Research Article

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Pollination behaviour of *Linum aretioides* Boiss. (Linaceae) and its relations with air temperature and humidity

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Abstract: *Linum aretioides* Boiss., a local endemic, is distributed only on 2 mountains (İzmir: Bozdağ; Denizli: Babadağ) at the western part of Turkey between 1630 and 2300 m altitudes, above the tree line. The studies were conducted on Mount Bozdağ above the ski complex between 1750 and 2150 m, and on Mount Babadağ between 1630-2300 m both located at subalpine zones. Four 8 × 8 m quadrats on Bozdağ and 5 on Babadağ were used for the experiments. The development of reproductive structures of plants and frequency of insect visits were observed from early May to late June in 2006 and 2007. Blooming and pollination periods terminated by the last week in May on Babadağ and by the second week in June on Bozdağ. Temperatures below 10 °C before these periods appear to affect the activities of main pollinators, such as bees and butterflies, resulting in a decline in pollination, and eventually in seed formation. In Bozdağ, the average relative humidity values at 1000 hours, when the insect activities were the highest, were 65.22 ± 2.79% in June 2006, 61.6 ± 4.44% in May 2007, and 59.6 ± 3.53% in June 2007. The corresponding values on Babadağ were 52.8 ± 3.1%, 59.58 ± 3.52%, and 53.28 ± 3.41%, respectively. The most effective species in pollination process were butterflies, in particular *Pieris brassicae*.

Key words: *Linum aretioides*, pollination, temperature, relative humidity, insects, butterflies

Linum aretioides Boiss. (Linaceae) türünün tozlaşma davranışı ile hava sıcaklığı ve nem ilişkileri

Özet: *Linum aretioides* Boiss., sadece Türkiye'nin batısında bulunan iki dağın (İzmir: Bozdağ, Denizli: Babadağ) ağaç sınırı üzerindeki yüksek zirvelerinde, 1630-2300 m arasında yayılış gösteren lokal bir endemiktir. Çalışmalar Bozdağ Kayak Kompleksi üzerinde 1750-2150 m ve Babadağ'da 1630-2300 m arasında, ağaç sınırı üzerinde subalpin zondaki iki lokalitede gerçekleştirilmiştir. Denemeler için Bozdağ'da 4 adet, Babadağ' da 5 adet 8 × 8 m kuadratta çalışılmıştır. Bitkilerin üreme yapılarının gelişimi ve böcek ziyaretlerinin sıklığı, Mayıs başından Haziran sonuna kadar 2006 ve 2007 yıllarında ardışık olarak iki yıl için gözlemlenmiştir. Çiçeklenme ve tozlaşma periyodları, Babadağ'da Mayıs'ın son haftasında ve Bozdağ'da ise Haziran'ın ikinci haftasında sonlanır. Bu peryotlardan önceki 10 °C' nin altındaki sıcaklıklar arılar ve kelebekler gibi ana tozlayıcıların aktivitelerini olumsuz etkileyerek, tozlaşma ve tohum oluşumunda azalmaya sebep olur. Bozdağ'da, böcek aktivitelerinin en fazla olduğu Haziran 2006 sabah saat 10:00'da ortalama nisbi nem değerleri %65,22 ± 2,79, Mayıs 2007' de %61,6 ± 4,44 ve Haziran 2007' de %59,6 ± 3,53'dır. Babadağ'da ise bu değerler sırasıyla %52,8 ± 3,1, %59,58 ± 3,52 ve %53,28 ± 3,41 olarak tespit edilmiştir. Tozlaşma sürecinde en etkili türler kelebekler, özellikle *Pieris brassicae*'dir.

Anahtar sözcükler: *Linum aretioides*, tozlaşma, sıcaklık, nispi nem, böcekler, kelebekler

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Introduction

Reproduction is one of the most important phases in plants' life cycles. Cooperation and harmony between flowers and insects in insect-pollinated plants are important for the success of pollination. Above the tree line, in alpine and subalpine zones, habitat and climate conditions can change in a very short period of time, causing difficulties for the survival of both plants and insects. Plant communities and fragments of habitat become smaller, and vegetation, temperature, humidity, wind, soil, and snow depth change depending on the conditions (Ellenberg, 1988). On high mountains and especially in the alpine and subalpine regions, daily, even hourly changes in microclimate, particularly in temperature, humidity and wind, determine the quantity and quality of insect activities.

