

## Insect pests associated with Andean lupin (*Lupinus mutabilis* Sweet) and their parasitoids in Peruvian central coast – (Lima, La Molina)

## Insectos plaga asociados al cultivo del tarwi (*Lupinus mutabilis* Sweet) y sus parasitoides en costa central del Perú– (Lima, La Molina)

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### Abstract

This survey aimed to determine the insect pests associated with Andean lupin (*Lupinus mutabilis* Sweet) and its parasitoids, under Peruvian central coast conditions. Sampling was made every seven days with the following methods: linear meter evaluations, plant organ evaluations, pitfall traps, and beating trays. Infested plant organs were taken to the laboratory for adult insect recovery (phytophagous or parasitoids). Pitfall traps and beating tray samples were also processed and stored. During the survey, 14,051 individuals belonging to 11 orders and 91 families were recorded. Insects that infested Andean lupin were *Melanagromyza lini* Spencer (stem borer), *Liriomyza huidobrensis* (Blanchard) (leafminer), *Crociosema aporema* (Walsingham) (budborer), *Grammopsoides tenuicornis* (Casey) (stem borer) and *Frankliniella occidentalis* (Pergande) (bud and flower thrips). *Diglyphus websteri* (Crawford), *D. begini* (Ashmead), *Chrysocharis flacilla* (Walker), *C. caribea* Boucek, *Chrysocharis* sp. and *Halticoptera arduine* (Walker) were recorded as parasitoids of *L. huidobrensis*, whereas *Carcelia* sp. was recorded for *C. aporema*.

**Key words:** *Lupinus mutabilis*, Andean lupin, *Liriomyza huidobrensis*, *Melanagromyza lini*, insect fauna.

### Resumen

El objetivo de esta investigación fue determinar los insectos plaga asociados al cultivo de tarwi (*Lupinus mutabilis* Sweet) y sus parasitoides, en condiciones de la costa central. Las evaluaciones se realizaron cada siete días y se emplearon las siguientes metodologías: evaluación por metro lineal, evaluación por órganos de la planta, trampas de caída y sacudida de plantas. Se llevaron al laboratorio órganos infestados de la planta para la recuperación de fitófagos adultos y/o parasitoides, las muestras provenientes de las trampas de caída y de sacudida de plantas, para ser procesados. Durante el periodo de las evaluaciones se registraron 14 051 individuos distribuidos en 11 órdenes y 91 familias. Las especies que infestaron al cultivo fueron: *Melanagromyza lini* Spencer (barrenador de tallos), *Liriomyza huidobrensis* (Blanchard) (minador de hojas), *Crociosema aporema* (Walsingham) (barrenador de brotes), *Grammopsoides tenuicornis* (Casey) (barrenador de tallos) y *Frankliniella occidentalis* (Pergande) (picador-chupador, raspador de brotes y flores). Se registraron los siguientes parasitoides de *L. huidobrensis*: *Diglyphus websteri* (Crawford), *D. begini* (Ashmead), *Chrysocharis flacilla* (Walker), *C. caribea* Boucek, *Chrysocharis* sp. y *Halticoptera arduine* (Walker), mientras que para *C. aporema* se registró a *Carcelia* sp.

**Palabras clave:** *Lupinus mutabilis*, tarwi, *Liriomyza huidobrensis*, *Melanagromyza lini*, entomofauna.

### Introduction

Andean lupin (*Lupinus mutabilis* Sweet) (“tarwi,” “tarhui,” “chocho”) is an Andean grain, used mainly as part of traditional cuisine. Nutritional value of this grain has been addressed in numerous publications (Jacobsen & Mujica, 2006), as well as its potential to prevent and support the treatment of degenerative diseases (Biesalski et al., 2009; Fornasini et al., 2012; Kris-Etherton et al., 2002).

In recent years, interest in Andean native crops has increased due to its nutritional and therapeutic qualities, which increases its demand and leads, as in the case of quinoa (Cruces et al., 2016), to be produced in large

extensions. This increment implies a higher risk in crop health. It is also known that when a crop is introduced to areas that are different from its place of origin, its phenology is modified and it can sometimes become host of new pests and diseases (White, 1984; Cammell & Knight, 1992; Kiritani, 2007; Sigsgaard, Jacobsen, & Christiansen, 2008).

In Peru, agricultural activity at high altitudes involves productive risks due to unfavorable climatic conditions and incipient productive technology. The opposite scenario is seen on the coast, where the accelerated phenology of this Andean crops, available technology and climatic stability

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results in better harvests. Publications about Andean lupin pests are relatively scarce and developed on high altitude agricultural ecosystems.

