

# A view from the mountain top: biodiversity of moths on Pink Mountain in British Columbia's northern alpine tundra

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## ABSTRACT

Taking inventory of insect biodiversity is a critical first step in creating a baseline against which one can evaluate threats and implement measures to protect biodiversity in the face of the massive declines of insects around the globe. Given the immense scale of this task, collection of insect biodiversity data for locations at greatest risk must be prioritised. In the present study, we catalogued moth biodiversity in the northern alpine habitats of Pink Mountain, British Columbia, Canada. Located in the Peace River region, in the province's far northwest, this alpine habitat may be at heightened risk of species loss due to accelerated climate change impacts in the north, industry threats, and physical isolation. We collected moths over five visits, from 2014 to 2023, using various insect-trapping methods (light traps, sweep netting, and interception traps). We identified species based on morphology and, for species difficult to distinguish generated cytochrome *c* oxidase subunit 1 barcodes. We inventoried more than 140 Lepidopteran species from Pink Mountain, with moths from the families Noctuidae (62%), Geometridae (14%), and Tortricidae (11%) being most common, as estimated by the percentage of the specimens collected from each of the respective families. Including Global Biodiversity Information Facility records, dating from 1998 to 2018, we added nine additional taxa to the species list, including the Family (Sphingidae). We noted conservation status ranks, where applicable, and deposited digital records of all specimens in the Canadian National Collection of Insects, Arachnids and Nematodes (Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada) database for future reference.

**Keywords:** Pink Mountain, Alpine Tundra, Biodiversity, Lepidoptera, Moth, Species at Risk, Species Inventory

## INTRODUCTION

Biodiversity declines are occurring at an unprecedented rate due to human activities that result in habitat destruction and fragmentation, climate change, and species invasions (Brook *et al.* 2008; Dawson *et al.* 2011; Watson *et al.* 2012; Raven and Wagner 2021). The risk varies greatly, depending on the location, the human activities, and the taxon in question (Bellard *et al.* 2022). Insects are by

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far the most diverse group of animals on Earth, with the million or so described species representing less than one-quarter of the estimated 5.5 million species thought to exist (Stork 2018). Although few described insect species have been evaluated for their risk of extinction (0.08% of described species), the results are striking, with more than 70% being listed as threatened (Berenbaum 2017). With so many unknowns, inventorying insect species that can be used to evaluate threats and building and implementing policy and recovery strategies to conserve insect biodiversity are important.

Observations and model predictions by Rangwala and Miller (2012) and Bellard *et al.* (2022), indicate that species that inhabit high-elevation mountaintops and northern regions may be at greater risk of decline or extinction due to climate change and the physical barriers that can impact their movement than species that occupy low-elevation habitats are. Therefore, assessment of current biodiversity in these regions is needed to establish baselines for future comparisons and risk assessments.

Pink Mountain is located in the Peace River Region of northern British Columbia, Canada, along the eastern foothills of the Rocky Mountains (Zonneveld and Bristan 2013; BC Parks 2025). The mountain is 1700 m at its highest peak and includes subalpine and alpine tundra habitats due to its northern latitude (Long 2015). Past surveys of flowering plants, insects, mammals, and birds on Pink Mountain and comparisons with nine other mountaintops west of Pink Mountain found that this mountain has specific biodiversity (Long 2015), perhaps in part due to Pink Mountain's unique location, where the northernmost climatic range of southern vegetation and the most southerly climatic region for Arctic tundra vegetation overlap (Wu *et al.* 2018).

Pink Mountain's biodiversity could be at risk due both to climate change and to proposed human activities, including the reopening of gas wells built in the 1960s and installation of wind turbines on the mountain summit (Long 2015; Wu *et al.* 2018; Aeolis Wind 2021). Establishing baseline biodiversity information for Pink Mountain is therefore critical for use in future comparisons and conservation decisions.

Insects of the Order Lepidoptera are diverse, with more than 2500 species reported for British Columbia (Pohl *et al.* 2015). As ectotherms, insects respond to temperature changes and can serve as indicators of climate change impacts (Hill *et al.* 2021). Furthermore, recent research documents widespread declines from 2000 to 2020 across more than 500 butterfly species in the United States of America (Edwards *et al.* 2025), making ongoing monitoring and surveys of lepidopterans all the more urgent.

As a first step to informing future conservation decisions for Pink Mountain, the present study inventories the moth species collected through surveys and collections in 2014–2023 and through records from the Global Biodiversity Information Facility (<https://www.gbif.org>) reported in 1998–2018 for sites in the mountain's alpine tundra zone, which, in northeastern British Columbia, is located 1400 m above sea level (Pojar and Stewart 1991). Using a combination of traditional taxonomy and molecular barcoding methods, we use these records to establish baseline moth diversity information for Pink Mountain, to identify the presence of species at risk and to determine new regional species records that could impact conservation management decisions.

