

Epidemiology, Diagnosis, Management, and Prevention of Common Caterpillar Envenomations in World Travellers

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Abstract

Caterpillars are the wormlike, larval forms of butterflies and moths of the insect phylum Arthropoda, order Lepidoptera. Next to flies, lepidopterans are the most abundant arthropods with over 165,000 species worldwide and with most species posing absolutely no human threats and serving as valuable agricultural and horticultural plant pollinators. Caterpillar species from several families of moths worldwide can, however, inflict significant human injuries. Since the 1970s, there have been increasing reports of isolated sporadic cases and clusters of dermatologic, ocular, pulmonary, and systemic reactions following caterpillar encounters worldwide. As travellers spend more leisure time outdoors in temperate and tropical climates, they will be predisposed to a variety of caterpillar-inflicted injuries ranging from transient dermatoses and reactive airway syndromes to lifethreatening consumption coagulopathies and chronic migrating polyarthropathies.

Introduction

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Methods

In order to describe the evolving epidemiology and outcomes of venomous caterpillar exposures worldwide, a computer literature search using the MESH term "caterpillars" was used to select data sources describing caterpillar envenomations by the National Library of Medicine (NLM) MEDLINE search engine, 1966-2008; and by the NLM OLD MEDLINE search engine for articles published prior to 1966. The peer reviewed articles that were analyzed descriptively included case reports, case series, laboratory investigations, epidemiological investigations, and reviews. In addition, the pathophysiological manifestations of venomous caterpillar exposures were stratified into five distinct presenting clinical syndromes including: (1) erucism, (2) lepidopterism, (3) dendrolimiasis, (4) *ophthalmia nodosa*, and (5) consumption coagulopathy with secondary fibrinolysis.

Results

Caterpillar life cycle, ecology, and morphology

The more advanced arthropods, such as butterflies, moths, fleas, flies, and beetles, undergo a complex life cycle or metamorphosis characterized by four separate developmental stages. These stages include (1) egg; (2) pupa, with pupae often encased within cocoons (moths) or chrysalises (butterflies); (3) larva, instar, or caterpillar form;

and (4) mature adult moth or butterfly. Adult moths and butterflies emerge from their pupae or chrysalises usually in late spring, summer, and early fall months, when trees and shrubs are blooming.

The mechanisms of caterpillar envenomation

Caterpillars have evolved unique systems of protection from predation including protective mimicry, foul scent-producing glands, and proteolytic and histaminergic venoms. Caterpillar venoms are produced by hypodermal, glandular epithelial cells, circulated in hemolymph, and stored in external tegument, tubercles or scoli, urticating hairs, and spines.¹

Taxonomy and global distribution of envenoming caterpillars (Table 1)

Table 1 lists some representatives of commonly envenoming caterpillars and their taxonomic classifications and world distributions.

