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Geographical and temporal distribution of Megalopygidae in the United States and Puerto Rico

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ABSTRACT

Background: The venom of Megalopygidae caterpillars causes inflammation and pain. Understanding geographic and temporal variation in exposure will help physicians and the public understand when and where the species in this family may be encountered.

Methods: Photographs uploaded by community scientists to the iNaturalist database were reviewed and identified. GIS data points were used to model distribution of species based on geographic variables at the location of photographs for each group. Data on temporal abundance was also noted.

Results: Maps were created predicting the geographic range for 11 species of Megalopygidae. Peak larval abundance for the most abundant species, *Megalopyge opercularis*, was determined as September in the southeastern United States and October in south-central US.

Conclusion: Geographic and temporal distributions, based on community science observations, allow for more accurate predictions on the likelihood of encountering venomous Megalopygidae caterpillars.

1. Introduction

Megalopygidae caterpillars, commonly called “asps,” “puss caterpillars,” or “flannel moth caterpillars” have hollow spines used to inject venom upon contact. The venom of most species is yet to be fully characterized, but the limited data available suggest that the venom includes substances and effects that differ from other families of venomous Lepidoptera (Quintana et al., 2017). Envenomation causes rapid pain and inflammation at the site of contact along with an ache in the regional lymph nodes draining the affected limb. Pain control includes both acute and longer term management (Branco et al., 2019). *Megalopyge crispata*, the black-waved flannel moth, and *M. opercularis*, the southern flannel moth and *Norape cretata*, the white flannel moth, are the three most commonly encountered species within the United States due to their abundance and wide-spread distribution, but all species within the flannel moth family can cause painful envenomation (Michienzi et al., 2022). Less is known about the geographic and temporal distribution of the other caterpillars in this family. The family Megalopygidae has two recognized subfamilies: Trosiinae and Megalopyginae. There are 7 species of Megalopyginae in the US, all in the genus *Megalopyge*: *M. crispata*, *M. opercularis*, *M. lacyi*, *M. pyxidifera*, *M. lapena heteropuncta, M. krugii* and *M. immaculata*. There are 5 species of Trosiinae in the US in two genera: *Norape cretata*, *N. sorpresa*, *N. tener*, *N. virgo*, and *Trosia obsolescens*.

iNaturalist is an international online community science platform where anyone can make an account and provide records of any life form by uploading photographs or sound files. Each record includes the time stamp and GIS location of the observation. Experts and non-experts can then review this data to provide taxonomic identifications to the geographic and temporal data. INaturalist provides researchers with data to assess phenology, morphological variation, and geographical distribution for species of interest. The use of community science networks plays an increasingly important role in monitoring changes as urbanization, invasive species, and global warming induce changes in the distribution and behavior of medically important taxa. In this study, we used the iNaturalist database to characterize the current temporal and geographic distribution of Megalopygidae in the United States including Puerto Rico. We also describe variations in color and morphology of caterpillars and moths. A population of *Megalopyge opercularis* were observed from Puerto Rico for the first time, a population of yellow unidentified asps were observed from Florida, and observations of *Megalopyge crispata* from the Southeast were found to have

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reduced forewing patterns compared to observations from the rest of the United States.

The research presented here provides information about which species may be encountered in different locations in the United States and Puerto Rico, what those species look like, and what time of year caterpillar stings are most likely to occur in order to inform local public safety and education. As an example, each year the Houston Chronicle publishes an article warning Texans that asps are emerging. The public safety warning for 2023 was published in July and the subheader reads, "The fuzzy creatures begin to emerge in Texas during the late spring to early summer months," (Garcia, 2023) in the absence of data to define the timing and number of larval peaks in abundance. iNaturalist data can be used to inform more effective public safety warnings by accounting for local seasonal occurrences of medically significant caterpillar species.

2. Methods

Submissions to iNaturalist were identified by users with variable levels of experience and expertise. For observations to be considered "verifiable," the observation must include a date, time, image, and location. This information is visible to reviewers making identifications. To be considered "research grade," the observation must have two or more identifications in agreement and a simple majority agreement. Reviewers can disagree with existing identifications and remove research grade status. Reviewers can also tag specimens for life stage and sex.