## MATERIALS AND METHODS

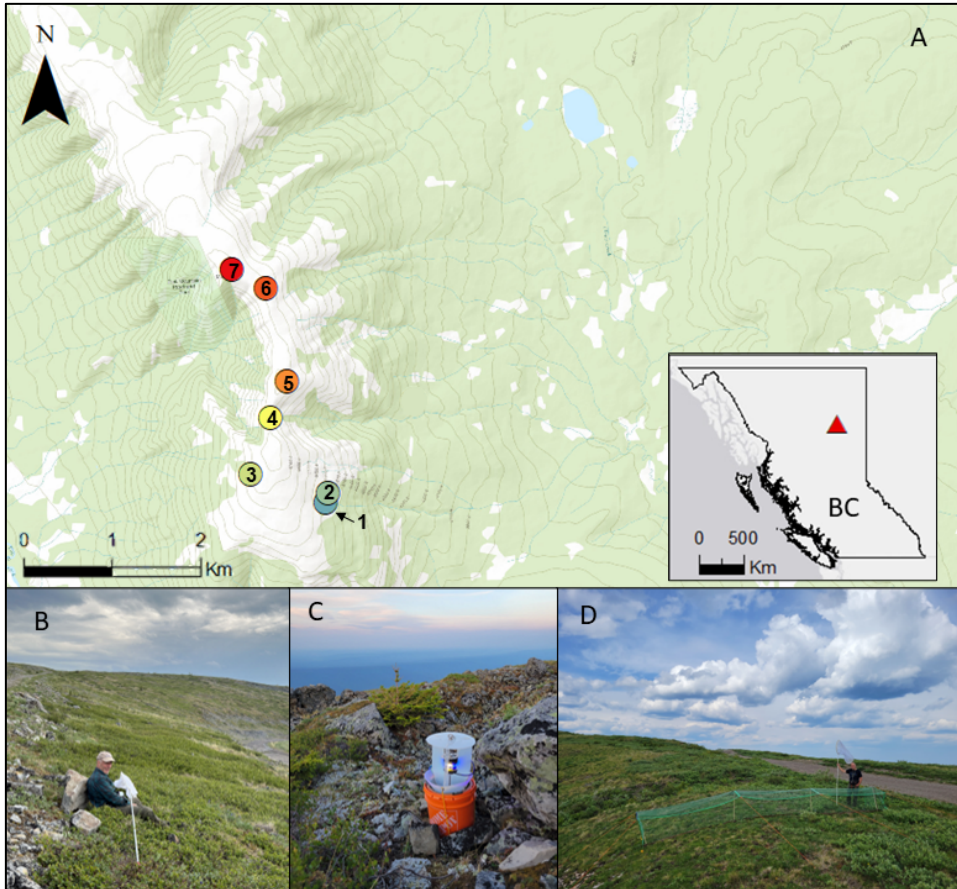
### Moth collection and identification

Lepidoptera specimens were collected from alpine tundra locations (elevation: 1573–1795 m above sea level) on Pink Mountain, Peace River region, British Columbia, Canada, between 25 June and 4 August on trips spanning 1–4 days in each of 2015, 2018, 2022, and 2023 (Table 1; Fig. 1). Three additional specimens collected by R. Long in 2014 were included in the collection data. Light-trap collections were performed at night at eight sampling sites, using traps with three different light sources — 175-W mercury vapour light, 15-W fluorescent black light, and 6.5- to 13-W LepiLED (Brehm 2017). Sweep-net sampling was performed during the day and at dusk along the ridge of Pink Mountain between the light-trapping sites. In 2023, flight-intercept traps, made of tulle fabric staked between poles (Fig. 1D), were also used for daytime moth collection.

**Table 1.** Pink Mountain sampling site locations and elevations

Pink Mountain sampling sites			
Site number	Latitude	Longitude	Elevation (m)
1	57.04801	–122.85805	1579
2	57.04897	–122.85764	1573
3	57.05125	–122.87181	1705
4	57.05682	–122.86766	1727
5	57.06040	–122.86430	1759
6	57.06992	–122.86755	1749
7	57.07166	–122.87333	1795

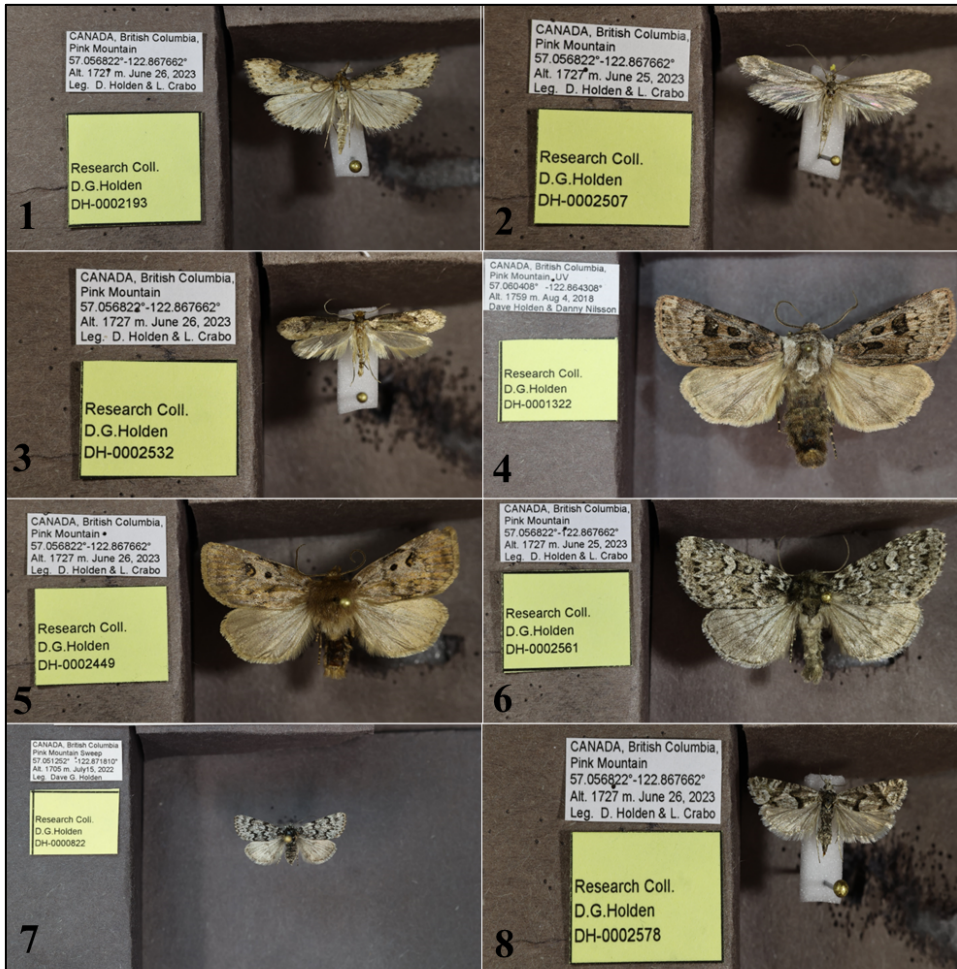
All collected specimens were pinned and labelled with location information, including latitude and longitude coordinates, elevation, date collected, and name of collector. Ferguson (1985, 2008), Hodges (1986, 1999), Neunzig (1986), Lafontaine (1987, 1998, 2004), Eichlin and Duckworth (1989), Lafontaine and Poole (1991), Mikkola *et al.* (2009), Powell and Brown (2012), Wright and Gilligan (2015, 2017), Schmidt and Anweiler (2020), and online platforms (BugGuide.net, <https://bugguide.net>; E.H. Strickland Entomological Museum collections, <https://www.ualberta.ca/en/museums/museum-collections/eh-strickland-entomological-museum.html>; North American Moth Photographers Group, <http://mothphotographersgroup.msstate.edu>; Moths of the Pacific Northwest, <https://pnwmoths.biol.wvu.edu/>) were used to identify specimens to species *via* examination of external morphology and genitalia where required. In some cases, only genus-level morphology-based identifications were possible.



