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Biology, host specificity and feeding potential of the Dock's leaf defoliator sawfly, *Kokujewia ectrapela* Konow (Hymenoptera: Argidae), a biocontrol agent of *Rumex* spp. (Polygonaceae)

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Abstract

Dock's leaf defoliator sawfly, *Kokujewia ectrapela* Konow (Hym.,Argidae), is a medium sized sawfly native to the Caspian fauna. The larvae were found living on *Rumex* spp. (Polygonaceae). In order to determine the biology, host specificity and feeding potential of the species, continuous rearing was conducted in field and laboratory conditions during 2011-2013. The results revealed that *K. ectrapela* completed six generations within the growing season and hibernated as a fully developed larva inside the protective cocoon in the plant litter surrounding the *Rumex* plants. The first generation appeared from the early April to the end of May and the last generation in the late September. After emergence, adults copulated and using their saw-like ovipositor fertile females inserted their eggs along the edges of the *Rumex* leaves. Mean fecundity was showed to be 148.67 ± 37.33 eggs per female. Newly hatched larvae aggregated and fed on the underside of the leaves. However, later instars dispersed on the host plant and continued to feed on the leaves, leaving only the major veins. Larvae developed through three instars and it took 9-23 days depending upon environmental conditions. Pupation occurs within silken whitish cocoons spun among or out of the host plant. Depending upon environmental conditions, the developmental time from eggs to adults lasted 28-43 days. Study on the parasitoids revealed that the larvae of *K. Ectrapela* were parasitized by *Cryptus inquisitor* (Hym., Ichneumonidae) and *Tetrastichus kokujewiae* (Hym., Eulophidae) in Urmia region. Results of no-choice feeding tests with the second instars on 27 plant species belonging to 13 families showed that *K. ectrapela* completed its life cycle mainly on plants of *Rumex* and occasionally fed on *Polygonum persicaria* L. (Polygonaceae). Investigation on feeding activity of the three larval instars of *K. ectrapela* on *Rumex obtusifolius* L. under laboratory conditions revealed that a single first-instar larva consumed mean 0.041 ± 0.001 g of *R. obtusifolius* leaves over its 3 days of development. Second and third instar larvae consumed mean 1.227 ± 0.006 g, and 3.058 ± 0.014 g, over their 4 and 5 days of development, respectively.

Key words: Biology, Host-specificity, *Kokujewia ectrapela*, Biocontrol agent, *Rumex* spp.

چکیده

زیست‌شناسی، تخصص میزبانی و توان تغذیه‌ای زنبور برگ‌خوار ترشک، *Kokujewia ectrapela* Konow (Hymenoptera: Argidae)، عامل بیوکنترل علف‌های هرز ترشک، *Rumex* spp. (Polygonaceae)

