Climate Change in Alaska: Impacts on the Entomofauna

Derek Sikes
University of Alaska
Museum of the North

Alaska Entomological Society Annual Meeting
Fairbanks, 9 Feb 2019

Photo © D. Sikes

Outline

Insects in General – *a "glue" that holds terrestrial ecosystems together*

Climate change impacts on insects globally

Climate change impacts on insects and other invertebrates in Alaska

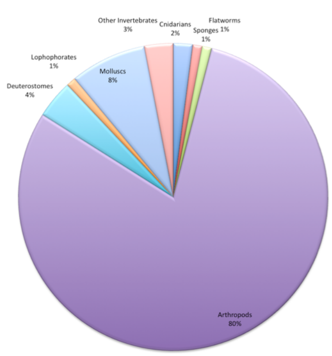
Species Richness

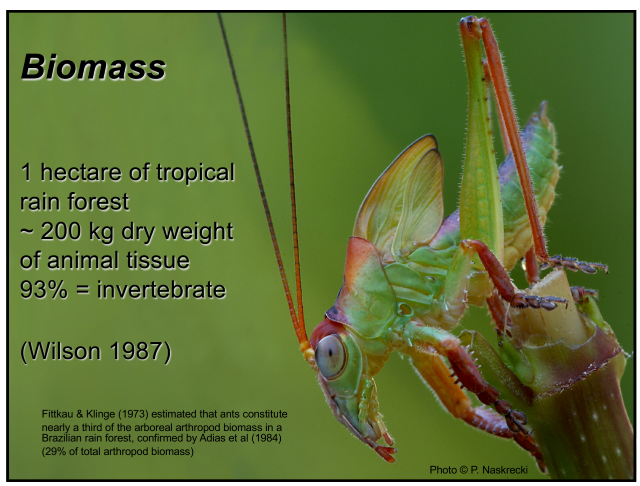
Known Animal species
(of 1.9 Million)

80% arthropods

if all unknown species are included
= 96% arthropod

A. D. Chapman, Numbers of Living Species in Australia and the World (Biodiversity Information Services, Toowoomba, Australia, 2009).





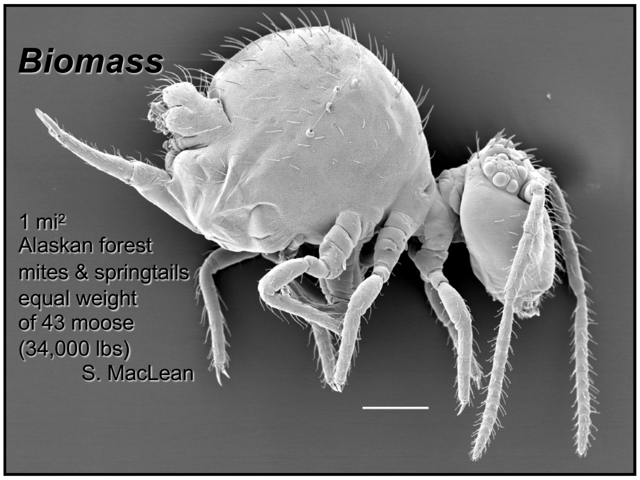
Biomass

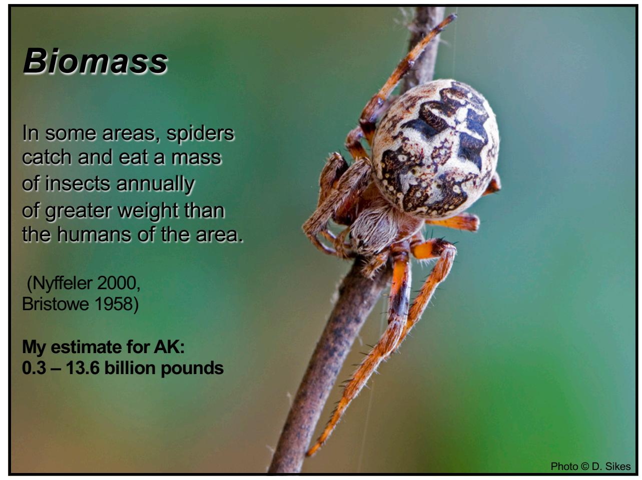
1 hectare of tropical rain forest
~ 200 kg dry weight of animal tissue
93% = invertebrate

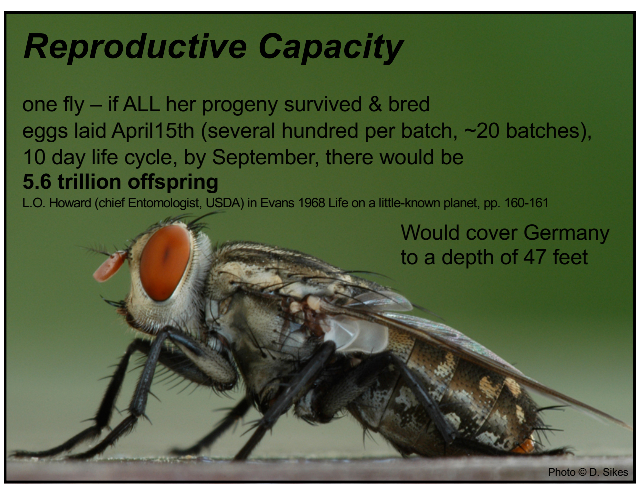
(Wilson 1987)