The evolving global epidemiology of caterpillar envenomation

Caffrey first reported a case of occupational asthma in an entomologist raising New Mexico range caterpillars, *Hemileuca nevadensis (oliviae)*, in an agricultural research facility in the United States (US) in 1918.² In 1982, Etkind and others reported another workplace outbreak of gypsy moth caterpillar-associated dermatitis and occupational asthma in agricultural research workers exposed to the juvenile (first) larval instars of gypsy moth caterpillars.³ Massive outbreaks of puss caterpillar (*Megalopyge opercularis*) stings in school-age children resulted in several days of springtime public school closings in San Antonio, Texas, in 1923, and later in Galveston, Texas, in 1951 (Figure 1).^{4,5} Typical sting sites included exposed arms, face, head, and, especially the neck behind the shirt collar.⁶ Puss caterpillar stings continue to follow this seasonal pattern and distribution of sting sites in the southern US and Central America. By the 1980s, multiple epidemics of pruritic rash and occasional urticaria, rarely associated with fever, chills, nausea, vomiting, and diarrhea, were reported from Massachusetts and Rhode Island in 1981, Pennsylvania in 1982, and several other northeastern US states in 1983-1984.⁸⁻¹⁰ These epidemics of gypsy moth dermatitis and urticaria all occurred during the springtime of years supporting large populations of first larval instars of gypsy moth caterpillars, *Lymantria dispar*, and were caused by the aerosolization of the caterpillars' urticating hairs and hemolymph with subsequent human skin and mucosal contact.⁸⁻¹⁰ Considered extremely rare in South America until the 1980s, stings by the *Lonomia* caterpillars, *L. oblique* and *L. achelous*, are now creating serious public health threats, especially in Southern Brazil.¹¹⁻¹⁸ Multiple stings by *Lonomia* caterpillars are common and may be associated with high case fatality rates from acute renal failure and intracerebral hemorrhage. Like gypsy moth caterpillars, both tussock moth (*Orygia* spp.) and browntail tussock moth (*Euproctis* spp.) caterpillars belong to the family Lymantriidae, and are frequently associated with outbreaks of caterpillar dermatitis, conjunctivitis, and urticaria following contact exposures. In 2001, Balit et al reported an outbreak of caterpillar dermatitis and conjunctivitis in indoor office workers exposed to aerosolized urticating hairs from Australian browntail moth caterpillars (*Euproctis edwardsii*) feeding communally in a nearby eucalyptus tree.¹⁷ In 2003, Maier and co-authors reported an epidemic of airborne caterpillar-associated illnesses in Vienna during regional tree infestations with the third through sixth larval instars of European oak processionary caterpillars, *Thaumetopoea processionea*.¹⁸ Of 1,025 people living within 500 meters of infested oak trees and surveyed by telephone, 96% reported pruritus, 95% dermatitis, 14% conjunctivitis, 14% pharyngitis, and 4% (n = 2) severe respiratory distress.¹⁸ Although not described until 1976, the first outbreak of dendrolimiasis, a migratory chronic polyarthritis following contact with pine caterpillars, *Dendrolimus pini*, probably occurred in Hangzhou, China, in 1955, in farmers picking cocoons out of pine firewood.¹⁸ Since then, several outbreaks have been described in several prefectures in central and southern China, including Guangdong, Hubei, Jiangxi, and Zhejiang, with epidemics peaking seasonally, and often annually, in April-May, July-August, and October-November.¹⁹ The mean incubation period for dendrolimiasis following exposure to live or dead caterpillars, their cocoons, or caterpillar-infested firewood is 1-3 days, with a mean

patient age of 27 years, and no gender preference.¹⁹ Some of the more unusual outbreaks of caterpillar associated illnesses have included an epidemic of 600 cases of caterpillar dermatitis among 6,000 Israeli soldiers in 1959, and 10 cases of pediatric caterpillar ingestion in the US in 1998.^{21,22}

The syndromic stratification of caterpillar-associated injuries and illnesses

The syndromic classification of caterpillar envenomation includes the following clinical presentations, some of which may often overlap or combine: (1) erucism, (2) lepidopterism, (3) dendrolimiasis, (4) *ophthalmia nodosa*, and (5) consumptive coagulopathy with secondary fibrinolysis. Erucism, the most common type of caterpillar envenomation, is the preferred term for caterpillar dermatitis characterized by localized, pruritic maculopapular to bullous contact dermatitis and urticaria, caused by contact with or airborne exposure to caterpillar urticating hairs, spines, or toxic hemolymph.²³ Unlike localized erucism, lepidopterism is a systemic illness caused by a constellation of adverse effects resulting from direct or aerosol contact with caterpillar, cocoon, or moth urticating hairs, spines, or body fluids, and characterized by generalized urticaria, headache, conjunctivitis, pharyngitis, nausea, vomiting, bronchospasm, wheezing, and, rarely, dyspnea.²⁴ Dendrolimiasis is a chronic form of lepidopterism caused by direct contact with urticating hairs, spines, or hemolymph of living or dead central Asian pinetree lappet moth caterpillars, *Dendrolimus pini*, or their cocoons.²⁰ Dendrolimiasis is characterized by urticating maculopapular dermatitis, migratory inflammatory polyarthritis, migratory inflammatory polychondritis, chronic osteoarthritis, and, rarely, acute scleritis.^{20,25,26} The pathophysiology of dendrolimiasis is incompletely understood, but the acute phase may result from IgE-mediated allergy and hypersensitivity to foreign proteins, and the chronic bone and joint disease may be autoimmune-mediated.^{32,35} *Ophthalmia nodosa* is a chronic ocular condition characterized by initial conjunctivitis with subsequent pan-uveitis caused by corneal penetration and subsequent intraocular migration of urticating hairs from lymantriid caterpillars and moths, and therapsid spiders (tarantulas).^{27,28}