یونس کریم‌پور

زنبور برگ‌خوار ترشک، *Kokujewia ectrapela* Konow (Hym., Argidae)، زنبوری تخم‌ریزاره‌ای، با اندازه متوسط، و بومی منطقه کاسپین است. لاروهای این زنبور روی برگ‌های ترشک، *Rumex* spp. (Polygonaceae)، زندگی می‌کنند. به‌منظور مطالعه زیست‌شناسی، تخصص میزبانی و توان تغذیه‌ای این زنبور به‌عنوان عامل کنترل بیولوژیک ترشک‌ها پرورش مداوم آن در شرایط صحرایی و آزمایشگاهی در طول سال‌های ۱۳۹۰ تا ۱۳۹۲ انجام گرفت. نتایج بررسی‌ها نشان داد که *K. ectrapela* دارای ٦ نسل در سال بوده و به‌شکل لارو کامل درون پیله حفاظتی در داخل بقایای گیاهی پیرامون گیاه میزبان زمستان‌گذرانی می‌کند. اولین نسل آن از نیمه دوم فروردین ماه تا اوایل خرداد و آخرین نسل آن در اوایل مهر ماه ظاهر می‌شود. حشرات کامل بعد از ظاهر شدن، جفت‌گیری و زنبورهای ماده تخم‌های خود را با استفاده از تخم‌ریز اره‌مانند خود به لبه‌های برگ ترشک فرو می‌کنند. میانگین تعداد تخم هر فرد ماده ۳۷/۳۳ ± ۱٤۸/٦۷ محاسبه شد. لاروهای جوان بعد از تفریخ در زیر برگ تجمع یافته و از آن تغذیه می‌کنند. لاروهای سنین بالاتر روی گیاه میزبان پراکنده شده و با ادامه تغذیه از برگ‌های آن تنها رگبرگ‌های ترشک را باقی می‌گذارند. این زنبور دارای ۳ سن لاروی بوده که بسته به شرایط آب و هوایی در طول ۹ تا ۲۳ روز مراحل رشدی خود را کامل می‌کند. لاروهای کامل با تنیدن پیله ابریشمی سفیدرنگ در بین و یا بیرون از گیاه میزبان در درون آن تبدیل به شفیره می‌شوند. بسته به شرایط محیطی، زمان لازم برای رشد و نمو این زنبور از مرحله تخم تا ظهور حشرات کامل بین ۲۸ تا ٤۳ روز طول می‌کشد. در مطالعه تعیین پارازیتوئیدهای زنبور برگ‌خوار ترشک معلوم شد که مرحله لاروی این حشره توسط زنبورهای پارازیتوئید *Cryptus inquisitor* (Hym., Ichneumonidae) و *Tetrastichus kokujewiae* (Hym.,Eulophidae) در منطقه ارومیه انگلی می‌شوند. نتایج آزمایشات تغذیه‌ای غیرانتخابی با لاروهای سن دوم روی ۲۷ گونه گیاهی از ۱۳ تیره نشان داد که زنبور برگ‌خوار ترشک اساساً چرخه زیستی خود را روی گیاهان جنس *Rumex* spp. کامل کرده و در موارد اتفاقی از برگ‌های گیاه *Polygonum persicaria* L. (Polygonaceae) تغذیه می‌کند. ارزیابی فعالیت تغذیه‌ای سه مرحله لاروی زنبور برگ‌خوار ترشک در شرایط آزمایشگاهی روی *Rumex obtusifolius* L. نشان داد که یک لارو منفرد سن اول در طول ۳ روز بطور متوسط ۰/۰۰۱ ± ۰/۰٤۱ گرم از برگ‌های این گیاه تغذیه می‌کند. دو سن آخر لاروی نیز در طول ٤ و ۵ روز به‌ترتیب و به‌طور میانگین ۰/۰۰٦ ± ۱/۲۲۷ و ۰/۰۱٤ ± ۳/۰۵۸ گرم از برگ‌های این گیاه مصرف می‌کنند.

واژگان کلیدی: زیست‌شناسی، تخصص میزبانی، زنبور برگ‌خوار ترشک، مهار ریستی، ترشک

Introduction

The genus *Rumex* L. (Polygonaceae) has been distributed worldwide and includes more than 250 species (Rao *et al.*, 2011). *Rumex* spp. are commonly known as "Torshak" in Iran and "docks" in English speaking countries. According to Ghahreman & Attar (1999), there are 33 species of *Rumex*in Iran. Two species of *Rumex* are considered as most problematic weeds worldwide, namely curly dock, *Rumex crispus* L. and broad-leaved dock, *Rumex obtusifolius* L., (Holm *et al*., 1977). The latter is also considered as one of the five most widely distributed non-cultivated plant species in the world (Allard, 1965). Another species, *Rumex pulcher* L., is a serious weed of the Mediterranean climatic areas of South Western Australia (Allen, 1975).

The farmers who produce organic products recently consider docks as one of the most troublesome weeds (Turner *et al.*, 2004). Bond & Turner (2003) have provided a comprehensive overview of dock's biology, ecology and management. Cavers & Harper (1964) listed a range of fungi and insects feeding on or existing on docks. Also, they mentioned 34 herbivorous insect species which can affect both *R. Crispus* and *R. obtusifolius*. The possibility of biological control of curly and broad-leaved dock using insects was reviewed in some detail by Grossrieder & Keary (2004) with special reference to organic farming in Switzerland. Spencer *et al.* (1981) listed 198 insect species which affecting mainly *R. crispus*in Italy. The *Gastrophys aviridula* Degeer (Coleoptera: Chrysomellidae) and the rust fungus, *Uromyces rumicis* (Schumach.) G. Winter (Uredinales) are the most carefully studied organisms for *Rumex* biocontrol. More than 50% of about 110 studies on the biological control of *Rumex* spp., used insects (mainly from the order of Coleoptera), ¼ used fungi and only a few number of them tested the influence of plant extracts or specific grazing by goats or sheep to control *Rumex* species (Zaller, 2004).