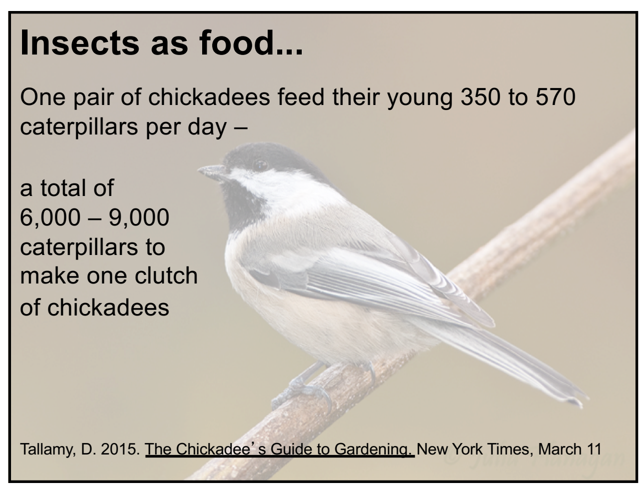
Fittkau & Klinge (1973) estimated that ants constitute nearly a third of the arboreal arthropod biomass in a Brazilian rain forest, confirmed by Adias et al (1984) (29% of total arthropod biomass)

Photo © P. Naskrecki


Biomass
1 mi^2
Alaskan forest
mites & springtails
equal weight
of 43 moose
(34,000 lbs)
S. MacLean

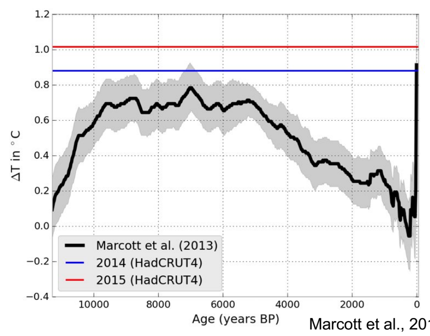

Biomass
In some areas, spiders
catch and eat a mass
of insects annually
of greater weight than
the humans of the area.
(Nyffeler 2000,
Bristowe 1958)
My estimate for AK:
0.3 – 13.6 billion pounds
Photo © D. Sikes


Reproductive Capacity
one fly – if ALL her progeny survived & bred
eggs laid April15th (several hundred per batch, ~20 batches),
10 day life cycle, by September, there would be
5.6 trillion offspring
L.O. Howard (chief Entomologist, USDA) in Evans 1968 Life on a little-known planet, pp. 160-161
Would cover Germany
to a depth of 47 feet
Photo © D. Sikes


Insects as food...
One pair of chickadees feed their young 350 to 570
caterpillars per day –
a total of
6,000 – 9,000
caterpillars to
make one clutch
of chickadees
Tallamy, D. 2015. The Chickadee's Guide to Gardening. New York Times, March 11

Climate Change

Global Warming – "We're still coming out of the last ice age…"
No, temperatures peaked 5-10k years ago



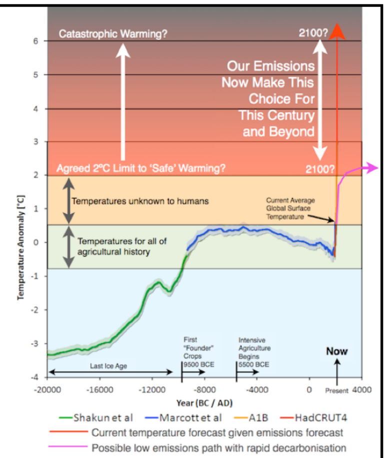
Marcott et al., 2013 Science

Climate Change

"Temperature can change dozens of degrees on a daily basis. Why worry about 2° of warming?"

Confusion of climate with weather.

Global climate average since the dawn of agriculture has been +/- ~ 1°



McKibben 2012 Global Warming's Terrifying New Math

PNAS

Impacts of climate warming on terrestrial ectotherms across latitude

Curtis A. Deutsch*†‡, Joshua J. Tewksbury†§, Raymond B. Huey§, Kimberly S. Sheldon§, Cameron K. Ghalambor¶, and David C. Haak§, and Paul R. Martin§‖

*Program on Climate Change and Department of Oceanography and §Department of Biology, University of Washington, Seattle, WA 98195; and ¶Department of Biology and Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO 80523

Edited by David B. Wake, University of California, Berkeley, CA, and approved March 3, 2008 (received for review October 4, 2007)