**Figure 1.** A, Map of the seven sampling sites used for light trapping at sub-alpine sites on Pink Mountain. Sweep net surveys were conducted along the ridge of Pink Mountain between light-trapping locations. The lower photos show representative sites for the following sampling methods: B, sweep netting; C, light trapping; and D, intercept trapping.

### Databasing records

Each pinned moth was photographed (Canon EOS R6 with 100-mm lens; Canon, Ota City, Tokyo, Japan) with species identification labels and assigned a unique specimen identification collection number (Fig. 2; Supplementary material, Table S1). Camera settings were remotely manipulated using the Canon EOS Utility 3 software ([https://www.canon.co.uk/support/consumer\\_products/software/eos-utility.html?softwareid=tcm:14-1330031&os=all](https://www.canon.co.uk/support/consumer_products/software/eos-utility.html?softwareid=tcm:14-1330031&os=all)). A database was created; it included information about each specimen's family, genus, species identification, British Columbia Lepidoptera Checklist identification number (Pohl *et al.* 2015), Canadian Lepidoptera Checklist identification number (Pohl *et al.* 2018), collection location, collection method (where available), collection date, and collector details. Digital records and data from all specimens were deposited in the Canadian National Collection of Insects, Arachnids and Nematodes database ([www.cnc.agr.gc.ca](http://www.cnc.agr.gc.ca); Agriculture and Agri-food Canada, Ottawa, Ontario, Canada) for reference.



**Figure 2.** Examples of the images captured for each individual collected from Pink Mountain: **1**, *Udea abstruse* (DH-0002193); **2**, *Rhigognostis* sp. (DH-0002507); **3**, *Tinea irrepta* (DH-0002532); **4**, *Agrotis ruta* (DH-0001322); **5**, *Xestia ursae* (DH-0002449); **6**, *Xestia mixta* (DH-0002561); **7**, *Xestia bryanti* (DH-0000822); **8**, *Eucosma southamptonensis* (DH-0002578). All images and data record information are stored in the Canadian National Collection.

### Molecular analysis for species identification

Cytochrome *c* oxidase subunit 1 (*CO1*) barcodes were generated for specimens that were difficult to identify based on morphological features. For each such specimen, the left middle leg was removed using forceps and placed in a 1.5-mL tube containing 1% phosphate-buffer saline. Samples were homogenised using a TissueLyser LT (QIAGEN, Hilden, Germany) and incubated overnight at 56 °C. Following this, 4 µg of carrier RNA (QIAGEN) were added to the homogenised sample to increase the recovery of DNA yield, and genomic DNA was extracted from samples with a DNeasy Blood & Tissue Kit (QIAGEN) that was automated on a QIAcube Connect (QIAGEN) with a reduced elution volume (2 × 50 µL Buffer AE). Genomic DNA was quantified

using a Qubit 4 fluorometer (ThermoFisher Scientific, Waltham, Massachusetts, United States of America).

Lepidopteran primers Lep F1 and Lep R1 (Hebert *et al.* 2004) were used to amplify the *CO1* region of each selected moth specimen. Genomic DNA (20–30 ng) was mixed with 2  $\mu\text{L}$  of 2-mM dNTP, 2  $\mu\text{L}$  of 5- $\mu\text{M}$  of forward and reverse primers (Integrated DNA Technologies, Toronto, Ontario, Canada), 0.2  $\mu\text{L}$  of Phusion High-Fidelity DNA polymerase (2 U/ $\mu\text{L}$ ; ThermoFisher Scientific), and 4  $\mu\text{L}$  of 1 $\times$  HF buffer (ThermoFisher Scientific) and 7.8  $\mu\text{L}$  of water, for a total reaction volume of 20  $\mu\text{L}$ . The following polymerase chain reaction conditions were applied: 1 $\times$  [30 seconds at 98 °C], 35 $\times$  [10 seconds at 98 °C; 30 seconds at 50 °C; 30 seconds at 72 °C], 1 $\times$  [5 minutes at 72 °C]. Polymerase chain reaction products were purified using ExoSAP-IT (ThermoFisher Scientific) and then sequenced in both directions at the Applied Genomics Centre, Kwantlen Polytechnic University (Surrey, British Columbia, Canada).

Sequences were inspected, aligned, and consensus sequences were generated in Geneious Prime, version 2022.1.1, and then uploaded to the Barcode of Life Database (BOLD; Ratnasingham and Hebert 2007). To determine species- or genus-level identifications when species identifications were ambiguous, we used the taxon identification tool in BOLD (Animal Identification *CO1*) using species-level barcode records and the neighbour-joining algorithm (Ratnasingham and Hebert 2007). In addition, we used the nucleotide BLAST (BLASTn) search in GenBank (National Center for Biotechnology Information, Bethesda, Maryland, United States of America; <https://www.ncbi.nlm.nih.gov/genbank/about/>) to determine the closest species match based on the percent identity score (Camacho *et al.* 2009). Taxonomic identifications were compared with assignments based on the results from BOLD and GenBank.

### **Global Biodiversity Information Facility records**

In order to construct a more comprehensive list of species known from Pink Mountain's alpine region, we scraped records from the Global Biodiversity Information Facility online portal (GBIF.org 2025a) and included these in our species list. The records include specimens from 1998 to 2018 that had been accessioned at the Canadian National Collection and the E.H. Strickland Entomological Museum (University of Alberta, Edmonton, Alberta, Canada; see Supplementary material, Table S1). Our initial dataset downloaded from GBIF.org (GBIF.org 2025a) included all records that met the following criteria: (1) scientific name: "Lepidoptera"; (2) basis of record: "material sample", "preserved specimen", "occurrence" (GBIF Secretariat 2022); and (3) location – we used a bounding box with the following coordinates: south 57.032, north 57.100, west –122.921, and east –122.846, which encompasses the entire Pink Mountain region.