For this project, all the verifiable US Megalopygidae observations on iNaturalist were reviewed by lepidopterist Emilio Peruzzi Sancio, who identified the observations to species level and tagged them with life stage and sex where possible. See supplemental figures 1 through 12 for examples of specimens demonstrating diagnostic characters. In cases where he replaced the identification, this removed the research grade designation of the entry, thereby removing the specimen from this analysis. In some cases, communication with other lepidopterists led to a reclassification of specimens into an alternate research-grade identification. The phenology and distribution data for the Mid-Atlantic, Southeast, and South-Central populations of *Megalopyge opercularis opercularis* were assessed on August 8, 2022. The phenology and distribution data for *Trosia obsolescens* were assessed on April 13, 2023. All other phenology and distribution data were assessed on September 26, 2022. Eggs and pupal stages were excluded from this analysis. When an observation was of a female laying eggs, the life stage was marked as adult and the sex was marked as female. When an observation included both larvae and adults, the life stage was not assigned. When an observation included both males and females or a mating pair, sex was not assigned.

Sex was determined by antennae and forewing markings when appropriate. Males of Megalopygidae have bipectinate antennae that fold longitudinally along the center. It was not possible to reliably distinguish between males and females for all observations of *Norape* which exhibit less degree of sexual dimorphism than *Megalopyge* spp. When antennae were not clearly visible in the photo of Trosiinae, sex was not assigned.

Observations of *Megalopyge* with reduced markings from the desert mountains of the Trans-Pecos and New Mexico had disagreeing species identifications (both *M. lacyi* and *M. immaculata*) and did not reach research grade status. A distribution of a reduced pattern Megalopyge morphospecies was made using the Traditional Project application of iNaturalist. For the purposes of this project, all observations of *Megalopyge* adults with reduced markings from Florida, Georgia, and Alabama were identified as *M. crispata*, while those from West Texas and New Mexico were identified as *M. immaculata*, although the latter could potentially represent *M. lacyi*.

Because all *Megalopyge lapena* within the US are thought to be a single subspecies, *Megalopyge lapena heteropuncta,* (Becker and Heppner, 1995) all specimens that fit the species-level identification were assigned this subspecies designation.

M. opercularis and *M. crispata* were differentiated in some photos using leg coloration. *M. o. opercularis* has black setae along the entire length of the tarsi while *M. crispata* only has black setae on the distal tarsomeres, excluding tarsomere 1. This is not a characteristic previously published in the literature, but appears stable with respect to identifiable specimens on iNaturalist.

Larvae of *Trosia obsolescens*, *Megalopyge lapena heteropuncta*, *M. opercularis bissesa,* and *M. pyxidifera* were excluded from the dataset. Because the larvae of *M. lapena heteropuncta* are unknown and the distribution of the adults largely overlaps with the distribution of *M. o. bissesa* adults, we considered the larvae of these two species to be potentially cryptic and did not identify beyond genus level. Because both *M. crispata* and *M. pyxidifera* have white larvae until the final instar, (Dyar, 1897; Smith and Abbot, 1797) white larvae from Florida were not identified to species level.

Observations of Megalopygidae from Mexico were excluded from this paper because many moths could not be identified to species level due to potential hybridization, the lack of identifying characters of adult *Norape*, and a dearth of published descriptions of Mexican Megalopygid larvae (Becker, 2022).

2.1. Distribution maps

Each of the illustrated range maps in this paper were created by comparing several different datasets:

1. Research-Grade observations of *Megalopyge, Trosia,* and *Norape* species on iNaturalist.org, which were reviewed for accuracy by EPS.
2. Level III Ecozones as delineated by the International Commission for Environmental Cooperation
3. Auto Contours in 3DEP Elevation from the United States Geological Survey GIS web application
4. Climate maps from the U.S. Department of Energy

The range of each species was estimated based on the consistent presence of Research-Grade observations within a specific ecozone, elevation, and latitude. Using this method, it is possible to extrapolate range information based on limited data. First, a taxon's observations were compared with a range map to determine approximate upper and lower bounds of elevation requirements. Then, if the taxon was observed within a given ecozone, the approximate area of that ecozone within the elevation range was included in the final map. If the taxon was not observed in a given area, but was observed at two locations on either side of the area with similar habitat and elevation, that area was also included in the final range map. Each map was drawn manually in the program Clip Studio Paint.

For the purposes of this paper, the "Mid-Atlantic" is defined as the states of New Jersey, Pennsylvania, Maryland, Virginia, West Virginia, and Delaware. The "Southeast" is defined as the states of Tennessee, Mississippi, Alabama, Georgia, Florida, South Carolina, and North Carolina. "South-Central" is defined as Texas, Oklahoma, Arkansas, and Louisiana.

Any datasets with 15 or fewer observations in a single month are labeled with "INSUFFICIENT DATA" or "INSF. DATA".

