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Influences of leaf-mining insects on their host plants: A review

W.-H. LIU (刘婉华)¹, X.-H. DAI (戴小华)^{1,2} & J.-S. XU (徐家生)¹¹ Leafminer Group, School of Life and Environmental Sciences, GanNan Normal University, CN-341000 Ganzhou, China² National Navel-Orange Engineering Research Center, CN-341000 Ganzhou, ChinaE-mail: X.-H. Dai (ecoinformatics@gmail.com)

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Abstract

INFLUENCES OF LEAF-MINING INSECTS ON THEIR HOST PLANTS: A REVIEW.— Leaf-mining insects are an herbivore group whose larvae live and feed inside plant leaves. Leaf mines are distinct marks on leaves and can provide much information on insect-plant relationships. Most leaf miners are monophagous or oligophagous. Therefore ecologists and paleontologists use them to study interactions and coevolution among plants, insects and natural enemies. There are many different types of leaf-mining patterns on plant leaves, which may have different impacts on host plants. Compared with ectophagous herbivores, leaf-mining insects should have unique influences on host plant characteristics, such as leaf morphology, leaf chemistry, plant physiology, plant growth and production. Obvious impacts include leaf asymmetry, callus formation, photosynthesis, and green islands. Types and degrees of such influences are varied for different leaf miner species or different host plant species. In turn, the change of plant features may have positive or negative impacts on oviposition and feeding of leaf-mining insects. Studies on plant responses to leaf-mining and the defensive mechanisms of plants are helpful in understanding the coevolution between leaf miners and their food plants.

Key words: chemical ecology; interspecific interactions; pest resistance.

Resumen

REVISIÓN DE LAS INFLUENCIAS DE LOS INSECTOS MINADORES DE HOJAS EN SUS PLANTAS HUÉSPED.— Los insectos minadores de hojas son un grupo de herbívoros cuyas larvas viven y se alimentan del interior de las hojas. Lo que denominamos minas son las diferentes marcas que quedan en las hojas y que pueden proporcionar valiosa información acerca de las relaciones planta-insecto. La mayoría de minadores son monófagos u oligófagos. Los ecólogos y paleontólogos los usan para estudiar las interacciones y la coevolución entre plantas, insectos y sus enemigos naturales. Existen numerosos tipos de patrones de minas en las hojas, que pueden producir diferentes impactos en la planta hospedadora. Si los comparamos con los insectos ectófagos, los minadores de hojas pueden tener una influencia muy característica en numerosos aspectos de la planta hospedadora, como por ejemplo la morfología y la química foliar, la fisiología de la planta y su crecimiento y producción. Entre los impactos más evidentes, podemos nombrar asimetría foliar, formación de callos, fotosíntesis e «islas verdes». La tipología y el gravedad de estos impactos varían según en tipo de insecto minador y de planta hospedadora. Además, los cambios funcionales que se producen en la planta hospedadora pueden a su vez tener efectos positivos o negativos en la oviposición y la alimentación de los minadores. El estudio de los mecanismos de defensa de la planta hospedadora para combatir a los minadores puede resultar de gran utilidad para entender la coevolución entre ambos organismos.

Palabras clave: ecología química; interacciones interespecíficas; resistencia a plagas.

摘要

潜叶昆虫对寄主植物的影响：综述。— 潜叶昆虫是一类植食性昆虫，以幼虫在叶片组织内取食并生活，不破坏叶表皮或至少不破坏外壁。潜道（潜叶幼虫在植物薄壁组织或表皮内部形成的取食道）为学者研究昆虫—植物关系提供了大量的信息。大部分潜叶昆虫为单食性或寡食性。因此，生态学家和古生物学家可将其作为模式生物，用于研究植物、昆虫和天敌三者的种间关系与协同进化。潜叶昆虫在植物叶片上形成许多不同类型的潜道，因而对植物造成的影响也不尽相同。与外食性昆虫相比，潜叶昆虫对植物形状有独特的影响，这些性状包括叶片形态、化学成分、植物生理、生长和产量。比较明显的影响包括叶片的不对称性、形成愈伤组织、降低光合作用以及形成“绿岛效应”。不同潜叶昆虫对不同植物的作用方式及影响程度不同。与此相反，植物特性的改变可能会促进或抑制潜叶昆虫的取食和产卵。因此，研究寄主植物对潜叶为害的应对措施及防御机制，有利于了解潜叶昆虫和寄主植物之间的协同进化。

关键词：化学生态；种间相互作用；抗虫性。

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INTRODUCTION

Leaf miners are a special insect group whose larvae feed and live on leaf tissues lying between the upper and lower epidermis, with the epidermis or at least the outer wall remaining undamaged (Hering, 1951; Kang, 1996; Dai *et al.*, 2011b). Most leaf-mining insects are monophagous or oligophagous. Their distinct species-specific feeding marks (that is, leaf mines) usually persist for a long time. Therefore, an ecologist or a paleontologist may easily reconstruct the life histories of leaf miners, identify their taxonomic group, evaluate the influences of leaf miners on host plants, and clarify the relationship between leaf miners and plants (Hespenheide, 1991; Labandeira *et al.*, 1994; Lopez-Vaamonde *et al.*, 2006; Dai *et al.*, 2011b). Thus, leaf-mining insects can be used as model organisms to study plant–insect–environment interactions (Hirowatari, 2009; Kang *et al.*, 2009). Systematic research on leaf-mining insects has been performed in Europe, America and Australia (Needham *et al.*, 1928; Hering, 1951, 1957; Spencer, 1990; Hespenheide, 1991). For example, the UK, the Netherlands and Australia have constructed websites on leaf miners and their host plants.

Compared with ectophagous insects, endophagous leaf miners are small; each individual consumes only a small quantity of leaves during the

whole life history, generally not causing a large loss on plant biomass. They are more difficult to control due to their hiding habits; more importantly, leaf-mining might not damage the integrity of leaf surface so the impact of leaf-mining on plant physiology should be lower than expected (Pincebourde *et al.*, 2006). However, a few mining species are considered as economic pests of agricultural crops and garden plants, e.g. coffee leaf miner (*Leucoptera coffeella*), apple blotch leaf miner (*Phyllonorycter crataegella*), Citrus leaf miner (*Phyllocnistis citrella*) and serpentine leaf miners (*Liriomyza* spp.). Their serious outbreaks may cause considerable damage. Leaf-mining insects have several direct effects on host plants, such as leaf morphology, leaf chemistry, plant physiology, plant growth and production. Plant responses to leaf-mining may vary depending on the leaf miner species and the plant species. Changing plant characteristics would have either negative or even positive impacts on the behavior, growth, or survival of leaf-mining herbivores. In comparison with ectophagous insects, there are fewer studies on the influence of leaf miners on host plants, especially in China. Therefore, it is necessary to summarize the effects of leaf-mining insects on their host plants, which may provide a basis for further studies on leaf miner–plant interactions and sustainable ecological control of leaf-mining pests.

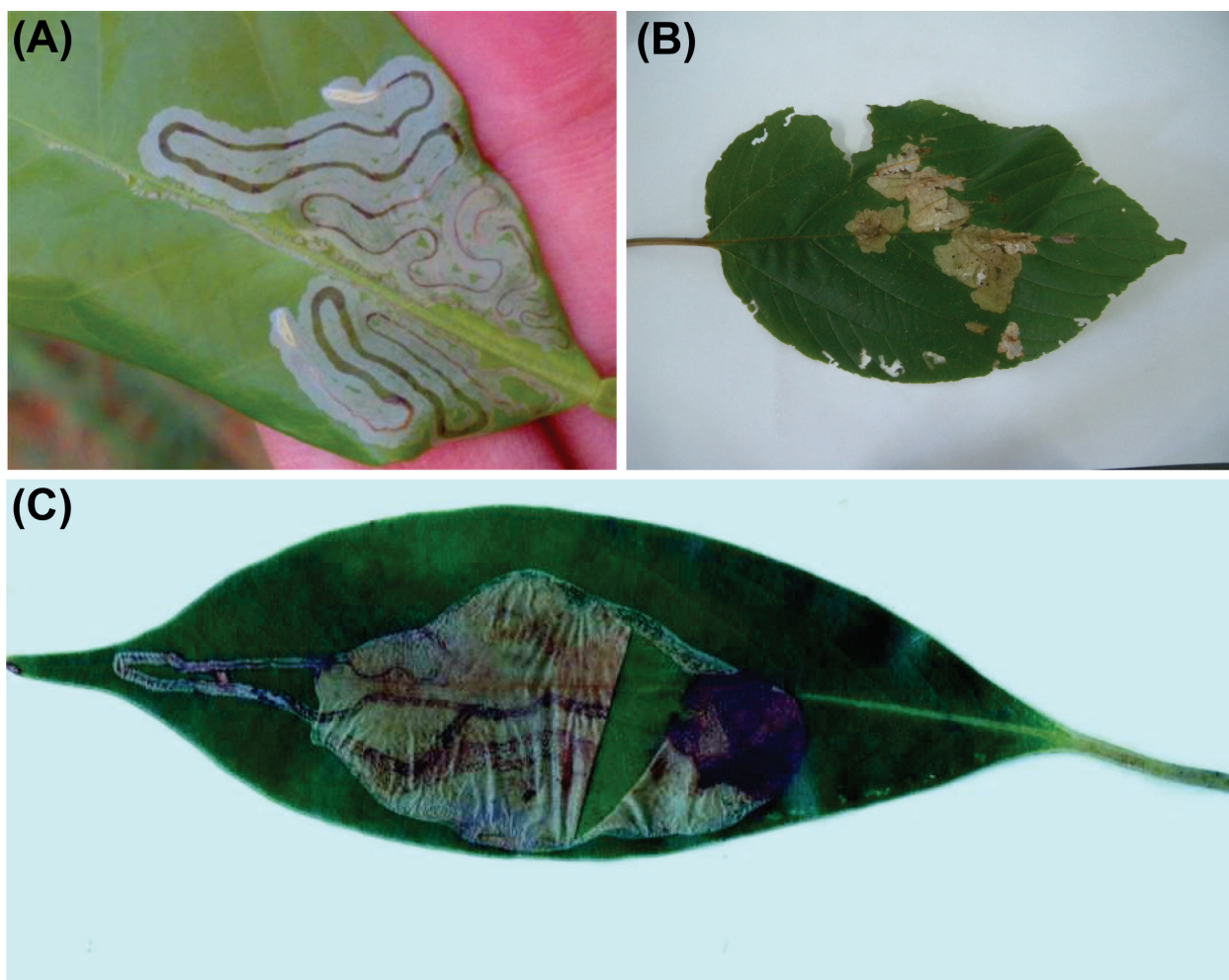


Figure 1. Three typical leaf mine shapes found in Ganzhou City, Jiangxi Province, China: (A), linear: citrus leaf miner (*Phyllocnistis citrella*) on navel orange; (B), blotch: a leaf-mining hispine beetle (*Platypria melli*) on *Hovenia acerba* Lindl.; (C), linear-blotch: a leaf-mining gracillariid moth (*Gibbovalva kobus*) on *Michelia maudiae* Dunn.