Pollination could be achieved by insects in these regions. Butterflies are the most effective pollinators of the insects. Butterflies replace bees in higher altitudes as they have less energy requirements and a passive thermoregulation mechanism (Arroyo et al., 2007). On the other hand, Nautiyal et al. (2009) stated that *Aconitum heterophyllum* Wall. is pollinated mostly by bees at 3550 m in India.

Temperature is important in insect-flower relations in habitats above the tree line. The number of the pollinators also increases with an increase in temperature during the day. Main effect is caused by the insolation that warms up the insect habitats with temperatures between 10 °C and 20 °C and above (Sorenson, 1941; Corbet, 1972).

Cloudiness, which affects the humidity and temperature, is important for insect habitats (Danks, 2007). Feeding of insects is also positively associated with air humidity. The amount of nectar secretion is high and nectar evaporation is low in high humidity (Peat & Goulson, 2005). Butterflies are diurnal and active in low humidity and during bright days with sunlight (Owen, 1971), and inactive during early morning and late evening hours, at night, and during wet and cold weather (Larsen, 1991).

Linum aretioides Boiss. is a relict endemic plant (Erik & Tarıkahya, 2004). This taxon is in the VU (vulnerable) category (Ekim et al., 2000). However, this category has changed to CR according to our research.

Spatial differentiation of the anther and stigma encourage allogamy between individual morphs through pollination by insects. In a complex reproduction like heterostyly, there is a need for genetically compatible couples and pollinators. Changes in the reproductive systems of heterostylic plant populations will determine the future of genetic/demographic structures (Washitani et al., 2005).

Linum aretioides is a distylic plant like many other *Linum* species, and Darwin (1877) was the first scientist who worked on this subject.

Studies on different *Linum* species reported that various insect species are responsible for pollination while gathering nectar and pollen. For example, Ockendon (1968) in *Linum perenne* subsp. *anglicanum*, Müller (1977) in *Linum catharticum* and *Linum usitatissimum*, Armbruster et al. (2006) in *Linum suffruticosum,* and Johnson & Dafni (1998) in *Linum pubescens*. It is not known whether such information is also true for *Linum aretioides*.

The primary purposes of this study were to find out (i) the insect species playing an effective role in pollination, (ii) the temperature and humidity values during the highest visits to flowers, and (iii) pollination mechanisms for distylic *Linum aretioides.*

Material and methods

The plant species and the study sites

Linum aretioides is a semi-shrub perennial with thick roots and multi-stems that forms mostly round or roundish tufts. Flowers are distylic, yellow and sessile. Petal length is between 7.97 ± 0.47 mm and 10.83 ± 0.24 mm and petal width is between 3.17 ± 0.09 mm and 4.05 ± 0.16 mm. The base of the petals forms tubes for nectar collection. Petals stay in flowers for a short time (3-4 days). Flowers bloom from the end of May until June.

Studies were conducted on Mount Bozdağ, on the treeless peaks, subalpine zones between 1750 and 2150 m in İzmir-Ödemiş above the ski complex, and on Mount Bozdağ, between 1630 and 2300 m in Denizli. Plant distribution is patchy in these areas.

Average annual temperatures vary between 7 °C and 9 °C at 2200 m on Bozdağ and between 5.7 °C and

6.0 °C at 2300 m on Babadağ. Average annual rainfall on Bozdağ summit was 1125.9 mm and on Babadağ summit 1139.6 mm with extrapolation charts according to the 31-year average precipitation values.

Nine 8 × 8 m quadrats [4 on Bozdağ (Q1: 2080 m, Q2: 2125 m, Q3: 2112 m, Q4: 2065 m) and 5 on Babadağ (Q1: 2010 m, Q2: 1800 m, Q3: 1948 m, Q4: 1958 m, Q5: 2014 m)] were used at different elevations for the experiments. In both populations, quadrats were randomly selected (Q: quadrat).

Phenology

Development of flowers and flower buds of the plants were observed in May and June in 2006 and 2007.