**Alata-Cóndor (1973)** made first publications about insects associated with Andean lupin, showing *Empoasca* sp. and *Metascarta impressifrons* Muir as harmful insects. *Frankliniella auripes* Hood, *Frankliniella regia* Hood, *Frankliniella regina* Hood and *Frankliniella alonsoae* Hood, were recorded associated with another plant of the genus *Lupinus* by **Ortiz (1973, 1977)**.

Later **Yabar & Baca (1981)** made observations on insects infesting Andean lupin in Cusco and recorded *Feltia* spp., *Copitarsia incommoda* (Walker), *Plusia chilensis* Btlr, *Heliothis titicacae* Hardwick (Noctuidae), *Colias* sp. (Pieridae), *Leptotes callangae* Dyar (Lycaenidae). They also mentioned *Astylus* sp., *Thrips* sp., *Agromyza* sp., *Melanagromyza* sp., *Apion* sp., *Epicauta* sp., *Liriomyza* sp., *Crociosema* sp., *Metascarta impressifrons* Signoret, *Empoasca* sp., *Agrotis* spp., *Puranius* sp. and two unknown species, Anthomyiidae and another belonging to Tenebrionoidea superfamily.

In the book “Plagas de Cultivos Andinos”, **Sánchez & Vergara (1991)** included a list of 22 species of pest insects associated with Andean lupin. **Carrasco (1995)** mentions eight species of insects infesting Andean lupin fields in Cusco: *Apion (Trichapion) lupini* (Coleoptera: Curculionidae), “black beetle of tarhui”; *Liriomyza andina* (Malloch) (Diptera: Agromyzidae), “fly borer of branches and stem”; *Liriomyza* sp. “Leafminer fly”; *Colias lesbia* (Fabricius) and *C. euxanthe* Feld (Lepidoptera: Pieridae), “leaf and pod eaters”; *Gnorimoschema* sp. (Lepidoptera: Gelechiidae), “leafminer moth”; *Hylemya santi-jacobi* (Diptera: Anthomyiidae) and *Diabrotica decempunctata* (Latreille) (Coleoptera: Chrysomelidae).

Recently, **Camarena-Mayta et al. (2012)** published extensive information about the center of origin, physiology, wild relatives, nutritional values and culinary recipes of Andean lupin, with a brief chapter dedicated to pests, mentioning cutworms as *Copitarsia turbata* Herrich & Schäffer, *Feltia* spp. and *Prodenia* spp; also Dr. Camarena considered as secondary pests to *Frankliniella alonsoae* Hood, *F. regia* Hood and *Liriomyza* sp; additionally, *Empoasca* sp. as an occasional pest.

Taking this into account, the objective of this research was studying insects associated with Andean lupin in central coast conditions, determining the main phytophagous species, the behavior of their populations, and predators and parasitoids of harmful species. This study will allow a comparative analysis between the harmful and the beneficial insect communities among the Andean and coastal agroecosystems. This information will help to establish baselines for Integrated Pest Management strategies for this crop on the Peruvian coast.

## Materials and methods

This survey was carried out in a field of Andean lupin in “Guayabo 01” farm, within the campus of Universidad

Nacional Agraria La Molina (UNALM), District of La Molina, Province of Lima, Lima Region, located at 12 ° 05'06 “S, 76 ° 57'06 “W and 251 meters above sea level, from June 30, 2013 to December 24, 2013.

*L. mutabilis* seed from INIA (Instituto Nacional de Innovación Agraria) of ‘Andenes’ variety was used. During growing season no application of insecticides was carried out; however, a fungicide was applied at the beginning to prevent fungi borne diseases in addition to herbicide 45 days after sowing.

Survey of the insects was carried out in an area of 2500 m<sup>2</sup> and was divided into five sectors, as recommended by **Sarmiento & Sánchez (2012)**.

Evaluations began on July 30, 2013, finished on December 24, 2013, and were made every seven days in the morning from 6 a.m. to 12 p.m. Five techniques were used: direct search at ground level, plant organ evaluation, beating tray, pitfall traps and in situ counting. Temperature and relative humidity were recorded.

### a) Field work.

#### *Direct search at ground level.*

Two linear meters at ground level were evaluated in each sector. Presence of cut seedlings or plant cutworms on each side of the linear meters was observed during the first four evaluations.

#### *Plant organ evaluation*

A total of 20 plants in the field were evaluated, four by sector. One terminal shoot (terminal bud and 2-3 first leaves) per plant was observed during vegetative development. Plants were divided by thirds for evaluation from the beginning of floral bud formation until the end of the growing season.