DIVERSE LEAF-MINING PATTERNS ON PLANT LEAVES

There are about 10,000 described species of leaf miners in more than 50 families and four orders: moths (Lepidoptera), flies (Diptera), beetles (Coleoptera) and sawflies (Hymenoptera) (Csóka, 2003). However, many more leaf-mining species remain undiscovered (Csóka, 2003; Hirowatari, 2009). For example, most nepticulid moths are leaf miners, with 804 described species but the estimated species number may be about 2500 (E. J. van Nieukerken, pers. comm.). After a long-period of coevolution and interspecific competition, there are diverse leaf-mining patterns (Fig. 1), even on the same plant species (Dai *et al.*, 2013, 2014).

Leaf-mine diversity shows niche differentiation of leaf-mining insects on host plant leaves, and the trade-off between seeking favorable microhabitats and nutrients and avoiding leaf defensive structures and competition.

The diversity of leaf-mining patterns may refer to different leaf mine shapes and different leaf-mining depths (Table 1; Hering, 1951; Dai *et al.*, 2013). The types of leaf mine shapes could be classified as linear mines, blotch mines, and linear-blotch mines (Fig. 1; Hering, 1951). Linear mines occur when the leaf-mining larvae keep feeding forward and have subtypes such as serpentine, spiral and branched (Kato, 1984). Blotch mines made by leaf miners have several feeding directions, with subtypes of circular, oval, rectangular, tentiform, ameba

Table 1. Effects of different vertical leaf-mining patterns on plant photosynthesis.

Leaf-mining depth	Damaged leaf tissues	Leaf miner and host plant	Effects on photosynthesis	Author (year)
Full depth mining	Both palisade and spongy parenchyma	<i>Platypria melli</i> on <i>Hovenia acerba</i> Lindl.	Very significant reduction	Liao <i>et al.</i> (2014), C. Liao <i>et al.</i> (unpubl. data)
Upper surface mining	Palisade parenchyma	<i>Liriomyza sativa</i> on tomato	Significant reduction	Johnson <i>et al.</i> (1983)
		<i>Liriomyza trifolii</i> on <i>Chrysanthemum morifolium</i> Ramat., lima bean, and potato	No or slight reduction	Parrella <i>et al.</i> (1985), Martens & Trumble (1987), Bueno <i>et al.</i> (2007)
		<i>Liriomyza trifolii</i> on celery	Significant reduction	Trumble <i>et al.</i> (1985)
		<i>Cameraria ohridella</i> on <i>Aesculus hippocastanum</i> L.	Slight reduction	Raimondo <i>et al.</i> (2003)
Lower surface mining	Spongy parenchyma	<i>Liriomyza huidobrensis</i> on <i>Chrysanthemum morifolium</i> Ramat.	Significant reduction	Parrella <i>et al.</i> (1985)
		<i>Phyllonorycter blancardella</i> on apple	Significant reduction	Kappel (1986)
Epidermal mining	Upper and lower epidermis	<i>Phyllocnistis populiella</i> on quaking aspen	Upper epidermis: no reduction; lower epidermis: significant reduction	Wagner <i>et al.</i> (2008)
		<i>Phyllocnistis citrella</i> on <i>Citrus × aurantium</i> L., <i>C. × limon</i> L. (Osbeck), and <i>C. paradisi</i> Macfad.	No reduction in the green areas of mined leaves; significant reduction in mined area only (especially in old and broken mines)	Raimondo <i>et al.</i> (2013)

shape, etc. Among linear and blotch leaf mines, there are a series of transitional types. For example, linear mines could suddenly become much wider, or blotch mines may extend a narrow mine. Both are called “linear-blotch mines” (Hering, 1951; Kang, 1996; Csóka, 2003), which may be due to a change on feeding habitats in different larval stages (Hering, 1951). The vertical feeding sites of leaf miners may be epidermal cells, palisade tissues, spongy tissues or whole leaf tissues, which are called epidermal mines, upper surface mines, lower surface mines, and full depth mines, respectively (Hering, 1951; Kang, 1996). One special case is interparenchymal mines when leaf miners forage among the lower layer of palisade tissues and the upper layer of spongy tissues (Hering, 1951). Depending on the different leaf-mining pattern, we can divide leaf-mining insects into different functional groups, and study the ecological effects of different functional groups on host plants.

IMPACTS ON LEAF MORPHOLOGY

The feeding or oviposition of leaf miners often contributes to deformities and cracks in plant leaves (Hering, 1951; Kang, 1996). Due to the presence of insect larvae inside leaves, the leaves become asymmetrical, holes appear or parts are missing from the mined leaves (Hering, 1951). The tunnel of some leaf-mining weevils ends as a circular blotch from which an exit is cut leaving a round hole. Some infested leaves are crumpled because the cuticular layer is damaged (Raimondo *et al.*, 2013). As for leaf asymmetry, the injured side of a birch leaf damaged by *Phylloporia bistrigella* is often smaller than the other (Hering, 1951); the width of each half and between side-ribs is variable in the leaves of elm (*Ulmus glabra* Huds.) mined by a leaf-mining weevil (*Rhynchaenus rufus*) (Møller, 1995). The abundance of leaf mines is associated with increasing leaf asymmetry in stone oak (*Quercus rotundifolia* Lam.)

(Møller & Lope, 1998). In unpolluted forests, the mined leaves are smaller and more asymmetric than the intact ones (Kozlov, 2005). There are a couple of factors responsible for the above growth abnormalities. If a new leaf has been oviposited in, young leaf cells are damaged and striking deformities occur during later growth (Hering, 1951). A disproportionate distribution in nutrients between damaged and normal areas of a leaf may lead to leaf asymmetry. The level of leaf asymmetry was higher when elm was provided with fertilizer. Besides, there is a positive relationship between leaf asymmetry and leaf size. That is, large-sized leaves infested by a leaf miner result in greater asymmetry than infested small ones (Møller, 1995). Oak trees with higher levels of asymmetry are more likely to die than those with lower levels (Møller & Lope, 1998). However, some researchers have argued that leaf asymmetry is induced by other environmental factors, which also result in higher leaf miner numbers (Møller, 1995). Not all miners have impacts on leaf external morphology. For example, *Liriomyza strigata* mines the main vein of leaves, and has minor effects on leaf distortion (Kang, 1996). In the other way, leaf anatomy such as vein patterns can also dictate the shape of leaf mines (Scheirs *et al.*, 1997).

IMPACTS ON LEAF CHEMISTRY

Leaf-mining may alter host plant chemical composition especially for secondary substances. Trees with leaf miners have less root carbohydrate and twig starch than healthy ones (Percival *et al.*, 2011). The midrib damaged by leaf-mining moths (Lepidoptera: Eriocranniidae) has slightly higher nitrogen concentration in tunnels than those in which the midrib was intact (Johnson *et al.*, 2002). The injured midrib would restrict water supply to the xylem, speed up protein degradation, and increase available nitrogen compounds (White, 1984). On the contrary, the alfalfa blotch leaf miner decreased the yield of protein and digestible dry matter in the field (Byers & Valley, 1981). Leaf nutritional quality changed by leaf miners may indirectly affect other insects (Johnson *et al.*, 2002). Plant secondary chemicals induced by leaf-mining larvae includes alkaloids, phenolic, benzaldehydes, methyl salicylates, benzyl alcohols, jasmonic acid, salicylic acid and so on (Mopper *et al.*, 2004; Johnne *et al.*,

2006; Magalhães *et al.*, 2010). The production of secondary metabolites may have either positive or negative impacts on the oviposition and feeding of conspecific or heterospecific herbivores (Johnne *et al.*, 2006; Magalhães *et al.*, 2010). Mined leaves can induce chemical, physical and even visual defensive signals to herbivores (Yamazaki, 2010). Leaf-mining impacts are not the same for different leaf-mining behaviors. For example, apple leaves injured by the tissue-mining stages of the spotted tentiform leaf miner (*Phyllonorycter blancardella*) contain higher levels of ethylene and 1-aminocyclopropane-1-carboxylic acid (ACC) than intact leaves or leaves injured by the sap-feeding stages of the same leaf miner (Kappel *et al.*, 1987).

Another reaction by the plant to leaf-mining is to form callus tissue in the damaged mine tunnels. A callus is a loose layer of parenchymal tissue formed by not only meristems but also in fully developed tissues (Hering, 1951). The function of callus tissue remains unclear. One reasonable guess is that callus might help to repair the leaf mines and compensate for leaf damage in photosynthesis (Hering, 1951). The main mortality factor of *Phytomyza ilicis* is the increasing quantities of callus which may squeeze the larvae to death (Ellis, 2000). On the other hand, *Liriomyza strigata* sometimes feeds on callus tissues (Kang, 1996).

Cytokinins are phytohormones with significant roles in plant growth and development (Naseem *et al.*, 2014), such as maintenance of chlorophyll (Engelbrecht *et al.*, 1969) and inhibition of leaf senescence (Pritchard & James, 1984b). Leaf miners could make “green islands” around leaf mines in autumn leaves, and leaf-mining larvae manage to complete their life history inside green islands. This phenomenon is attributed to high concentrations of cytokinins in the mined leaf area to keep living green tissues functional for photosynthetic activity (Giron *et al.*, 2007). It is amazing that insect bacterial symbionts are found to manipulate cytokinin levels to induce green islands (Kaiser *et al.*, 2010).

IMPACTS ON PLANT PHYSIOLOGY

The activities of leaf miners such as oviposition and feeding have negative effects on plant photosynthesis, which varies with different leaf-mining depths.

