size.

Plant species in 28 different localities

Plant species were collected from inside the forest, edges (forest area) and outside of the forest (non-forest area) from 28 locations. In the surveyed area *Geranium glaberrimum, Ricoata sinua, Papaver* sp., *Delphinum cilicium, Corydalis solida* and *Rubus sanctus* were common outside the forest. Common species in all the forested locations were: *Pinus halepensis, P. pinea, Quercus infectoria,* and *Salix* spp. (Table II). In areas other than forests *Rosa canina, Paliurus spina-christi, Veronica macrostachya, Cerasus* sp., *Ranunculus* sp.,

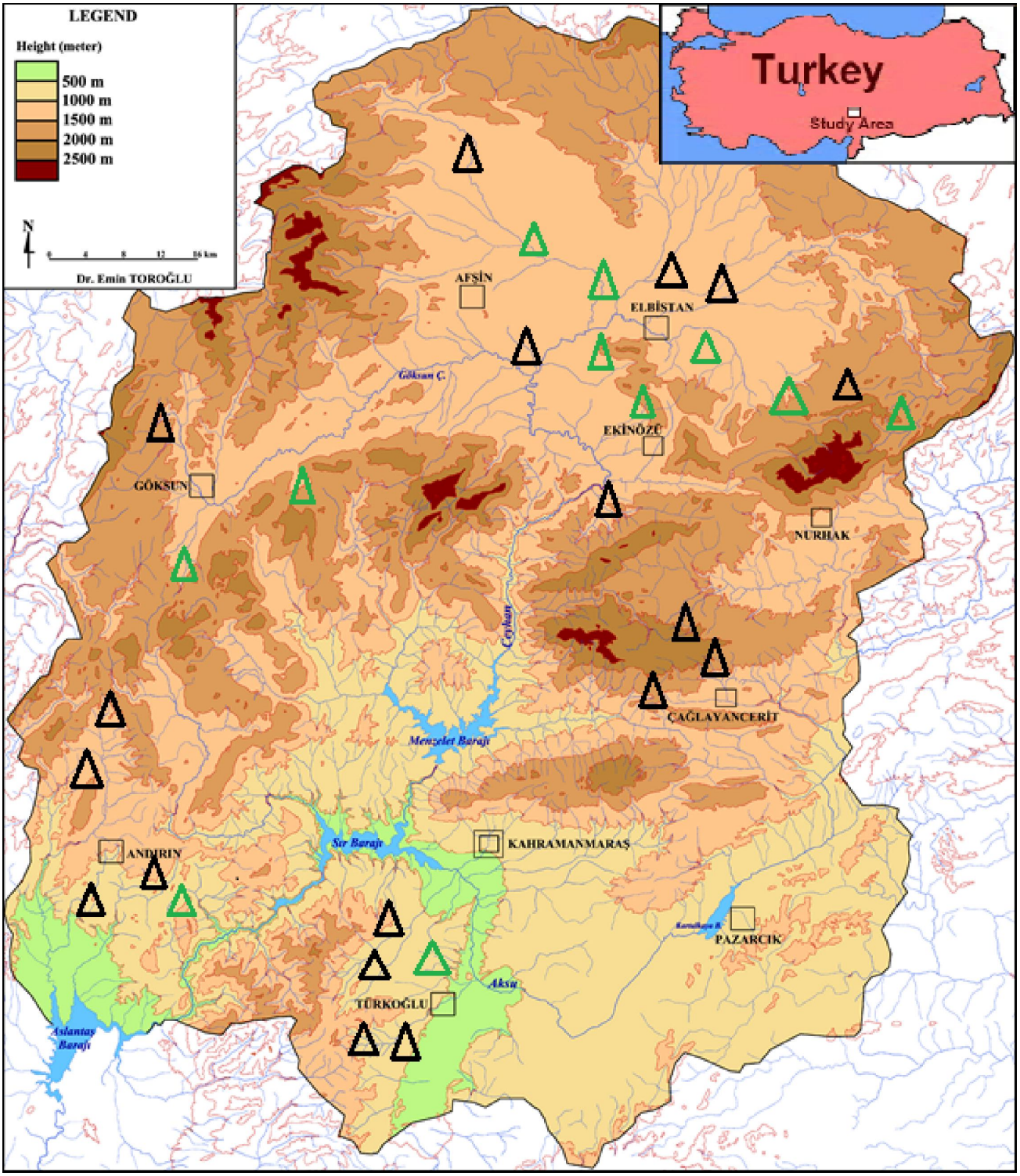

Fig. 3. Observation points of *M. formicarius* larvae pits in Kahramanmaraş in Turkey. Localities with pit size are marked with black (non-forest area) and green (forestry area) triangles.

Astragalus sp., *Orlaya sp.*, *Polygonum* sp., *Chenopodium* sp., *Coronilla* sp., *Lathyrus* sp. were sparsely found.