The impact of anthropogenic climate change on terrestrial organisms is often predicted to increase with latitude, in parallel with the rate of warming. Yet the biological impact of rising temperatures also depends on the physiological sensitivity of organisms to temperature change. We integrate empirical fitness curves describing the thermal tolerance of terrestrial insects from around the world with the projected geographic distribution of climate change for the next century to estimate the direct impact of warming on insect fitness across latitude. The results show that warming in the tropics, although relatively small in magnitude, is likely to have the most deleterious consequences because tropical insects are relatively sensitive to temperature change and are currently living very close to their optimal temperature. In contrast, species at higher latitudes have broader thermal tolerance and are living in climates that are currently cooler than their physiological optima, so that warming may even enhance their fitness. Available thermal tolerance data for several vertebrate taxa exhibit similar patterns, suggesting that these results are general for terrestrial ectotherms. Our analyses imply that, in the absence of ameliorating factors such as migration and adaptation, the greatest extinction risks from global warming may be in the tropics, where biological diversity is also greatest.

biodiversity | fitness | global warming | physiology | tropical

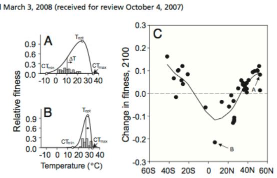


Fig. 1. Fitness curves for representative insect taxa from temperate (*A*) and tropical (B) locations, and (*C*) the change in fitness because of climate warming for all insect species studied, as a function of latitude. (*A* and *B*) Fitness curves are derived from measured intrinsic population growth rates versus temperature for 38 species, including *Acyrthosiphon pisum* (Hemiptera), from 52°N (England) (*A*), and the same for *Clavigralla shadabi* (Hemiptera) from 6°N (Benin) (*B*). CT_{min}, T_{hab}, T_{opt}, and CT_{max} are indicated on each curve. Climatological mean annual temperature from 1950–1990 (T_{hab}, drop lines from each curve), its seasonal and diurnal variation (gray histogram), and its projected increase because of warming in the next century (ΔT, arrows) are shown for

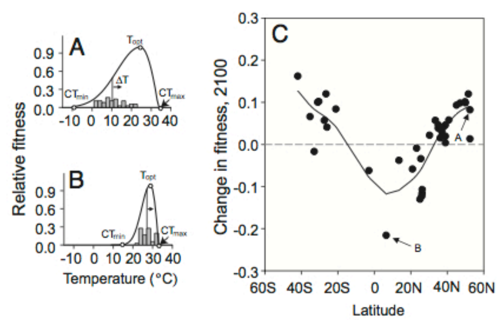


Fig. 1. Fitness curves for representative insect taxa from temperate (*A*) and tropical (B) locations, and (*C*) the change in fitness because of climate warming for all insect species studied, as a function of latitude. (*A* and *B*) Fitness curves

Example of a species that might benefit from warming

Gypsy moth

12% of aspen area at risk 1950-1980

99% at risk 2070-2100

Logan et al. 2003. Assessing the impacts of global warming on forest pest dynamics. Front Ecol. Environ. 1(3) 130-137.

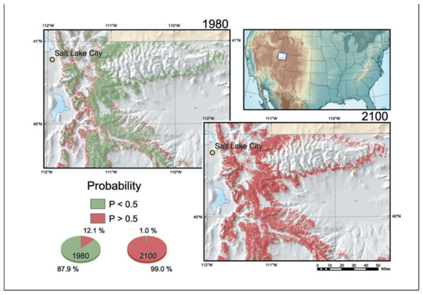


Figure 3. Probability map for the predicted establishment (as defined in Régnière and Nealis 2002) of a gypsy moth introduction in northern Utah. Green: aspen-dominated stands with less than 0.5 probability of gypsy moth establishment; red: aspen stands with greater than 0.5 probability of gypsy moth establishment. Climate evaluation was based on the 30-year normal temperatures for 1950–80 and for 2070–2100. Temperatures for the latter range were predicted by the CGCM1 model assuming a 1% per year increase in CO_2 production from 1990 to 2100 (Kittel et al. 1995). Approximately 12% of the shown Utah distribution of aspen is at high risk in pre-climate change conditions, whereas 99% of aspen in the same area is predicted to be at high risk by the end of the century.

PLOS | ONE

RESEARCH ARTICLE

More than 75 percent decline over 27 years in total flying insect biomass in protected areas

Caspar A. Hallmann[1]*, Martin Sorg[2], Eelke Jongejans[1], Henk Siepel[1], Nick Hofland[1], Heinz Schwan[2], Werner Stenmans[2], Andreas Müller[2], Hubert Sumser[2], Thomas Hörren[2], Dave Goulson[3], Hans de Kroon[1]

1 Radboud University, Institute for Water and Wetland Research, Animal Ecology and Physiology & Experimental Plant Ecology, PO Box 9100, 6500 GL Nijmegen, The Netherlands, 2 Entomological Society Krefeld e.V., Entomological Collections Krefeld, Marktstrasse 159, 47798 Krefeld, Germany, 3 University of Sussex, School of Life Sciences, Falmer, Brighton BN1 9QG, United Kingdom

* c.hallmann@science.ru.nl

Check for updates

OPEN ACCESS

Citation: Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, et al. (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE 12 (10): e0185809. https://doi.org/10.1371/journal.pone.0185809