Generally, the impacts on photosynthesis from large to small should be: full depth mining > lower surface mining > interparenchymal mining > upper surface mining > epidermal mining (Table 1; Johnson *et al.*, 1983; Parrella *et al.*, 1985; Trumble *et al.*, 1985; Kappel, 1986; Martens & Trumble, 1987; Raimondo *et al.*, 2003; Bueno *et al.*, 2007; Wagner *et al.*, 2008; Liao *et al.*, 2014). The possible explanation should be that different leaf tissues play different roles in photosynthesis. For example, stomata are mainly distributed on the lower epidermis and mining in the spongy tissue and the lower epidermis may lead to the close of stomata (Parrella *et al.*, 1985; Wagner *et al.*, 2008). Different leaf-mining depths thus have different impacts on leaf hydraulics, gas exchange, water use and chlorophyll fluorescence (Johnson *et al.*, 1983; Parrella *et al.*, 1985; Trumble *et al.*, 1985; Kappel, 1986; Raimondo *et al.*, 2003, 2013; Pincebourde *et al.*, 2006; Bueno *et al.*, 2007; Wagner *et al.*, 2008; Lombardini *et al.*, 2013). However, the whole-plant photosynthetic loss from most leaf miners is slight because insect populations are small in natural vegetation (Hileman & Lieto, 1981; Nardini *et al.*, 2004) and the photosynthetic loss does not extend beyond the mined leaf area (Lombardini *et al.*, 2013; Raimondo *et al.*, 2013). While in some economic plants, photosynthesis is negatively correlated with leaf miner density and injury leaf area (Fujiie, 1982; Johnson *et al.*, 1983; Lombardini *et al.*, 2013).

IMPACTS ON PLANT GROWTH AND PRODUCTION

Plant growth may be significantly subjected to leaf miner activities such as oviposition and feeding (Wagner *et al.*, 2008). One interesting phenomenon is that mined leaves fall earlier than unmined leaves (Owen, 1978; Fujiie, 1982; Maier, 1983, 1989; Nagasaki, 2004; Nardini *et al.*, 2004; Bueno *et al.*, 2007; Wagner *et al.*, 2008). The effects of leaf-mining on leaf life span are stronger than other herbivore guilds (Kozlov & Zvereva, 2014). Some researchers argued that premature leaf abscission is simply a response to herbivore damage (Pritchard & James, 1984b; Stiling & Simberloff, 1989). While others suggested that early leaf fall is an evolutionary adaptation, which is beneficial to host plants themselves (Owen, 1978; Pritchard & James, 1984b). First, premature leaf fall stops

the further development of young leaf miner larvae lessening leaf miner numbers in the next generation. The falling of mined leaves earlier than unmined leaves may attribute high mortality of some leaf miners (Faeth *et al.*, 1981; Simberloff & Stiling, 1987; Stiling *et al.*, 1987, 1991; Auerbach & Simberloff, 1989; Preszler & Price, 1993; Connor *et al.*, 1994; Waddell *et al.*, 2001), since the development of most leaf miner larvae is restricted to a single leaf (Zvereva & Kozlov, 2014). Second, leaf miners could make leaves fall year-round and return the nutrients back to the tree in a more even way (Owen, 1978). Premature leaf abscission is positively correlated with the densities of the mines (Shinozaki *et al.*, 2012). Infested cranberry leaves by *Coptodisca negligens*, those with two mines drop earlier than those with only one mine (Maier, 1989). Leaf-mining (and other herbivorous feeding) damage to young leaves and to plants with a higher specific leaf area reduce more in leaf life span than damage to old leaves and to plants with a lower specific leaf area (Zvereva & Kozlov, 2014). Premature abscission due to leaf-mining is lower for deciduous trees than for evergreen ones (Bultman & Faeth, 1986). Impacts of mining on plant leaves differ from season to season or from insect generation to generation (Pritchard & James, 1984b).

However, early leaf drop is not a characteristic of all plants infested with leaf miners and appears to be a relatively minor ecological factor. For example, <40% of mined leaves drop early (Kahn & Cornell, 1983); less than 3% of leaf miner larvae in dropped leaves suffer mortality (Pritchard & James, 1984a; Oishi & Sato, 2007; Gripenberg & Roslin, 2008; Shinozaki *et al.*, 2012); and photosynthesis is not reduced enough to severely damage the host plant (Parrella *et al.*, 1985; Martens & Trumble, 1987; Raimondo *et al.*, 2003; Bueno *et al.*, 2007). Moreover, early leaf abscission has no influence on holly leaf miner survivorship (Kahn & Cornell, 1989). Possible reasons are that fallen leaves onto the forest floor would escape searching by parasitoids and the maggots are already in the pupal stage (Kahn & Cornell, 1989). *Coptotriche japoniella* can prevent premature leaf abscission to make sure the successful emergence of the imago before leaf falls (Oishi & Sato, 2007). Some plants retain and change the visibility of leaf mines to deter other herbivores and to attract natural enemies (Yamazaki, 2010).

Leaf-mining may have a detrimental effect on whole plant primary productivity (Nardini *et al.*, 2004). Leaf miner outbreaks have strong negative influences on plant development and aboveground biomass production: more basal sprout dieback, lower plant height, lower girth, smaller leaf size, fewer leaf number, fewer petiole number, and fewer shoot number (Trumble *et al.*, 1985; Norris, 1997; Kozlov, 2005; Wagner & Doak, 2013). Leaf-mining injury could cause severe loss of the total leaf area (Hileman & Lieto, 1981; Peña *et al.*, 2000; Nardini *et al.*, 2004). Leaf miners markedly increased the mortality of floral leaves, but not of vegetative leaves (Hileman & Lieto, 1981). Leaf miners could significantly reduce whole-tree energy, seed weight, seed germination, seedling vigor and stem extension (Percival *et al.*, 2011; Straw & Williams, 2013). Serious leaf-mining could also lead to reduction in fruit set, fruit size, fruit weight and fruit quality, and even premature ripening, early fruit fall, and total yield loss (Fujiie, 1982; Reissig *et al.*, 1982; Peña *et al.*, 2000; Nardini *et al.*, 2004; Straw & Williams, 2013). However, leaf-mining does not reduce plant productivity in three *Citrus* L. species (Raimondo *et al.*, 2013). Leaf-mining could also mediate the competition between different plant species (Norris, 1997).

LEAF MINERS AS PHYSICAL ECOSYSTEM ENGINEERS FOR OTHER PLANT PARASITES

Leaf miners can change resource availability to other organisms. First, other arthropods such as springtails can use empty leaf mines as feeding and reproductive sites (Kagata & Ohgushi, 2004). We also noticed that many insects and mites overwinter inside abandoned leaf mines in the field. Second, leaf-mining damage to leaf midribs may reduce the survival rate of an aphid (Johnson *et al.*, 2002). Third, the feeding galleries of leaf miners can be an entrance for pathogens. For example, the Asian citrus leaf miner (*Phyllocnistis citrella*) has increased the incidence of Asiatic citrus canker (*Xanthomonas axonopodis* pv. *citri*) and changed the spatial distribution type of canker-infested trees (Chagas *et al.*, 2001; Christiano *et al.*, 2007). Moreover, leaf miners may transmit plant virus as a vector. A leaf-mining beetle (*Dactylispa lenta*)

unexpectedly transmits rice yellow mottle virus in Africa (Banwo *et al.*, 2001). Another leaf-mining beetle (*Phylloplatypus pandani*) can also transmit diseases among plants (Sugiura & Masuya, 2010).

STUDIES ON LEAF MINERS AND THEIR HOST PLANTS IN CHINA

Leaf miner taxonomy

Researchers have described some major leaf miner groups in China, although some publications have not emphasized much on leaf-mining habit. Well-studied leaf-mining moths (Lepidoptera) included Gracillariidae (Liu & Zeng, 1985, 1989; Yuan, 1986, 1992; Yuan & Robinson, 1993; Bai & Li, 2008, 2009a, b, 2011a, b, 2012; Xu *et al.*, 2009; Bai, 2011; Kobayashi *et al.*, 2011, 2013; Cai, 2013), Lyonetiidae (Wu *et al.*, 2006), Nepticulidae (Yang, 1989; Nieuwerkerken & Liu, 2000; Liu & Nieuwerkerken, 2001), and Tischeriidae (Huang & Tan, 2009). Leaf-mining flies (Diptera) included Agromyzidae (Lin, 1983; Feng & Jer, 1989; Gu *et al.*, 1991; Shiao *et al.*, 1991; Shiao & Wu, 1995, 1996, 1999, 2005; Chen & Wang, 2001, 2003a, b, c, d, 2008; Shiao, 2004; Sasakawa, 2006, 2008; Chen *et al.*, 2007). Leaf-mining beetles (Coleoptera) included Alticinae (Wang, 1990; Zhang & Yang, 2004), Cassidinae (Gressitt, 1950, 1953; Chen *et al.*, 1961, 1962, 1964, 1986; Gressitt & Kimoto, 1963, 1965; Chen & Tan, 1964, 1985; Takizawa, 1978; Yu, 1985; Lee, 2009), and Rhynchaenae (Yang *et al.*, 1991, 1996). Leaf-mining sawflies included Tenthredinidae (Wei, 1994, 1997; Nie & Wei, 1998; Wei & Nie, 1998, 1999; Wei *et al.*, 2003; Wu *et al.*, 2010; Hou *et al.*, 2012). However, the reported number of Chinese leaf miner species is much lower than estimated. For example, China hosts much more species in Fagaceae family than North America (7 genera and 294 species vs. 5 genera and 97 species) (Nixon, 1997; Huang *et al.*, 1998), but species number of Tischeriidae are 4 vs. 40 (J.-S. Xu *et al.*, unpubl. data). There are over 400 leaf-mining species feeding on 600–1000 Fagaceae plant species in the whole world, with only 10% leaf miners with Chinese names (X.-H. Dai *et al.*, unpubl. data). Our Leaf Miner Group began to collect and rear leaf miners in 2007, and at present we have built a database on Chinese leaf miners and their

host plants collected in 25 provinces. We have got nearly 300 leaf-mining species in over 30 families and four orders, with about 140 described species. We have also obtained 3000 parasitoid specimens (X.-H. Dai *et al.*, unpubl. data).

Host plant diversity

Not much systematic work on host plant diversity has been completed in China (Dai *et al.*, 2011b), except for some economically important leaf-mining pests such as *Liriomyza* spp. (Kang, 1996; Dai *et al.*, 2000, 2001d; Zhang *et al.*, 2000; He *et al.*, 2001) and *Phyllocnistis* spp. (Liu & Zeng, 1980). Host plant records of non-economic leaf miners are still poor in China. At Mt. Jiulianshan in South China, from 2008 to 2011 we have collected 69 families, 155 genera, and 293 species of host plants of leaf miners (Dai *et al.*, 2011a), while in 2014 the numbers have increased to 92 families, 232 genera, and 471 species, occupying about 1/5 of total plant species number in the area (X.-H. Dai *et al.*, unpubl. data).