Some specific and representative caterpillar envenomations

Family Lasciocampidae

Dendrolimus pini (Chinese pine-tree lappet moth caterpillar).

This caterpillar is a hairy, brown to grayish-brown, tree-dwelling, communally feeding caterpillar, 2.5-3.5 cm in length, with bands of white scale-like hairs hiding hollow spines along its back or dorsal surface. Although the distribution of pine caterpillars ranges from East Europe and North Africa across Central and Northern Asia, the caterpillar feeds preferentially on pine needles in the temperate, mountainous (above 200 meters) pine forests of central and southern China. Pine caterpillars possess spines or setae that range from 1.0-1.6 mm long and cluster dorsally on the second and third thoracic segments, hidden by whitish bands of urticating hairs. Poison glands or, more likely, clusters of toxin-producing epithelial cells occur at the bases of breakaway spines and can release toxic hemolymph from live or even dead caterpillars or their cocoons.²⁰ Dead caterpillars will actually release more toxic hemolymph than live caterpillars, which release toxins only from broken spines, or even cocoons, which are lightly armed with spines to frustrate predators.²⁰ The tegument-produced venom contains formaldehyde and several uncharacterized histamine analogues with a tropism for receptors in bone, joints, and cartilage.²⁰ Direct contact with urticating hairs and spines of living or dead pine caterpillars or their cocoons may result in dendrolimiasis characterized by urticating maculopapular dermatitis, migratory inflammatory polyarthritis, migratory inflammatory polychondritis, chronic osteoarthritis, and, rarely, acute scleritis.^{20,25,26} Since the 1970s, Chinese investigators have reported several outbreaks of dendrolimiasis in central and southern China.^{20,25,25} Treatment for dendrolimiasis remains entirely supportive with early surgical intervention recommended to excise draining sinus tracts and infected cartilage and to prevent permanent bone and joint deformities.²⁰

Family Limacodidae (slug caterpillars)

Sibene stimulea (saddleback caterpillar)

Saddlebacks are the most venomous of the slug caterpillars, and are among the most common stinging caterpillars in North America. The adult caterpillar is brownish-red, 2.0-2.5 cm in length, and characterized by several distinctive features including 2 prominent fleshy horns or filaments studded with spines on each end, shorter armed horns along both sides, and a bright green dorsal midsection or "blanket" trimmed in white, with a dorsal brown-to-purple central spot or "saddle", also trimmed in white (Figure 2). Saddlebacks are most active in the late summer and early fall and are widely distributed throughout North America. The saddleback sting is immediately painful with proximal radiation to local lymphatic groups, and subsequent localized erythema, edema, and, possibly, later blistering, especially if the urticating spines are not stripped from the sting site. Rings and watches and any constricting jewelry or clothing should be immediately removed in the event of extensive swelling. Without blistering, the localized chemical contact dermatitis will subside within 2-8 hours. Treatment is entirely supportive with immediate washing of the site to remove toxic hemolymph; stripping of the bite site with cellophane or, preferably, adhesive duct tape; application of ice packs with cooling enhanced by topical alcohol or ammonia; topical and oral antihistamines; topical corticosteroids; and oral or intramuscular corticosteroids for prolonged reactions. Anaphylactic reactions are rare.

Family Lymantriidae (tussock moth caterpillars).