Capture and observation of insects

Insect visits were observed during June 7-8, 2006 and June 13, 2007 on Bozdağ and May 30-31, 2006 and May 25, 2007 on Babadağ. The frequencies of insect visits to the plants in Q3 in both populations at 1000, 1200 and 1700 hours during the dates listed above were recorded (Table 1). Each visit was 30 min.

Climatic data

Portable Hobo data loggers (Spectrum Technologies, Plainsfield. IL, USA), integrated with air temperature and relative and absolute humidity sensors, were installed in Q2 on Bozdağ and Q3 on Babadağ. The data loggers were used from June 2006 to November 2007 on Bozdağ and from June 2006 to

Table 1. Insects observed on the plants in the study area.

	Bozdağ		Babadağ	
	7-8 June 2006	13 June 2007	30-31 May 2006	25 May 2007
Nectar and pollen gatherers				
Lepidoptera				
Pieris brassicae	***	***	***	***
Vanessa cardui	**	**	**	**
Argynnis adippe	*	*	*	
Aglais urticae	*	**	**	
Glaucopsyche alexis	*	*		
Hymenoptera				
Apis mellifera	*	*	**	**
Plant predators				
Forficula smyrnensis		**		
Dendarus messenius	***	***	*	*
Otiorhynchus escherichi	*			
Pedinus (s.str.) *strabonis*	*			
Mylabris sp.	*			
Predators				
Coccinella semptempunctata	***	***	*	*
Harmonia sp.	*			
Calyptopsis capnisiformis	*			
Dailognatha quadricollis	*			
Pimelia polita	*			
Gnaptor prolixus	*			
Probaticus sp.	*			
Calathus sp.	*			
Cardiophorus sp.	*			
Lacon punctatus	*			
Geotrupes sp.	*			

*** (more than 10), ** (between 2 and 10), * (only once)

September 2007 on Babadağ. The daily sampling durations were 8 h on Bozdağ and 6 h on Babadağ. The air temperature and relative humidity values were evaluated in our study.

Results

Phenology

The plants developed flower buds around weeks 3 or 4 in May in Q2, Q3, and Q4 on Bozdağ, and in Q3, Q4, and Q5 on Babadağ (Table 2). It was observed that the plants in Q1 on Bozdağ budded and flowered later than did the plants in the other quadrats. This could be the result of relatively later removal of snow cover in this quadrat.

Plants in Q2 (1800 m) on Babadağ produced buds and flowers earlier than did plants in all the other Qs. They are budded in the middle of May. This region is at the lowest altitude of the distribution range, faces south, and is in a sheltered position from wind. Other areas are in higher places and are exposed to windy conditions. This case suggests that decreasing temperature with increasing altitude causes delays in the reproductive phase. However, there is dense fog and cloud cover and a decrease in temperature above 1900 m.

Temperature

The life cycle of plants begins with root activity above 5 °C at alpine and subalpine regions (Ellenberg, 1988). While daily average soil and air temperatures were below 5 °C until the first week of May on Bozdağ and Babadağ, they exceeded this temperature within several days in the first week. In 2006 on Bozdağ, the temperature varied between 6.8 °C and 10.8 °C from June 8 to 18, and from June 19 until the end of the month, they varied between 10.3 °C and 15.1 °C. The temperature varied between 4.8 °C and 20.7 °C from the second week of May 2007 until the end of June (May 15 / June 30) (Figures 1-3).

Table 2. Time of bud formation and flowering on Bozdağ and Babadağ (2006-2007).

		Quadrats	May				June			
			Weeks							
			1	2	3	4	1	2	3	4
BOZDAĞ	Bud formation	1						■		
		2			■	■				
		3			■	■				
		4			■	■				
	Blooming	1						▲■		
		2				■	▲			
		3				■	▲			
		4				■	▲			
BABADAĞ	Bud formation	1								
		2		▲						
		3				■				
		4			■					
		5			■					
	Blooming	1								
		2		▲						
		3			■▲					
		4			■▲					
		5			■▲					

(▲: 2006; ■: 2007)