Insect-plant relationship

Chinese scholars have done many studies on the interactions between leaf miners and host plants, mainly on *Liriomyza* spp. Topics are as follows: (1) host selection and location by leaf-mining insects (e.g. Wei *et al.*, 2000; Dai *et al.*, 2001c, 2003; He *et al.*, 2001; Zhao & Kang, 2001, 2002a, b, 2003; Zeng *et al.*, 2003; Pang *et al.*, 2004, 2006; Zhang *et al.*, 2004; Ko, 2006; Yan *et al.*, 2008; Yu *et al.*, 2008; Zheng *et al.*, 2010); (2) plant resistance to leaf miners (e.g. Cheng *et al.*, 2006; Zhang *et al.*, 2008); (3) influences of different host plants on leaf miners (Zhang *et al.*, 1998; Li *et al.*, 2002; Wei *et al.*, 2004; Pang *et al.*, 2005); (4) impacts of leaf miners on plants (Sun *et al.*, 2012); (5) effects of environmental factors on insect-plant interactions (e.g. Dai *et al.*, 2001a, b, 2002, 2011a, 2013, 2014; Cen *et al.*, 2003); (6) coevolution and codiversification (e.g. Du *et al.*, 2008; Liao *et al.*, 2015).

CONCLUSIONS

Different leaf miners have variable degrees of impact on the morphology, chemistry, physiology and growth of their host plants, while different plant

species show inconsistent resistance or tolerance to leaf-mining (Trumble *et al.*, 1985; Williams, 1989). The influence of leaf-mining on plants is also affected by other ecological factors such as light, water, soil, temperature and biotic relationship. Such factors not only directly act on plant growth and development, but also on the performance of leaf-mining insects. In turn, the induced changes of plant physical and chemical features may have either positive or negative impacts on oviposition and feeding of leaf-mining insects. Studies on plant responses to leaf-mining and the defensive mechanisms of plants are helpful in understanding the coevolution between leaf miners and their food plants. Plant resistance to leaf-mining may be altered by both the environment and genetics, therefore we could adopt suitable management strategies and genetic breeding technology to control pest leaf miners. Future research trends may include but not be limited to: (1) cophylogeny and cophylogeography between leaf miners and host plants; (2) coexistence and niche differentiation of different leaf-mining species in the same plant; (3) how plant community diversity affect leaf miner abundance and richness, and vice versa.

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REFERENCES

- Auerbach, M. & Simberloff, D. 1989. Oviposition site preference and larval mortality in a leaf-mining moth. *Ecological Entomology* 14: 131–140. <http://dx.doi.org/10.1111/j.1365-2311.1989.tb00763.x>
- Bai, H. 2011. A new species of *Micrurapteryx* Spuler (Lepidoptera: Gracillariidae) from Tibet, China. *Entomological News* 122: 324–327. <http://dx.doi.org/10.3157/021.122.0404>
- Bai, H. & Li, H. 2008. A review of the genus *Gibbovalva* (Lepidoptera: Gracillariidae: Gracillariinae) from China. *Oriental Insects* 42: 317–326. <http://dx.doi.org/10.1080/00305316.2008.10417556>

- Bai, H. & Li, H. 2009a. First record of *Dextellia triberti* (Lepidoptera, Gracillariidae, Gracillariinae) in China, with description of one new species. *Acta Zootaxonomica Sinica* 34: 451–453.
- Bai, H. & Li, H. 2009b. Review of *Spulerina* (Lepidoptera: Gracillariidae) from China, with description of three new species. *Oriental Insects* 43: 33–44. <http://dx.doi.org/10.1080/00305316.2009.10417573>
- Bai, H. & Li, H. 2011a. 细蛾科中国三新纪录属及四新纪录种记述(昆虫纲,鳞翅目) [Three newly recorded genera and four newly recorded species of Gracillariidae (Lepidoptera) in China]. *Acta Zootaxonomica Sinica* 36: 477–481 [in Chinese].
- Bai, H. & Li, H. 2011b. 细蛾科中国新纪录属: 翼细蛾属及其三新纪录种记述 [First record of the genus *Micrurapteryx* Spuler (Lepidoptera: Gracillariidae) and three newly recorded species in China]. *Entomotaxonomia* 35: 148–152 [in Chinese].
- Bai, H. & Li, H. 2012. Genus *Hyoconis* new to China, with descriptions of two new species (Lepidoptera: Gracillariidae, Lithocolletinae). *Entomologica Fennica* 23: 227–230.
- Banwo, O. O., Makundi, R. H., Abdallah, R. S. & Mbapila, J. C. 2001. First report of *Dactylispa lenta* Weise (Coleoptera: Chrysomelidae) as a vector of rice yellow mottle virus. *Acta Phytopathologica et Entomologica Hungarica* 36: 189–192. <http://dx.doi.org/10.1556/APhyt.36.2001.1-2.22>
- Bueno, A. D. F., Zechmann, B., Hoback, W. W., Bueno, R. C. O. D. F. & Fernandes, O. A. 2007. Serpentine leafminer (*Liriomyza trifolii*) on potato (*Solanum tuberosum*): Field observations and plant photosynthetic responses to injury. *Ciência Rural* 37: 1510–1517. <http://dx.doi.org/10.1590/S0103-84782007000600001>
- Bultman, T. L. & Faeth, S. H. 1986. Selective oviposition by a leaf miner in response to temporal variation in abscission. *Oecologia* 69: 117–120. <http://dx.doi.org/10.1007/BF00399046>
- Byers, R. & Valley, K. 1981. Losses in digestible dry matter and crude protein in alfalfa caused by the alfalfa blotch leafminer *Agromyza frontella*. *Melsheimer Entomological Series* 31: 8–13.
- Cai, Y. 2013. 中国丽细蛾属分类及八仙山七种潜叶蛾初步研究(鳞翅目: 细蛾科) [Taxonomic study of the genus *Caloptilia* Hiibner from China and a preliminary survey on seven leaf miners in Mt. Baxian (Lepidoptera: Gracillariidae)]. Master Thesis, Nankai University, Tianjin [in Chinese].
- Cen, Y., Pang, X., Zhang, M., Deng, Q., Du, Y. & Wang, B. 2003. 26种非嗜食植物乙醇提取物对柑桔潜叶蛾的产卵驱避作用 [Oviposition repellent of alcohol extracts of 26 non-preferable plant species against citrus leafminer]. *Journal of South China Agricultural University* 24: 27–29 [in Chinese].
- Chagas, M. C. M., Parra, J. R. P., Namekata, T., Hartung, J. S. & Yamamoto, P. T. 2001. *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) and its relationship with the citrus canker bacterium *Xanthomonas axonopodis* pv. *citri* in Brazil. *Neotropical Entomology* 30: 55–59. <http://dx.doi.org/10.1590/S1519-566X2001000100009>
- Chen, S., Sun, T. & Yu, P. 1964. 中国及越南铁甲虫新种记述 [New hispine beetles from China and Vietnam]. *Acta Zootaxonomica Sinica* 1: 106–121 [in Chinese].
- Chen, S., Tan, C., Yu, P. & Sun, T. 1962. 云南生物考察报告(鞘翅目, 铁甲亚科II) [Results of the Zoologico-Botanical Expedition to Southwest China, 1955–1957 (Coleoptera, Hispinae II)]. *Acta Entomologica Sinica* 11: 120–138 [in Chinese].
- Chen, S. & Tan, J. 1964. 中国趾铁甲虫新种记述 [New species of *Dactylispa* from China (Coleoptera, Hispinae)]. *Acta Entomologica Sinica* 13: 414–427 [in Chinese].
- Chen, S. & Tan, J. 1985. 云南趾铁甲属一新种(鞘翅目: 铁甲科) [A new species of *Dactylispa* from Yunnan, China]. *Acta Zoologica Sinica* 31: 269–272 [in Chinese].
- Chen, S., Tan, J. & Yu, P. 1961. 云南生物考察报告(鞘翅目, 铁甲亚科I) [Results of the Zoologico-Botanical Expedition to Southwest China, 1955–1957 (Coleoptera, Hispinae I)]. *Acta Entomologica Sinica* 10: 457–481 [in Chinese].
- Chen, S., Yu, P., Sun, C. & Zia, Y. 1986. 中国动物志 昆虫纲 鞘翅目 铁甲科 [Coleoptera: Hispidae. Fauna Sinica (Insecta)]. Science Press, Beijing [in Chinese].
- Chen, W., Li, Z., Gu, D. & Liu, Q. 2007. 中国斑潜蝇属种类和2新纪录种记述(双翅目, 潜蝇科) [Species summary of the genus *Liriomyza* in China (Diptera: Agromyzidae)]. *Journal of Southwest University (Natural Science Edition)* 29: 154–158 [in Chinese].
- Chen, X. & Wang, X. 2001. 中国潜蝇科一新纪录属和新纪录种 [A new record genus and species of Agromyzidae (Diptera) from China]. *Entomotaxonomia* 23: 281–282 [in Chinese].
- Chen, X. & Wang, X. 2003a. A taxonomic study of Chinese members of the subgenus *Butomyza* Nowakowski, genus *Cerodontha* Rondani (Diptera, Agromyzidae). *Acta Zootaxonomica Sinica* 28: 356–358.
- Chen, X. & Wang, X. 2003b. A review of the genus *Calycomyza* Hendel in China (Diptera: Agromyzidae). *Acta Entomologica Sinica* 46: 359–362.
- Chen, X. & Wang, X. 2003c. A review of the genus *Napomyza* Westwood in China (Diptera: Agromyzidae). *Acta Entomologica Sinica* 46: 640–643.
- Chen, X. & Wang, X. 2003d. A new species of the genus *Tropiomyia* Spencer, 1973 from China (Diptera, Agromyzidae). *Acta Zootaxonomica Sinica* 28: 751–753.
- Chen, X. & Wang, X. 2008. A new species of the genus *Nemorimyza* Frey (Diptera, Agromyzidae) from China. *Acta Zootaxonomica Sinica* 33: 77–79.
- Cheng, W. N., Wu, J. X., Li, X. L. & Li, J. J. 2006. Influence of chemicals and physical structure characteristics of host plant leaves on resistance to *Liriomyza sativae* Blanchard. *Acta Scientiarum Naturalium Universitatis Sunyatseni* 45: 71–75.
- Christiano, R. S. C., Dalla Pria, M., Jesus Junior, W. C., Parra, J. R. P., Amorim, L. & Bergamin Filho, A. 2007. Effect of citrus leaf-miner damage, mechanical damage and inoculum concentration on severity of symptoms of Asiatic citrus canker in Tahiti lime. *Crop Protection* 26: 59–65. <http://dx.doi.org/10.1016/j.cropro.2006.03.016>
- Connor, E. F., Adams-Manson, R. H., Carr, T. G. & Beck, M. W. 1994. The effects of host plant phenology on the demography and population dynamics of the leaf-mining moth, *Cameraria hamadryadella* (Lepidoptera: Gracillariidae). *Ecological Entomology* 19: 111–120. <http://dx.doi.org/10.1111/j.1365-2311.1994.tb00400.x>
- Csóka, G. 2003. *Leaf mines and leaf miners*. Hungarian Forest Research Institute, Budapest.
- Dai, X., Liu, R. & Xu, J. 2011a. Host plant phylogeny of leaf-mining insects at Jiulianshan. In: *Book of Abstracts of the 2011 National Systematic and Evolutionary Botany Seminar–10th Youth Seminar (Kunming, China, 26–27 October 2011)*. Botanical Society of Yunnan: 98 [in Chinese].
- Dai, X.-H., Xu, J.-S. & Cai, L.-R. 2014. Effects of roads on *Castanopsis carlesii* seedlings and their leaf herbivory in a subtropical forest in China. *Journal of Insect Science* 14: 17. <http://dx.doi.org/10.1093/jis/14.1.17>