***Lymantria dispar* (Gypsy Moth Caterpillar).**

The lymantriid or tussock moth caterpillars are all hairy and brightly colored with long urticating hairs on both ends that often form distinctive toothbrushlike tufts or tussocks. In humans, the urticating hairs of most lymantriid caterpillars may cause severe urticarial dermatitis and conjunctivitis on contact, or wheezing and bronchospasm if inhaled, especially in subjects with prior histories of asthma or atopic allergies.^{3,6,9,10} Although gypsy tussock moth and *Euproctis* lymantriid caterpillars cause most cases of caterpillar-associated dermatitis and conjunctivitis each year in the US, Australia, and Europe, several other tussock moth caterpillars can also cause regional outbreaks of dermatitis and conjunctivitis, including the whitemarked tussock or toothbrush caterpillar, *Orygia leucostigma*, in the northeastern US, and *Orygia pseudotsuga* in the US and Canadian Pacific Northwest.^{3,6,9,10,17,24} The gypsy moth tussock caterpillar is bluish gray, covered with hairs, 3-5 cm in length, with round, raised bumps or tubercles on each segment. The dorsal tubercles on the first 5 segments behind the head are blue, and the dorsal tubercles on the remaining 7 segments are red. The side tubercles are yellow, and the mature caterpillars have a dorsal yellow stripe and 2 white side stripes. Although native to Europe, North Africa, and temperate Asia, gypsy moth caterpillars were intentionally introduced into the US New England states in 1868-1869 to initiate a failed silk industry, and have become much more serious agricultural pests in the US than in their native regions, often defoliating huge tracks of temperate, deciduous forests.⁶ Allen and coauthors have described gypsy moth caterpillar dermatitis as an acute pruritic, papular, urticarial eruption on exposed skin that occurs most commonly after contact with first larval instars of gypsy moth caterpillars.²⁹ Systemic manifestations of gypsy moth caterpillar stings may include conjunctivitis, allergic rhinitis, sneezing, upper airway hyperreactivity, wheezing and bronchospasm, especially in victims with histories of asthma or atopic allergies.³ Unlike limited workplace outbreaks, massive outbreaks of gypsy moth dermatitis with pulmonary reactions (lepidopterism) have now been reported in the Northeast US in the 1980s, and risk factors have included pre-existing asthma and hay fever histories and hanging washed clothing outside to dry.^{5,9,10} Although the pathogenesis of gypsy moth erucism and has not been clearly elucidated, the mechanism probably involves local and pulmonary histamine release and delayed hypersensitivity reactions in susceptible victims. Treatment is supportive with topical and parenteral antihistamines, oral or parenteral corticosteroids, and bronchodilators, as indicated, for bronchospasm.

***Euproctis* species caterpillars (browntail moth caterpillars)**

The hairy browntail moth caterpillars of the genus *Euproctis* are distributed worldwide, and possess highly allergenic, barbed urticating hairs, that can cause erucism on contact or lepidopterism via inhalation of aerosolized hairs. *E. chrysorrhoea* was introduced into the eastern US from Europe and is widespread throughout Europe, including the UK, extending south into North Africa and the Canary Islands. *E. chrysorrhoea* is a hairy brown caterpillar, 2-3 cm in length, with distinctive dorsal red spots, and white scale-like hairs on its sides. *Euproctis* caterpillars frequently cause outbreaks of dermatitis and allergic bronchitis following exposures to urticating hairs or to aerosols containing urticating hairs, especially in Australia, the Eastern US, Western Europe, and Japan (*E. subflava*).^{17,30,31} The treatment of lymantriid moth-induced erucism and lepidopterism is entirely symptomatic and supportive with antipruritics, anti-inflammatory agents, and nebulized and parenteral bronchodilators, as indicated, for asthmatic bronchitis.^{17,30}

Family Megalopyridae (Flannel Moth Caterpillars) (Figure 1)