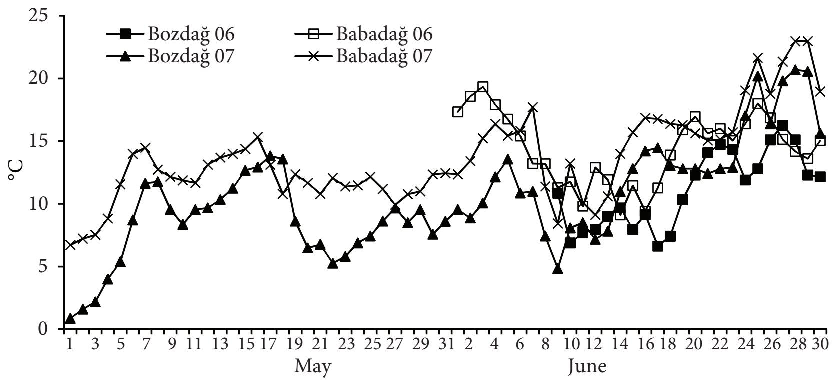

Figure 1. Average daily temperatures on Bozdağ and Babadağ during the blooming and pollination periods.

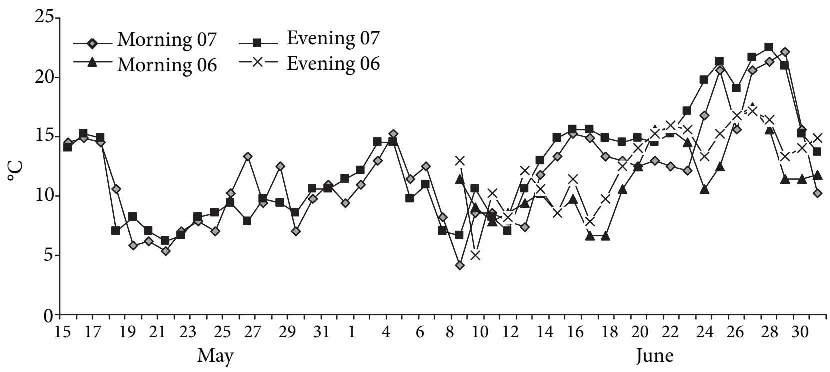

Figure 2. Temperatures in the morning (1000) and evening (1700) hours on Bozdağ.

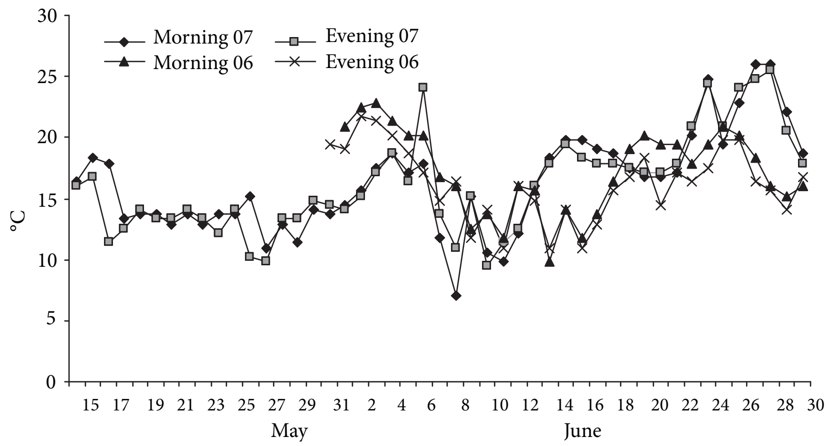

Figure 3. Temperatures in the morning (1000) and evening (1700) hours on Babadağ.

Average temperatures in both localities in June 2006 and in May and June 2007 are shown in Table 3. When the daily average temperatures of Bozdağ and Babadağ in 2006 and 2007 are compared, it is obvious that Babadağ is warmer than Bozdağ.

Relative humidity

The relative humidity varied between 28.7% and 93.5% in June 2006, 25.1% and 98.9% in May 2007, and 30% and 100% in June 2007 on Bozdağ. The relative humidity varied between 25.1% and 83.3% in June 2006, 27% and 85% in May 2007, and 24% and 92% in June 2007 on Babadağ (Figure 4).

The average relative humidity was 71.51% in June 2006 on Bozdağ, 87.88% and 89.97% in May and June 2007 on Babadağ, respectively (Table 3).

Insect visits

When the above data about the effects of plants on life history in the 2 mountains are considered, it is seen that blooming and pollination periods end by the second week in June on Bozdağ and by the last week of May on Babadağ (Table 2). The temperatures below 10 °C before this period affect the activities of main pollinators, such as bees and butterflies, negatively resulting in a decline in pollination and subsequent seed formation. After the second week of July, temperatures reach 15 °C.