Editor: Eric Gordon Lamb, University of Saskatchewan, CANADA

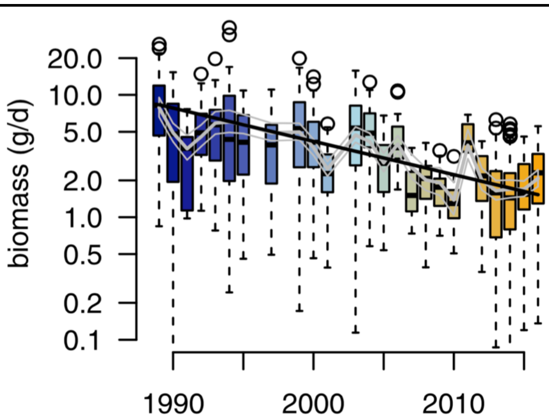
Received: July 28, 2017

Accepted: September 19, 2017

Published: October 18, 2017

Abstract

Global declines in insects have sparked wide interest among scientists, politicians, and the general public. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and to jeopardize ecosystem services. Our understanding of the extent and underlying causes of this decline is based on the abundance of single species or taxonomic groups only, rather than changes in insect biomass which is more relevant for ecological functioning. Here, we used a standardized protocol to measure total insect biomass using Malaise traps, deployed over 27 years in 63 nature protection areas in Germany (96 unique location-year combinations) to infer on the status and trend of local entomofauna. Our analysis estimates a seasonal decline of 76%, and mid-summer decline of 82% in flying insect biomass over the 27 years of study. We show that this decline is apparent regardless of habitat type, while changes in weather, land use, and habitat characteristics cannot explain this overall decline. This yet unrecognized loss of insect biomass must be taken into account in evaluating declines in abundance of species depending on insects as a food source, and ecosystem functioning in the European landscape.



Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, et al. (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE12(10): e0185809. https://doi.org/10.1371/journal.pone.0185809

ECOGRAPHY

Research

Declining diversity and abundance of High Arctic fly assemblages over two decades of rapid climate warming

Sarah Loboda, Jade Savage, Christopher M. Buddle, Niels M. Schmidt and Toke T. Høye

S. Loboda (http://orcid.org/0000-0002-4330-4405) (sarah.loboda@mail.mcgill.ca) and C. M. Buddle, Dept of Natural Resource Sciences, McGill Univ., Sainte-Anne-de-Bellevue, QC, Canada. – J. Savage, Dept of Biological Sciences, Bishop's Univ., Sherbrooke, QC, Canada. – N. M. Schmidt, Arctic Research Centre, Dept of Bioscience, Aarhus Univ., Roskilde, Denmark. – T. T. Høye, Aarhus Inst. of Advanced Studies, Arctic Research Centre, Dept of Bioscience, Aarhus Univ., Rønde, Denmark

Ecography
41: 265–277, 2018
doi: 10.1111/ecog.02747

Subject Editor: Eric Post
Editor-in-Chief: Miguel Araújo
Accepted 7 April 2017

Insects are particularly vulnerable to rapid environmental changes, which are disproportionally affecting high latitudes. Increased temperature could influence insect species differentially and reshape assemblages over time. We quantified temporal assemblage turnover of Arctic Diptera (flies) in the Muscidae, one of the most diverse and abundant families of Arctic insects, using time series data from Zackenberg, north-east Greenland. We measured temporal patterns of abundance, diversity, and composition of muscid assemblages in wet fen, mesic and arid heath habitats from yearly collections spanning 1996–2014 and tested their relationship to climate. A total of 18 385 individuals representing 16 species of muscid flies were identified. A significant decrease of 80% of total muscid abundance was observed during the study period. Species richness declined in each habitat type but this trend was not significant across habitats. The number of common and abundant species also decreased significantly over time across habitats revealing a temporal modification of species evenness. Significant temporal changes in composition observed in the wet fen and across habitats were mainly driven by a change in relative abundance of certain species rather than by species replacement. Shift in composition in each habitat and decline in muscid abundance across habitats were associated with summer temperature, which has significantly increased over the study period. However, relationships between temperature and muscid abundance at the species level were noticeable for a few species only. Significant directional change in composition was documented in the wet fen but no biotic homogenization across habitats was observed. As one of the few studies of species-level changes in abundance, diversity and composition of an insect taxon in the Arctic over the past two decades, our study shows that habitat types may modulate insect species responses to recent climate change and that contrasting species responses can alter species assemblages within a few decades.