- Dai, X.-H., Xu, J.-S. & Ding, X.-L. 2013. Circular distribution pattern of plant modulars and endophagous herbivory within tree crowns: The impact of roadside light conditions. *Journal of Insect Science* 13: 141. <http://dx.doi.org/10.1673/031.013.14101>
- Dai, X., You, M. & Fu, L. 2000. 美洲斑潜蝇、南美斑潜蝇寄主植物比较 [Comparison of host-plants of *Liriomyza sativae* Blanchard and *L. huidobrensis* (Blanchard)]. *Wuyi Science Journal* 16: 202–205 [in Chinese].
- Dai, X., You, M. & Fu, L. 2001a. 土壤水分和盐分对美洲斑潜蝇寄主选择性的影响 [Effect of water and salinity of soil on the host selection of *Liriomyza sativae*]. *Journal of Fujian Agricultural University (Natural Science)* 30: 205–208 [in Chinese].
- Dai, X., You, M. & Fu, L. 2001b. 植物水溶物对美洲斑潜蝇寄主选择性的影响 [The influences of water-soluble substances from other plants on the host-selection of *Liriomyza sativae*]. *Journal of Fujian Agricultural University (Natural Science)* 30: 490–492 [in Chinese].
- Dai, X., You, M. & Fu, L. 2001c. 美洲斑潜蝇寄主选择性和寄主植物叶片营养物质含量的关系 [The relationship between the host-selection by *Liriomyza sativae* and the content of nutritional substances in foliage]. *Journal of Shandong Agricultural University* 32: 311–313 [in Chinese].
- Dai, X., You, M. & Fu, L. 2001d. 福州郊区美洲斑潜蝇、南美斑潜蝇寄主植物初步名录 [The preliminary list of host-plants of *Liriomyza sativae* Blanchard and *L. huidobrensis* (Blanchard) in the suburb of Fuzhou]. *Entomological Journal of East China* 10: 22–28 [in Chinese].
- Dai, X., You, M. & Fu, L. 2002. 氮磷钾用量对美洲斑潜蝇寄主选择性的影响 [Effects of nitrogen, phosphorus and potassium via leaf on host-selection by *Liriomyza sativae*]. *Acta Entomologica Sinica* 45: 145–147 [in Chinese].
- Dai, X., You, M. & Fu, L. 2003. 美洲斑潜蝇寄主选择性的初步研究 [Preliminary study on host-plant selection by *Liriomyza sativae* Blanchard]. *Journal of Shandong Agricultural University* 34: 202–205 [in Chinese].
- Dai, X., Zhu, C., Xu, J., Liu, R. & Wang, X. 2011b. 寄主植物叶片物理性状对潜叶昆虫的影响 [Effects of physical leaf features of host plants on leaf-mining insects]. *Acta Ecologica Sinica* 31: 1440–1449 [in Chinese].
- Du, Y. Z., Wang, L. P., Lu, Y. J., Zheng, F. S. & Lu, Z. Q. 2008. 美洲斑潜蝇不同寄主种群及地理种群间的 β -tubulin 基因序列分析 [Differentiation of different host-populations and geo-populations of *Liriomyza sativae* Blanchard based on beta-tubulin gene sequences]. *Scientia Agricultura Sinica* 41: 1542–1547 [in Chinese].
- Ellis, W. N. 2000. Biological notes on the holly leaf miner, *Phytomyza ilicis* (Diptera: Agromyzidae). *Entomologische Berichten* 60: 165–170.
- Engelbrecht, L., Orban, U. & Heese, W. 1969. Leaf-miner caterpillars and cytokinins in the “green islands” of autumn leaves. *Nature* 223: 319–321. <http://dx.doi.org/10.1038/223319a0>
- Faeth, S. H., Connor, E. F. & Simberloff, D. 1981. Early leaf abscission: A neglected source of mortality for folivores. *The American Naturalist* 117: 409–415. <http://dx.doi.org/10.1086/283724>
- Feng, S. S. & Jer, W. W. 1989. Four new records of *Liriomyza* leaf-miners (Diptera: Agromyzidae) from Taiwan. *Journal of the Taiwan Museum* 42: 15–23.
- Fujiie, A. 1982. Ecological studies on the population of the pear leaf miner *Bucculatrix pyrivorella* Kuroko (Lepidoptera: Lyonetiidae). IV. Effects of injury by the pear leaf miner on leaf fall and photosynthesis of the pear tree. *Applied Entomology and Zoology* 17: 188–193. <http://dx.doi.org/10.11337/ktpps1954.1982.154>
- Giron, D., Kaiser, W., Imbault, N. & Casas, J. 2007. Cytokinin-mediated leaf manipulation by a leafminer caterpillar. *Biology Letters* 3: 340–343. <http://dx.doi.org/10.1098/rsbl.2007.0051>
- Gressitt, J. L. 1950. The hispine beetles of China (Coleoptera: Chrysomelidae). *Lingnan Science Journal* 23: 53–142.
- Gressitt, J. L. 1953. Supplement to “The hispine beetles of China (Coleoptera: Chrysomelidae)”. *The Pan-Pacific Entomologist* 29: 121–126.
- Gressitt, J. L. & Kimoto, S. 1963. The Chrysomelidae (Coleoptera) of China and Korea. Part 2. *Pacific Insects Monograph* 1B: 301–1026.
- Gressitt, J. L. & Kimoto, S. 1965. Second supplement to “The Chrysomelidae (Coleopt.) of China and Korea”. *Pacific Insects* 7: 799–806.
- Gripenberg, S. & Roslin, T. 2008. Neither the devil nor the deep blue sea: larval mortality factors fail to explain the abundance and distribution of *Tischeria ekebladella*. *Ecological Entomology* 33: 346–356. <http://dx.doi.org/10.1111/j.1365-2311.2007.00975.x>
- Gu, X., Fan, Z. & Sasakawa, M. 1991. Descriptions of seven new species of Agromyzidae (Diptera) from China. *Japanese Journal of Entomology* 59: 331–342.
- He, C.-X., Wu, W.-W., Wang, S.-F. & Wang, L.-Z. 2001. 南美斑潜蝇的寄主植物种类及其嗜食性 [Host plants and feeding preference of *Liriomyza huidobrensis*]. *Acta Entomologica Sinica* 44: 384–388 [in Chinese]. <http://dx.doi.org/10.3321/j.issn:0454-6296.2001.03.023>
- Hering, E. M. 1951. *Biology of the leaf miners*. Dr. W. Junk, The Hague. <http://dx.doi.org/10.1007/978-94-015-7196-8>
- Hering, E. M. 1957. *Bestimmungstabellen der blattminen von Europa: einschliesslich des Mittelmeerbeckens und der Kanarischen Inseln*. Dr. W. Junk, The Hague. <http://dx.doi.org/10.1007/978-94-010-3702-0>
- Hespenheide, H. A. 1991. Bionomics of leaf-mining insects. *Annual Review of Entomology* 36: 535–560. <http://dx.doi.org/10.1146/annurev.en.36.010191.002535>
- Hileman, D. R. & Lieto, L. F. 1981. Mortality and area reduction in leaves of the bog shrub *Chamaedaphne calyculata* (Ericaceae) caused by the leaf miner *Coptodisca kalmiella* (Lepidoptera: Heliozelidae). *American Midland Naturalist* 106: 180–188. <http://dx.doi.org/10.2307/2425147>
- Hirowatari, T. 2009. Biology of leaf mining insects. *Nature & Insects* 44: 2–3.
- Hou, G.-K., Wu, X.-Y. & Zhang, X.-Z. 2012. 甘肃叶蜂新记录科属及中国新记录属名录 (膜翅目: 广腰亚目) [A list of new record families and genera from Gansu & new record genera from China of Tenthredinidae (Hymenoptera: Symphyta)]. *Journal of Gansu Forestry Science and Technology* 3: 5–7, 11 [in Chinese]. <http://dx.doi.org/10.3969/j.issn.1006-0960.2012.03.002>
- Huang, C., Chang, Y., Hsu, Y. & Jen, H. 1998. Fagaceae. In: Chun, W. & Huang, C. (Eds.), *Flora Reipublicae Popularis Sinicae* 22. Science Press, Beijing: 1–332 [in Chinese].
- Huang, G. & Tan, J. 2009. 中国冠潜蛾科一新记录属及一新记录种 [New records of a genus and a species of the family Tischeriidae (Lepidoptera) from China]. *Entomotaxonomia* 31: 58–61 [in Chinese]. <http://dx.doi.org/10.3969/j.issn.1000-7482.2009.01.011>
- Johne, A. B., Weissbecker, B. & Schütz, S. 2006. Volatile emissions from *Aesculus hippocastanum* induced by mining of