2.2. Phenology

Each of the phenology charts in this paper were created by accessing occurrence data from iNaturalist.org. Observations of *Megalopyge* and *Norape* species on iNaturalist.org were reviewed for accuracy by EPS and assigned annotations for life stage and sex, using characteristics demonstrated in Supplemental Figures 1 through 12. Observations of each species were analyzed and tallied by month, annotation, and region (as delineated by iNaturalist.org), as appropriate.

3. Results

A total of 8588 research-grade observations of Megalopygidae in the United States submitted to iNaturalist by September 26, 2022, were confirmed as Megalopygidae. The earliest observation was October 19, 1981. Of those, 1249 were Trosiinae (*Trosia* and *Norape*) and 7320 were Megalopyginae (*Megalopyge*). Of the 7320 *Megalopyge*, 3009 were larvae and 4018 were adults. Of the Trosiinae, 416 were larvae and 833 were adults. For the purposes of this paper, eggs and pupae were excluded.

Not all specimens were easily characterized. In Florida, a population of caterpillars that look similar to *M. crispata,* but have long curled white or gray setae extending from the body and yellow setae along the body were observed. These did not fit the description of any megalopygid larvae from the Southeast. These specimens were not identified to species level but could potentially represent the larvae of *M. pyxidifera*. See Supplemental Fig. 6.

There were two observations of a white *Megalopyge* caterpillar with red caudal setae: one from the Chihuahuan Desert Research Institute in the foothills of the Texas Davis Mountains (30.541 N, 103.836 W) and one from Sitting Bull Falls in Guadalupe Mountains, New Mexico (32.243 N, 104.696 W). The observation from the Texas Davis Mountains is the same type locality of *M. immaculata,* (Cassino, 1928) but the larvae matches Alexander Klots' description of *Megalopyge lacyi* (Klotz, 1966), which was described from Kerrville and Shovel Mountain in Central Texas (Barnes and McDunnough, 1910). These larvae were not identified to species level.

A population of *Megalopyge* larvae and adults identified by EPS as *M. opercularis* were observed from Puerto Rico. The only Megalopygid species previously published from Puerto Rico is *M. krugii* (Becker and Heppner, 1995). These were included in the *M. opercularis* dataset.

3.1. Geographic distribution

Megalopyge crispata and *M. opercularis* have the broadest geographical ranges of the species of Megalopygidae found within the United States (See Fig. 1). This includes the nominate subspecies of *M. opercularis* (*M. o. opercularis*) along with a more geographically restricted subspecies, *M. o. bissesa*. More restricted distributions were identified for other species of Megalopygidae (See Figs. 2 and 3). The ranges of many species along the southern US border extend into Mexico. Detailed distribution notes for each species is provided below.

3.2. Megalopyge crispata

M. crispata is found throughout the eastern United States in temperate deciduous and mixed forests and disturbed land, with the highest concentration in upland habitats around the central Appalachian Mountains. Its northernmost continental extent is near 41° N latitude, though its range extends further north along the east coast to Massachusetts. *M. crispata* appears to become less common in the pine-dominated forests of the Southeast. *M. crispata* is also present, though much less common, in scattered forest and shrubland habitat throughout the southern Great Plains.

3.3. Megalopyge opercularis bissesa

M. o. bissesa is found at high elevations in the Madrean Sky Islands in southeastern Arizona and the northern Sierra Madre Occidental in western Mexico. It is reasonable to hypothesize based on range data that *M. o. bissesa* may intergrade with *M. o. opercularis* along the southern Sierra Madre Occidental.

3.4. Megalopyge opercularis opercularis

M. o. opercularis is found in deciduous and mixed forests and disturbed land along the eastern and gulf coastal plains of the United States, from New Jersey to Florida, Texas, and the Mexican state of Veracruz. *M. o. opercularis* is also present in the Florida Everglades, the Southern and Eastern Sierra Madre in Mexico, and wet tropical forest in Central America (though populations south of the United States are severely understudied).

3.5. Megalopyge immaculata

M. immaculata is known from the Chisos Mountains of southwestern Texas and the Guadalupe Mountains of southeastern New Mexico.

3.6. Megalopyge krugii

M. krugii is found in tropical forest habitat throughout Puerto Rico. It is notably absent from urban areas.

3.7. Megalopyge lapena heteropuncta

M. lapena heteropuncta is found at high elevations in the Madrean Sky Islands in southeastern Arizona. Based on habitat and proximity, it may also be present in northern Sonora along the Sierra Madre Occidental in Mexico.