Toke Hoye ESA Arctic Symposium 2017
Greenland, Zackenberg – 85% decline in Muscidae
1996-2014 (18 years)

1996-2014

All

Arid

Mesic

Wet fen

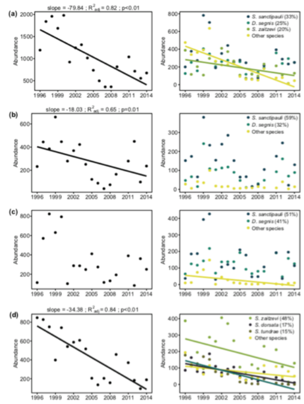


Figure 3. Temporal variations of annual muscid abundance (left column) and species-level abundance of common species (right column) at Zackenberg, NE Greenland, between 1996 and 2014 (a) across habitats and within each habitat; arid heath (b), mesic heath (c) and wet fen (d). Percentages in parentheses represent the proportion of individuals of a particular species in the assemblage, from 1996 to 2014. Regression lines based on simple linear regression analysis are given when the temporal trend in abundance in each assemblage is significantly different from zero. Regressions were corrected for first-order temporal autocorrelation when needed (Supplementary material Appendix 2 Table A2). Estimates, standard errors and p-values for species-specific trends in abundance are presented for each assemblage in Supplementary material Appendix 2 Table A2.

Climate-driven declines in arthropod abundance restructure a rainforest food web

Bradford C. Lister[a,1] and Andres Garcia[b]

[a]Department of Biological Sciences, Rensselaer Polytechnic University, Troy, NY 12180; and [b]Estación de Biología Chamela, Instituto de Biología, Universidad Nacional Autónoma de México, 47152 Chamela, Jalisco, Mexico

Edited by Nils Christian Stenseth, University of Oslo, Oslo, Norway, and approved September 10, 2018 (received for review January 8, 2018)

A number of studies indicate that tropical arthropods should be particularly vulnerable to climate warming. If these predictions are realized, climate warming may have a more profound impact on the functioning and diversity of tropical forests than currently anticipated. Although arthropods comprise over two-thirds of terrestrial species, information on their abundance and extinction rates in tropical habitats is severely limited. Here we analyze data on arthropod and insectivore abundances taken between 1976 and 2012 at two midelevation habitats in Puerto Rico's Luquillo rainforest. During this time, mean maximum temperatures have risen by 2.0 °C. Using the same study area and methods employed by Lister in the 1970s, we discovered that the dry weight biomass of arthropods captured in sweep samples had declined 4 to 8 times, and 30 to 60 times in sticky traps. Analysis of long-term data on canopy arthropods and walking sticks taken as part of the Luquillo Long-Term Ecological Research program revealed sustained declines in abundance over two decades, as well as negative regressions of abundance on mean maximum temperatures. We also document parallel decreases in Luquillo's insectivorous lizards, frogs, and birds. While El Niño/Southern Oscillation influences the abundance of forest arthropods, climate warming is the major driver of reductions in arthropod abundance, indirectly precipitating a bottom-up trophic cascade and consequent collapse of the forest food web.

climate warming | rainforest | food web | arthropods | bottom-up cascade

mechanisms (9, 10). While demonstrated impacts of climate change on tropical forests include reductions in plant diversity (14), changes in plant species composition (15), and increases in tree growth, mortality, and biomass (16), little is known about the impact of climate warming on rainforest arthropods (17, 18). Here we analyze long-term data on climate change, arthropod abundance, and insectivores within the Luquillo rainforest in northeastern Puerto Rico, with the aim of determining if increases in ambient temperature may have driven reductions in arthropod numbers and associated decreases in consumer abundance.

Results

Climate Trends in the Luquillo Forest. Fig. 1 compares trends in mean maximum yearly temperature (MnMaxT) for the El Verde Field Station and Bisley Tower meteorological stations, both located at an altitude of 350 m. Between 1978 and 2015, MnMaxT at El Verde rose by 2.0 °C at an average rate of 0.050 °C per year. Between 1993 and 2015, the rate of temperature increase at Bisley Tower was 0.055 °C per year, not significantly different from the rate at El Verde.

As several authors have pointed out, increased exposure to extreme temperatures may have a greater impact on fitness than gradual increases in average temperatures (6, 19, 20). At El Verde the proportion of maximum daily temperatures equal to or exceeding 29.0 °C increased significantly between 1978 and

Hyperalarming' study shows massive insect loss

– Washington Post, 15 Oct 2018

"This is one of the most disturbing articles I have ever read." "If anything, I think their results and caveats are understated. The gravity of their findings and ramifications for other animals, especially vertebrates, is hyperalarming," – David Wagner

"Holy crap," Wagner said of the 60-fold loss

Anole biomass dropped by more than 30 percent. Some anole species have altogether disappeared from the interior forest.

Insect-eating frogs and birds plummeted, too. Another research team used mist nets to capture birds in 1990, and again in 2005. Captures fell by about 50 percent.