As mentioned above, the blooming period starts when the temperature exceeds 10 °C. Flower buds reach maturity in 3-4 days. Sepals, the outermost part of a flower, form a cup with its overlapping membranous parts. Inside the sepals are petals, which have long claws. Just in the middle of a claw, there is a rib. These ribs function like barriers around stamens. Thus, at the base of the flower form 5 nectaries.

On the first day, flowers bloom; reproductive organs all together lie vertically in the centre of the flower. Organs existing in both morphs bend from centre towards outside within 1-2 days. Five styles in thrum flowers bend towards outside and appear between stamens, so 5 short styles are situated on 5 nectar pits. In the same flowers, after anthesis of basifixed anthers, the opening surface becomes

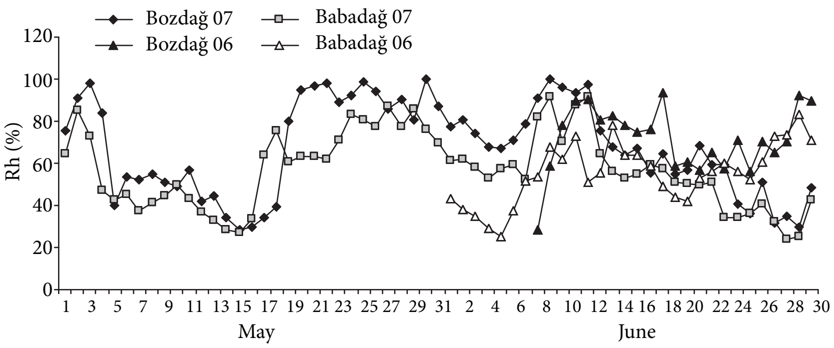

Figure 4. Daily average relative humidity during blooming and pollination period on Bozdağ and Babadağ.

Table 3. Average temperatures and relative humidity (RH) values on the study areas.

Years	Months	Bozdağ		Babadağ	
		°C	RH (%)	°C	RH (%)
2006	June	11.5 ± 0.73	71.51 ± 3.22	14.43 ± 0.51	51.22 ± 2.78
2007	May	8.3 ± 0.59	69.23 ± 4.51	11.69 ± 0.36	87.88 ± 1.53
	June	12.6 ± 0.76	65.3 ± 3.57	15.7 ± 0.68	89.97 ± 0.008

horizontal. In the case of pin flowers, styles and stamens perform same bending action towards outside and, at this time, short stamens are situated on nectar pits and receptive surface of stigmas take facing up position.

After the observations, it was seen that, in addition to usual pollinators that were involved in pollination while collecting nectar and pollen, some other insects feeding on plants also contributed to pollination indirectly (Table 1).

In both of the study sites, the most active species in pollination were butterflies, in particular *Pieris brassicae*. The process in reproductive organs of a flower mentioned above contributes to pollination as follows: a butterfly landing on pin flowers extend its proboscis into nectar holes placed on the base of flowers. During this time, contact between the anthers placed just over the nectar pits and the proboscis is inevitable. The butterfly moves all over the flower surface and check all nectar pits. Later it may visit a thrum flower with 50% possibility. If this happens, the butterfly performs the same nectar collection action. However, this time the proboscis contacts with stigmas instead of anthers and pollination occurs. Meanwhile, the butterfly moves all over the flower surface, touches and collects pollen from the anthers with its 6 legs, and transfers them to stigmas of pin flowers and thus helps pollination (Figure 5).

Some pollens were observed on the phytophagous insect *Dendarus* during its feeding on *Linum* petals. Of the other insects feeding on plants; *Forficula smyrnensis* and *Mylabris* sp. were also found to have a few pollen grains on them.

Discussion

Among the climatic factors, temperature is the most critical habitat factor for insect activities. Although it may vary depending on the species, the lowest temperature limit for the activities of insects is around 10-11 °C (Utida, 1957; Honek & Kocourek, 1990). Butterflies are affected by temperature, humidity, and time of day. Their numbers and mobility decrease with an increase in moisture. They are most active at 50%-60% humidity but inactive early in the mornings, late in the evenings, and at night. Clouds and fog affect the amount of moisture by blocking light and temperature. The nectar gathering insects are affected by these factors. In very high humid conditions, evaporation is low whereas nectar secretion is high (Peat & Goulson, 2005). Thus, butterflies and bees travel less for feeding.

