

Caterpillars and moths

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ABSTRACT: Lepidoptera (moths, butterflies, and caterpillars) are an uncommon cause of adverse reactions in humans. Most reactions to Lepidoptera are mild and self-limited; however, reactions in sensitive individuals and reactions to particular species can be severe and life threatening. Specific syndromes caused by Lepidoptera include erucism (cutaneous reactions from contact with caterpillars, moths, or cocoons), lepidopterism (systemic involvement), ophthalmia nodosa (ocular involvement), dendrolimiasis and pararamose (each with joint symptoms relating to a specific species of caterpillar), lonomism (a severe hemorrhagic disease related to *Lonomia* species), and seasonal ataxia (related to ingestion of *Anaphe venata*). In most cases, reactions to Lepidoptera can be treated symptomatically with prompt removal of offending hairs. Antipruritic or anesthetic topical preparations, topical steroids, and oral antihistamines are often used. In the case of potentially fatal *Lonomia* envenomation, an effective antivenin has been manufactured.

KEYWORDS: consumptive coagulopathy, dermatitis, insect stings, urticaria

Introduction

The order Lepidoptera is made up of moths and butterflies, with between 125,000 and 150,000 described species worldwide (1). Of these, only a handful of species are known to cause adverse reactions in humans. Most medically important encounters with Lepidoptera occur with exposure to the larval form (i.e., caterpillars), though some adult moths are known to cause disease. To escape predation, caterpillars have developed an immense array of defense mechanisms, including irritating hairs (“setae”), spines, and toxic venoms. In this review, the most common and most medically important species of Lepidopterans are discussed, with attention to diagnosis, species identification, and treatment.

Terminology

Contact with caterpillars, moths, cocoons, or parts thereof can cause purely cutaneous reactions

(erucism) or systemic signs and symptoms with or without cutaneous findings (lepidopterism) (2,3). In addition, there are five additional described syndromes resulting from contact with Lepidoptera: (i) ophthalmia nodosa, which refers to ocular inflammation resulting from exposure to hairs or setae from any arthropod, typically caterpillars or tarantulas; (ii) lonomism, a syndrome of consumptive coagulopathy and fibrinolysis from contact with *Lonomia* caterpillars; (iii) seasonal ataxia, a syndrome of unsteady gait and dysarthria which occurs after ingestion of the caterpillar of *Anaphe venata*; (iv) dendrolimiasis, consisting of dermatitis with associated chondritis stemming from exposure to *Dendrolimus* caterpillars; and (v) pararamose, similar to dendrolimiasis, with pruritic or painful dermatitis associated with arthritis and joint deformity, arising from contact with the caterpillar of *Premolis semirufa*.

Epidemiology

Despite the nearly worldwide distribution of Lepidoptera, there are few species with clear documentation of adverse reactions in humans. The number of adverse lepidopteran exposures is difficult to quantify. Between 2001 and 2005, there was an

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average of 2094 stings from caterpillars annually reported to poison control centers in the United States (4). This likely underestimates the true number of adverse reactions, considering that many stings are mild and self-limited.

Although most adverse reactions to Lepidoptera involve only one or a few individuals, massive infestations or environmental factors can facilitate "epidemics" of erucism and lepidopterism. Infestations of medically important Lepidoptera have been reported with *Lymantria dispar* (5–7), several *Euproctis* species (8–11), *Megalopyge opercularis* (12–14), *Orygia pseudotsugata* (15), *Hemileuca maia* (16), *Hemileuca oliviae* (17), and several species of *Thaumetopoea* (18–20). Temporary reduction in natural parasites because of hurricanes was blamed for the abundance of *Hylesia alinda* moths, causing an epidemic of dermatitis in Cozumel, Mexico in 1989 (21). Introduced species, such as *L. dispar*, *Uraba lugens*, and *Darna palivita* may benefit from a lack of natural predators, facilitating overabundance. Artificial illumination has been reported to congregate *Hylesia* (22,23) and *Euproctis bipunctapex* moths (24), causing outbreaks.

Wind dispersion of larvae or setae can also facilitate epidemics. Newly hatched larvae of *O. pseudotsugata* (15,25) and *L. dispar* (5,26,27) are capable of wind dispersal by means of a silken thread. Wind dispersion of setae from the following species have been reported to cause human disease: *Thaumetopoea processionea* (18,20,28), *Thaumetopoea pityocampa* (29), *Euproctis edwardsi* (30), *Euproctis flava* (10), and *Hylesia* (22). Strong winds and dry weather facilitated dispersion of *E. flava* setae, blamed for an epidemic of dermatitis in 500,000 Shanghai residents in 1972 (10). Windblown setae have also been implicated in cases of ophthalmia nodosa (31).