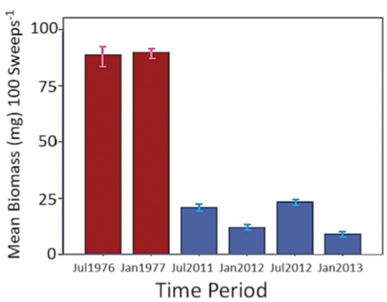
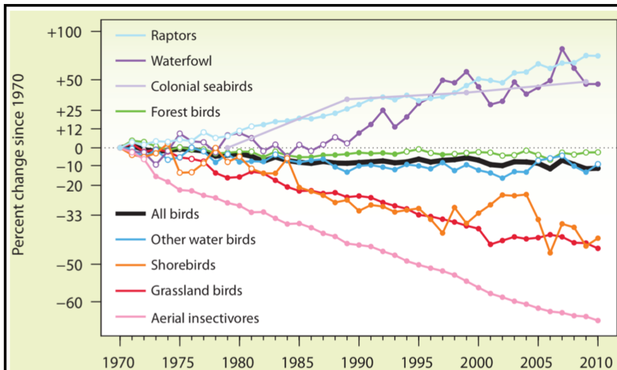
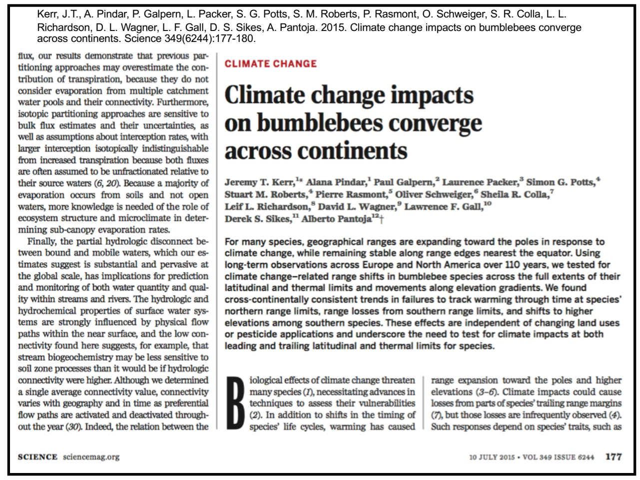


Fig. 2. Mean dry-weight arthropod biomass per 100 sweeps taken in the same sample area in the Luquillo rainforest during July 1976, January 1977, July 2011, and January 2013. One SE around the mean biomass is shown for each bar. Total sweeps taken in each period was 800, except for July 1976, when 700 sweeps were taken. Data for 1976 and 1977 are from Lister (22).



Indicators of the national population status of all regularly occurring native bird species in Canada and eight selected subgroups.

North American Bird Conservation Initiative, 2012. The state of Canada's birds, 2012. Environment Canada, Ottawa, ON.


Kerr, J.T., A. Pindar, P. Galpern, L. Packer, S. G. Potts, S. M. Roberts, P. Rasmont, O. Schweiger, S. R. Colla, L. L. Richardson, D. L. Wagner, L. F. Gall, D. S. Sikes, A. Pantoja. 2015. Climate change impacts on bumblebees converge across continents. Science 349(6244):177-180.

flux, our results demonstrate that previous partitioning approaches may overestimate the contribution of transpiration, because they do not consider evaporation from multiple catchment water pools and their connectivity. Furthermore, isotopic partitioning approaches are sensitive to bulk flux estimates and their uncertainties, as well as assumptions about interception rates, with larger interception isotopically indistinguishable from increased transpiration because both fluxes are often assumed to be unfractionated relative to their source waters (*6*, *20*). Because a majority of evaporation occurs from soils and not open waters, more knowledge is needed of the role of ecosystem structure and microclimate in determining sub-canopy evaporation rates.

Finally, the partial hydrologic disconnect between bound and mobile waters, which our estimates suggest is substantial and pervasive at the global scale, has implications for prediction and monitoring of both water quantity and quality within streams and rivers. The hydrologic and hydrochemical properties of surface water systems are strongly influenced by physical flow paths within the near surface, and the low connectivity found here suggests, for example, that stream biogeochemistry may be less sensitive to soil zone processes than it would be if hydrologic connectivity were higher. Although we determined a single average connectivity value, connectivity varies with geography and in time as preferential flow paths are activated and deactivated throughout the year (*30*). Indeed, the relation between the

CLIMATE CHANGE

Climate change impacts on bumblebees converge across continents

Jeremy T. Kerr,[1*] Alana Pindar,[1] Paul Galpern,[2] Laurence Packer,[3] Simon G. Potts,[4] Stuart M. Roberts,[4] Pierre Rasmont,[5] Oliver Schweiger,[6] Sheila R. Colla,[7] Leif L. Richardson,[8] David L. Wagner,[9] Lawrence F. Gall,[10] Derek S. Sikes,[11] Alberto Pantoja[12]†

For many species, geographical ranges are expanding toward the poles in response to climate change, while remaining stable along range edges nearest the equator. Using long-term observations across Europe and North America over 110 years, we tested for climate change–related range shifts in bumblebee species across the full extents of their latitudinal and thermal limits and movements along elevation gradients. We found cross-continentally consistent trends in failures to track warming through time at species' northern range limits, range losses from southern range limits, and shifts to higher elevations among southern species. These effects are independent of changing land uses or pesticide applications and underscore the need to test for climate impacts at both leading and trailing latitudinal and thermal limits for species.