#### *Beating tray*

This procedure was done in a plastic tray (30 cm x 40 cm) with water and detergent to prevent insects from escaping. Four plants for each sector were tilted towards the tray and shaken vigorously, trying that all arthropods fall on it, then the content of the tray was transferred into hermetic containers and was labeled indicating the corresponding sector.

#### *Pitfall traps*

A fall trap was installed per sector. The traps consisted of cylindrical containers of polypropylene of 400 ml capacity, placed at ground level, with a mixture of coolant and water (1:1), as well as a detergent. The coolant was used to prevent the decomposition of the collected arthropods, and the detergent was used to break the surface tension.

#### *In situ counting*

This method consisted in counting by direct observation of the insects perched on the plants.

## **b) Laboratory procedures**

### ***Screening and preservation of samples of pitfall traps and beating tray.***

The contents of each container were sifted; water was applied carefully to clean the dirt. Each sieved sample was moved to another bowl with 75% alcohol.

### ***Sorting, coding, counting, recording and preserving of morphotypes***

#### ***Sorting***

Each sample was transferred to a 6 mm diameter Petri dish. Each plate was examined through a Karl Zeiss Jena stereoscope with 10-100x magnification, where morphotypes were separated. According to [Oliver & Beattie \(1993\)](#), a morphotype is a group of specimens provisionally equivalent to species, based on conspicuous differences in their external morphology.

#### ***Coding***

Each morphotype was provisionally placed in a taxonomic category and assigned a code using the first 3 or 4 letters of the taxon in which it was classified, followed by a number. The provisional determination was preferably family, Example: "DOL01", if the specimen was provisionally determined as a Dolichopodidae; "DIP01", if the specimen was determined only up to its order level, in this case, Diptera case and so on. To the identified and encoded morphotype, at least one photograph was taken as reference for subsequent samples. The code of the picture was added to the morphotype code, in such a way that each container had the morphotype code and the code of the corresponding photograph annotated to help the comparison.

#### ***Count and record***

Once the morphotype was established and a code assigned, all individuals corresponding to said morphotype were counted by sector and by week. It was recorded in a physical record and later this information was transferred to a digital spreadsheet. In the case of very abundant morphotypes such as some of Collembola, Thysanoptera, Eulophidae, and Cicadellidae, a manual hand counter was used.

#### ***Preserving***

Each morphotype was preserved in a glass container of 2 cm in diameter x 5 cm in height with a rubber cap and ordered alphabetically, considering its code. All samples were stored in Museo de Entomología Klaus Raven Büller (MEKRB) at UNALM.

### ***Procedure for adults and / or parasitoids recovery***

Leaves and stems infested with immature phytophagous insects were taken to the laboratory and were conditioned in 400 ml polypropylene containers covered with organza

fabric to allow perspiration and a double layer of paper towel on the base to avoid excess moisture. It was observed periodically until adults or parasitoids were obtained.

### ***Location in the corresponding taxonomic category of specimens by morphotype collected***

All morphotypes were determined at a family level, some at a genus level and others at a species level, depending on their abundance or importance in the crop. The determination at the family level in most cases was made without the need of mounting; however, in the case of small or tiny specimens, it was necessary to make a tip or slide mounting before clarification treatment according to the corresponding taxonomic group.

### ***Aphididae and Thysanoptera mounting***

The procedure suggested by [Voegtlin et al. \(2003\)](#) for Aphididae was used.

### ***Procedure for mounting Diptera preserved in 75 ° alcohol***

Specimens were placed in containers with 96° alcohol for 24 hours, then transferred to containers with ethyl acetate for 48 hours and then mounted in entomological tips.

### ***Microhymenoptera mounting***

Mounting was carried out according to steps suggested by [Pitkin \(2003\)](#).

### ***Taxonomic keys used***

#### ***Families***

- Insecta ([Triplehorn & Johnson, 2005](#))
- Hymenoptera ([Fernandez & Sharkey, 2006](#))

#### ***Genera***

- Tachinidae ([Wood & Zumbado, 2010](#))

#### ***Species***

- Thysanoptera ([Mound & Kibby, 2005](#))
- Agromyzidae ([Korytkowski, 2014; Spencer, 1973](#))
- *Halticoptera* ([De Santis, 1987](#))
- *Diglyphus* ([Gordh & Hendrickson, 1979](#)) and [Dr. Mujica \(pers. comm.\)](#)
- *Chrysocharis* ([Hansson, 1987](#))

## **Results and discussion**

A total of 14,051 specimens were recorded in 11 orders and 91 families ([Table 1](#)). The most abundant insect families were: Thripidae (3626 specimens), order Thysanoptera; Eulophidae (1713), Scelionidae (672) and Formicidae (523), order Hymenoptera; Cicadellidae (1347) and Aphididae (632), order Hemiptera; Sciaridae (511), Agromyzidae (244), Phoridae (231), Sphaeroceridae (229) and Dolichopodidae (207), order Diptera; and Latridiidae (348), order Coleoptera.