A disproportionate number of caterpillar exposures occur in children, presumably because of increased curiosity and therefore direct contact. Brightly colored attractive caterpillars, such as *U. lugens*, may increase the chances of a child innocently picking up the offending caterpillar (32). The American Association of Poison Control Centers Toxic Exposure Surveillance System reported that 51.6 to 57% of caterpillar exposures occurred in persons 18 or younger (33,34). Langley found that 24% of reported caterpillar exposures occurred in children less than 6 years old (4). The following species have been reported to disproportionately affect children: *Euproctis similis* (35), *Lasiocampa quercus* (35), *U. lugens* (32), *Chelepteryx collesi* (36), *H. maia* (16), *Hylesia*

metabus (37) and *H. alinda* (21), and *Lonomia obliqua* (38).

Diagnosis

Accurate diagnosis of these reactions requires a high index of suspicion and a thorough history. Symptoms are often nonspecific and the differential diagnosis may be broad. However, certain clinical findings, especially in children, suggest contact with caterpillars or moths, and investigation should be executed. These findings are summarized in Table 1. Localized urticarial papules or bite-like reactions, particularly in exposed areas, are suggestive of erucism and a history of insect contact should be elicited. Lepidopterism is suggested by systemic symptoms, such as malaise, fever, abdominal pain, nausea or vomiting, or headache. Acute unilateral ocular inflammation should cause consideration of slit-lamp examination for setae causing ophthalmia nodosa. Caterpillar stings in South America, associated with cutaneous bruising and laboratory evidence of coagulation pathway abnormalities, are suggestive of lonomism.

Table 1. Diagnostic clues to lepidopteran encounters

Organism	Symptom
Various	Acute onset of eczematous or urticarial papules and plaques in exposed areas, especially in children or outdoor workers
Various, especially <i>Automeris</i> and <i>Hemileuca</i> sp; members of Limacodidae	Acute stinging dermatitis
Members of <i>Thaumetopoea</i> , <i>Megalopyge opercularis</i>	Urticarial papules and plaques, angioedema, and anaphylaxis
<i>Lophocampa caryae</i>	Grid-like hemorrhagic papular eruption with severe radiating pain
<i>Lonomia obliqua</i> , <i>Lonomia achelous</i>	Acute oropharyngeal irritation, dysphagia, pain, and edema
<i>Dendrolimus</i> sp. and <i>Premolis semirufa</i>	Mucocutaneous bleeding, hematologic evidence of fibrinolysis
<i>Anaphe</i> sp.	Eczematous or urticarial dermatitis plus joint symptoms
	Acute ataxia, confusion, mental status changes after ingestion of <i>Anaphe</i> larvae

Pathology

Pathology is usually not diagnostic. Most often, there is an arthropod assault-like reaction, with epidermal edema, a perivascular lymphohistiocytic infiltrate, and eosinophils (39–41). Embedded spines have been found after contact with *Hylesia* moths (22) and the caterpillars of *Euproctis chrysorrhea* (42) and *M. opercularis* (43). Epidermal necrosis can also occur after *M. opercularis* stings (43) and exposure to *Hylesia* moths (23). Vasculitis has also been reported after contact with *Hylesia paulex* moths in Brazil (44).

Species accounts

Table 2 provides a list of known offending Lepidoptera.

Family Saturniidae (giant silk moths)

It appears that all medically important Saturniidae belong to a single subfamily, Hemileucinae, which is found only in the Western Hemisphere. In the eastern United States, the most important member of this subfamily is the Io moth, *Automeris io*. Contact with *A. io* caterpillars typically causes a nettle-like stinging sensation and a pruritic papulourticarial eruption, which self resolves in hours (45). Rarely, radiating pain, paresthesias, dizziness, diaphoresis, or abdominal pain are reported (46). The caterpillar of the closely related *Automeris randa* possesses enlarged and characteristically mobile scoli that cause very painful stings (17). There are five other species of *Automeris* in North America, north of Mexico, and many more in Central and South America. All should be assumed to be urticating (17).

The genus *Hemileuca* is closely related to *Automeris* and contains 18 species in the United States and Canada, all of which possess stinging capacity (17). Contact with the range caterpillar (*H. oliviae*) causes immediate stinging, itching, and swelling, which can last up to a week. Caffrey noted that cutaneous symptoms were absent on first contact, but appeared and grew stronger with increasing frequency of contact. In addition, the hairs may be aerosolized, and inhalation can cause sneezing, rhinitis, bronchitis, or asthma (17,47). Ophthalmia nodosa has also been reported (47). The caterpillar of the buck moth (*H. maia*) accounted for 49% of 112 consecutive caterpillar stings in one series (46). Contact causes an immediately painful dermatitis consisting of vesi-

culatation, ecchymosis, edema, and occasional adenopathy or secondary bacterial infection (16). Several closely related Central and South American genera, including *Leucanella*, *Molippa*, and *Dirphia*, have similarly urticating larvae (48,49).