***Megalopyge opercularis* (puss caterpillar)**

The flannel moth caterpillars are widely distributed throughout the New World and inflict neuropathically painful stings, often during seasonal outbreaks in the late summer or early fall in temperate regions and during both spring and fall in tropical regions that support two larval generations per year. *Megalopyge opercularis*, the puss caterpillar, is the most widely distributed and carefully studied species in the US and Latin America. The puss caterpillar is dirty white to grayish-yellow or brown, 2.5-3.5 cm in length, tear or pear-shaped, and covered in fluffy hairs that taper into hairy ponytails hiding dorsal breakaway spines (Figure 1). On contact, the breakaway, hollow spines release toxic venom with uncharacterized proteolytic components. Puss caterpillar stings may be multiple as caterpillars fall from trees and lodge in clothing, particularly shirt collars. Like saddleback moth caterpillar stings, puss caterpillar stings are instantaneously painful and quickly followed by localized edema, erythema, and pain radiating proximally toward regional lymph nodes. To relieve pain, victims commonly hold affected extremities completely still in a reflex pseudoparalysis.³² Although no deaths have been reported, systemic manifestations of puss caterpillar stings may occur and include headache, fever, nausea, vomiting, tachycardia, hypotension, seizures, and, rarely, acute abdominal pain and myospasm, mimicking acute appendicitis or latrotoxicism.^{33,34} Following the initial sting with radiating, often allodynic, pain, the puss caterpillar sting site develops into a distinct lesion surrounded by an erythematous halo with an inner footprint or grid-like pattern reflecting each broken-spine hypodermic injection point.^{33,34} The individual puncture sites often become hemorrhagic and vesicular, and may later become pustular and coalesce into large bullous lesions.³³⁻³⁵ Treatment is supportive and includes adhesive stripping of retained broken spines, topical and systemic antihistamines, and parenteral corticosteroids for severe, prolonged reactions.³³⁻³⁵ Subcutaneous epinephrine may be indicated for anaphylactic reactions with peripheral vasodilation and hypotension.³³ Although untested in controlled trials, intravenous calcium gluconate, 10 ml of a 10% solution, has provided dramatic relief of acute abdominal pain and myospasm associated with puss caterpillar stings.^{4, 35}

Family Saturniidae (giant silkworms)

***Automeris io* (io moth caterpillar)**

This caterpillar is pale yellowish-green, 5-6 cm in length, with red true legs and prolegs. There is a broad white stripe on either side, bordered above by a similar red stripe, and below by a thinner, and often broken, reddish-purple line. Raised tubercles or scoli, each armed with a whorl of black-tipped green spines, occur on each dorsal segment of the back. Io moth caterpillars are widely distributed throughout North America and range from southern Canada, throughout the US, and south to Mexico. Although the io moth caterpillar sting is immediately painful and pruritic, the contact, urticarial dermatitis resolves rapidly, and prolonged systemic sequelae and anaphylaxis are rare. Treatment is supportive and follows the generally recommended management strategies of stripping embedded urticating spines and topically applying cooling icepacks, antihistamines, and corticosteroids.

South American *Lonomia* caterpillars

The South American *Lonomia* saturniid moth caterpillars, *L. achelous* and *L. obliqua*, are large, communally feeding caterpillars that range in length from 4.5-5.5 cm, and sport a variety of camouflage colors, primarily shades of green and brown. *Lonomia* caterpillars are covered with rows of raised tubercles or scoli, all crowned with whorls of breakaway spines. *Lonomia* caterpillars range from Venezuela to northern Argentina, and now pose a serious public health threat in Brazil and Venezuela, due to high case fatality rates from venom-induced consumptive coagulopathy, intracerebral hemorrhage, and acute renal failure, possibly due to a combination of venom nephrotoxicity and microcirculatory fibrin deposition.^{11,36} Venom extracts from the hairs, spines, and hemolymph of the South American *Lonomia* caterpillars, *L. achelous* and *L. obliqua*, contain fibrinolytic proteases and clotting activators that can cause consumptive coagulopathies, intracerebral hemorrhage, and acute renal failure, following caterpillar contact.³⁷ The main venom component of *Lonomia* caterpillars is a proteolytic enzyme, lonomin V, which has been isolated from the hairs, spine, and hemolymph of *L. achelous*.³⁸ In experimental investigations in rabbits, Guerrero and colleagues demonstrated that lonomin V was a proteolytic inactivator of platelet factor XIII and a potent activator of both factor X and prothrombin.³⁸⁻⁴⁰ Since *Lonomia* caterpillars are communal feeders, caterpillar contacts often result in multiple venom exposures with high case fatality rates. The initial clinical manifestations of *Lonomia* envenoming include immediate burning pain at the contact site, followed rapidly by localized sting-site ecchymoses and bleeding, spontaneous bleeding from the mucous membranes, epistaxis, hematemesis, melena, hematuria, and oliguria.⁴¹ Without emergency treatment, victims may die rapidly from acute intracerebral hemorrhage or develop acute renal failure.⁴¹ Pregnant victims may be at greater risks of consumptive coagulopathy and renal failure.⁴¹ The treatment of *Lonomia* envenoming must be immediate and includes restoration of clotting factors with plasma, whole blood, platelet, and cryoprecipitate infusions, during continuous monitoring of clotting status by thromboelastography and activated clotting times. Nevertheless, procoagulant replacement therapy for *Lonomia* envenoming is often ineffective. In addition, antifibrinolytic therapy should be instituted. Since lonomin V is an inhibitor of platelet factor XIII and an activator of intravascular clotting, aspirin-containing medications are contraindicated in potential *Lonomia* envenomings.³⁸