A dataset with 625 entries resulted (GBIF.org 2025a). From this dataset, we removed all individuals within the Superfamily Papilionoides (*e.g.*, butterflies) by filtering out the families Hedyliidae, Hesperidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, and Riodinidae. After this filtering step, 191 records remained.

From these, we filtered out records with an elevation lower than 1400 m or with no verifiable altitude. Most records in this subset have no elevation measurement and include latitude and longitude coordinates to only two decimal

places, which, at the latitude of Pink Mountain, introduces an east–west uncertainty of approximately 600 m. These records were excluded because we could not confirm whether they occurred in alpine zones, due to the geographical uncertainty, which was determined as follows: at the equator, one degree of latitude represents 111 319.5 m (World Geodetic System 2014). As one moves further from the equator, degrees of latitude become shorter in length, eventually reaching 0 at the poles. At any point on the globe, the distance represented by one degree of latitude is proportional to the cosine of the longitude at that point. At Pink Mountain, at roughly 57.05° N, one degree of latitude  $\alpha \cos(57.05) = 60\,547.4$  m. Thus, at a precision of 0.01 degree of latitude, each 0.01-degree increment represents a span of 605.4 m.

For entries without elevation measurements but with precise latitude and longitude coordinates (greater than two decimal places), we assigned a putative elevation that was determined by entering the coordinates into Google Earth Pro, version 7.3.6.10201 (<https://www.google.com/earth/about/>).

After filtering out all entries without verifiable alpine elevations, our dataset included 71 individual records. We excluded one additional record of *Lasionycta conjugata* (Smith, 1899) because Pohl *et al.* (2018) noted that individuals identified historically as *L. conjugata* from British Columbia and Alberta are actually *L. fergusonii*, a more recently described species that was already captured in our collection data.

### Status ranking

Conservation status ranks for the moth species were based on the 2020 Canadian Wild Species Report (Canadian Endangered Species Conservation Council 2022), which contains the British Columbia Conservation Data Centre's (2020) provincial conservation status ranks. The centre's methodology for ranking is based on that of NatureServe (Arlington, Virginia, United States of America; <https://www.natureserve.org/biodiversity>), a nonprofit organisation of conservation experts that provides biodiversity data across North America. The British Columbia Conservation Data Centre's 'S' designation denotes subnational ranking, with number scores from "1" to "5", with "1" being at highest risk (critically imperiled) and "5" being at lowest risk (widespread, abundant, and secure; British Columbia Conservation Data Centre 2020). If a species' status is uncertain, it may be assigned two scores, indicating the range of uncertainty (e.g., "S1S3" indicates that a species may be critically imperiled or simply of special concern). Depending on these scores, the Conservation Data Centre assigns a species to the red (endangered/threatened), blue (vulnerable or at risk), or yellow (not of concern) list (Harper *et al.* 1994).

## RESULTS

### Moth collection and GBIF.org records

Our Pink Mountain collection contains a total of 640 specimens, representing 141 moth confirmed species. Seventeen moth families are represented, with Noctuidae representing 62% of all specimens captured, Geometridae representing 14%, and Tortricidae representing 11% (Table 2). These were also the most species-rich families, with 76, 27, and 12 species identified, respectively (Table 2). The GBIF.org records increased the list with 12 additional

taxa, including the Family Sphingidae, five species, and seven genera in which no specimens were identified to species. These are indicated by their GBIF ID in Table 2.

### **Species identification via CO1 barcodes**

We generated CO1 barcode data for 24 specimens for which morphological identifications were uncertain or the species was rare or undocumented from the region (Table 3). The barcodes generated for four of the specimens showed confident species-level identifications, based both on tree-based methods and BLAST-based analysis: these species are *Xanthorhoe abrasaria* (Herrich-Schaffer, 1855), *Scopula frigidaria* (Möschler, 1860), *Epirrhoe alternata* (Müller, 1764), and *Leucania anteroclara* (Smith, 1902). For one tortricid specimen identified to genus based on morphological characters, the CO1 barcode analysis resulted in a species-level barcode index number (BIN) assignment in BOLD (BIN: AAA6264 – *Eana osseana* (Scopoli, 1763)). However, examination of BOLD BINs for this species indicates that it likely represents a complex of cryptic species (Gilligan *et al.* 2020), and we therefore report only the genus-level identification. For all other specimens for which CO1 barcodes were generated, only genus-level identifications were possible because tree-based analysis was ambiguous and revealed two or more species assigned to a single clade.

### **Species of note from Pink Mountain**

We collected and identified two blue-listed (vulnerable or at-risk) species from Pink Mountain, including *Chionodes lugubrella* (Fabricius, 1794) and *Tinea irrepta* (Braun, 1926) (GBIF Secretariat 2023). Four other species found on Pink Mountain have a subnational ranking range of imperilled to apparently secure (S2S4), including *Agrotis ruta* (Eversmann, 1851), *Xestia bryanti* (Benjamin, 1933), *Xestia ursae* (McDunnough, 1940), and *Xestia mixta* (Walker, 1856). Twenty-four other species have a subnational ranking range of special concern and vulnerable to extinction to apparently secure (S3S4, S3S5), whereas an additional 20 species were yellow listed, being of low concern (British Columbia Conservation Data Centre 2020; Supplementary material, Table S1).

**Table 2.** List of all moth species collected and identified through surveys conducted from 2014 to 2023 and GBIF records included from 1998 to 2018 for alpine sites on Pink Mountain, British Columbia, Canada. The British Columbia Lepidoptera checklist ID (BC list no.) and Canadian Lepidoptera checklist ID (Canadian list no.) are provided for each record, along with the number of individuals collected from Pink Mountain during the 2014–2023 surveys, the conservation status rank, GBIF.org ID, and relevant notes, as applicable.