Hylesia is notable because it is one of the few genera in which the adult moth is responsible for human disease. Hollow urticating setae are found only on the abdomen of the female moth (50). *H. metabus* has caused several outbreaks of dermatitis in Venezuela, especially near the port city of Caripito, where the rash is called “Caripito itch” (22,23). Contact with setae from *Hylesia* moths or egg masses (upon which female moths deposit setae) causes symptoms within minutes to hours, consisting of intense pruritic papulourticarial or vesicular eruptions that can be localized or generalized (51). Less commonly, there is mucous membrane or eye involvement, malaise, fatigue, or arthralgias. Even after contact with moths and moth parts is discontinued, symptoms may last for up to a week (22,23,37,52,53). *Hylesia* moths can be subject to periodic outbreaks and can be so numerous that schools are closed and shops shut down early (52). Caripito itch has also been reported in international travelers to Venezuela or Central America (53). Several other species of *Hylesia* found in South and Central America are also known to cause eruptions: *Hylesia nigricans*, *H. paulex*, *H. alinda*, and *Hylesia frigida* (54,55).

The genus *Lonomia* has caused concern because of the rising number of fatal stings in South America. Since the initial report in 1967, approximately 1000 cases of lonomism have been reported in Venezuela, Brazil, Peru, French Guyana, Paraguay, and Argentina (56). Stinging initially presents as mild burning pain, headache, nausea, and vomiting, but can rapidly progress to a severe hemorrhagic diathesis, not uncommonly resulting in widespread bruising, mucosal and visceral hemorrhages, and hematuria. Fatal alveolar or intracerebral hemorrhage and renal failure may result (57–60).

Family Limacodidae (slug moths)

Several members of Limacodidae are well known for their ability to sting. Contact with *Acharia stimulea* (FIG. 1), the saddleback caterpillar, causes immediate intense stinging associated with urtication; vesiculation has also been reported (40). In the author’s experience, the sting is moderately more intense than the sting produced by *Natada nasoni* or *Parasa chloris*. *N. nasoni* stings cause moderately painful blanching erythema and

Table 2. Medically important Lepidoptera and their locations

Family	Genus and species	Location
Saturniidae	<i>Hylesia metabus</i> , <i>Hylesia alinda</i> , <i>Hylesia nigricans</i> , <i>Hylesia paulex</i> , <i>Hylesia frigida</i> <i>Automeris io</i> , <i>Automeris randa</i> ^a <i>Hemileuca maia</i> , <i>Hemileuca oliviae</i> ^a <i>Lonomia obliqua</i> , <i>Lonomia achelous</i> <i>Dirphia</i> sp.	Central and South America United States United States Brazil, Venezuela South America
Limacodidae	<i>Acharia stimulea</i> <i>Parasa chloris</i> , <i>Parasa indetermina</i> <i>Euclea delphinii</i> <i>Adoneta spinuloides</i> <i>Isa textula</i> <i>Natada nasoni</i> <i>Doratifera vulnerans</i> , <i>Doratifera oxleyi</i> , <i>Doratifera</i> <i>quadriguttata</i> <i>Thosea penthima</i> <i>Darna pallivitta</i> <i>Latoia lepida</i>	United States United States United States United States United States United States Australia Australia Hawaii, Southeast Asia Japan
Megalopygidae	<i>Megalopyge opercularis</i> , <i>Megalopyge crispata</i> <i>Norape ovina</i>	United States United States
Lasiocampidae	<i>Dendrolimus</i> sp. <i>Eriogaster lanestris</i> <i>Malacosoma americanum</i> <i>Lasiocampa quercus</i>	China Palearctic United States UK, Europe
Arctiidae	<i>Lophocampa caryae</i> <i>Arctia caja</i> <i>Spilosoma virginica</i> <i>Spilosoma lutea</i> <i>Spilosoma glatingnyi</i> <i>Hyphantrea cunea</i> <i>Manuela replana</i> <i>Eutane terminalis</i> <i>Premolis semirufa</i> <i>Euchaetes egle</i> <i>Estigmene acrea</i> <i>Pyrrharctia isabella</i>	United States Holarctic United States UK, Europe Australia Holarctic Australia Australia South America United States Canada, United States, Central America United States
Notodontidae	<i>Ochrogaster lunifer</i> , <i>Ochrogaster contraria</i> <i>Epicoma</i> sp. <i>Anaphe venata</i> <i>Trichiocercus</i> sp. <i>Thaumetopoea pityocampa</i> <i>Thaumetopoea wilkinsoni</i> <i>Thaumetopoea processionea</i>	Australia Australia Africa Australia Western and Central Europe Israel, Turkey, Southwest Asia South and Central Europe
Lymantriidae	<i>Euproctis chrysorrhea</i> <i>Euproctis edwardsi</i> <i>Euproctis similis</i> <i>Euproctis flava</i> <i>Euproctis bipunctapex</i> <i>Euproctis pseudoconspersa</i> <i>Porthesia lutea</i> <i>Acyphas leucomelas</i> <i>Leptocneria reducta</i> <i>Lymantria dispar</i> <i>Orgyia leucostigma</i> <i>Orgyia pseudotsugata</i> <i>Orgyia antiqua</i> <i>Orgyia anartoides</i> <i>Dasychira</i> sp.	Europe, United States ^b Australia Europe Japan, China Singapore Japan Australia Australia Australia Europe, Eastern United States Eastern United States and Canada Pacific United States Holarctic Australia Europe