- larval stages of *Cameraria ohridella* influence oviposition by conspecific females. *Journal of Chemical Ecology* 32: 2303–2319. <http://dx.doi.org/10.1007/s10886-006-9146-4>
- Johnson, M., Welter, S., Toscano, N., Ting, I. & Trumble, J. 1983. Reduction of tomato leaflet photosynthesis rates by mining activity of *Liriomyza sativae* (Diptera: Agromyzidae). *Journal of Economic Entomology* 76: 1061–1063. <http://dx.doi.org/10.1093/jee/76.5.1061>
- Johnson, S. N., Mayhew, P. J., Douglas, A. E. & Hartley, S. E. 2002. Insects as leaf engineers: Can leaf-miners alter leaf structure for birch aphids? *Functional Ecology* 16: 575–584. <http://dx.doi.org/10.1046/j.1365-2435.2002.00654.x>
- Kagata, H. & Ohgushi, T. 2004. Leaf miner as a physical ecosystem engineer: Secondary use of vacant leaf mines by other arthropods. *Annals of the Entomological Society of America* 97: 923–927. [http://dx.doi.org/10.1603/0013-8746\(2004\)097\[0923:LMAAPE\]2.0.CO;2](http://dx.doi.org/10.1603/0013-8746(2004)097[0923:LMAAPE]2.0.CO;2)
- Kahn, D. M. & Cornell, H. V. 1983. Early leaf abscission and folivores: Comments and considerations. *The American Naturalist* 122: 428–432. <http://dx.doi.org/10.1086/284146>
- Kahn, D. M. & Cornell, H. V. 1989. Leafminers, early leaf abscission, and parasitoids: A tritrophic interaction. *Ecology* 70: 1219–1226. <http://dx.doi.org/10.2307/1938179>
- Kaiser, W., Huguet, E., Casas, J., Commin, C. & Giron, D. 2010. Plant green-island phenotype induced by leaf-miners is mediated by bacterial symbionts. *Proceedings of the Royal Society B-Biological Sciences* 277: 2311–2319. <http://dx.doi.org/10.1098/rspb.2010.0214>
- Kang, L. 1996. 斑潜蝇的生态学与控制 [Ecology and sustainable control of serpentine leafminers]. Science Press, Beijing [in Chinese].
- Kang, L., Chen, B., Wei, J.-N. & Liu, T.-X. 2009. Roles of thermal adaptation and chemical ecology in *Liriomyza* distribution and control. *Annual Review of Entomology* 54: 127–145. <http://dx.doi.org/10.1146/annurev.ento.54.110807.090507>
- Kappel, F. 1986. *Influence of spotted tentiform leafminer on apple leaf and tree physiology*. PhD Thesis, University of Guelph, Guelph.
- Kappel, F., Proctor, J. T. A. & Murr, D. P. 1987. Effect of spotted tentiform leafminer injury on ethylene production and ACC content in apple leaves. *HortScience* 22: 469–471.
- Kato, M. 1984. Mining pattern of the honeysuckle leaf-miner *Phytomyza lonicerae*. *Researches on Population Ecology* 26: 84–96. <http://dx.doi.org/10.1007/BF02515509>
- Ko, N. 2006. 非洲菊斑潜蝇的寄主偏好性及其在不同寄主上之特徵變異(雙翅目: 潛蠅科) [*Host preference and trait variations of Liriomyza trifolii* (Diptera: Agromyzidae)]. Master Thesis, National Taiwan University, Taipei [in Chinese].
- Kobayashi, S., Huang, G. H. & Hirowatari, T. 2011. Two species of Gracillariidae (Lepidoptera) new to China, and description of the pupal morphology of the genera *Corythoestis* and *Eumetriochoa*. *Zootaxa* 2892: 25–32.
- Kobayashi, S., Huang, G.-H., Nakamura, A. & Hirowatari, T. 2013. Four new species of Gracillariidae (Lepidoptera) from China and Japan, and description of the pupal morphology of the genera *Corythoestis*, *Eumetriochoa*, *Guttigera*, and *Metriochoa*. *Zootaxa* 3619: 101–129. <http://dx.doi.org/10.11646/zootaxa.3619.2.1>
- Kozlov, M. V. 2005. Contrasting response of mountain birch to damage by *Eriocrania* leafminers in polluted and unpolluted habitats. *Canadian Journal of Botany* 83: 73–79. <http://dx.doi.org/10.1139/b04-158>
- Kozlov, M. V. & Zvereva, E. L. 2014. Variations in the effects of local foliar damage on life span of individual leaves of downy birch (*Betula pubescens*). *Botany* 92: 477–484. <http://dx.doi.org/10.1139/cjb-2013-0324>
- Labandeira, C. C., Dilcher, D. L., Davis, D. R. & Wagner, D. L. 1994. Ninety-seven million years of angiosperm-insect association: Paleobiological insights into the meaning of coevolution. *Proceedings of the National Academy of Sciences of the United States of America* 91: 12278–12282. <http://dx.doi.org/10.1073/pnas.91.25.12278>
- Lee, C.-F. 2009. The taxonomic status of *Dactylispa taiwana* Takizawa, 1978 (Coleoptera: Chrysomelidae: Cassidinae). *Genus. International Journal of Invertebrate Taxonomy* 20: 109–110.
- Li, S., Deng, W. & Xie, X. 2002. 不同菜豆品种(系)对美洲斑潜蝇种群参数的影响 [Influence of different phaseolous vulgaris varieties on the population parameters of *Liriomyza sativae*]. *Acta Ecologica Sinica* 22: 1354–1357 [in Chinese].
- Liao, C., Xu, J., Dai, X. & Zhao, X. 2014. 枣掌铁甲生物学特性研究 [Study on the biological characteristics of *Platypria melli*]. *Northern Horticulture* 2014(3): 118–120 [in Chinese].
- Liao, C., Xu, J., Dai, X. & Zhao, X. 2015. 潜叶铁甲及其寄主植物多样性 [Species diversity of leaf-mining hispines and their host plants]. *Ecological Science* 34(5): 159–166 [in Chinese].
- Lin, C. S. 1983. 臺灣的潛蠅科昆蟲 [Agromyzidae of Taiwan]. *Annual of Taiwan Museum* 26: 87–99 [in Chinese].
- Liu, S.-K. & Zeng, R.-G. 1980. 柑桔潜叶蛾 (*Phyllocnistis citrella* Stainton) 的形态及其寄主植物 [The morphology of the Citrus leaf miner (*Phyllocnistis citrella* Stainton) and its food plants in Kwangtung Province]. *Journal of South China Agricultural College* 1: 113–120 [in Chinese].
- Liu, S.-K. & Zeng, R.-G. 1985. 叶潜蛾科一个新种——黄皮叶潜蛾 (鳞翅目: 叶潜蛾科) [A new species of Phyllocnistidae from China]. *Acta Entomologica Sinica* 28: 412–416 [in Chinese].
- Liu, S.-K. & Zeng, R.-G. 1989. 叶潜蛾科在华南二新种 [Two newly found species of Phyllocnistidae in South China]. *Acta Entomologica Sinica* 32: 85–89 [in Chinese].
- Liu, Y. & Nieukerken, E. J. van 2001. 我国山毛榉科植物上的10种微蛾简介 [Brief introduction of 10 species of *Stigmella* (Lepidoptera, Nepticulidae) on Fagaceae in China]. *Forest Pest and Disease*, 20: 3–7 [in Chinese]. <http://dx.doi.org/10.3969/j.issn.1671-0886.2001.02.001>
- Lombardini, L., Volder, A., Nesbitt, M. L. & Cartmill, D. L. 2013. Consequences of injury caused by *Cameraria caryaefoliella* (Lepidoptera: Gracillariidae) on pecan gas exchange and chlorophyll fluorescence. *Journal of the American Society for Horticultural Science* 138: 263–266.
- Lopez-Vaamonde, C., Wikström, N., Labandeira, C., Godfray, H. C. J., Goodman, S. J. & Cook, J. M. 2006. Fossil-calibrated molecular phylogenies reveal that leaf-mining moths radiated millions of years after their host plants. *Journal of Evolutionary Biology* 19: 1314–1326. <http://dx.doi.org/10.1111/j.1420-9101.2005.01070.x>
- Magalhães, S. T. V., Fernandes, F. L., Demuner, A. J., Picanço, M. C. & Guedes, R. N. C. 2010. Leaf alkaloids, phenolics, and coffee resistance to the leaf miner *Leucoptera coffeella* (Lepidoptera: Lyonetiidae). *Journal of Economic Entomology* 103: 1438–1443. <http://dx.doi.org/10.1603/EC09362>
- Maier, C. T. 1983. Effect of the apple blotch leaf miner *Phyllonorycter crataegella* (Lepidoptera: Gracillariidae) on apple leaf abscission. *Journal of Economic Entomology* 76: 1265–1268. <http://dx.doi.org/10.1093/jee/76.6.1265>