Family Notodontidae, Subfamily Thaumetopoeidae (processionary tree caterpillars)

Processionary tree caterpillars, including the European *Thaumetopoea* caterpillars and the Australian *Ochrogaster lunifer*, are all dark, grayishblack caterpillars with slightly raised dark red to brown tubercles and fine hairs varying from white (*T. pityocampa*) to black (*O. lunifer*). The European pine processionary caterpillar, *T. pityocampa*, is found in all Mediterranean countries, including those of North Africa. The European oak processionary caterpillar, *T. processionea*, has a wider distribution and ranges from northern Europe to North Africa. The American pine processionary caterpillar, *T. wilkinsonii*, ranges from southern Canada to Mexico, and is an unusual cause of *ophthalmia nodosa* and blepharoconjunctivitis in the US.⁴² The Australian processionary caterpillars include coastal ground-dwelling *Ochrogaster* species that feed on Acacia species shrubs, and inland canopy-nesting *Ochrogaster* species that feed on Acacia and Eucalyptus trees. Processionary caterpillars frequently cause outbreaks of caterpillar dermatitis, *ophthalmia nodosa*, and allergic reactions following exposures to their urticating hairs or aerosols containing hairs, especially in Australia, Europe Japan, and the US. Venom extracts from the hairs and spines of the European pine processionary caterpillar, *Thaumetopoea pityocampa*, contain a 28-kDa IgE-binding protein toxin, thaumetopoein, a potent skin irritant and systemic histamine and kinin releaser.⁴³⁻⁴⁵ Treatment of processionary caterpillar envenoming is entirely supportive and follows generally recommended management strategies of washing loose urticating hairs off the skin, stripping off skin-embedded urticating hairs, and applying cooling icepacks and topical antihistamines and corticosteroids. Nebulized and parenteral bronchodilators may be indicated for asthmatic bronchitis with bronchospasm and wheezing following exposures to aerosols containing urticating hairs from processionary caterpillars.⁴⁵

Ophthalmia nodosa may be caused by intraocular migration of urticating hairs from lymantriid caterpillars and moths; and may be complicated by chorioretinitis, corneal granulomas, cataracts, glaucoma, and reduced visual acuity; and should always be managed by an ophthalmologist.^{28,46-48}