In our study, the average air temperature and relative humidity were recorded between 1000 and 1700 hours when an increase in insects visiting activity was observed. Average temperatures and

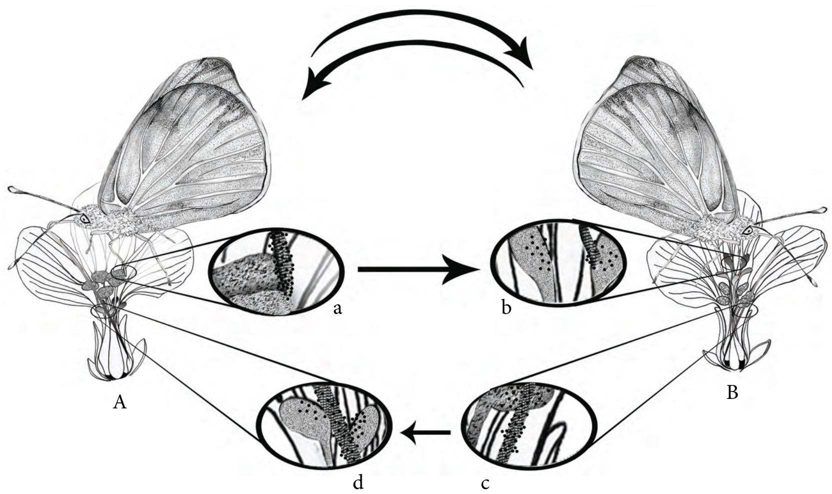

Figure 5. Pollination between morphs. A- Thrum flower, B- Pin flower; a- Legs attached to stamens of thrum flower, b- Legs attached to stigmas of pin flower, c- Proboscis attached to stamens of pin flower, d- Proboscis attached to stigmas of thrum flower (illustrated by Beril Şenol).

relative humidity values determined in these localities are shown in Table 4. The temperatures (°C) on Bozdağ were between 9.47 ± 0.63 and 14.1 ± 0.78; however, the temperature (°C) was higher on Babadağ and varied between 13.09 ± 0.38 and 17.83 ± 0.75. Average relative humidity values (%) were higher on Bozdağ and varied between 66.93 ± 2.58 and 59.6 ± 3.53 (Table 4; Figures 6-7).

According to the results obtained in our study, the average temperature was 10.84 °C, and the average relative humidity was 58.8% on June 08, 2006, during which 20 insect taxa were seen on Bozdağ population and the temperature and humidity measured were considered as an optimum level for insect activities (Sorenson, 1941; Corbert, 1972; Danks, 2007; Larsen, 1991). The measurements taken on June 13, 2007 in the same locality showed that the average temperature was lower (7.81 °C) and the average relative humidity was higher (75.6%) than those taken during the previous year. At that date, only 6 insect taxa visited the plants. The reason for this can be attributed to changes in temperature and humidity values. It was also seen that, at the dates when the observations were conducted, of the insect taxa that visited the plants, the most dominant ones were *Pieris brassicae*, *Dendarus messenius,* and *Coccinella semptempunctata* (Table 1).

On Babadağ locality, the average temperature was 23.5 °C, and the average relative humidity was 38.5% on May 31, 2006 whereas the average temperature was 12.15 °C, and the average relative humidity was 80.5% on May 25, 2007. The same 8 insect taxa were seen in

Table 4. Average temperatures and relative humidity values at 1000 and 1700 hours.