Two chrysomelid beetles *Gastrophysa atrocyanea* Motschulsky and *G. Viridula* Deg. are well known herbivorous species that feed on the taproot of *Rumex* species. *G. atrocyanea*is distributed over a wide area, recorded throughout China, and from parts of Japan, Korea, the former Soviet Union and Vietnam (Xiaoshui, 1991). Of 40 or more species of insects feeding on *R. Obtusifolius* in Japan, *G. atrocyanea* appeared to be the most promising agent for biological control, although Naito *et al*. (1979) suggested that it would be unlikely to give complete control on its own. Field observations in China indicated that *G. Atrocyanea* caused a progressive decline in natural *Rumex japonicus* L. populations. Thus it was recommended as a possible biocontrol agent for this weed (Xiaoshui, 1991).

The European species, *G. Viridula* is an oligophagous insect whose adults occasionally attacking *Rheum rhaponticum* L. (Guile, 1984) but it can only complete its life cycle on *Rumex*, particularly *R. obtusifolius* (Bentley & Whittaker, 1979). Both adults and larvae could be the good biological control agents of their host plants. *G. Viridula* develops three generations every growing season (Piesik, 2000). Laboratory research to determine the potential of *G. Viridula* to control *R. confertus* Willd. Indicated that, total weight of consumed leaves per larva over development of the three instars (50 day period) was 1.243 g (Piesik & Wenda-Piesik, 2005).

Species of the sawfly genus,*Kokujewia* Konow (Argidae) are restricted to the north-eastern Mediterranean and Caucasian regions. This genus includes three species namely, *Kokujewia clement* Zirngiebl, 1949, *Kokujewia palestina* Benson, 1954, and *Kokujewia ectrapela* Konow, 1902. The distribution areas of *K. Ectrapela* includes the Russian states of Stavropol and North Ossetia, and Georgia, Armenia, Azerbaijan (together known as Transcaucasia), and north-western Iran (Blank & Taeger, 1998). Larvae of *K. Ectrapela* use *Rumex* spp. as the host plant in Russia (Gussakovskii, 1935).

The objectives of the current study were to determine the general biology, host specificity and feeding potential of the *Rumex* leaf defoliator sawfly, *K. ectrapela.*

Materials and methods

Study site

Field and laboratory studies on the biology, host specificity and potential of *Rumex* leaf defoliator sawfly

were conducted in Urmia (Orümïyeh) region, (N37°31Í-E45°01Í), West Azerbaijan Province, Iran from 2011 to 2013. The study site was located 11 km Northwest of Urmia at the field research station of Urmia University. Laboratory studies were conducted in growing chambers of the Plant Protection Department of Urmia University.

Establishment of field cage colony and life-history studies

Following egg laying by females of *K. Ectrapela* on docks in the field in early April, plants containing eggs were marked and around 30-40 different developmental stages of larvae were collected from marked plants and placed together in a 0.5 by 0.5 by 1.2 m rearing cage, made from an Aluminum frame covered with Aluminum gauze containing *R. Obtusifolius* plants that were 35-45 cm in height. During the continuous rearing of larvae, the cages were established outside, under natural conditions, in the fields of research station. The larvae were transferred to fresh, caged, host plant when the host plants were nearly completely consumed. Six to seven days after pupation, 10-12 pupae were transferred to the ventilated glass boxes (20 × 20 × 30 cm) for adult emergence and mating. After mating, one female was returned to the rearing cage with fresh host plants. This was repeated for each generation for three years and the cages were checked daily to record the developmental time of all immature stages of *K. ectrapela*. The life stage of each individual and date of inspections were recorded. Overwintering, feeding, egg laying and feeding damage were assessed in cages held under natural conditions at the field of research station. Larval, prepupal and adult activities were observed as well.