Family	Genus	Species	BC list		Canadian No. collected	Conservation status rank <sup>c</sup>	GBIF ID <sup>d</sup>	Notes and BOLD ID <sup>e</sup>
			list no. <sup>a</sup>	list no. <sup>b</sup>				
Coleophoridae	<i>Coleophora</i>	<i>idaeella</i>	not listed	2			Not included in BC or Canadian Checklist because records or identification occurred after publication. PKMTN010-25	
Crambidae	<i>Catoptria</i>	<i>maculalis</i>	1434	800734	2			
		<i>trichostomus</i>	1433	800845	8			
	<i>Crambus</i>	<i>whitmerellus</i>	1444	800933	1	Yellow		
		<i>Loxostege</i>	<i>ephippialis</i>	not listed	801490	2		Newly observed in BC
	<i>Mecyna</i>	<i>mustelinalis</i>	1544	801358	1	Yellow		
		<i>Udea</i>	<i>abstrusa</i>	1538	801251	1		PKMTN002-25
	<i>radiosalis</i>		1539	801252	1			
	sp.				3		PKMTN015-25	
	Drepanidae	<i>Drepana</i>	<i>arcuata</i>	1553	850019	1		
	Erebidae	<i>Apantesis</i>	<i>quenseli</i>	not listed	930250	3	Yellow	
<i>Arctia</i>							Not on the BC list, but Canadian list indicates present in BC	
<i>Caenurgina</i>		<i>opulenta</i>	2015	930291	2			
		<i>plantaginis</i>	2010	930283	3	Yellow	769127318	
		<i>crassiuscula</i>	2099	930923	1			

<i>Catocola</i>	<i>sp.</i>				1	
	<i>unijuga</i>	2075	930797		1	
<i>Chelis</i>	<i>beanii</i>	1995	930235		2	Yellow
<i>Gnophaela</i>	<i>vermiculata</i>	2032	930356		3	Yellow
<i>Gynaephora</i>	<i>rossii</i>	1982	770776		1	
<i>Hypena</i>	<i>humuli</i>	2058	930584		1	
<i>Platarctia</i>	<i>parthenos</i>	2012	930288			Yellow
<i>Scoliopteryx</i>	<i>libatrix</i>	2062	930601		1	769125321
<b>Gelechiidae</b>	<i>Aproaerema</i>					4918937493
	<i>sp.</i>					
	<i>continuella</i>	0408	421057		7	Yellow S3S5
	<i>Chionodes</i>					blue
	<i>lugubrella</i>	0396	421009		15	
<b>Geometridae</b>	<i>Antepirrhoe</i>					
	<i>semiatrata</i>	1612	910046		1	
	<i>Aspitates</i>	1897.2	911144		4	
	<i>Cabera</i>	1886	911100		1	Yellow
	<i>Campaea</i>	not listed	911226		1	Not on the BC list, but Canadian list indicates present in BC List no. refer to old name <i>Gnophos macguffini</i>
	<i>Charissa</i>	1866	911015		4	
	<i>Eclipoptera</i>	1615	910049		1	
	<i>Entephria</i>	1649	910141			S3S4
	<i>Entephria</i>				1	769061960 2250565678
	<i>Epirrhoe</i>	1687	910238		1	
	<i>Eulithis</i>	1607	910040		9	
	<i>sp.</i>				1	PKMTN009-25

<i>Eufidonia</i>	<i>discospilata</i>	1871	911041	1		
<i>Eupithecia</i>	<i>cretaceata</i>	1737	910374	5		PKMTN007-25
	<i>perfusca</i>	1742	910382	2		
	sp.			5		
<i>Gnophos</i>	sp.					1413877469 2250564724 2250564880 769168156
<i>Hydriomena</i>	<i>furcata</i>	1637	910095	8		PKMTN003-25
	<i>macdunnoughi</i>	1636	910093	4	S3S4	
<i>Lobophora</i>	<i>nivigerata</i>	1773	910481	2		
<i>Macaria</i>	<i>boreata</i>	1817	910710	8		
<i>Macaria</i>	<i>truncataria</i>	1828	910693	2		
<i>Physchophora</i>	sp.					2250565115
<i>Rheumaptera</i>	<i>hastata</i>	1648	910132	1		PKMTN005-25, PKMTN006-25, PKMTN008-25
<i>Scopula</i>	<i>frigidaria</i>	1788	910575	3		
<i>Sicya</i>	<i>sentinaria</i>	1794	910581	1	Yellow	
	sp.			1		
<i>Spargania</i>	<i>luctuata</i>	1656	910156	2		
	<i>magnoliata</i>	1655	910155	6		
<i>Thera</i>	<i>otisi</i>	1619	910056	4		
<i>Trichodezia</i>	<i>albovittata</i>	1703	910274	2		
<i>Venusia</i>	<i>cambrica</i>	1699	910269	1		PKMTN001-25
<i>Xanthorhoe</i>	<i>abrasaria</i>	1671	910213	3		PKMTN004-25
	<i>ferrugata</i>	1683	910231	1		
	<i>fossaria</i>	1679	910223	3		

Gracillariidae	<i>Parornix</i>	sp.			2	PKMTN023-25
Lasiocampidae	<i>Phyllodesma</i>	<i>americana</i>	1557	870003	1	
Noctuidae	<i>Acronicta</i>	<i>grisea</i>	2180	931433	2	
		<i>lupini</i>	2193	931489	3	
	<i>Actebia</i>	<i>balanitis</i>	2622	933230	2	PKMTN018-25
		<i>fennica</i>	2621	933229	1	
	<i>Agrotis</i>	<i>obliqua</i>	2733	933522	1	
		<i>ruta</i>	2729	933510	28	S2S4
	<i>Anaplectoides</i>	<i>prasina</i>	2757	933564	1	
	<i>Anarta</i>	<i>farnhami</i>	2500	932837	7	
		<i>nigrolunata</i>	2493	932823	6	
	<i>Apamea</i>	<i>oregonica</i>	2497	932831	4	
<i>commoda</i>		2326	932329	1		
<i>scoparia</i>		2333	932343	1	Yellow	
<i>sora</i>		2325	932327	1	Yellow	
sp.					2251277963	
<i>zeta</i>		2338	932351	9	769037147 769037148 769128553	
<i>Autographa</i>	<i>ampla</i>	2132	931204	1		
	<i>mappa</i>	2124	931194	2		
	<i>sansoni</i>	2134	931207	2		
<i>Brachionycha</i>	sp.				2251283719	
<i>Chersotis</i>	<i>juncta</i>	2747	933550	12	S3S4	
<i>Diarsia</i>	<i>calgary</i>	2738	933531	7	S3S5	
	<i>dislocata</i>	2739	933532	10		