Parameters	Time Period	Bozdağ			Babadağ		
		2006	2007		2006	2007	
		June	May	June	June	May	June
Temperature (°C)	1000	11.5 ± 0.65	9.48 ± 0.62	13.05 ± 0.78	17.27 ± 0.62	13.52 ± 0.44	17.58 ± 0.81
	1700	12.66 ± 0.67	9.47 ± 0.63	14.1 ± 0.78	16.5 ± 0.54	13.09 ± 0.38	17.83 ± 0.75
Humidity (%)	1000	65.22 ± 2,79	61.6 ± 4.44	59.6 ± 3.53	52.8 ± 3.1	59.58 ± 3.52	53.28 ± 3.41
	1700	66.93 ± 2.58	66.6 ± 4.42	60.4 ± 3.62	49.5 ± 2.75	56.63 ± 3.74	48.49 ± 3.81

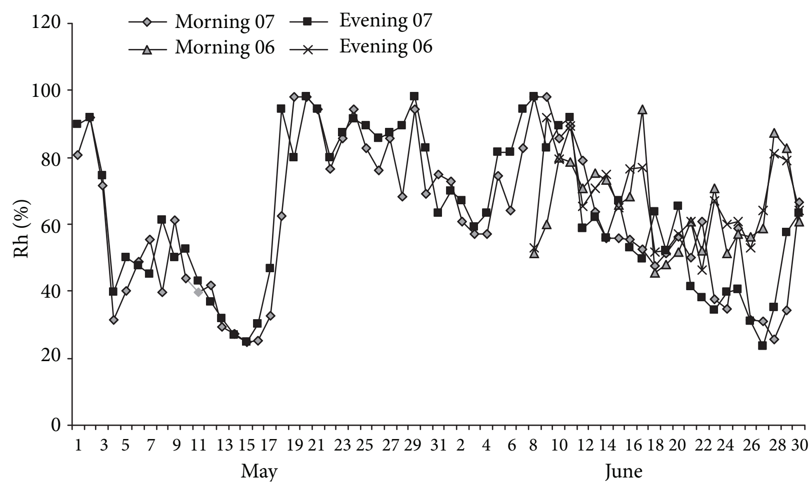

Figure 6. Relative humidity in the morning (1000) and evening (1700) hours on Bozdağ.

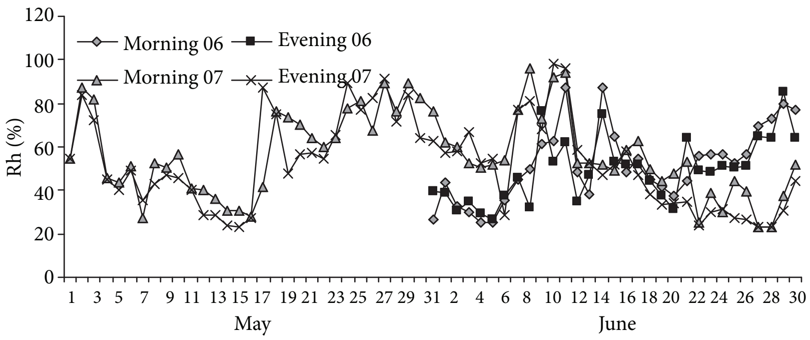

Figure 7. Relative humidity in the morning (1000) and evening (1700) hours on Babadağ.

both years and the most dominant species was *Pieris brassicae*, which was especially effective in the pollination (Table 1). It is thought that the humidity values measured in this locality might have led to the decrease in the number of insect taxa.

Flowering period of *Linum aretioides* is from May to late June when 80%-90% of flowers bloom. It is essential that pollination should take place during this period. Temperature and humidity values during the blooming period in Babadağ and Bozdağ populations positively contribute to the optimum blooming and pollination activity. Temperatures above 10 °C appear to be sufficient for the insect activity. Particularly butterflies and bees need temperatures above this in order to be active. However, even if the temperature is sufficient in this period, other conditions must also be appropriate. However, very strong winds and fog seen around 1900 m in mid- or even late-May reduce the insect activity, particularly butterfly activity, thus resulting in reduced pollen transport.

Big bright flowers of *Linum aretioides* and nectar at the bottom of petals indicate that they are pollinated by insects through allogamy. Observations in the field and experiments carried out at the greenhouse of Ege University Botanic Garden, where there are no insects and thus flowers bear no seed or fruit, support this hypothesis. Pollinators of bright, yellow, and red flowers are usually butterflies (Glover, 2007). *Linum aretiodes* possesses these features. According to our study, an important proportion of the pollinators are butterflies. Since butterflies are light in weight and do not have to feed their young, they do not need much energy as bees do. Therefore, they may visit plant species producing nectar even in small amounts, such as *Linum aretioides*.