Eggs

Observations were made on the shape and colour of eggs in the field colonies. Egg laying site selections by females also were determined in the field colonies. To determine fecundity, one fertilized female was placed in a ventilated box containing fresh leaves of *R. obtosifolius*. Then, the number of eggs per female during her lifetime was recorded for 12 fertilized females and 38 leaves on which eggs were deposited

In order to determine the number of eggs per leaf in natural conditions, they were counted on 36 leaves on which eggs were deposited.

Larvae

A total of 75 larvae were used to determine the number of instars. For each larval age, 25 head capsule width were carefully measured. The same larvae were also weighted and their lengths were measured. The mean and variance of mentioned characters associated with each instars were calculated.

Pupa

General observations were made on the size and color of more than 100 pupal cocoons.

Adults

Newly emerged adults were sexed using the key provided by Blank & Taeger (1998).

Parasitoids

To obtain the parasitoids, more than 300 fully grown larvae were collected from fields in the growing season over three years of the study and reared on the host plant under laboratory conditions (20-25 °C and 60-70% R. H.) in ventilated glass boxes (75 × 25 × 30 cm) covered by muslin. Boxes were checked daily for emergence of parasitoids.

Host range test

Host range was determined in laboratory by exposing 27 species of plants to unfed neonate larvae. Second instar larvae were transferred in groups of 10 into 20 cm Petri dishes and provided with leaves and cut shoots of the plant species; held in the laboratory at a temperature of 25 °C and a photoperiod of 14L: 10D.

Feeding potential of *K. Ectrapela* on *R.obtusifolius*

The aim of this experiment was to determine the larval feeding on *R. Obtusifolius* leaves at 25 °C, under moist conditions and supplied unlimited food. The trial was performed in five replications in Petri dishes with

moist filter paper. Each Petri dish contained 10 larvae; fresh leaves of *R. Obtusifolius* were daily provided to the larvae. The filter paper was changedand weights of the consumed leaves and larvae were measured daily. The observations continued over the whole larval development period and measurements were made daily.

Results

Biology and development of immature stages

The continuous rearing of *K. Ectrapela* using field cages in natural conditions revealed that the species completed six generations within a growing season and hibernated as a fully developed larva inside a protective cocoon in the plant litter under dock plants. The first generation appeared from early April to the end of the May (spring) and the latest generation appeared from late September to late October (end of summer, early autumn). Adult emergence of overwintered sawflies was recorded on 11th, 7th and 9th April in 2011, 2012 and 2013, respectively. After emergence, they copulated (fig. 1) and using their saw-like ovipositors, females inserted eggs into the edge of *Rumex* leaves in a single row (fig. 2, 3). The first oviposition was observed on April 15th, April 10th and on April 11th in 2011, 2012 and 2013, respectively. The life cycles of *K. Ectrapela* under field cage in natural conditions are summarized in table 1. The total life cycle from egg to adult ranged from 28 to 43 days in natural conditions.

Fig. 1. Mating of *K. Ectrapela* in the field.

Fig. 2. Fertile female of *K. ectrapela* is inserting her eggs into the edge of *R. Obtusifolius* leaf.

Fig. 3. *K. ectrapela* eggs (along leaf margins).

Eggs

The eggs of *K. Ectrapela* are ovate and light green in color when first deposited and change to light brown to cream-colored 3-4 days after ovipositon. The eggs was 1.86, SE = 0.12 mm (range 1.62-1.92 mm) long and 0.81, SE = 0.04 mm (range 0.64-0.96 mm) wide (n = 16) in average. The average number of eggs per leaf were calculated as 86, SE=21 (n = 36 leaves, range = 31 – 125 eggs). Depending upon daily temperature, the incubation period takes 6-16 days. Minimum incubation period took place from June 25th till 1st July, 2011. The longest time for egg incubation was 16 days which took place for the first generation in early growing season from 11th till 27th April, 2013. Eggs were found up to early October in natural conditions.

Table 2 represents the dates and the number of eggs inserted by one female on the edge of leaves inside the cages. According to the table 2, the mean number of eggs deposited by one female was 148.67, SE = 37.33.

Table 1. The life cycles of *K. Ectrapela* over three years (2011-13) in cages under natural conditions in Urmia, West Azerbaijan Province, Iran.