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Table 1. Orders, number of specimens and number of families of insects collected from July 30 to December 24, 2013. La Molina, Lima - Peru

| Order        | Number of specimens | Number of families |
|--------------|---------------------|--------------------|
| Thysanoptera | 5191                | 1                  |
| Hymenoptera  | 3200                | 23                 |
| Hemiptera    | 2264                | 12                 |
| Diptera      | 2155                | 29                 |
| Coleoptera   | 841                 | 15                 |
| Psocoptera   | 193                 | 2                  |
| Orthoptera   | 90                  | 1                  |
| Lepidoptera  | 65                  | 4                  |
| Neuroptera   | 42                  | 2                  |
| Dermaptera   | 7                   | 1                  |
| Dyctioptera  | 3                   | 1                  |
| Total        | 14,051              | 91                 |

### Insect pests associated with Andean lupin in La Molina.

*Melanagromyza lini* Spencer, 1963 (Diptera: Agromyzidae).

This is a Neotropical species, registered in Colombia (Ruiz & Checa, 1990), in Chile cited as *M. aguilerai* by Spencer (1982) (Sasakawa, 1994), Peru (Korytkowski, 2014; Spencer, 1963) and Argentina (Sasakawa, 1992). *M. lini* is a stemborer species and has been reported on *Linum usitatissimum* L. (Spencer, 1963), on *Vicia faba* L. (Ruiz & Checa, 1990), *Phaseolus vulgaris* and *Chenopodium pallidicaule* (Korytkowski, 2014). In Andean lupin, the larvae of this species came to infest 100% of the plants evaluated and caused the weakening of the stems and subsequent entry of pathogens. No parasitoids were recovered, so biological control of this species is probably very limited, a fact that could not be confirmed due to the scarce information about the biology of this species.

*Liriomyza huidobrensis* Blanchard, 1926 (Diptera: Agromyzidae)

This is a polyphagous species (Spencer, 1973, Benavent et al. (2004) indicate that it has 109 host species distributed in 33 families. In Peru Korytkowski (2014) records species from Amaranthaceae, Asteraceae, Brassicaceae, Cucurbitaceae, Fabaceae, Malvaceae, Solanaceae, Apiaceae and Liliaceae families, as hosts of *L. huidobrensis*. In this study, *L. huidobrensis* has been present during the whole period of the crop, infesting up to 98% of the leaves of the lower third, 85% of the middle third and 26% of the upper third. This preference for the lower leaves has been described in other crops such as potatoes (*Solanum tuberosum* L.) and broad bean (*Vicia faba* L.) (Galantini & Redolfi 1993, Neder et al., 1993). Gonzales-Bustamante (1995) mentions the phenomenon of “extrusion” of the eggs of *L. huidobrensis* as one of the causes for the lower infestation of the upper third. The adult females performed

feeding punctures in the leaves, so the presence of these punctures would constitute evidence of a future attack of this species, even before the mines made by the larvae become evident. According to Martin et al. (2005), these punctures also helps the female to detect if the plant is suitable for oviposition.

*Crocidosema aporema* (Walsingham, 1914) (Lepidoptera: Tortricidae)

This tortricid moth is an oligophagous species of Neotropical origin that colonized soybean when this crop was introduced into the New World (Sánchez & Pereyra, 2008). Small larvae feed on growing buds and occasionally tunnel into leaf petioles (Turnipseed & Kogan, 1976). *C. aporema* also feeds on shoots of many other cultivated legumes such as peanuts, clover, alfalfa, lotus, melilotus, lupin, broad bean, beans and others (Sánchez & Pereyra, 2008). In this study, *C. aporema* showed a preference for the upper third, due to the architecture of Andean lupin, since it presents most of its buds in the upper third. Another detail to mention is that due to the continuous sprouting of *L. mutabilis*, the damage of this species occurred from four weeks before flowering to the end of the growing season, unlike soybeans, where flowering periods and therefore of infestation, are shorter (Correa, 1980).