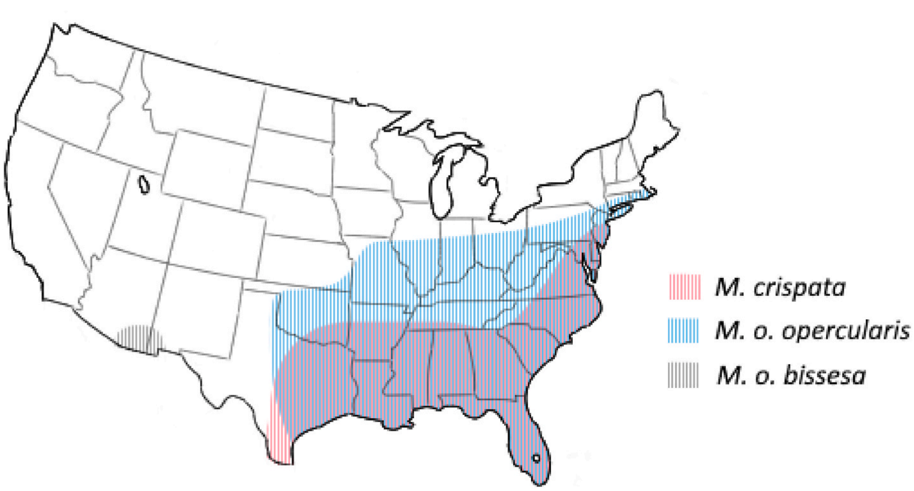

Fig. 1. A distribution map showing the approximate range of *Megalopyge crispata*, *M. opercularis opercularis*, and *M. o. bissesa*.

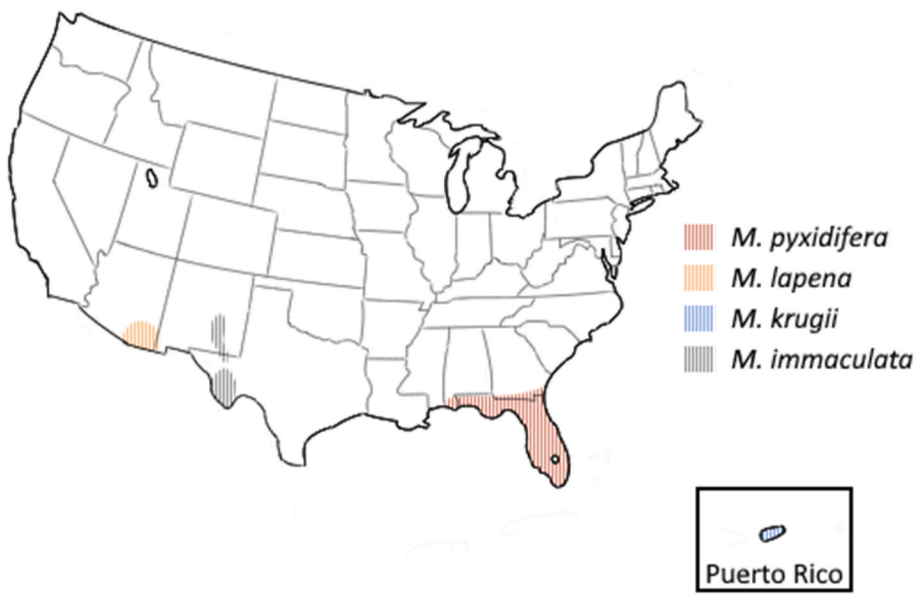

Fig. 2. A distribution map showing the approximate range of *Megalopyge pyxidifera*, *M. lapena*, *M. krugii*, and *M. immaculata*.