Table 2. Continued

Family	Genus and species	Location
Nolidae	<i>Uraba lugens</i>	Australia, New Zealand
Anthelidae	<i>Chelepteryx collesi</i>	Southeast Australia
	<i>Anthela nicotiae</i> , <i>Anthela acuta</i>	Australia
Noctuidae	<i>Calyptra</i> sp.	Southeast Asia
Zygaenidae	<i>Neoproctis floridana</i>	Florida
	<i>Harrisina americana</i>	Eastern United States
Nymphalidae	<i>Nymphalis antiopa</i>	Holarctic
	<i>Hypolimnys misippus</i>	Southeast Asia, Africa, Central and South America, Australia
Morphoidae	<i>Morpho</i> sp.	Mexico, Central and South America
Eupterotidae	<i>Panacela lewiniae</i>	Australia
Pylalidae	<i>Scirpophaga innotata</i>	Australia

^aAll members of these genera should be considered urticating.

^bLimited distribution to coastal Maine and Massachusetts.

FIG. 1. *Achardia stimulea*, larva.

wheals, followed by follicular prominence because of arrector pili constriction, as well as increased perspiration in the affected area. These symptoms linger for approximately 5 hours and leave residual blanching red macules at the site of envenomation.

Many other Limacodids are capable of mild to severe stings. In the eastern United States, offending species include *Parasa indetermina*, *Euclea delphinii*, *Isa textula*, and *Adoneta spinuloides* (61). In Japan, *Latoia lepida* has caused several cases of dermatitis (62,63). *Parasa hilarata* is found in China and is capable of stings (64). *D. pallivitta*, the stinging nettle moth, is native to Southeast Asia, but was recently introduced to Hawaii. Contact with larvae causes immediate stinging and wheal formation, which may take up to 5 days to resolve (65,66). The genus *Doratifera* contains several Australian caterpillars capable of human stings (67,68). Another Australian Limacodid, the billy-goat plum stinging caterpillar (*Thosea penthima*), caused crushing chest pain and a severe local reac-

FIG. 2. *Megalopyge opercularis*, larva (courtesy of Henning von Schmeling).

tion in one patient (69). Mullen also mentions the stinging ability of the genera *Microleon*, *Monema*, and *Scopelodes* (61).

Family Megalopygidae (flannel moths)

The caterpillar of *M. opercularis* (FIG. 2) is most commonly called the puss caterpillar, but is also called the woolly slug, the opossum bug, the asp, the Italian asp, “el perrito” (the little dog), or “bicho peludo negro” (the black hairy bug) (12,14,70). Contact with caterpillar results in immediate intense burning pain, edema, and erythema, eventuating in a characteristic grid-like hemorrhagic eruption (FIG. 3) (12,70–74). This pattern is created by parallel rows of short, stiff hollow spines on the dorsum of the caterpillar (71). Urticarial reactions have also been reported (73). Pain can be severe, with some patients likening the amount of pain to a broken bone, kidney stones (75), or being hit with a hammer (75) or baseball bat (76). Often, the pain radiates up the affected extremity and can cause pseudoparalysis (12–14,43,70,74–76). In



FIG. 3. Characteristic grid-like petechiae from *Megalopyge opercularis* sting (courtesy of Dirk M. Elston, MD).

McGovern's series of 2130 cases, almost 32% of victims reported lymphadenopathy, and 29% reported headache (12). Less commonly reported symptoms include acute abdominal distress (14,75,77), muscle spasm, faintness (75,76), vertigo, respiratory distress, swallowing difficulty (74), shock-like symptoms, or convulsions (12).

Outbreaks of *M. opercularis* have caused epidemics of stings in Texas, Oklahoma, South Carolina, and Virginia (73). In San Antonio, Texas, caterpillars have been so numerous and stings so frequent that some public schools had to be closed until nearby trees could be sprayed (14). Several large series have noted a bimodal distribution of stings with most stings reported in late September into October, and a smaller peak from June into July (14,75,76). The closely related *Megalopyge crispata* is reported to have a less severe sting (73). Other *Megalopyge* species, including *Megalopyge urens*, *Megalopyge lanata*, and *Megalopyge krugi* are found in Central and South America, and are also capable of severe stings (49,64,78). The caterpillar of the flannel moth, *Norape ovina*, also causes mild stings (79,80).

Family Lasiocampidae (lappet moths)

Exposure to *Dendrolimus* caterpillars or their cocoons causes dendrolimiasis, consisting of a self-limited pruritic maculopapular or urticarial eruption associated in 34–63% of cases with monoarticular osteoarthropathy affecting peripheral joints such as the hands, knees, feet, or ankles (81,82). It has been reported only in the Chinese provinces of Zhejiang, Guangdong, Jiangxi, and Hubei (81). Victims may also have severe painful soft tissue swelling, loss of extremity function, and



FIG. 4. *Lophocampa caryae*, larva.

long-term disability (81,82). Radiologic findings vary from soft tissue swelling to osteoporosis, sclerosis, and joint destruction (82). In addition, chondritis may affect the thyroid, auricular, costal, or articular cartilages, and can result in deformation of the auricle, dyspnea, or dysphagia. Less commonly, there can be ophthalmia nodosa, causing scleritis or iridocyclitis that can result in blindness (81,83).