*Grammopsoides tenuicornis* (Casey, 1913) (Coleoptera: Cerambycidae)

This longhorn beetle is a species registered in Panama, Ecuador, Colombia (Monné 2014) and Peru (Vergara-Cobián & Amaya, 1978). It has been previously registered as *Grammopsoides rufipes* Breuning in Peru by (Vergara-Cobián & Amaya, 1978) in a potato crop in Chimbote, later by Campbell (1980) and the International Soybean Program (1980) in soybeans. In Andean lupin, this species infested the stems, maintaining a level of infestation of 30%, not as high as in the case of *M. lini*, however, it was observed that a single larva of *G. tenuicornis*, due to its size, caused a significant weakening of the stem.

*Frankliniella occidentalis* (Pergande, 1895) (Thysanoptera: Thripidae)

*F. occidentalis* is a widely distributed (Kirk & Terry, 2003) and highly polyphagous species, since it feeds more than 250 crops from more than 60 botanical families (Reitz, 2009); however, a considerable degree of specificity has been found towards some hosts in certain populations (Mound & Marullo, 1996). *F. occidentalis* was by far the most numerous species of phytophagous insect collected in Andean lupin. The number of specimens recorded by evaluation was increasing, starting with 15 individuals three weeks after flowering until reaching 1296 individuals at harvest period. This species infested the buds and flowers of Andean lupin, causing deformations in the growing leaves and feeding on the petals, however, direct damage to the pods was not observed. According to van

Emden (2013), the highest damage they can cause in other legumes is the non-formation of the pods. This damage is of particular importance in 'determinate' legume varieties. The latter is not the case of Andean lupin, which would be able to compensate the damage due to its continuous flowering behavior.

#### b) Parasitoids of insect pests associated with tarwi culture in La Molina

In this survey was registered parasitoidism for *Liriomyza huidobrensis* and *Crociosema aporema*, both species of insect pests associated with Andean lupin.

*Chrysocharis caribea* Boucek, *C. flacilla* (Walker), *Chrysocharis* sp., *Diglyphus begini* (Ashmead), *D. websteri* (Crawford) (Hymenoptera: Eulophidae) and *Halticoptera arduine* (Walker) (Hymenoptera: Pteromalidae) were recorded in this research as parasitoids for *L. huidobrensis*.

According to the literature, in Peru, *L. huidobrensis* has a considerable amount of parasitoid insects, 16 species of the Eulophidae (Sánchez & Redolfi, 1987, 1989, Cisneros & Mujica, 1998, Delgado & Aguilar, 1980; Mujica & Kroschel, 2011), a species of Pteromalidae (Delgado & Aguilar, 1980, Cisneros & Mujica, 1998, Arellano & Redolfi, 1989, Mujica & Kroschel, 2011); a species Braconidae (Delgado & Aguilar, 1980, Sánchez & Redolfi, 1989, Cisneros & Mujica, 1998) and a species of the Eucoilidae (Sánchez & Redolfi, 1989, 1987, Cisneros & Mujica, 1998, Mujica & Kroschel, 2011).

As parasitoid of *Crociosema aporema* was recorded in this survey *Carcelia* sp. (Diptera: Tachinidae)

In Peru, *Trichogramma bactrae* Nagaraja (Trichogrammatidae) has been registered as an egg parasitoid of *C. aporema* (Whu & Valdivieso, 1999); however, researchers from Argentina, Uruguay and Chile have registered different parasitoids from the families Braconidae, Ichneumonidae, Aphelinidae, Trichogrammatidae and Tachinidae (Liljeström & Rojas-Fajardo, 2005, Ribeiro et al., 2015, Rojas, 1968, Sánchez & Pereyra, 2008).

#### Conclusions

Species that could be considered pests in Andean lupin in this survey for its damage and abundance are: *Melanagromyza lini* Spencer, *Liriomyza huidobrensis* (Blanchard), *Crociosema aporema* (Walsingham), *Frankliniella occidentalis* (Pergande) and *Grammopsoides tenuicornis* (Casey).

*Diglyphus websteri* (Crawford), *D. begini* (Ashmead), *Chrysocharis flacilla* (Walker), *C. caribea* Boucek, *Chrysocharis* sp., *Closterocerus* sp. (Hymenoptera: Eulophidae), *Halticoptera arduine* (Walker) (Hymenoptera: Pteromalidae), were recorded as parasitoids of *Liriomyza huidobrensis*.

*Carcelia* sp. (Diptera: Tachinidae) was recorded as a parasitoid of *Crociosema aporema*.

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