Although bees obtain less pollen and nectar from *Linum* species, they are among the main pollinators of *Linum*. However, they are not as effective as butterflies at altitudes of 1700-2300 m, where *Linum* is most widely distributed. In our study sites, the butterflies visited *Linum aretioides* flowers more often than bees did. Arroyo et al. (2007) stated that butterflies are the main flower visitors in high altitudes and alpine zones where they replace bees. However, not many butterflies are good pollinators (Wiklund et al., 1979) because pollen does not stick to their legs and proboscis or they cannot touch the stigma properly. *Pieris brassicae* of *Pieridae* is a butterfly that collects nectar from *Linum aretioides*. It reproduces 3 generations of mature individuals per year. The first generation is effective from May to early June, whereas the 2nd and 3rd generations are effective from the beginning of July until the end of September. The first generation fully synchronizes with the blooming period of *Linum aretioides. Vanessa cardui* migrates long distances and is abundant in our research fields. The other butterfly is *Argrynnis adippe*. Both are active from June to August, and effective on *Linum aretioides* pollination.

Müller (1977) states that *Linum catharticum* is pollinated by *Systoechus sulphureus* and *Empis livida* of the Bombylidae, whereas *Linum usitatissimum* is pollinated by *Apis mellifica and Halictus cylindiricus of* the Apidae (Hymenoptera), and *Plusia gamma* of the Noctuae (Lepidoptera). Ockendon (1968) states that *Linum perenne* subsp. *anglicanum* is pollinated by *Bombus*, *Apis,* and *Syrphus* species. Armbruster et al. (2006) reports that 2 flies of *Usia* genus of the Bomylidae and another fly of the same family and cf.

Megachile pollinate *Linum suffruticosum*. Johnson and Dafni (1998) states that *Usia bicolor* pollinates *Linum pubescens* while collecting nectar and pollen.

Herbivore and insect predators have also been observed on the flowers. *Forficula smyrnensis* and *Dendarus messenius* are among the most common herbivore insects. In Bozdağ localities, especially *Dendarus messenius* causes damage to reproductive organs by cutting the flower buds. Although it is a small possibility, these insects are likely to transfer pollens from one flower to another. *Otiorhynchus escherichi*, *Pedinus* (s. str.) *strabonis* species are less widespread. *Coccinella semptempunctata* and *Harmonia sp.* are among the predator insects found on plants. These insects may carry pollen from one plant to another while moving on the flowers to feed on aphids or lice (Table 1).

The location and arrangement of reproductive organs in flowers like *Linum aretioides* are more suitable for insects like bees collecting nectar with their short proboscis. In order to get nectar, bees easily enter into the petals through the gap among the petals, during when they can pollinate the flowers. However, such arrangement and location is not necessary for insects with long proboscis, such as butterflies, herbivores and predator insects when they collect nectar. Butterflies transfer pollen with their long legs and proboscis whereas other insects may transfer pollen as they move along the flower parts.

Armbruster et al. (2006) stress that the arising angles and turning degrees of stamen and styles from the central axis of a flower play a more important role in pollination between morphs than do the length of reproductive structures in *Linum suffruticosum*. These differences help insects to receive pollen from thrum flowers with their dorsal part and with their abdomen from pin flowers. As a result, the stigmas of thrum flowers contact with the abdomen of the insects and pin flowers contact with the dorsal part of the insects and avoid self-fertilization. Our observations are consistent with this hypothesis. Johnson and Dafni (1998) mentioned this phenomenon in an experiment with model flowers of *Linum pubescens*.

Negatively affected pollinators from daily and seasonal climatic changes, fragmentation, and destruction of the area, less opportunity for suitable substrate for the establishment and germination of seeds, heterostyly, and environmental and demographic uncertainties, such as low seed, set cause important problems for the sustainability of *Linum aretioides* populations. Uncertainties in the microclimate preventing pollinators' activities cause low seed set during the short time of blooming when pollen and stigma are active.

In unfavourable climatic conditions preventing insect activity during blooming, so pollination fails and this leads to problems in seed formation. Consequently, the average seed set when insect activity is prevented by unfavourable climatic conditions during blooming period, would be limited to only 1-2 seed from an ovarium with 10 ovules instead of 10 seeds (Seçmen et al., unpublished data). These findings suggest that populations will be adversely affected by both low seed set resulting from butterfly pollination and unpredictable (stochastic) climatic parameters.

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