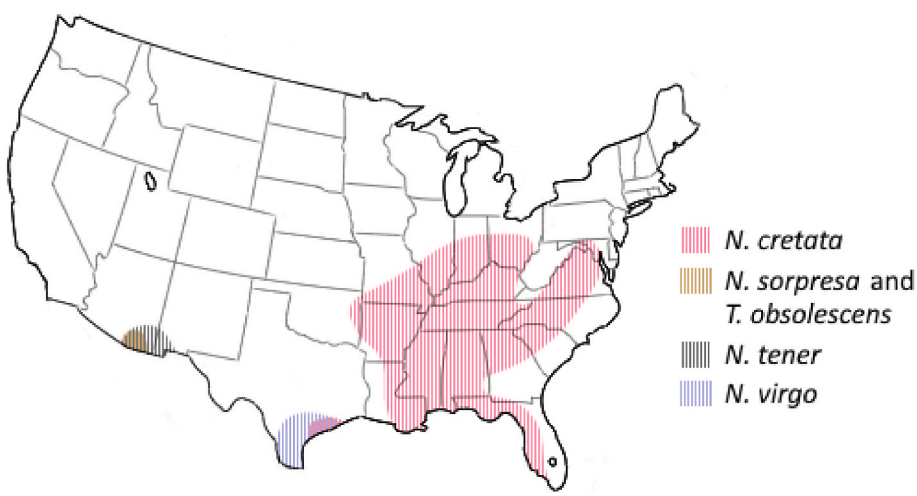

Fig. 3. A distribution map showing the approximate range of *Norape cretata*, *N. sorpresa*, *N. tener*, *N. virgo*, and *Trosia obsolescens*.

3.8. Megalopyge pyxidifera

M. pyxidifera is found in subtropical forest and disturbed land throughout the Florida coastal plain and bayou systems, including the Florida Everglades.

3.9. Norape cretata

N. cretata is found throughout the eastern United States in temperate deciduous and mixed forests and disturbed land. However, it appears to be largely absent from low elevations along the eastern coastal plain and high elevations along the central Appalachians. Its northernmost continental extent is near 40° N latitude in Ohio and Maryland. Its southernmost record in Florida comes from Naples on the western edge of the Everglades (25.991°N, 81.596°W). There is also a disjunct population of *N. cretata* along the Gulf Coast of Texas between Houston and Corpus Christi. Only adult moths and no larvae have been identified from this Texas population.

3.10. Norape virgo

N. virgo is found along the gulf coastal plain of southern Texas. It is also found throughout the Sierra Madre and wet tropical forest in Mexico and Central America.

3.11. Norape tener

N. tener is found in arid shrubland habitat at moderate elevations in the Madrean Sky Islands in southeastern Arizona and the Mexican plateau. It can also be found throughout Mexico in the Sierra Madre.

3.12. Norape sorpresa and Trosia obsolescens

N. sorpresa and *T. obsolescens* are found in the Madrean Sky Islands in southeastern Arizona and the Sierra Madre Occidental in Mexico.

3.13. Phenology

M. opercularis appears to be bivoltine in the South-Central states, with a small larval peak in July followed by a larger period of larval abundance in October through November, while in the Southeast, there is one peak larval abundance in September suggesting a univoltine reproduction in this region (see Fig. 4). Additionally, most of the observations from the Southeast and Mid-Atlantic US were adults while the South-Central region had more observations of larvae (see Table 1). *M. crispata* appears to have a univoltine reproduction throughout its distribution with larvae most common in July (see Fig. 5). Regional differences in phenology were determined only for *M. opercularis* and *M. crispata* given the more restricted distributions and lower abundance of the other megalopygid species (see Table 1). *N. tener* larval abundance peaks in August, *N. cretata* has a period of larval abundance from August through September, and larvae of *N. virgo* are most abundant in November (See Fig. 6). Adult males were recorded more often than females for all Megalopygidae (see Table 1).

4. Discussion

Megalopyge opercularis is the megalopygid species with widest geographic and temporal distribution in the US, and therefore the primary species of medical relevance in this group. *M. crispata* and *N. cretata* are also widely distributed species and are likely the cause of stings sustained earlier in the season and those sustained in the geographic ranges in which *M. opercularis* does not generally occur. Other species have restricted geographic ranges and are less likely to be of widespread medical significance.

Multiple broods per year increases the likelihood of interactions between humans and *M. opercularis*. The two peaks in the iNaturalist database corresponds to reports of envenomation in Texas reported to poison control centers (Forrester, 2018). Given the polyphagous diet of *M. opercularis*, climate change may cause this species to range further north, and people in these areas may increasingly encounter these venomous caterpillars. Climate change and habitat loss may also affect the natural enemies of Megalopygidae and in turn affect megalopygid abundance. Human disturbance of caterpillar ecology has resulted in outbreaks of Megalopyge opercularis in Houston, Texas, suggesting that the current data may vary locally (Hood et al., 2019). Changes in distribution and phenology should be episodically reassessed.

Submissions to iNaturalist do not represent true abundance, but rather the interaction between abundance of caterpillars and human population density. The distribution of observations to iNaturalist is therefore relevant to researchers' interest in human interaction with a medically relevant taxa. Higher population densities increase the probability that someone will encounter a caterpillar, photograph it, and submit it to the iNaturalist platform. In remote areas, undersampling of Megalopygidae indicates that fewer people are likely to encounter the larvae, rather than an absence of stinging caterpillars in that location. In contrast, the lack of observations of Megalopygidae from urban areas and cities of Puerto Rico suggests that stings are a greater risk to people who are hiking or camping. Public education should target those at highest risk of exposure; for example, flyers could be posted in outdoor gear stores in Puerto Rico, while Texan public education campaigns need to reach the large population of people that live in major urban areas.