Other Lasiocampids are rarely implicated in erucism. Two European species, the oak eggar (*Lasiocampa quercus*) and small eggar (*Eriogaster lanestris*), have been reported to cause widespread erucism after exposure to the caterpillar setae (35). Mullen also mentions *Malacosoma americanum*, *Tolyte* sp., *Macrothylacia rubi*, and *L. quercus* (61).

Family Arctiidae (tiger moths)

Tiger moth caterpillars are often densely hairy, and several species are known to cause erucism or lepidopterism. *Lophocampa caryae* (the hickory tussock moth) (FIG. 4) caused 365 cases of pruritic rash over a 2-year period in Pittsburgh, Pennsylvania in 2001. Eight per cent of children also had direct oral contact with caterpillars, resulting in crying, drooling, refusal to drink, and oral or lip irritation. Six children required direct laryngoscopy to remove seta as well as overnight hospital observation. In all cases, including those with oral involvement, reactions subsided within 24 hours (84).

A syndrome called "pararamose" results from contact with *P. semirufa* caterpillars found in the Brazilian Amazon rainforests. Contact with the bristly caterpillars initially results in pruritic or painful dermatitis, which can be associated with severe arthralgia and arthritis with permanent deformity (85,86). Rubber tree plantation workers are particularly at risk (86). Costa reported that

despite the use of gloves, 60 of 337 rubber tree plantation workers reported symptoms including edema, intense itching, and pain at the site of contact with the caterpillars (85).

There are many other Arctiid caterpillars that may cause erucism or lepidopterism. Mullen specifically mentions the genera *Eilema*, *Lithosia*, *Adolia*, *Callimorpha*, and *Parasemia* (61). In Australia, *Manuela replana*, *Eutane terminalis*, and *Spilosoma glatingnyi* all can cause dermatitis (67,87). In the United States, other potentially offensive species are *Hyphantrea cunea* (fall webworm moth) (88), *Spilosoma lutea* (89), *Spilosoma virginica* (90,91), *Euchaetes egle* (61,90), *Pyrrharctia Isabella* (90), and *Estigmene acrea* (90). The caterpillar of the garden tiger moth (*Arctia caja*) can cause pruritic papular eruptions (35,64) and ophthalmia nodosa (92).

Family Notodontidae (prominents)

Caterpillars of the genus *Thaumetopoea* are well-known causes of erucism, lepidopterism, and ophthalmia nodosa. Contact with caterpillars, cocoons, or soil contaminated with setae can cause urticaria or angioedema that may last for several days (93–98). Severe vomiting, abdominal pain, and hypertension have been reported after cutaneous exposure to *Thaumetopoea wilkinsoni* (99,100). Anaphylaxis has been reported after contact with *T. processionea* and *T. pityocampa* (18,101). Setae may also become airborne and cause pulmonary disease in children and adults (28,93). *Thaumetopoea* species have caused outbreaks among military personnel in Israel and Germany (19,97), and were implicated in an outbreak of dermatitis and bronchial asthma in a German kindergarten (18).

Other important members of Notodontidae include the Australian caterpillar *Ochrogaster lunifer* (bag-shelter moth or processionary caterpillar), which can cause an intensely pruritic dermatitis or ophthalmia nodosa (67,68,102). The closely related *Ochrogaster contraria* of New Guinea and Australia causes similar symptoms (64). Southcott also mentions the Australian genera *Epicoma* and *Trichiocercus* (67).

Consumption of *A. venata* larvae is responsible for seasonal ataxia in areas of Nigeria, where they are an important source of protein (103). Ingestion of roasted larvae causes acute nausea and vomiting that progresses to dizziness, ataxia, and unsteady gait in more than 90% of victims. Symptoms take days or weeks to resolve (103,104). In one series, dysarthria was noted in 29 of 34 patients, and 10 patients had impaired consciousness (103). The

pathogenesis is related to thiamine deficiency induced by the caterpillars. Moths of this genus are also capable of causing erucism similar to *Hylesia* (48,50,61).

Family Lymantriidae

The gypsy moth (*L. dispar*) is well known for its destructive capability in the United States. Early instar larvae are capable of wind dispersion and commonly cause dermatitis, although later instars are also urticating (26,27). Epidemics of gypsy moth dermatitis have been reported in Massachusetts, Connecticut, Rhode Island, and Pennsylvania (5–7). After contact with the caterpillars, pruritic eczematous dermatitis and urticaria in uncovered areas persists for 4–7 days (5,6).

The reaction to contact with browntail moth caterpillars (*E. chrysorrhea*) is similar, with eczematous or urticarial eruptions occurring primarily in exposed areas (9,105). Most reactions are mild and self resolve within a week, but allergic persons may develop more serious reactions, including bruising, conjunctivitis, or rhinitis (9,105,106). At least one death attributed to “severe internal poisoning caused by inhaling the hairs” has been reported (107).