- Maier, C. T. 1989. Accelerated abscission of cranberry leaves damaged by the leafminer, *Coptodisca negligens* (Lepidoptera: Heleozelidae). *Environmental Entomology* 18: 773–777. <http://dx.doi.org/10.1093/ee/18.5.773>
- Martens, B. & Trumble, J. T. 1987. Structural and photosynthetic compensation for leafminer (Diptera: Agromyzidae) injury in lima beans. *Environmental Entomology* 16: 374–378. <http://dx.doi.org/10.1093/ee/16.2.374>
- Møller, A. P. 1995. Leaf-mining insects and fluctuating asymmetry in elm *Ulmus glabra* leaves. *Journal of Animal Ecology* 64: 697–707. <http://dx.doi.org/10.2307/5849>
- Møller, A. P. & Lope, F. de 1998. Herbivory affects developmental instability of stone oak, *Quercus rotundifolia*. *Oikos* 82: 246–252. <http://dx.doi.org/10.2307/3546964>
- Mopper, S., Wang, Y., Criner, C. & Hasenstein, K. 2004. *Iris hexagona* hormonal responses to salinity stress, leafminer herbivory, and phenology. *Ecology* 85: 38–47. <http://dx.doi.org/10.1890/02-0705>
- Nagasaki, O. 2004. Influence of the leaf-mining and petiole-boring moth *Neoshoenobia testacealis* on the leaf longevity of the water lily *Nuphar subintegerrimum*. *Ecoscience* 11: 387–389.
- Nardini, A., Raimondo, F., Scimone, M. & Salleo, S. 2004. Impact of the leaf miner *Cameraria ohridella* on whole-plant photosynthetic productivity of *Aesculus hippocastanum*: insights from a model. *Trees* 18: 714–721. <http://dx.doi.org/10.1007/s00468-004-0358-3>
- Naseem, M., Wölfling, M. & Dandekar, T. 2014. Cytokinins for immunity beyond growth, galls and green islands. *Trends in Plant Science* 19: 481–484. <http://dx.doi.org/10.1016/j.tplants.2014.04.001>
- Needham, J. G., Frost, S. W. & Tothill, D. 1928. *Leaf-mining insects*. Williams & Wilkins, Baltimore. <http://dx.doi.org/10.5962/bhl.title.6488>
- Nie, H. & Wei, M. 1998. Studies on the genus *Metallus* Forbes of China (Hymenoptera: Tenthredinidae). *Insect Science* 5: 310–316. <http://dx.doi.org/10.1111/j.1744-7917.1998.tb00326.x>
- Nieukerken, E. J. van & Liu, Y. 2000. Nepticulidae (Lepidoptera) in China, 1. Introduction and *Stigmella* Schrank feeding on Fagaceae. *Tijdschrift voor Entomologie* 143: 145–181. <http://dx.doi.org/10.1163/22119434-99900042>
- Nixon, K. C. 1997. Fagaceae. In: Morin, N. R. (Ed.), *Flora of North America North of Mexico* 3. Oxford University Press, New York: 436–506.
- Norris, R. F. 1997. Impact of leaf mining on the growth of *Portulaca oleracea* (common purslane) and its competitive interaction with *Beta vulgaris* (sugarbeet). *Journal of Applied Ecology* 34: 349–362. <http://dx.doi.org/10.2307/2404881>
- Oishi, M. & Sato, H. 2007. Inhibition of premature leaf abscission by a leafminer and its adaptive significance. *Environmental Entomology* 36: 1504–1511. [http://dx.doi.org/10.1603/0046-225X\(2007\)36\[1504:IOPLAB\]2.0.CO;2](http://dx.doi.org/10.1603/0046-225X(2007)36[1504:IOPLAB]2.0.CO;2)
- Owen, D. F. 1978. The effect of a consumer *Phytomyza ilicis* on seasonal leaf fall in the holly *Ilex aquifolium*. *Oikos* 31: 268–271. <http://dx.doi.org/10.2307/3543573>
- Pang, B.-P., Bao, Z.-S., Zhou, X.-R. & Cheng, J.-A. 2004. 寄主挥发物、叶色和表皮毛在美洲斑潜蝇寄主选择中的作用 [Effects of host volatiles, leaf color, and cuticular trichomes on host selection by *Liriomyza sativae* Blanchard]. *Acta Ecologica Sinica* 24: 547–551 [in Chinese].
- Pang, B., Cheng, J., Huang, E. & Bao, Z. 2005. 不同寄主植物对美洲斑潜蝇种群参数的影响 [Effects of different host plants on population parameters of *Liriomyza sativae*]. *Plant Protection* 31: 26–28 [in Chinese].
- Pang, B.-P., Gao, J.-P., Zhou, X.-R. & Wang, J. 2006. 南美斑潜蝇寄主选择性 with 植物次生化合物及叶毛的关系 [Relationship between host plant preference of *Liriomyza huidobrensis* (Blanchard) (Diptera: Agromyzidae) and secondary plant compounds and trichomes of host foliage]. *Acta Entomologica Sinica* 49: 810–815 [in Chinese].
- Parrella, M. P., Jones, V. P., Youngman, R. R. & Lebeck, L. M. 1985. Effect of leaf mining and leaf stippling of *Liriomyza* spp. on photosynthetic rates of *Chrysanthemum*. *Annals of the Entomological Society of America* 78: 90–93. <http://dx.doi.org/10.1093/aesa/78.1.90>
- Peña, J. E., Hunsberger, A. & Schaffer, B. 2000. Citrus leafminer (Lepidoptera: Gracillariidae) density: Effect on yield of ‘Tahiti’ lime. *Journal of Economic Entomology* 93: 374–379. <http://dx.doi.org/10.1603/0022-0493-93.2.374>
- Percival, G. C., Barrow, I., Noviss, K., Keary, I. & Pennington, P. 2011. The impact of horse chestnut leaf miner (*Cameraria ohridella* Deschka and Dimic; HCLM) on vitality, growth and reproduction of *Aesculus hippocastanum* L. *Urban Forestry & Urban Greening* 10: 11–17. <http://dx.doi.org/10.1016/j.ufug.2010.11.003>
- Pincebourde, S., Frak, E., Sinoquet, H., Regnard, J. L. & Casas, J. 2006. Herbivory mitigation through increased water-use efficiency in a leaf-mining moth–apple tree relationship. *Plant, Cell and Environment* 29: 2238–2247. <http://dx.doi.org/10.1111/j.1365-3040.2006.01598.x>
- Preszler, R. W. & Price, P. W. 1993. The influence of *Salix* leaf abscission on leaf-miner survival and life history. *Ecological Entomology*, 18: 150–154. <http://dx.doi.org/10.1111/j.1365-2311.1993.tb01196.x>
- Pritchard, I. M. & James, R. 1984a. Leaf fall as a source of leaf miner mortality. *Oecologia* 64: 140–141. <http://dx.doi.org/10.1007/BF00377556>
- Pritchard, I. M. & James, R. 1984b. Leaf mines: their effect on leaf longevity. *Oecologia* 64: 132–139. <http://dx.doi.org/10.1007/BF00377555>
- Raimondo, F., Ghirardelli, L. A., Nardini, A. & Salleo, S. 2003. Impact of the leaf miner *Cameraria ohridella* on photosynthesis, water relations and hydraulics of *Aesculus hippocastanum* leaves. *Trees* 17: 376–382. <http://dx.doi.org/10.1007/s00468-003-0248-0>
- Raimondo, F., Trifilò, P. & Lo Gullo, M. A. 2013. Does citrus leaf miner impair hydraulics and fitness of citrus host plants? *Tree Physiology* 33: 1319–1327. <http://dx.doi.org/10.1093/treephys/tpt094>
- Reissig, W. H., Weires, R. W. & Forshey, C. G. 1982. Effects of gracillariid leafminers on apple tree growth and production. *Environmental Entomology* 11: 958–963. <http://dx.doi.org/10.1093/ee/11.4.958>
- Sasakawa, M. 2006. Agromyzidae (Diptera) from Hong Kong. *Acta Entomologica Sinica* 49: 835–842.
- Sasakawa, M. 2008. Agromyzidae (Insecta: Diptera) from the Alishan Mountains, Taiwan, with descriptions of five new species. *Species Diversity* 13: 133–148.
- Scheirs, J., Vandevyvere, I. & De Bruyn, L. 1997. Influence of monocotyl leaf anatomy on the feeding pattern of a grass-mining agromyzid (Diptera). *Annals of the Entomological Society of America* 90: 646–654. <http://dx.doi.org/10.1093/aesa/90.5.646>
- Shiao, S.-F. 2004. Morphological diagnosis of six *Liriomyza* species (Diptera: Agromyzidae) of quarantine importance in Taiwan. *Applied Entomology and Zoology* 39: 27–39. <http://doi.org/10.1303/aez.2004.27>