<i>Euchalcia</i>	<i>esurialis</i>	2737	933530	1		
	<i>rosaria</i>	2741	933535	1		2251277676
<i>Eurois</i>	sp.					
	<i>astricta</i>	2754	933561	3		
	<i>nigra</i>	2755	933562	24		
	<i>occulta</i>	2753	933560	2		
<i>Euxoa</i>	<i>comosa</i>	2676	933405	2		
	<i>divergens</i>	2638	933320	2		
	<i>nomas</i>	2715	933476	10	S3S5	
	<i>ochrogaster</i>	2684	933424	1		
	<i>quebecensis</i>	2641	933328	1	S3S5	
	<i>ridingsiana</i>	2722	933485	1	S3S5	
	sp.					2251280024
<i>Feltia</i>	<i>nigrita</i>	2725	933489	2	S3S4	
<i>Hada</i>	<i>sutrina</i>	2534	932897	5		
<i>Hyppa</i>	<i>contrasta</i>	2430	932665	3		
<i>Lacanobia</i>	<i>radix</i>	2521	932880	1		
<i>Lacinipolia</i>	<i>anguina</i>	2585	933019	5		
<i>Lasionycta</i>	<i>fergusoni</i>	2560	932974	10		
	<i>illima</i>	2566	932984	8	S3S4 (2020)	
	<i>leucocycla</i>	2564	932978	11	S3S5 (2020)	769300365
	<i>perplexa</i>	2567	932988	2		
	<i>secedens</i>	2559	932970	10	S3S5	
	<i>uniformis</i>	2572	932999	3		



<i>Paradiarsia</i>	<i>littoralis</i>	2744	933544	4		
<i>Parastichtis</i>	<i>suspecta</i>	2418	932625	1		
<i>Polia</i>	<i>richardsoni</i>	2512	932871	2	S3S5	
	<i>rogenhoferi</i>	2510	932869	8	S3S5	
	<i>esmeralda</i>	2119	931182	1	S3S4	
<i>Polychrysia</i>	<i>rufipectus</i>	2803	933648	3		
<i>Protolampra</i>	<i>funebri</i>	2255	931910	1		
<i>Sympistis</i>	<i>heliophila</i>	2263	931930	3	S3S4	
	<i>zetterstedtii</i>	2264	931931	8		769057579
	sp.					2251279451 2251279484
<i>Syngnapha</i>	<i>altas</i>	2148	931225	1		
	<i>alticola</i>	2153	931232	4		769119662 769179761
	<i>borea</i>	2144	931220	1		
	<i>diasema</i>	2143	931219	4	S3S4	
	<i>ignea</i>	2146	931223	3		769118661
	<i>interrogationis</i>	2137	931212	2		
	<i>orophila</i>	2145	931221	1		
	<i>parilis</i>	2154	931233	4	S3S4	769119968 769119969
	<i>viridisigma</i>	2138	931213	2		
	<i>bryantii</i>	2785	933614	14	S2S4	
	<i>c-nigrum</i>	2773	933588	2		
<i>Xestia</i>	<i>imperita</i>	2777	933598	25	S3S4	
	<i>mixta</i>	2776	933597	7	S2S4	
	<i>oblata</i>	2764	933575	6		

	<i>okakensis</i>	2780	933604	15	S3S5	
	<i>perquiritata</i>	2781	933606	1		
	<i>smithii</i>	2762	933572	4		
	<i>speciosa</i>	2775	933596	3		
	<i>ursae</i>	2779	933601	29	S2S4	2251282713 2251273222 2251283256 2251284062
	sp.					
Plutellidae	<i>Plutella xylostella</i>	0189	360083	2	Yellow	
	<i>Rhigognostis</i> sp.			1		
Prodoxidae	<i>Greya variabilis</i>	0040	210019	1		
Pterophoridae	<i>Amblyptilia pica</i>	0570	460051	1	Yellow	769110219 769110220 769110221 769180575 769180630
	<i>Platyptilia comstocki</i>	0551	460007			
Pyralidae	<i>Pyla</i> sp.			9		PKMTN026-25, PKMTN027-25, PKMTN029-25
Sesiidae	<i>Albuna pyramidalis</i>	1070	640069	3	Yellow	
	<i>Synanthedon gallii</i>	1590	890216		Yellow	4915957453 769127119 769169929
Tineidae	<i>Tinea irrepta</i>	0072	300151	2	Blue, S3S5	
Tortricidae	<i>Aethes deuschiana</i>	0692	620096	8	Yellow	1415879099 1415879163
	sp.					

<i>Ancylis</i>	sp.					4				PKMTN013-25
<i>Archips</i>	sp.					1			769040052	
<i>Argyroploce</i>	sp.					2				
<i>Clepsis</i>	<i>moeschleriana</i>	0760	620361			1				
	<i>persicana</i>	0757	620357			1		Yellow		
<i>Cydia</i>	<i>prosperana</i>	1053	620619			4		Yellow		
<i>Dichrorampha</i>	sp.					2				
<i>Eana</i>	<i>argentana</i>	0668	620068			1		Yellow	769039102	PKMTN011-25, PKMTN012-25
	sp.					8				Newly observed in BC Newly observed in BC
<i>Eucosma</i>	<i>camdenana</i>	new	620781			3				
	<i>southamptonensis</i>	new	620868			3				
	<i>tarandana</i>	0888	620816			7				
	sp.								4915968404 1415879206	
<i>Hystrichophora</i>	sp.					11				PKMTN014-25
<i>Olethreutes</i>	<i>bowmanana</i>	not listed	620619			1				Not on BC list, but Canadian list indicates present in BC
	<i>galaxana</i>	0809	620601			1				
	sp.								1415879124	
<i>Pelochrista</i>	<i>dodana</i>	0925	620929			6				
	sp.								4916060075	
<i>Phiaris</i>	<i>schulziana</i>	0822	620615			8				List IDs refer to <i>Olethreutes schulziana</i>
<i>Pseudosciaphila</i>	<i>duplex</i>	not listed	not listed						769038401	
<i>Yponomeutidae</i>	<i>Paraswammerdamia</i> sp.					1				PKMTN024-25

<sup>a</sup> Pohl *et al.* (2015)

<sup>b</sup> Pohl *et al.* (2018)

<sup>c</sup> Provincial conservation status ranks assigned by the British Columbia Conservation Data Centre (2020)

<sup>d</sup> GBIF.org IDs for records scraped from GBIF.org. The GBIF.org records are not included in the No. of moths collected. Individual records can be viewed online using the URL <https://www.gbif.org/occurrence/X>, where “X” is the GBIF ID.