In southeast Australia, the caterpillar of the closely related mistletoe browntail moth (*E. edwardsi*) causes pruritic urticarial wheals and papular eruptions that typically subside within 3–4 hours. Cocoons bear embedded caterpillar setae and cause similar symptoms (108,109). Airborne spread of hairs causing widespread cutaneous eruptions have been reported, and garments hung on clotheslines may harbor airborne setae, causing dermatitis only when the dried garments are worn (30,108). Other notable *Euproctis* species are the Asian mulberry tussock moth (*E. flava*) (10,11), *E. bipunctapex* (24), the Japanese tea tussock moth (*E. pseudoconspersa*) (64,110), *E. stenomorpha* (87), *E. flavociliata*, and *E. funeralis* (64).

The caterpillar and cocoon of the white marked tussock moth caterpillar (*Orgyia leucostigma*) (FIG. 5) has been reported to cause erucism after contact with the skin (61,80,90,111–113). *O. pseudotsugata* caterpillars have caused epidemics of dermatitis in loggers in the US Pacific northwest. Newly hatched larvae can be dispersed by winds, facilitating epidemics (25). In the vast majority of patients, symptoms are limited to welts, papular urticaria, or dermatitis predominantly in uncovered areas. However, some victims suffer from itchy or swollen eyes, mild respiratory



FIG. 5. *Orgyia leucostigma*, larva (courtesy of the Pennsylvania Department of Conservation and Natural Resources – Forestry Archive, Bugwood.org).

symptoms, fatigue, and headache (25,114,115). In one series, questionnaires suggested that loggers with comorbid allergic diathesis were more likely to report symptoms because of exposure (25). In the author's experience, the closely related *Orgyia antiqua* is also able to cause mild dermatitis.

Other potential causes of erucism from this family are *Dasychira pudibunda* (61,64), *Porthesia lutea*, *Acyphas leucomelas*, *Leptocneria reducta*, and *Orgyia* (*Teia*) *anartoides* (67,87).

Family Nolidae

U. lugens (the gum-leaf skeletonizer moth) appears to be the only known member of this family that causes adverse reactions. Native to Australia, it was accidentally introduced into New Zealand, where it is a pest of eucalyptus. Contact with caterpillars of any instar causes pain, erythema, and wheal formation (32,67,87,116).

Family Anthelidae

Caterpillars of *Chelepteryx collesi* (white-stemmed gum moth) bear stiff setae that readily penetrate unprotected skin, break off, and cause severe irritation (67). Setae embedded in cocoons cause similar symptoms (117). Balit et al. described 13 confirmed exposures to either caterpillars or cocoons, which both caused predominantly pain and swelling. Redness, discoloration, or pruritus of the hands and feet were also noted (36). More severe reactions, such as urticaria, angioedema, and dyspnea, have also been reported (117).

Several members of the related genus *Anthela*, all found in Australia, have been implicated in dermatitis and ophthalmia nodosa (31,67,87).

Family Noctuidae

Many species of moths and butterflies are known to imbibe tears, urine, fecal matter, even blood, but only one known genus (*Calyptra*) is known to pierce uncompromised vertebrate skin to feed directly on blood. Only male moths of certain species are known to bite, and the bites can be painless or intensely painful with persistent swelling that may last into the next day (61,118). These moths pose a theoretical, albeit unproven, risk of transmissible disease.

Other families

There are at least five additional families with one or more members reported to cause limited adverse reactions in humans. *Neoproctis floridana* and *Harrisina americana* are both members of family Zygaenidae; both species can cause mild stings. Several Australian genera within this family may also cause stings (87). *Panacela lewiniae* (family Eupterotidae) is an Australian caterpillar capable of mild stings (67,87). Several species of *Morpho* caterpillars (family Morphoidae) have irritating hairs that cause erucism (61). Scales from the Australian moth *Scirpophaga innotata* (family Pyralidae) can cause hay fever-like symptoms in exposed individuals (87). Finally, at least two species of caterpillars in the family Nymphalidae are capable of mild stings: *Nymphalis antiopa* (mourning cloak butterfly, Camberwell beauty) (61,90) and *Hypolimnys misippus* (67).

Treatments

An outline of treatments, and level of evidence, is presented in Table 3.

General treatment measures

First-line management of caterpillar and moth exposure is prevention. Unknown species of caterpillars that bear hairs or spines (especially branched spines) should not be intentionally handled. During periods of heavy caterpillar outbreak, sensitive individuals should actively avoid infested areas. Use of long sleeve clothing, pants, and even gloves may be warranted, especially for those who work in and around potentially offensive species (18,19). For heavy infestations, manual removal and destruction of egg nests, caterpillars, or cocoons may be useful (18,26,52,119). Pesticides, such as *Bacillus thuringiensis* and difluben-

Table 3. Treatment levels of evidence (LOE)