Biological effects of climate change threaten many species (*1*), necessitating advances in techniques to assess their vulnerabilities (*2*). In addition to shifts in the timing of species' life cycles, warming has caused range expansion toward the poles and higher elevations (*3*–*6*). Climate impacts could cause losses from parts of species' trailing range margins (*7*), but those losses are infrequently observed (*4*). Such responses depend on species' traits, such as

SCIENCE sciencemag.org 10 JULY 2015 • VOL 349 ISSUE 6244 177


UNIVERSITY OF ALASKA MUSEUM OF THE NORTH

Search

Entomology

Home » Research & Collections » Entomology

Plan Your Visit
Exhibitions
Events & Programs
Education
Research & Collections
Archaeology
Earth Science
Entomology
Collection History
Donations
Loans
Current Projects
Department Staff
Links
Ethnology & History
Film Center
Fine Art
Genomic Resources
Herbarium
Ichthyology & Aquatics

Entomology

Overview

Welcome to the University of Alaska Museum Entomology Web Page. The collection was established as part of a NSF - funded Arctic Archival Observatory grant in late 2000.

The UAM Insect collection is the northern-most facility of its kind in the United States. It has the potential to become a world-class depository for dry and preserved-tissue samples of northern arthropods, primarily from Alaska.

Although a young collection, we already have a backlog of more than 100,000 insects (mostly aquatics) from Alaska and other regions, including Canada, Eastern Russia, and the contiguous United States. The collection is currently in need of significant curatorial attention to make it an accessible and valuable resource.

Stay tuned for what will surely be some exciting developments in the world of Alaskan insects at the museum!

Volunteers

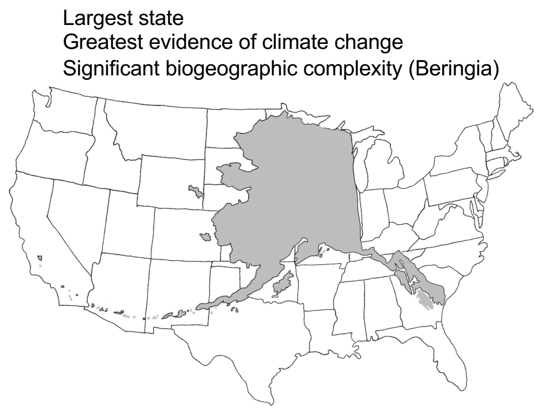
If you have a few hours a week and would like to volunteer in the Entomology Department please contact the Curator, Derek Sikes.

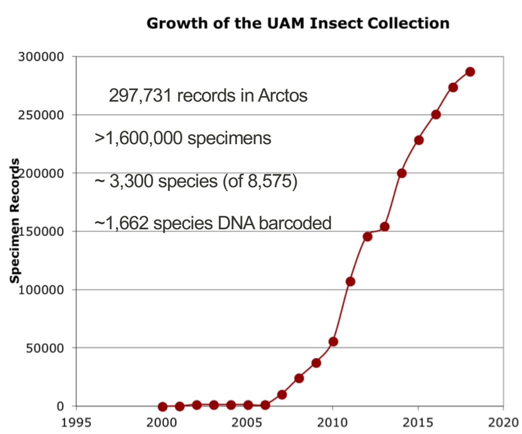
Donations

If you are thinking of starting a project that will produce insect specimens which you would like to donate, please contact the Curator to discuss details such as which pins to use if you are pinning specimens (stainless #3 are highly recommended) and how to record latitude / longitude for your

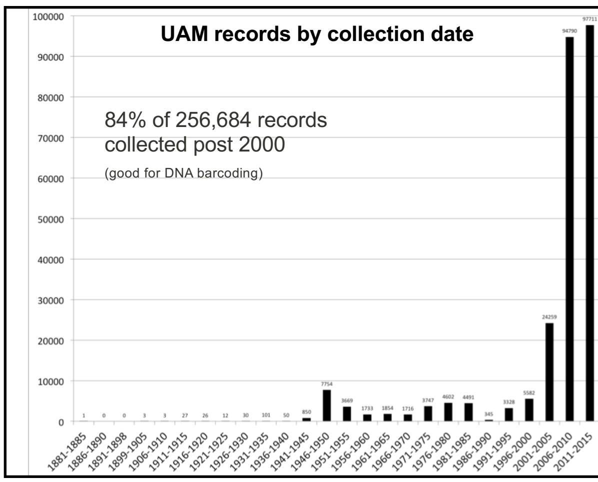
University of Alaska Museum Insect Collection