Months	Years		
	2011	2012	2013
April (Spring)	11th first adult emergence, 15th first oviposition. 27-29th eggs hatched.	7th first adult emergence. 10th first oviposition, 23-24th eggs hatched.	9th first adult emergence. 11th first oviposition, 26-27th eggs hatched.
May (Spring)	10-13th pupation occurred. 20-22th adults emerged. 24thoviposition.	8-10th pupation occurred. 18-20th adults emerged. 22thoviposition.	9-12th pupation occurred. 22-24th adults emerged. 25thoviposition
June (Spring-Summer)	3-5th eggs hatched. 14-16th pupation occurred. 22-24th adults emerged. 25thoviposition.	2-3rd eggs hatched. 16-18th pupation occurred. 26-27th adults emerged. 29thoviposition.	1-3rd eggs hatched. 17-20th pupation occurred. 25-27th adults emerged. 30thoviposition
July (Summer)	1-3th eggs hatched. 10-12th pupation occurred. 19-20 adults emerged. 21thoviposition. 28-29th eggs hatched.	7-8th eggs hatched. 16-18th pupation occurred. 24-26th adults emerged. 26thoviposition.	8-11th eggs hatched. 18-20th pupation occurred. 29-30th adults emerged. 31thoviposition
August (Summer)	6-8th pupation occurred. 19-21th adults emerged. 21thoviposition. 30-31th eggs hatched.	2-3th eggs hatched. 12-14th pupation occurred. 23-25th adults emerged. 26thoviposition.	7-9th eggs hatched. 16-19th pupation occurred. 29-31th adults emerged.
September (Summer-Early Autumn)	9-11th pupation occurred. 20-23th adults emerged. 23thoviposition.	3-6th eggs hatched. 11-12th pupation occurred. 21-23th adults emerged. 24thoviposition.	2edoviposition. 10-12th eggs hatched. 19-21th pupation occurred. 29-30th adults emerged.
October (Autumn)	4-7th eggs hatched. Some larvae dead and some of them pupated on 21-25th. By the end of October all larvae disappeared from host plant.	6-8th eggs hatched. By the end of October all larvae disappeared on host plant for pupation.	1st October oviposition. 12-15th eggs hatched. By the end of October all larvae disappeared on host plant

Table 2. Date and the number of eggs per female inserted by *K. ectrapela* on the edge of leaves.

Year	2011				2012				2013			
Date of oviposition	26th Jun.	23th Jul.	25th Aug.	27th Sept.	30th Jun.	29th Jul.	28th Aug.	27th Sept.	26th Jun.	23th Jul.	25th Aug.	27th Sept.
Number of eggs	84	186	115	160	187	162	194	97	119	183	154	143

Larvae

After hatching, young larvae aggregated and began feeding between small veins on the underside of leaves (fig. 4). However, second and third instar larvae consumed the leaf entirely and leaving only the midrib and major veins. Small plants were killed in their early growing stages by the sawfly damages.

The newly hatched larvae are olive green with black heads. Coloration changes with development and the last instar larvae are yellow with black spots on the thoracic and abdominal segments (fig. 5).

The larvae of different generations developed on host plants for 9-23 days with the minimum period for larval development occurring from the late July to the early August. Upon maturity, final instar larvae of the first to fifth generations climb the host or nearby dock plants and construct white or brownish silken cocoon for pupation (fig. 6). Fully developed larvae of sixth generation leave host plant and spin their cocoon in plant litter at the depth of 1-3 cm in the soil under the dock plants. The larva stay in the cocoon until the March of the following year when they change to the pupae and emerge in early April as adult sawfly.

Larval weight, length, and head capsule measurements (n = 25) for each instar are shown in table 3. The maximum weight of a fully developed larva was found to be 402 mg.

Fig. 4. Early instar larvae of *K. Ectrapela*.

Fig. 5. Fully grown larvae of *K. Ectrapela.*

Fig. 6. Cocoons of *K. Ectrapela* on host plant.

Table 3. Measurements of head capsule, weight and length of larval *K. ectrapela*in each instar (mean ± SD) (n = 25).

Instar	Head capsule measurements mm	Weight mg	Length mm
First	0.295 ± 0.082^{a}	46 ± 31^{a}	4.79 ± 1.41^{a}
Second	1.17 ± 0.09^{b}	147 ± 39^{b}	11.8 ± 2.82^{b}
Third	1.91 ± 0.26^{c}	327 ± 72^{c}	26.18 ± 3.36^{c}

Mean values followed by different letters in each column are significantly different based on Duncan's multiple range test ($p > 0.05$, $df = 2$).