<sup>e</sup> BOLD IDs for select species where specimens were barcoded to help with species-level identifications.

**Table 3.** Comparison of taxonomic identification and species identification based on barcoding of the *CO1* region. Two methods were used to examine the closest species match: the tree-based identification tool implemented in BOLD and percent identity based on a BLASTn search performed in the NCBI database.

Collection no.	Taxonomic identification	BOLD: tree-based identification	Probability of placement	BLASTn closest match	% identity	BOLD ID
DH0002445	<i>Actebia balnitis</i>	<i>Actebia balanitit</i>	tribe: 100%	<i>Actebia balnitit</i>	100.00	PKMTN018-25
		<i>Euxoa sp. 1</i>				
		<i>Euxoa sp. 2</i>				
		<i>Actebia squallida</i>				
DH0002357	<i>Ancylis sp.</i>	<i>Ancylis myrtiliana</i> ; <i>Ancylis subaeguana</i> ; <i>Ancylis sp.</i>	genus: 100%	<i>Ancylis myrtiliana</i>	99.67	PKMTN013-25
DH0002324	<i>Coleophora ideaella</i> .	<i>Coleophora ideaella</i> ; <i>Coleophora atriplicis</i>	genus: 100%	<i>Coleophora ideaella</i>	99.83	PKMTN010-25
DH0002330	<i>Eana sp.1</i>	<i>Eana osseana</i>	species: 100%	<i>Eana osseana</i>	100.00	PKMTN012-25
DH0002328	<i>Eana sp.2</i>	<i>Eana osseana</i> ; <i>Eana argentana</i> ; <i>Eana nivosana</i>	genus: 100%	<i>Eana sp.</i>	99.47	PKMTN011-25
DH0002317	<i>Epirrhoe alternata</i>	<i>Epirrhoe alternata</i>	species: 100%	<i>Epirrhoe alternata</i>	99.83	PKMTN009-25
DH0002296	<i>Eupithecia perfusca</i>	<i>Eupithecia perfusca</i> ; <i>Eupithecia lachrymosa</i> ; <i>Eupithecia miserulata</i> ; <i>Eupithecia n sp.</i>	genus: 100%	<i>Eupithecia perfusca</i>	100.00	PKMTN007-25
DH0002228	<i>Hydriomena furcata</i>	<i>Hydriomena furcata</i> ; <i>Hydriomena quinquefasciata</i>	genus: 100%	<i>Hydriomena furcata</i>	99.83	PKMTN003-25
DH0002360	<i>Hystrichophora sp.</i>	<i>Hystrichophora stygiana</i> ; <i>Hystrichophora asphodelana</i>	genus: 100%	<i>Hystrichophora asphodelana</i>	98.30	PKMTN014-25
DH0002490	<i>Leucania anteroclara</i>	<i>Leucania anteroclara</i>	species: 100%	<i>Leucania anteroclara</i>	100.00	PKMTN019-25
DH0002520	<i>Leucania sp.</i>	<i>Leucania insueta</i> ; <i>Leucania dia</i>	genus: 100%	<i>Leucania insueta</i>	100.00	PKMTN020-25
DH0002191	<i>Mecyna mustelinalis</i>	<i>Mecyna mustelinalis</i> ; <i>Mecyna submedialis</i> ; <i>Mecyna fuscimaculalis</i>	genus: 100%	<i>Mecyna mustelinalis</i>	100.00	PKMTN002-25

DH0002418	<i>Mniotype</i> sp.	<i>Mniotype tenera</i> ; <i>Mniotype pallescens</i> ; <i>Mniotype ducta</i>	genus: 100%	<i>Mniotype tenera</i>	99.40	PKMTN016-25
DH0002537	<i>Paraswammerdamia</i> sp.	<i>Paraswammerdamia canadensis</i> ; <i>Paraswammerdamia lapponica</i>	genus: 100%	<i>Paraswammerdamia lapponica</i>	98.54	PKMTN024-25
DH0002536	<i>Parornix</i> sp.	<i>Parornix arbutifoliella</i> ; <i>Parornix oblitterella</i>	genus: 100%	<i>Parornix</i> sp.	99.83	PKMTN023-25
DH0002582	<i>Pyla</i> sp.	<i>Pyla aequivoca</i> ; <i>Pyla fusca</i> ; <i>Pyla aenigmatica</i>	genus: 100%	<i>Pyla aequivoca</i> ; <i>Pyla fusca</i>	99.02	PKMTN026-25
DH0002584	<i>Pyla</i> sp.	<i>Pyla aequivoca</i> ; <i>Pyla fusca</i> ; <i>Pyla aenigmatica</i>	genus: 100%	<i>Pyla fusca</i>	99.67	PKMTN027-25
DH0002585	<i>Pyla</i> sp.	<i>Pyla aequivoca</i> ; <i>Pyla fusca</i> ; <i>Pyla aenigmatica</i>	genus: 100%	<i>Pyla aequivoca</i>	99.45	PKMTN029-25
DH0002245	<i>Scopula frigidaria</i>	<i>Scopula frigidaria</i> ; <i>Scopula ternata</i>	genus: 100%	<i>Scopula frigidaria</i>	100.00	PKMTN005-25
DH0002246	<i>Scopula frigidaria</i>	<i>Scopula frigidaria</i> ; <i>Scopula ternata</i>	genus: 100%	<i>Scopula frigidaria</i>	100.00	PKMTN006-25
DH0002316	<i>Scopula frigidaria</i>	<i>Scopula frigidaria</i>	species: 100%	<i>Scopula frigidaria</i>	100.00	PKMTN008-25
DH0002400	<i>Udea</i> sp.	<i>Udea itysalis</i> ; <i>Udea radiosalis</i> ; <i>Udea tillialis</i> ; <i>Udea turmalis</i> ; <i>Udea beringialis</i> ; <i>Udea griseor</i> ; <i>Udea clarkensis</i> ; <i>Udea turmalis</i> ; <i>Udea itysalis</i> ; <i>Udea brevipalpis</i>	genus: 100%	<i>Udea</i> sp.	100.00	PKMTN015-25
DH0002159	<i>Venusia cambrica</i>	<i>Venusia cambrica</i> ; <i>Venusia pearsalli</i>	genus: 100%	<i>Venusia cambrica</i>	100.00	PKMTN001-25
DH0002244	<i>Xanthorhoe abrasaria</i>	<i>Xanthorhoe abrasaria</i>	species: 100%	<i>Xanthorhoe abrasaria</i>	99.65	PKMTN004-25