DISCUSSION

Aphids are the most numerous prey that inhabit *Salix* trees. More than 120 aphid species use willows as food sources in almost every country of Europe. Poplar aphids may be free living species or pseudogall or gall formers. More or less 225 aphid species belonging to more than 40 genera have been recorded using *Quercus* species as a host plant (Blackman and Eastop, 1994). More than 140 coccoid species have been recorded on various *Quercus* species from the Palaearctic region (Kozar, 1998).

Lacewings are closely associated with alders (Betulaceae) (McEwen, 2001). We can mention *Alnus incana* and *A. viridis* in the European alders. Forest associations (Alnetum) created by alders provide special habitats with wet and cool microclimate for lacewings similar to Ekinözü, Elbistan and Nurhak in Turkey. These associations are located along the edges of brooks, in flood plains, and in wetlands (Eglin, 1980 a,b,c,).

Secondary plant substances produced in conifers affect the food quality of potential phytophagous insects. Among the secondary organic compounds in conifers, resins are characteristic. Conifer resins consist of mixtures of monoterpenoids, sesquiterpenoids, and phenolic compounds produced in cavities or ducts in all parts of the tree. Terpenoids are considered to serve as defence agents againts herbivores. Many diterpens found in conifers have been reported to have toxic effects in conifers againts the phytophagous insects and their predators. Consequently, the metabolism of both sap-feeding Homoptera (aphids, scales) and their lacewing predators has to adapt to terpenoids in the diet. With the exception of *Sympherobius* sp. all predatory adults of lacewings examined in conifer forests consumed aphids. Adults of certain conifer lacewings prey upon Diptera or even Lepidoptera. Lacewings have also been recorded in European stands of *Abies alba*, *Picea abies*, *Pinus silvestris*, *P. nigra*, *P. pinea*, and *P. halepensis* (McEwen, 2001). Lacewings therefore play a very important role by controlling the population of tree pests.

Because of antlions' extremely rapid growth and considerable water consumption they have been introduced in the Mediterranean region of Europe including Kahramanmaraş, Turkey. It is probable that polyphagus Homoptera species are the main food sources for lacewings on Eucalypt trees in the Mediterranean region (McEwen, 2001). According to Palaearctic scale insect catalogue (Kozar, 1998).

In Klein's study (1982), the greatest amount of pit construction occurred in the cool-dark condition, but in our study there was no meaningful difference based on temperature. Kitching, (1984) reported his studies conducted in Australia that the Myrmeleontid antlions did not build their pits in sand of grain size more than 1 mm. Similarly in our study pit diameters from 0.15- 0.60 mm confirm the finding. Devetak (2001) observed that the Europen Myrmeleontidae larvae preferred sheltered areas, mostly occurring in the edge of the microhabitat. However, we have collected antlions both in forests and non-forest areas. Kitching (1984), Matsura (1986) and Devetak (2004) reported that above 40°C antlion capacity to build pit, potential hunting and metabolic activity were reduced. The absence of a significant difference in pit building behavior between the altitude levels supports the view that the construction of pits was related to the habitat and climatic factors rather than to light.

M. formicarius larvae can therefore be considered a specialised species among all the Neuroptera families as they adapted themselves to the large scale environmental variations (27-34°C temp.; 615-1674 m elevation) well. The maximum pit diameter was recorded as 40 mm in non-forest areas, as against the maximum 25 mm. in forest areas. Similarly maximum sand particle size was 0.60 mm in non-forest areas compared to 0.30 mm in forest areas. The variable results could probably be explained on the basis of soil types and specific micro habitat factors. We hypothesise that even though the temperature and altitude factors did not affect the pit size, these physical characters did carry a relative value in the ecosystem functioning. Our results indicate that *M. formicarius* larvae dwelling in the non-forest areas have higher pit size than that in forest areas. The pit size in localities 6,

8, 12 and 28 was higher than in localities 13 and 17 (Table II).

In localities 6, 8, 12 and 28 (Table II) in non-forest areas main plant species are *Paliurus spina-christi, Veronica macrostachya, Ranunculus sp., Rubus sanctus, Delphinium cilicium, Papaver rhoeas, Lathyrus inconspicuus* and in localities 13 and 17 (Table II) in forest areas main plant species are *Pinus pinea, Abies cilicia, Fagus orientalis, Sanicula europea, Salvia pilifera, F. orientalis,* and *P. nigra.* Away from the forest and forest edge, the pit size incresased. The increase in the pit size father away from the forest and forest edge was interesting. A positive relationship may be found between pit size and plant species (Table I). We hypothesise that plant species in non-forest areas may provide convenient living conditionals for Antlion larvae.

We intend to continue our research on Antlion (Myrmeleontidae) in this region to verify our hypothesis.

CONCLUSIONS

Based on the present results it can be concluded that *M. formicarius* pit diameter and sand particle size in non-forest areas is higher than in forest areas. The altitude had no impact on the diameter of the pit and sand particle size. There was no relationship between the altitude of the larval habitat and the pit size. The locality may affect plant species. Due to the surveyed area, the weather conditions (Kahramanmaraş province) did not have any impact on the diameter of pit size.

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