Pupa

The duration of pupal stage was 7-13 days depending on environmental conditions. Cocoons measured 14.12 ± 1.93 mm in length, 5.66 ± 0.71 mm in width, and weighed 185.42 ± 16.49 mg in average.

Adults

Newly emerged adults were sexed using the key provided by Blank & Taeger (1998).

Parasitoids

During this study, two parasitoids, *Tetrastichus kokujewiae* Yegorenkowa & Yefremova (Eulophidae) and *Cryptus inquisitor* Tschek, 1871 (Ichneumonidae) were reared from larvae of *K. ectrapela* collected from Urmia region. The parasite larvae reared inside the host larvae, but adults emerged from pupal cocoons and there were no pupal parasitoids.

Both parasitoid species were recorded at every three years of the study and both emerged from overwintering pupae collected from the field. This suggested that both species overwinter as larvae in the host. Both species were also collected during the growing season from different generations of the host; suggesting that the two species are multivoltine.

Recently *T. kokujewiae* described as a new species (Yegorenkova *et al.*, 2012). It parasitized up to 18.2% of *K. Ectrapela* larvae. This parasitoid is gregarious and the adults emerged from each host numbered 19-38 (fig. 7).

The distribution of *Cryptus inquisitor* in Iran has been reported by Karimpour & Razmi (2010). It killed up to 27.2% of *K. Ectrapela* larvae in July 2013, on fourth generation of its host. This parasitoid completes more than 3 generations per year. In the spring (April), this parasitoid appears about 7-10 days prior to emergence of the first generation of *K. ectrapela*.

Host range of larvae

K. ectrapela only feed on *Rumex* species in the field. However, to demonstrate its specificity and safety as a biological control agent,*K. Ectrapela* was tested against a series of plants (table 4). Heavy larval feeding on leaves was observed on all *Rumex* species and occasionally occurred on *Polygonum persicaria* L. However, complete larval development occurred

only on four species of *Rumex* (table 4). Although feeding occurred on *P. persicaria*, survival was reduced in the first and second instar larvae and no larva survived to third instar (table 4). On all other plant species, larvae died within 3-4 days without feeding. These no-choice tests, suggested that *K. Ectrapela* would only attack and survive on *Rumex* species.

Fig. 7. Fully developed larvae and pupae of *T. Kokujewiae* inside the cocoon of *K. Ectrapela*.

Table 4. Plant species used in no-choice feeding tests with first instars of *K. Ectrapela* and its larval development from second instars and survival to the third larval stage and pupa.

Plant species	Family	No. of Larvae	% larvae surviving to stage		
			II	III	P
Rumexobtusifolius	Polygonaceae	10	100	100	100
Rumexacetosa	Polygonaceae	10	100	100	100
Rumexcrispus	Polygonaceae	10	100	100	100
Rumexacetosella	Polygonaceae	10	100	100	100
Polygonumpersicaria	Polygonaceae	10	60	20	----
Amaranthusretroflexus	Amaranthaceae	10	----	----	----
Helianthus annus	Asteraceae	10	----	----	----
Helianthus tuberosus	Asteraceae	10	----	----	----
Achilleamillefolium	Asteraceae	10	----	----	----
Anchusaitalica	Boraginaceae	10	----	----	----
Myosotissylvatica	Boraginaceae	10	----	----	----
Cardariadraba	Crucifera	10	----	----	----
Crambeorientalis	Crucifera	10	----	----	----
Conringiaorientalis	Crucifera	10	----	----	----
Medicagosativa	Leguminosae	10	----	----	----
Glycine max	Leguminosae	10	----	----	----
Plantago major	Plantaginaceae	10	----	----	----
Plantagolanceolata	Plantaginaceae	10	----	----	----
Epilobiumdodonaei	Onagraceae	10	----	----	----
Malvaneglecta	Malvaceae	10	----	----	----
Solanumtuberosum	Solanaceae	10	----	----	----
Lycopersicumesculentum	Solanaceae	10	----	----	----
Chenopodium album	Chenopodiaceae	10	----	----	----
Beta vulgaris	Chenopodiaceae	10	----	----	----
Ricinuscommunis	Euphorbiaceae	10	----	----	----
Poteriumsanguisorba	Rosaceae	10	----	----	----
Potentillareptans	Rosaceae	10	----	----	----