Treatment category	Treatment	LOE
General recommendations	Avoidance during periods of heavy infestation	IIIC
	Manual removal of caterpillars, cocoons, or egg nests	IIIC
	Pesticide application	IIB
	Turning off artificial lights	IIIC
Erucism and lepidopterism	Removal of setae with cellophane tape stripping or forceps	IIC
	Immediate washing with soap and water	IIIC
	Removal of constricting clothing	IIIC
	Topical antipruritics and anesthetics	IIIC
	Topical aspirin	IIB
	Topical, intralesional, or oral steroids	IIIC
	Oral antihistamines	IIIC
	Acetaminophen, oral narcotics	IIIC
	Intravenous calcium gluconate ^a	IIIC
	Nebulized or subcutaneous epinephrine	IIIC
Lonomism	Antivenin ^b	IIB
	Antifibrinolytics ^c	IIIC
Ophthalmia nodosa	Removal of setae	IIIC
	Topical or oral steroids	IIIC
	Surgery	IIIC
Seasonal ataxia	Oral thiamine replacement	IA

Evidence is graded using a three-point scale based on the quality of methodology as follows:

I. Good quality patient-oriented evidence.

II. Limited quality patient-oriented evidence.

III. Other evidence including consensus guidelines, extrapolations from bench research, opinion, or case studies.

Clinical recommendations are ranked as follows:

A. Recommendation based on consistent and good quality patient-oriented evidence.

B. Recommendation based on inconsistent or limited quality patient-oriented evidence.

C. Recommendation based on consensus, opinion, or case studies.

^aFor *Megalopyge opercularis* stings.

^bFor *Lonomia obliqua* stings.

^cFor *Lonomia achelous* stings.

zuron, have been used for massive infestations (10,19,30,52,108,109,120). In one study, application of *B. thuringiensis* reduced *Hylesia* dermatitis incidence rates from 10.3 to 1.8%, with a larval mortality at 96 hours of 100% (121). Pheromone

disruption may play a role in suppressing gypsy moth populations in the United States (122). Insect repellants such as DEET are unlikely to be of benefit in prevention of Lepidopteran exposures.

When removing caterpillars from the skin or clothing, extreme care should be taken to avoid dislodging setae or spines. Reflexively brushing off or smashing caterpillars may cause fragile setae or spines to break off and become embedded in the skin. Instead, remove larvae gently with a stick, forceps, or similar object. When moths are the offending form, artificial lighting should be turned off when it is not needed to avoid congregation (112,119). The use of yellow lighting, insect-repelling bulbs, or installing electric insect traps has also been suggested (21).

Erucism and lepidopterism

When symptoms occur, it is important to keep in mind that almost all adverse effects caused by moths and caterpillars are self-limited. Therefore, treatment should be based on symptoms. Therapy remains largely empiric; to my knowledge, there have been no controlled therapeutic trials for erucism or lepidopterism.

The first step is complete removal of offending hairs or setae from the skin. Cellophane or duct tape stripping or use of fine forceps can be very effective to remove loose and partially embedded hairs and spines from the skin (18,30,108,109,112). Immediate washing with soap and water may also be effective (30,108,109). Clothing that has become contaminated with caterpillar setae should be changed and laundered thoroughly (25,115). Constricting jewelry, such as rings or wristwatches, should be removed from affected extremities in anticipation of swelling (2).

For pruritus, topical antipruritics, such as camphor and menthol 0.5% in creams, lotions, or gels, may be applied several times a day. Topical anesthetics such as pramoxine 1% also are safely used several times daily. One study found that topical aspirin was helpful in histamine-induced pruritus (123). For persistent eruptions, topical steroids may be useful (20,41,112). Mild to mid-potency steroids such as hydrocortisone 2.5% or desonide 0.05% may be useful in mild cases of erucism. For moderate reactions, triamcinolone 0.1% or desoximetasone 0.25% can be found in ointments, creams, and gels, and should be applied once or twice daily as needed. For more rapid results and in more severe cases, steroids may be used under occlusion or more potent formulations, such as clobetasol 0.05%, may be used. Therapy with

topical steroids should be limited to a few days to avoid atrophy, striae, and acneiform eruptions. In recalcitrant cases or those with pseudolymphomatous nodules, intralesional steroids (such as triamcinolone 5–10 mg/mL) can be used with excellent results. Care should be taken to ensure intradermal injection to avoid cutaneous atrophy.

The use of antihistamines in caterpillar and moth dermatitis is unclear. Some reports have found that oral antihistamines can be helpful (20,24,73,100,112), while others found them to be ineffective (22,115,124,125). Fexofenadine 180 mg, loratadine 10 mg, and cetirizine 10 mg can all be used safely in once or twice daily PO doses. Cetirizine is also available in chewable 5 and 10 mg tablets as well as 1 mg/mL syrup. If patients are unable to sleep because of itching, first generation antihistamines such as diphenhydramine or hydroxyzine, in doses 25–50 mg PO at bedtime, can be helpful because of their sedative and antipruritic effects. These medicines can also be taken every 6 hours as needed, but care should be taken to avoid driving while taking any sedating medication. Both diphenhydramine and hydroxyzine also are available as syrups and are dosed 1 mg/kg. Topical antihistamines, such as diphenhydramine, are not recommended because of their sensitizing potential.