We also report the first official British Columbia records of four Lepidoptera species: *Eucosma southamptonensis* (Heinrich, 1935) (Lepidoptera: Tortricidae), *Eucosma camdenana* (McDunnough, 1925) (Lepidoptera: Tortricidae), *Loxostege ephippialis* Zetterstedt (Lepidoptera: Crambidae), and *Coleophora idaeella* (Hofmann, 1869) (Lepidoptera: Coleophoridae). *Eucosma southamptonensis* is recorded from Alaska, the Yukon, the Northwest Territories, and Nunavut (Pohl *et al.* 2018). Little is known about *E. camdenana*, but it has been recorded previously from Alaska (preserved specimens, GBIF: 5100141153; UAM:Ento:429940) and Nunavut (GBIF: 5100163161; UAM:Ento:429941). *Loxostege ephippialis* is a low Arctic–alpine species (E.H. Strickland Entomological Museum 2025) that has been recorded from the Northwest Territories (preserved specimen GBIF: 1502515811; KWP:Ento:62022), Alberta (preserved specimen GBIF: 769151216; UASM42300, <https://search.museums.ualberta.ca/9-44633> and <https://search.museums.ualberta.ca/g/2-6317/9-44633>), and the Yukon (preserved specimen GBIF: 3349975743; CNCLEP00074410). *Coleophora idaeella* has Holarctic distribution and has been reported previously in Canada, based on DNA barcode results from the Northwest Territories, Nova Scotia, and the Yukon (BOLD: AAF3856). This species may be undersampled because it has a two-year life cycle (Emmet *et al.* 1996) that could make collection of adult moths difficult. It is not recorded in Pohl *et al.* (2015, 2018), because its records or identifications occurred after the publication of these lists.

## DISCUSSION

The present study documents 146 confirmed moth species from a collection of 640 moths from Pink Mountain and an additional 70 GBIF.org moth records — roughly 7% of the estimated provincial richness of 2101 moth species, according to Cannings and Scudder (2007). The results represent a community of moths that includes both northern and southern tundra specialists and species previously undocumented in British Columbia and is the first published inventory of moths from alpine tundra habitats in Canada.

Several factors may contribute to Pink Mountain’s diverse moth community. The diverse plant community found on the mountain (Long 2015) could be a key driver of moth species diversity. Pink Mountain hosts a broad range of microhabitats that likely support a high diversity of plant hosts and, therefore, also support a wide range of lepidopteran herbivores (Long 2015; Wu *et al.* 2018). The location also sits at the intersection of the northernmost climatic range of southern vegetation and the most southerly climatic range for Arctic tundra vegetation. Pink Mountain is known to support a community of butterflies of “range-edge populations of species” that are primarily southern in distribution (Kondla *et al.* 1994). Tundra specialists, such as *Arctia opulenta* and *Apantesis quenseli*, are also found at the southernmost edge of their range in western North America in Pink Mountain’s alpine (Moths of the Pacific Northwest, <https://pnwmoths.biol.wvu.edu/>). Moths are known to be even more ecologically and taxonomically diverse than butterflies (Wagner *et al.* 2021): we therefore expect the moths of Pink Mountain to exhibit greater diversity than the butterflies do.

Our research documents two blue-listed species that are considered vulnerable or at risk, as well four species with a possible subnational ranking

range of potentially imperilled and of special concern (S2S4) in Pink Mountain's alpine habitat. Some of these species of note are broadly distributed but uncommon in British Columbia, including *Chionodes lugubrella* and *Tinea irrepta* (GBIF Secretariat 2023; GBIF.org 2025b, 2025c). Similarly, *Xestia mixta* (currently S2S4; British Columbia Conservation Data Centre 2020) is on the western edge of its distribution in British Columbia, which could cause it to be blue-listed in British Columbia but not in other Canadian provinces (L. Gelling, personal communication), whereas *Xestia ursae* may be a northern-distributed species that lives in wet Arctic shrubby tundra (Pacific Northwest Moths, <https://pnwmoths.biol.wvu.edu/browse/family-noctuidae/subfamily-noctuinae/tribe-noctuini/xestia/xestia-ursae/>) and so is likely undersampled, not rare. For many of these species, lack of information hampers understanding as to whether these species are uncommon or of special conservation concern, leading either to uncertainty in their rankings or to a lack of ranking altogether (Table 2). Nonetheless, the presence of species at the edges of their ranges, as well as of uncommon, poorly sampled, or poorly studied species, suggests the presence of a unique moth community at Pink Mountain.

We generated *COI* barcodes for 24 specimens from Pink Mountain where morphologically based identification was uncertain. Accurate identification depends on the accuracy and resolution of the available reference library (e.g., BOLD or GenBank; Antil *et al.* 2023). In the majority of cases, *COI* barcode data did not resolve species-level identifications in the present study; however, the barcodes provide a database of publicly available records linked to morphological specimens from Pink Mountain that can be used for future data comparisons.

This study provides essential baseline biodiversity data for future research and confirms that Pink Mountain's alpine and subalpine areas host a unique moth community that should be a conservation priority. Given that most southern tundra in Canada is at risk from industry and climate change (Hill and Henry 2011; Lemieux *et al.* 2025), the data we present provide important baseline information for future comparisons. Future research should build on this to incorporate long-term monitoring to document changes over time and to establish much-needed basic natural history information on poorly studied northern species.

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