Fig. 4. Phenology charts of *Megalopyge opercularis opercularis* (1) throughout its range in the United States, (2) within only the South-Central states, (3) within only the Southeastern states, and (4) within only the Mid-Atlantic states. Chart (5) shows the phenology of the subspecies *Megalopyge o. bissesa*.

Table 1
Summary chart for all phenology data.

Genus	Species	Subspecies	Region	Adult Peak Incidence	Larva Peak Incidence	N (adults)	N (larvae)
Megalopyge	opercularis	opercularis	USA	MAY - JUL	SEP - NOV	2750	2556
Megalopyge	opercularis	opercularis	South-Central	MAY, AUG	OCT - NOV	1303	1869
Megalopyge	opercularis	opercularis	Southeast	JUN - JUL	SEP	1062	522
Megalopyge	opercularis	opercularis	Mid-Atlantic	JUL	INSF. DATA	198	4
Megalopyge	opercularis	bissesa	USA	JUL	INSF. DATA	62	2
Megalopyge	crispata		All	JUN - JUL	AUG - SEP	1083	569
Megalopyge	immaculata		All	INSF. DATA	INSF. DATA	4	1
Megalopyge	krugii		All	INSF. DATA	INSF. DATA	10	5
Megalopyge	lapena		USA	AUG	INSF. DATA	27	0
Megalopyge	pyxidifera		All	INSF. DATA	INSF. DATA	45	0
Norape	cretata		All	JUL	AUG - SEP	591	335
Norape	virgo		USA	SEP	NOV	117	38
Norape	tener		USA	JUL - AUG	AUG	93	37
Norape	sorpresa		USA	INSF. DATA	INSF. DATA	17	8
Trosia	obsolescens		USA	INSF. DATA	INSF. DATA	19	0

Fig. 5. Phenology charts of (1) *Megalopyge crispata*, (2) *M. immaculata*, (3) *M. krugii*, (4) *M. lapena*, and (5) *M. pyxidifera*.

An examination of tick phenology and distribution found iNaturalist data comparable with known data on medically relevant species (Cull, 2022). This suggests that despite the limitations in unequal geographic sampling the data retain validity. To help predict exposures in less populated locations, we used geographic modeling to predict the distribution of species into less populated areas. It is possible that pockets of sparsely populated regions were excluded from the distribution maps provided in this paper. The range maps provided should be interpreted as the best current understanding of megalopygid ranges in the United States and Puerto Rico, but some biases cannot be accounted for. For example, *Megalopyge crispata* is well-represented in iNaturalist observations for both upland and coastal habitat in the southeastern US, but there are very few observations from lowland habitat in-between. There are also no *M. crispata* observations from the Mississippi river valley. We suspect that this is due to sampling bias since these regions are less affluent and less densely populated, though it is possible that *M. crispata* is absent from these areas.

Another data limitation is the uncertainty with which photographs alone can be used to definitively identify specimens. We believe that the characters used in identification are reliable, though we acknowledge