- Shiao, S.-F., Lin, F.-J. & Wu, W.-J. 1991. Redescription of four *Liriomyza* species (Diptera: Agromyzidae) from Taiwan. *Chinese Journal of Entomology* 11: 65–74.
- Shiao, S.-F. & Wu, S. 2005. A new fern-feeding species of Agromyzidae (Diptera) from Taiwan. *Transactions of the American Entomological Society* 131: 355–363.
- Shiao, S.-F. & Wu, W.-J. 1995. A new *Liriomyza* species from Taiwan (Diptera: Agromyzidae). *Pan-Pacific Entomologist* 71: 161–168.
- Shiao, S.-F. & Wu, W.-J. 1996. Four new agromyzid species from Taiwan (Diptera: Agromyzidae). *Transactions of the American Entomological Society* 122: 213–226.
- Shiao, S.-F. & Wu, W.-J. 1999. Supplements to the species of Agromyzinae (Diptera: Agromyzidae) from Taiwan, with notes on three new records. *Chinese Journal of Entomology* 19: 343–364.
- Shinozaki, Y., Yamamoto, A., Oishi, M. & Sato, H. 2012. Early leaf abscission has little effect on larval mortality of *Ectoedemia cerviparadisicola* (Lepidoptera, Nepticulidae) associated with *Quercus gilva*. *Annals of the Entomological Society of America* 105: 572–581. <http://dx.doi.org/10.1603/AN11185>
- Simberloff, D. & Stiling, P. 1987. Larval dispersion and survivorship in a leaf-mining moth. *Ecology* 68: 1647–1657. <http://dx.doi.org/10.2307/1939857>
- Spencer, K. A. 1990. *Host specialization in the world Agromyzidae (Diptera)*. Kluwer Academic Publishers, Dordrecht. <http://dx.doi.org/10.1007/978-94-009-1874-0>
- Stiling, P. & Simberloff, D. 1989. Leaf abscission: Induced defense against pests or response to damage? *Oikos* 55: 43–49. <http://dx.doi.org/10.2307/3565870>
- Stiling, P. D., Simberloff, D. & Anderson, L. C. 1987. Non-random distribution patterns of leaf miners on oak trees. *Oecologia* 74: 102–105. <http://dx.doi.org/10.1007/BF00377352>
- Stiling, P., Simberloff, D. & Brodbeck, B. V. 1991. Variation in rates of leaf abscission between plants may affect the distribution patterns of sessile insects. *Oecologia* 88: 367–370. <http://dx.doi.org/10.1007/BF00317580>
- Straw, N. A. & Williams, D. T. 2013. Impact of the leaf miner *Cameraria ohridella* (Lepidoptera: Gracillariidae) and bleeding canker disease on horse-chestnut: direct effects and interaction. *Agricultural and Forest Entomology* 15: 321–333. <http://dx.doi.org/10.1111/afe.12020>
- Sugiura, S. & Masuya, H. 2010. Leaf-mining beetles carry plant pathogenic fungi amongst hosts. *Journal of Natural History* 44: 2179–2186. <http://dx.doi.org/10.1080/00222933.2010.487161>
- Sun, X.-H., Zhou, X.-R., Pang, B.-P. & Meng, Q.-J. 2012. 南美斑潜蝇为害对黄瓜体内主要营养物质、次生代谢物质及叶绿素含量的影响 [Effects of infestation of *Liriomyza huidobrensis* (Diptera: Agromyzidae) on the contents of main nutrients, secondary metabolites and chlorophyll in cucumber leaves]. *Acta Entomologica Sinica* 10: 1178–1184 [in Chinese].
- Takizawa, H. 1978. Notes on Taiwanese chrysomelid-beetles, 2. *Japanese Journal of Entomology* 46: 596–602.
- Trumble, J. T., Ting, I. P. & Bates, L. 1985. Analysis of physiological, growth, and yield responses of celery to *Liriomyza trifolii*. *Entomologia Experimentalis et Applicata* 38: 15–21. <http://dx.doi.org/10.1111/j.1570-7458.1985.tb03492.x>
- Waddell, K. J., Fox, C. W., White, K. D. & Mousseau, T. A. 2001. Leaf abscission phenology of a scrub oak: consequences for growth and survivorship of a leaf mining beetle. *Oecologia* 127: 251–258. <http://dx.doi.org/10.1007/s004420000576>
- Wagner, D., DeFoliart, L., Doak, P. & Schneiderheinze, J. 2008. Impact of epidermal leaf mining by the aspen leaf miner (*Phyllocnistis populiella*) on the growth, physiology, and leaf longevity of quaking aspen. *Oecologia* 157: 259–267. <http://dx.doi.org/10.1007/s00442-008-1067-1>
- Wagner, D. & Doak, P. 2013. Long-term impact of a leaf miner outbreak on the performance of quaking aspen. *Canadian Journal of Forest Research* 43: 563–569. <http://dx.doi.org/10.1139/cjfr-2012-0486>
- Wang, S. 1990. 潜跳甲属二新种(鞘翅目:叶甲科) [Two new species of *Podagricomela* Heikertinger from China]. *Entomotaxonomia* 12: 123–126 [in Chinese].
- Wei, J., Zou, L., Kuang, R. & He, L. 2000. Influence of leaf tissue structure on host feeding selection by pea leafminer *Liriomyza huidobrensis* (Diptera: Agromyzidae). *Zoological Studies* 39: 295–300.
- Wei, M. 1994. Studies on the tribe Fenusini of China (Hymenoptera: Tenthredinidae). *Insect Science* 1: 110–123. <http://dx.doi.org/10.1111/j.1744-7917.1994.tb00201.x>
- Wei, M. 1997. Further studies on the tribe Fenusini (Hymenoptera: Tenthredinidae). *Acta Zootaxonomica Sinica* 22: 286–300.
- Wei, M., Huang, N. & Xiao, W. 2003. 广西十万大山叶蜂四新种(膜翅目:叶蜂总科) [New sawfly species from Mt. Shiwandashan, Guangxi (Hymenoptera: Tenthredinoidea)]. *Journal of Central-South Forestry University* 23: 10–13 [in Chinese].
- Wei, M. & Nie, H. 1998. New genera and species of Fenusini from China (Hymenoptera: Tenthredinidae). *Journal of Jishou University (Natural Sciences Edition)* 19: 20–24.
- Wei, M. & Nie, H. 1999. New taxa of Fenusini from China (Hymenoptera: Tenthredinidae). *Journal of Jishou University (Natural Sciences Edition)* 20: 25–30.
- Wei, Q.-X., He, Y.-X., Yang, X.-J., Weng, Q.-Y. & Wang, M.-M. 2004. 寄主植物对南美斑潜蝇羧酸酯酶及乙酰胆碱酯酶活性的影响 [Effects of host plants on CarE and AChE activity of *Liriomyza huidobrensis*]. *Acta Agricolae Universitatis Jiangxiensis* 26: 345–347 [in Chinese].
- White, T. C. R. 1984. The abundance of invertebrate herbivores in relation to the availability of nitrogen in stressed food plants. *Oecologia* 63: 90–105. <http://dx.doi.org/10.1007/BF00379790>
- Williams, C. E. 1989. Damage to woody plants by the locust leafminer *Odonotota dorsalis* (Coleoptera: Chrysomelidae), during a local outbreak in an Appalachian oak forest. *Entomological News* 100: 183–187.
- Wu, C.-S., Xiao, C. & Li, Z.-Y. 2006. A new species of the genus *Lyonetia* attacking *Eriobotrya japonica* in China (Lepidoptera, Lyonetiidae). *Acta Zootaxonomica Sinica* 31: 410–412.
- Wu, X.-Y., Yang, Y.-L. & Han, S.-Z. 2010. 甘肃叶蜂种类调查及分类研究 vii. 叶蜂科潜叶蜂亚科、粘叶蜂亚科、凹颜叶蜂亚科及平背叶蜂亚科属种名录 [The investigation and taxonomical research of the sawflies species from Gansu province VII. A list of the genera and species (Hymenoptera: Tenthredinidae: Fenusinae, Caliroinae, Heterarthrinae, Allantinae)]. *Journal of Gansu Forestry Science and Technology* 2: 9–15 [in Chinese].
- Xu, M., Huang, G. & Liao, L. 2009. A new record genus and species of Gracillariidae (Lepidoptera) from China. *Entomotaxonomia* 33: 301–304.
- Yamazaki, K. 2010. Leaf mines as visual defensive signals to herbivores. *Oikos* 119: 796–801. <http://dx.doi.org/10.1111/j.1600-0706.2009.18300.x>

- Yan, L.-Y., Pang, B.-P., Zhou, X.-R. & Zhang, C.-Q. 2008. 南美斑潜蝇对不同菜豆品种的偏好性与寄主化学物质含量的关系 [Relationship between host plant preference of *Liriomyza huidobrensis* for different *Phaseolus vulgaris* varieties and plant compound contents]. *Scientia Agricultura Sinica* 41: 713–719 [in Chinese].
- Yang, C.-K. 1989. 中华微蛾新属新种记述 (鳞翅目: 微蛾科) [*Sinopticula sinica* (Lepidoptera: Nepticulidae). A new genus and species from China]. *Entomotaxonomia* 11: 79–82 [in Chinese].
- Yang, L., Dai, H. & Zhang, X. 1991. 大兴安岭地区跳象属二新种 (鞘翅目: 象虫科) [Two new species of *Rhynchaenus* (Coleoptera: Curculionidae) from Daxinganling Mountains Region]. *Entomotaxonomia* 13: 25–27 [in Chinese].
- Yang, L., Yao, Y., Che, L. & Qi, H. 1996. 四种跳象新记录 [Four new records of *Rhynchaenus* (Coleoptera: Curculionidae) from China]. *Journal of Northeast Forestry University* 24: 75–78 [in Chinese].
- Yu, G.-H., Cheng, P., Gu, D.-X. & Zhang, G.-R. 2008. 三种寄主植物叶片提取物对美洲斑潜蝇雌成虫嗅觉记忆的影响 [Influence of host leaf extractions on the olfactory memory of female adults of the vegetable leafminer, *Liriomyza sativae* (Diptera: Agromyzidae)]. *Acta Entomologica Sinica* 51: 659–664 [in Chinese].
- Yu, P. 1985. 铁甲科四新种 [Four new species of Hispididae]. *Entomotaxonomia* 7: 1–5 [in Chinese].
- Yuan, D. 1986. 中国尖细蛾属二新种 (鳞翅目: 细蛾科) [Two new species of the genus *Acrocercops* Wallengren from China (Lepidoptera: Gracillariidae)]. *Entomotaxonomia* 8: 63–66. [in Chinese].
- Yuan, D. 1992. Additional records on the genus *Caloptilia* from China (Lepidoptera: Gracillariidae). *Entomotaxonomia* 14: 209–211.
- Yuan, D. & Robinson, G. S. 1993. *Caloptilia* leaf-miner moths (Gracillariidae) of South-East Asia. *Bulletin of the Natural History Museum, Entomology series* 62: 1–37.
- Zeng, X., Wu, M. & Luo, S. 2003. 植物挥发性成分对柑桔潜叶蛾产卵行为的影响 [Effects of plant volatile constituents on the oviposition of citrus leafminer (*Phyllocnistis citrella* Stainton)]. *Acta Phytophylacica Sinica* 30: 198–202 [in Chinese].
- Zhang, G., Zhu, W., Liu, C. & Huang, T. 1998. 寄主植物对美洲斑潜蝇各虫态发育历期的影响 [Studies on the influence of different host plant on the developmental duration of each developmental stage of American leafminer]. *Acta Phytophylacica Sinica* 25: 11–14 [in Chinese].
- Zhang, H.-J., Li, J.-S., Zhang, L.-P. & Liang, Y.-H. 2000. 美洲斑潜蝇的寄主植物种类、适合度及其为害性的评价 [Evaluation on the host plant species and fitness to vegetable leafminer and its harmfulness]. *Acta Ecologica Sinica* 20: 134–138 [in Chinese].
- Zhang, M.-X., Ling, B., Ling, Z. & Pang, X.-F. 2004. 六种植物叶片中葫芦素B对美洲斑潜蝇寄主选择性的影响 [Effect of cucurbitacin B in leaves from six plants species on plant selectivity of the leafminer, *Liriomyza sativae*]. *Acta Ecologica Sinica* 24: 2564–2568 [in Chinese].
- Zhang, Y. & Yang, X.-K. 2004. A study of the genus *Podagricomela* Heikertinger (Coleoptera: Chrysomelidae: Alticinae) from China. *Entomotaxonomia* 26: 272–283.
- Zhang, Z., Liang, L., Huang, W. & Wang, J. 2008. 5个不同腰果品系对腰果细蛾抗性研究 [Evaluation of the resistance of five cashew germplasms to the cashew miner]. *Plant Protection* 34: 113–115 [in Chinese].
- Zhao, Y.-X. & Kang, L. 2001. 多食性斑潜蝇对寄主植物的选择 [Host plant preference of the polyphagous leafminers *Liriomyza* spp.]. *Acta Entomologica Sinica* 44: 567–573 [in Chinese].
- Zhao, Y. X. & Kang, L. 2002a. Role of plant volatiles in host plant location of the leafminer, *Liriomyza sativae* (Diptera: Agromyzidae). *Physiological Entomology* 27: 103–111. <http://dx.doi.org/10.1046/j.1365-3032.2002.00275>.
- Zhao, Y. X. & Kang, L. 2002b. The role of plant odours in the leafminer *Liriomyza sativae* (Diptera: Agromyzidae) and its parasitoid *Diglyphus isaea* (Hymenoptera: Eulophidae): Orientation towards the host habitat. *European Journal of Entomology* 99: 445–450. <http://dx.doi.org/10.14411/eje.2002.056>
- Zhao, Y. X. & Kang, L. 2003. Olfactory responses of the leafminer *Liriomyza sativae* (Dipt., Agromyzidae) to the odours of host and non-host plants. *Journal of Applied Entomology* 127: 80–84. <http://dx.doi.org/10.1046/j.1439-0418.2003.00687.x>
- Zheng, D., Cui, X., Li, Z., Chen, Y. & Shang, H. 2010. 三叶草斑潜蝇对6种寄主植物的选择适应性及其与寄主化学物质含量的关系 [Selectivity and fitness of *Liriomyza trifolii* to different host plants and their relationships with the chemical components in foliage]. *Plant Protection* 36: 93–96 [in Chinese].
- Zvereva, E. L. & Kozlov, M. V. 2014. Effects of herbivory on leaf life span in woody plants: a meta-analysis. *Journal of Ecology* 102: 873–881. <http://dx.doi.org/10.1111/1365-2745.12252>