Feeding potential of *K. ectrapela*on *Rumexobtusifolius*

Feeding activity of three larval instars of *K. Ectrapela* was investigated on *Rumex obtusifolius* L.. Weight of consumed leaves differed between instars (table 5). During 3 days of the developmental time, one first instar larva consumed 0.041g of *R. obtusifolius* leaves. Consecutive two instars during 4 and 5 days consumed significantly larger amounts of leaves; viz, 1.227g, and 3.058g, respectively. Total weight of consumed leaves by all three instars of a single larva, amounted 4.310g during 12 days of the developmental time.

Discussion

K. ectrapela is a taxonomically well-defined species, (Blank & Taeger, 1998). But apart from short description by Scott & Yeoh (1996) and Blank & Taeger (1998), no detailed information on the *K. Ectrapela* has been found in the literature.

A wide range of insect herbivores attack docks and a reasonable amount of data is available regarding their biology and ecology (Salt & Whittaker, 1998). *K. ectrapela* merely feeds on the leaves of docks and often removes a large proportion of host plant leaves. Hence, its ecology and biology should also be studied just like the other herbivorous insects which attack the docks. Among the insect species found feeding on *Rumex* species in Urmia region, the dominant species is *K. ectrapela*. The larvae feed on the leaves of host plants and were observed to cause extensive damage in the field. Data concerning the biology, host specificity and feeding activity of *K. Ectrapela* were recorded for the first time.

As expected from observations of the field host range of *K. ectrapela*, the host specificity tests confirmed that *Rumex* spp. were the only acceptable host plants for this insect. Determination of a suitable biocontrol agent's host range is the most critical step in biological control of weeds. Since, host range of docks leaf defoliator saw fly is restricted to *Rumex* spp. it can be considered as a promising biocontrol agent in docks management.

Three parts of the life cycle would seem to be important in any dock management programme; 1) reduction or elimination of (viable) seed production, 2) prevention of establishment of plants and/or 3) destruction of the taproot. Good candidates need to cause substantial damage to the weeds, sustained over the long growing season, and prevent the plants accumulating energy stores in the taproot (Davies & Turner, 2003).

The *K. Ectrapela* is the most effective leaf feeding species on *Rumex* spp. in comparison with both *G. Atrocyanea* and *G. viridula*. As mentioned earlier, a single larva of *G. Viridula* consumes 1.243 g over the developmental time (Piesik & Wenda-Piesik, 2005). While it was for *K. ectrapela*4.310g. In addition, *K. Ectrapela* produces more generations than the two species of *Gastrophysa*.

As already noted, *K. Ectrapela* is the most important herbivore insect occurring on *Rumex* species in Urmia region and it can produce six generations per growing season. Finally, it can be concluded that *K. Ectrapela* has strong potential in dock species biocontrol and it could be an effective biological control agent of *Rumex* species, because:

1- The insect produces several generations each year; so different larval stages can be present throughout the growing season on docks and causing continuous damages.

2- The species has high fecundity.

3- Host range of sawfly is limited to *Rumex* species and

4- In comparison to *other* herbivorous *insec*ts, it consumes larger amounts of host plant leaves.

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Table 5. Characterization of larval consumption in laboratory.

Larval instars	Days of experiment	Average weight of consumed leaves (95% confidence interval of mean)* (g/larva/day)	Total consumed weight of leaves (g/larva)
L_1	3	0.013 (0.0127-0.0143) [a]	0.041 ± 0.00 [a]
L_2	4	0.307 (0.303-0.311) [b]	1.227 ± 0.006 [b]
L_3	5	0.612 (0.605-0.620) [c]	3.058 ± 0.014 [c]
L_1-L_3	12	---------	4.310 ± 0.01

*Average of 10 larvae in 5 replications.
Mean potential feeding of each larval instars, followed by different letters in each column are significantly different based on Duncan's multiple range test ($p > 0.05$, $df = 2$).

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