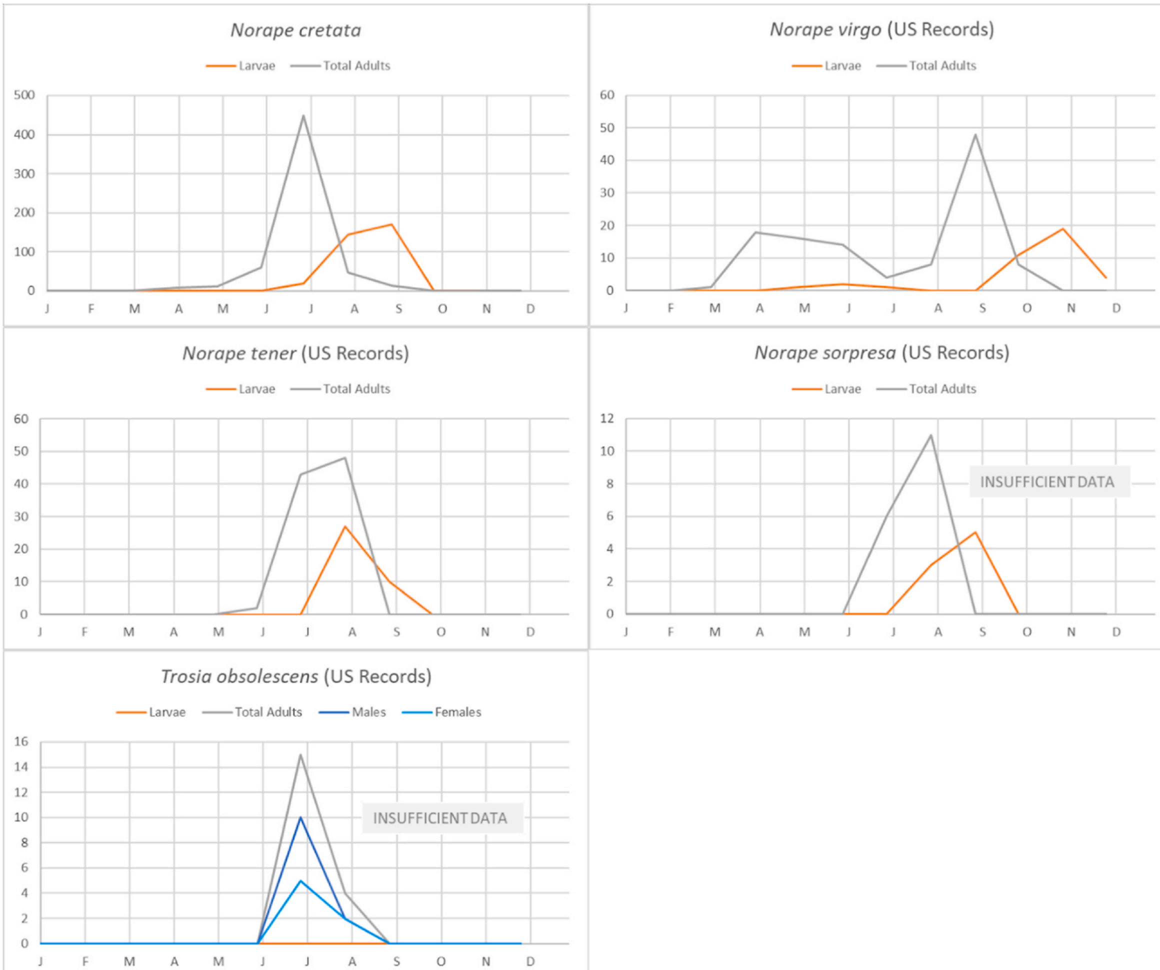

Fig. 6. Phenology charts of (1) *Norape cretata*, (2) *N. virgo*, (3) *N. tener*, (4) *N. sorpresa*, and (5) *Trosia obsolescens*.

the possibility that phenotypic overlap may decrease the precision of our findings.

A majority of *M. crispata* observations from Florida, Georgia, and Alabama have reduced patterning of the forewings compared to Northern contiguous populations of *M. crispata*, where this morphology is uncommon. Marc Epstein, an expert of Megalopygidae, disagrees that this Southeastern population represents the species *M. crispata* and identifies these observations as *M. lacyi* (personal communication, Marc Epstein, 2023) and George T. Austin lists *M. lacyi*, not *M. crispata*, on the checklist of Lepidoptera in Florida (Austin, 2010). However this Southeastern population with reduced wing patterns is disjunct from the type locality of *M. lacyi* in Central Texas (Barnes and McDunnough, 1910). Additionally, no observations were made of larvae from the Southeastern US that matched the description of *M. lacyi* larvae by Alexander Klots, which is primarily white with red setae on terminal segments (Klotz, 1966). Specimens collected from a female Megalopyge with reduced pattern from Midway, Alabama were reared from larva to adult by John Trent (@johntrent) and posted to iNaturalist. The larvae were white until the final instar, which had the gray and brown setae consistent with the description of *M. crispata*. The single moth that emerged from pupation had patterning typical of *M. crispata*. This supports a hypothesis that this Southeastern population of reduced pattern flannel moths represents a regional color variation.

Observations of *Megalopyge* with reduced markings from the Trans-Pecos region of Texas and contiguous desert mountain region of New Mexico were assigned the identification of *Megalopyge immaculata* by EPS, inferred from the type locality of the Texas Davis Mountains (Cassino, 1928). However, *M. lacyi,* which was described from Central Texas (Barnes and McDunnough, 1910) ten years earlier, has also been identified by Klots from the Trans-Pecos regions (Klotz, 1966) in the Guadalupe Mountains and the moths of this species are impossible to distinguish from *M. immaculata* by appearance. *M. immaculata* is potentially a synonym of *M. lacyi*, or Klots may have erroneously identified larvae of *M. immaculata* as *M. lacyi*, or the two may represent a cryptic species. Comparison of holotypes, rearing of larvae, and collection of adult moths is necessary to validate the larval descriptions and distribution of moths.