The General Management of Caterpillar Envenomation

The general management of most caterpillar stings is entirely supportive and includes: (1) immediate soap-and-water washing of the sting site to remove toxic hemolymph and any loose urticating hairs; (2) "no touch" drying of the sting site with a hair dryer, not a towel; (3) gentle stripping of the bite site with cellophane or, preferably, adhesive duct tape; (4) application of ice packs with cooling enhanced by initial topical swabbing with isopropyl alcohol or ammonia; (5) topical and oral antihistamines; (6) topical and oral corticosteroids; and (7) oral or intramuscular antihistamines and corticosteroids, if indicated for prolonged, allergic reactions. Recently recommended, but untested, alternatives to adhesive stripping of urticating hairs and spines following soap and water washing of sting sites include topical applications of rapidly drying clear fingernail polish or lacquer, rubber cement, or commercial facial peel solutions or impregnated tapes. These solutions should then be allowed to dry thoroughly under a hair dryer, and then carefully peeled off sting sites, effectively excavating embedded urticating hairs or spines. Rings and all constricting bands from watches and jewelry or clothing with elastic bands must be removed immediately following caterpillar contact in anticipation of potentially extreme swelling and lymphedema, especially with hag moth and puss caterpillar stings of distal extremities. Tetanus prophylaxis should be administered if indicated. The treatment of lepidopterism is also entirely symptomatic and supportive with oral and intramuscular antipruritics and anti-inflammatory agents, including antihistamines and corticosteroids. Nebulized and parenteral bronchodilators may be indicated for asthmatic bronchitis with bronchospasm and wheezing following exposures to aerosols containing urticating hairs from gypsy moth and processionary caterpillars. The treatment of *Lonomia* envenoming must be immediate and includes antifibrinolytic therapy and restoration of clotting factors with plasma, whole blood, platelet, and cryoprecipitate infusions. Experimental treatments of *Lonomia* envenoming with hirudin and with new equine vaccines have not been tested in controlled trials in humans.^{38, 39} *Ophthalmia nodosa* with subsequent pan-uveitis caused by corneal penetration and subsequent intraocular migration of urticating hairs from lymantriid and processionary caterpillars should be managed exclusively by ophthalmologists for initial assessment and all follow-up care, both of which may include surgical management.^{2, 7,28,47}

The Prevention of Caterpillar Envenomation

As travelers spend more leisure time outdoors, there will be more opportunities for human-caterpillar contacts and envenomings. If one sees or encounters brightly colored, hairy or tufted caterpillars feeding on the leaves of trees or shrubs, one should avoid unnecessary contact, including attempting to touch, slap, or squash caterpillars. If one finds an un-welcomed caterpillar on oneself, do not flick, brush, slap, or squash the caterpillar with either a bare or gloved hand, or even a rolled newspaper. Such violent maneuvers could easily trap urticating hairs, spines, or hemolymph in clothing, hair, or skin, for later envenoming, or disseminate them as aerosols, to be inhaled or lodged in the eyes. Never rub or massage a potential caterpillar sting site, which could serve to further embed urticating hairs and spines into the skin or clothes or spread hemolymph over the skin, increasing venom exposures. Always use a stick or pencil or other long, thin object to gently lift the caterpillar off your skin or clothing. During peak larval instar seasons of tree canopydwelling, communally-feeding caterpillars, such as gypsy moth and processionary caterpillars, close all exterior windows and doors, and do not hang wet clothes outside to dry and to trap aerosols of urticating hairs and spines. While indoors, rely on central air-conditioning, heating, and circulation systems with adequate filtration of fresh air intake, and increased air exchanges per minute per cubic meter of interior space in order to avoid potential inside air recirculation of outside aerosols. Such aerosols may contain the urticating hairs, spines, or hemolymph of allergenic and venomous caterpillars, feeding in the natural environment, or on common outdoor ornamental

trees, including eucalyptus, oak, maple, and pine trees. Finally, consider all caterpillars venomous and avoid unnecessary contact with living or dead caterpillars, or even their squashed external or internal contents and their cocoons. Many brightly colored caterpillars will mature into butterflies and not moths, and even expert entomologists and plant pathologists may have difficulty in differentiating stinging from harmless caterpillars.

Conclusions

Caterpillar species from about 12 families of moths and, rarely, butterflies worldwide can inflict serious human injuries ranging from urticarial dermatitis and atopic asthma to osteochondritis, consumption coagulopathy, renal failure, and intracerebral hemorrhage. Unlike bees and wasps, the envenoming or “stinging” caterpillars do not possess “stingers” or modified ovipositors attached to venom glands, but instead secrete toxic hemolymph from their teguments, and bear highly specialized external netting or urticating hairs and breakaway spines or setae to defend against attacks by predators and enemies. Since the 1970s, there have been an increasing number of reports of mass dermatologic, pulmonary, and systemic reactions following direct caterpillar encounters and indirect exposures to aerosols containing toxic caterpillar hairs, spines, or hemolymph throughout the world. Most caterpillar exposures can be prevented by simple personal protective and domestic measures taken during peak larval instar seasons.