Systemic steroids may be warranted in extreme cases (112,125). Oral prednisone, in doses starting at 1 mg/kg/day with a taper over 2–3 weeks, is a popular regimen with good efficacy and minimal side effects. Intramuscular injection of triamcinolone 40 mg was used with rapid success in two cases of *Megalopyge* envenomation (71).

Pain may be a prominent symptom after caterpillar stings. Ice application can be very effective in mild cases (12,73). Oral analgesics, such as acetaminophen 500–1000 mg every 4–6 hours, is also helpful. Oral or intravenous narcotic analgesia may be necessary in severe cases of caterpillar stings, particularly those because of *M. opercularis* and Limacodids such as *T. penthima* (12,69,74). Codeine given 0.5–1.0 mg/kg orally or intravenously every 6 hours is useful for some cases; in others, morphine 5 mg given intravenously and repeated until efficacy may be necessary. Isbister found that 2.5 mg of intravenous morphine was helpful for severe local pain because of *T. penthima* stings (69). *Megalopyge* stings may also cause muscle spasm; in these cases, diazepam 5 mg intravenously has been effective (74). Several reports have used 10 mL of 10% intravenous calcium gluconate for *Megalopyge* stings, providing complete relief of symptoms within hours (12,13,77).

Although anaphylactic reactions are rarely reported, they are certainly possible in sensitive persons. In these cases, 0.3–0.4 mL of 1 : 1000 epinephrine should be given subcutaneously and can be repeated every 10–15 minutes. Nebulized bronchodilators such as albuterol can also be utilized.

In the case of oral or ocular exposure, immediate removal of hairs by a qualified health care provider is mandatory and often curative. For oropharyngeal involvement, direct microscopic examination is recommended, with endoscopy under sedation reserved for cases of caterpillar ingestion causing symptoms such as drooling or dysphagia. Any visible spines or setae should be promptly removed, under conscious sedation if needed. Lee et al. successfully used systemic corticosteroids (dexamethasone or prednisone), systemic antibiotics, and antihistamines in several cases, all with full resolution of symptoms at 2 days (126).

Lononism

In all cases of suspected *Lonomia* envenomation, consultation with an experienced hematologist is suggested. It is of utmost importance to distinguish stings of *L. obliqua* from those of *Lonomia achelous* because while cryoprecipitate, purified fibrinogen, and antifibrinolytic drugs such as aprotinin and ϵ -aminocaproic acid have been used successfully in *L. achelous* (58), these drugs may exacerbate hemorrhagic symptoms because of *L. obliqua* with fatal consequences (58,127). In both species, neither whole blood nor fresh-frozen plasma should be given, as they may worsen clinical symptoms (58,127).

A specific antivenin has been developed for *L. obliqua* envenomation. When given intravenously within 24–48 hours of envenomation, the antivenin is effective in reversing the clinical signs of hemorrhage and may also help prevent chronic renal failure (60). It is developed from horse serum and consists of purified F(ab')₂ against a procoagulant toxin found in *L. obliqua* (128,129). In a rat model, antivenin normalized fibrinogen and other coagulation tests after *L. obliqua* envenomation (127). The antivenin may be obtained from the Instituto Butantan (Sao Paulo, Brazil). A recent double-blind trial demonstrated that infusion of 10.5 mg (three vials) had the same clinical outcomes as infusion of 17.5 mg (five vials) of antivenin (130). Unfortunately, the antivenin has not been proven effective for envenomation by *L. achelous*, likely because of distinct venom mechanisms.

Dendrolimiasis

Dezhou reported success with topical and oral antihistamines in combination with analgesics for joint pain. However, surgical correction of chondritis or drainage of a purulent joint space was occasionally necessary (81).

Ophthalmia nodosa

Diagnosis of ophthalmia nodosa requires a high index of suspicion. The sudden onset of a unilateral painful red eye with a foreign body sensation, even in the absence of a history of caterpillar or other arthropod exposure, should prompt immediate and thorough slit-lamp examination for offending setae (131). Copious irrigation and removal of hairs should be performed, although removal of all hairs is often impossible because of their small size and fragility (132,133). Topical steroids may be used in mild cases, especially if there is uveitis or iritis. Granulomas may be surgically removed (132,133). Deeper hairs may be observed but should be periodically monitored because of the tendency for them to advance deeper into the eye over time (132,134,135). Setae that move significantly should be surgically removed (132,133). Oral steroids are reserved for severe intraocular reactions. In rare cases unresponsive to steroids, vitrectomy may be required (132,135). In a few severe historic cases, enucleation was necessary (92,136).

Seasonal ataxia

Oral thiamine hydrochloride 100 mg every 8 hours was effective in a double blind, placebo-controlled trial. Reversal of symptoms typically occurred within 48 hours without long-term sequelae (137).

Conclusion

Lepidoptera are an uncommon cause of adverse reactions in humans. Most reactions are self-limited, but angioedema, anaphylaxis, arthritis, loss of vision, and a potentially fatal bleeding diathesis are known to occur after contact with certain species. Therapies are largely symptomatic and based on anecdotal experience. An antivenin has recently been developed for *L. obliqua*. More research is needed to investigate the mechanisms of disease, as well as determine the most effective therapies.

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