The larvae of several North American Megalopygidae are unknown or poorly described. Larvae of *Trosia obsolescens* and *Megalopyge lapena heteropuncta* are unknown, and larvae of *M. pyxidifera* are incompletely described. Rearing eggs from females would solve these mysteries. However, our data shows that females of all megalopygid species are much rarer than males, making this a challenge. It is unclear why the sex ratio of Megalopygidae is skewed male. Additionally, most of the observations from the Southeast and Mid-Atlantic US were adults while the South-Central region had more observations of larvae (see Table 1). This may be related to lower rates of eclosure due to high rates of parasitism in the South-Central region. (Hall)

M. pyxidifera is described by Abbot and Smith as having white larvae until the final instar (Smith and Abbot, 1797), like *M. crispata*. The final instar is depicted in an illustration (Becker, 2022) by Abbott, but the art is not realistic enough to differentiate larvae from final instar *M. crispata*. Dyar describes Abbot and Smith's illustration as, "erroneous and misleading" and described the final instar of *M. pyxidifera* as differing only in color from *M. crispata* (Dyar, 1897). However, Dyar describes the color of M. pyxidifera as gray. Final instar M. crispata vary in color and are found in shades of gray, brown, and red. In Florida, a population of caterpillars that look similar to *M. crispata*, but have long, white or gray, curled setae extending from the body and yellow setae along the body were observed (see Supplemental Fig. 6). These potentially represent final instar larvae *M. pyxidifera*, however, unlike *M. pyxidifera*, there were no observations of these larvae in the Florida panhandle.

Of note, *Megalopyge opercularis* larvae and adults were posted to iNaturalist from Puerto Rico, which is outside of previously published distribution within the contiguous US. This may represent a recent introduction or an endemic undescribed species.

Adult *Norape* identified as *N. cretata* were observed from Texas along the Gulf Coast, North of Corpus Christi and South of Houston. This population appears to be disjunct from the primary range of *N. cretata*. No *N. cretata* larvae have yet been observed from Texas on iNaturalist, despite the presence of their host species (Eastern Redbud) throughout this area. Rearing larvae, comparison of specimens to types, and DNA barcoding could clarify whether this represents the same species as *N. cretata*.

Before iNaturalist, BugGuide.net was a novel community science platform that allowed members of the general public to upload photographs of nearctic arthropods for expert identification. While the BugGuide database has been useful for case studies of envenomation (Austin, 2010) the data are limited by lack of GIS locations and loss of information through removal of images that are not needed for identification purposes (Carlson et al., 2012). The iNaturalist platform incorporates GIS data directly from photographs when GIS location is included in the file, or those uploading photos can manually select the location where the photograph was taken using a world map. We anticipate the quality of community science data will continue to improve as the technical capabilities of cellphone cameras advance, and the costs associated with macrophotography decrease.

iNaturalist uses artificial intelligence algorithms that place specimens generally within taxonomic groups for expert identifiers to review. Experts can then tag the life stage and sex of each observation. A drawback of the machine-learning algorithm is that superficially similar insects are commonly misidentified. For example, mantis ootheca are frequently misidentified as *Megalopyge opercularis* by iNaturalist users relying on the algorithm for identification. The thousands of observations of larvae and moths could not meaningfully be used to make inferences about phenology and distribution without expert review. While they are helpful, we do not anticipate that machine-learning algorithms will replace the need for the expertise of entomologists.

5. Conclusion

The venomous caterpillars of Megalopygidae include both widespread species and species endemic to small geographic areas. Location and seasonality play important roles in determining the likelihood of exposure. The data provided in this paper will help physicians predict human-caterpillar encounters and serve as a model for the importance of community science data in the field of medicine.

Ethical statement

This manuscript does not contain any data on humans or data on vertebrate animals. Therefore, no ethics board review was needed. In addition, all data used are publicly available on the iNaturalist website.

CRediT authorship contribution statement

Emilio Peruzzi Sancio: Writing - review & editing, Writing - original draft, Investigation, Data curation, Conceptualization. **Chris Alice Kratzer:** Writing - review & editing, Visualization, Methodology, Formal analysis. **John C. Carlson:** Writing - review & editing, Writing - original draft, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.toxcx.2023.100181.

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