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<i>Lepidopteran Family or Subfamily</i>	<i>Adult forms</i>	<i>Representative genera/species (spp)</i>	<i>Common names</i>	<i>Global Distribution</i>
Arctiidae	Moth	<i>Arctia</i> spp. <i>Hyphantria</i> spp.		Worldwide USA, Europe, Japan
Euclidae	Moth	<i>Euclea delphinii</i>		North America
North America	Moth	<i>Hemileuca</i> spp.	Buck moth caterpillars	New World
Lasiocampidae		<i>Malacosoma</i> spp. <i>Dendrolimus pini</i>	Chinese pine tree or lappet moth caterpillars	USA, Southern Canada Central Asia, North Africa
Limacodidae	Moth	 <i>Sibene stimules</i> <i>Phobetron pithecium</i>	Slug Caterpillars Saddleback Caterpillars Hag moth caterpillar	 Eastern and Southern USA North America
Lymantriidae	Moth	<i>Euproctis</i> spp. <i>Euproctis Chrysorrhoea</i> <i>E. Pseudoconspersa</i> <i>E. edwardsii</i> <i>E. flava</i> <i>E. similis</i> <i>Lymantria dispar</i> <i>Orgyia</i> <i>O. leucostigma</i> <i>O. pseudotsuga</i>	Tussock moth Caterpillars Browntail tussock moth caterpillars Australia or mistletoe browntail moth caterpillar Gypsy moth Caterpillar Tussock moth caterpillars	 USA, Europe North Africa Japan Asia Worldwide Eastern USA, Europe North Africa, Europe, Asia, North America North America US and Canadian Pacific Northwest
Megalopygidae	Moth	 <i>Megalopyge opercularis</i>	Flannel moth Caterpillars Puss caterpillar	USA, Latin America
Notodontidae	Moth	<i>Lochmaeus</i> spp.		New World
Nymphalidae	Butterfly	<i>Nymphalis</i> spp.		North America. Europe, Asia

Saturniidae	Moth	<i>Automeris</i> <i>Lonomia</i> <i>achelous</i> <i>Lonomia obliqua</i>	Giant silkworm caterpillar lo moth caterpillar	Worldwide Southern Canada, USA, Mexico South America (Brazil, venezuela, Argentina)
Subfamily Thaumetopoeidae, Family Notodontidae (Processionary caterpillars)	Moth	<i>Thaumetoea</i> <i>Pityocampa</i> <i>T. processionea</i> <i>T. wilkinsonii</i> <i>Orchrogaster contraria</i>	Processionary tree caterpillars	Asia , North Africa Europe Europe USA, Asia, Africa, Europe Australia
Zygaenidae	Moth	<i>Neoprocris</i> spp. <i>Zygaena</i> spp.		New World Central and Southern Europe



V Figure 1. The dorsal aspect of a puss caterpillar (*Megalopyge opercularis*). The puss caterpillar is a commonly encountered venomous slug caterpillar along the Central American and US Gulf Coasts, especially in the spring, when it often falls from trees and stings unsuspecting victims on the neck when it lodges in shirt collars. Source: US Department of Health and Human Services, CDC Public Health Image Library (PHIL). PHIL ID # 6303. No copyright permission required.



Figure 2. The dorsal aspect of a saddleback caterpillar (*Sibene stimulea*). The saddleback caterpillar is a commonly encountered venomous slug caterpillar in the US, especially among deciduous leaf foliage in the late summer and early fall. Note the characteristic central purplish spot or “saddle” trimmed in white. Source: US Department of Health and Human Services, CDC Public Health Image Library (PHIL). PHIL ID # 3158. No copyright permission required.

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