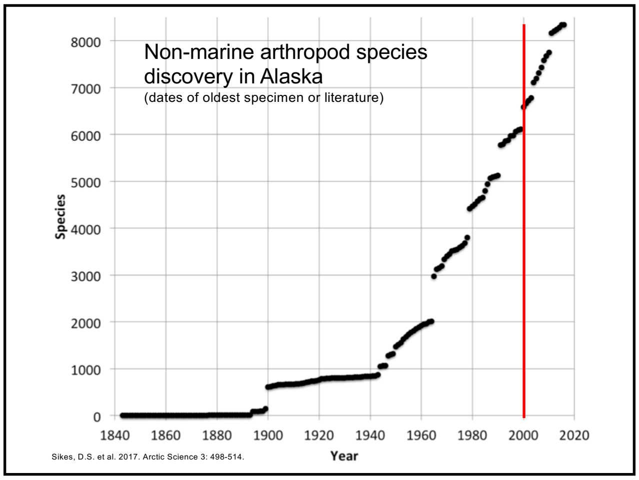
Photo © L. Olson

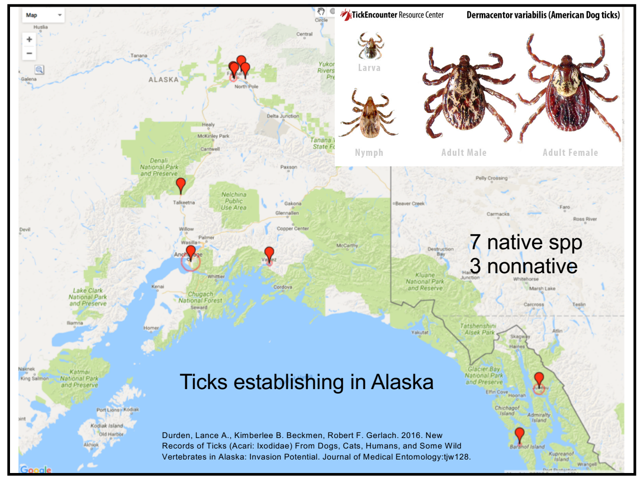




Sikes, D.S. et al. 2017. Arctic Science 3: 498-514.








Biodiversity Data Journal 6: e27427
doi: 10.3897/BDJ.6.e27427

Research Article

Earthworms (Oligochaeta: Lumbricidae) of Interior Alaska

Megan Booysen[‡], Derek Sikes[§], Matthew L. Bowser[|], Robin Andrews[¶]

‡ West Valley High School, Fairbanks, United States of America
§ University of Alaska Museum, Fairbanks, United States of America
| U.S. Fish & Wildlife Service, Kenai National Wildlife Refuge, Soldotna, United States of America
¶ Department of Biology and Wildlife, University of Alaska Fairbanks, Fairbanks, United States of America

Corresponding author: Derek Sikes (dssikes@alaska.edu)

Academic editor: Robert Blakemore

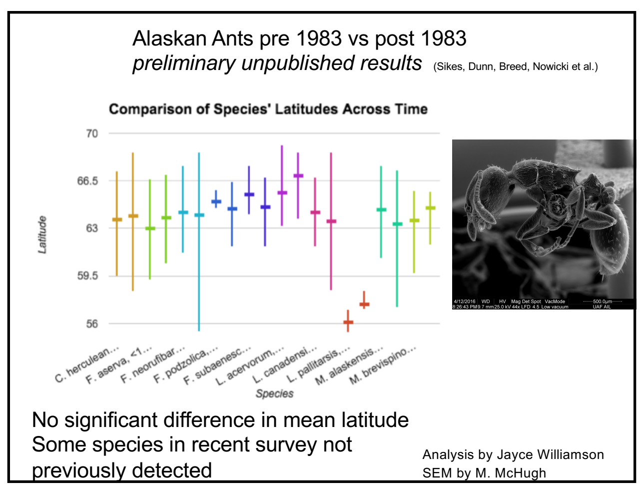
Received: 13 Jun 2018 | Accepted: 01 Jul 2018 | Published: 10 Jul 2018

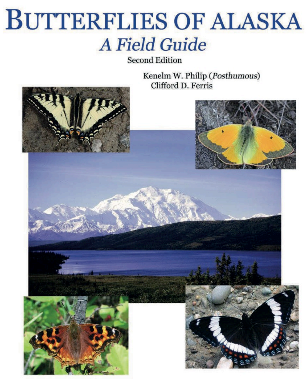
Citation: Booysen M, Sikes D, Bowser M, Andrews R (2018) Earthworms (Oligochaeta: Lumbricidae) of Interior Alaska. Biodiversity Data Journal 6: e27427. https://doi.org/10.3897/BDJ.6.e27427

ZooBank: urn:lsid:zoobank.org:pub:F514E9A6-61B3-4E4D-BA6B-DDFA6FEFBC58

Abstract

Earthworms in the family Lumbricidae in Alaska, which are known from coastal regions, primarily in south-central and south-eastern Alaska, are thought to be entirely non-native and have been shown to negatively impact previously earthworm-free ecosystems in study regions outside of Alaska. Despite occasional collections by curious citizens, there had not been a standardised earthworm survey performed in Interior Alaska and no published records exist of earthworms species from this region. Mustard extraction was used to sample six locations that differed in elevation, mostly in the College region of Fairbanks, Alaska. Two of the six locations yielded earthworms. There was no relationship between earthworm abundance and elevation ($p = 0.087$), although our sample size was small. Our sampling, combined with specimens in the University of Alaska Museum, has documented four exotic species and one presumed native species of lumbricid earthworms in Interior Alaska.





Butterflies of Alaska Nymphalidae

Species 79 *Oeneis tanana* A. Warren & Nakahara — **Tanana Arctic**

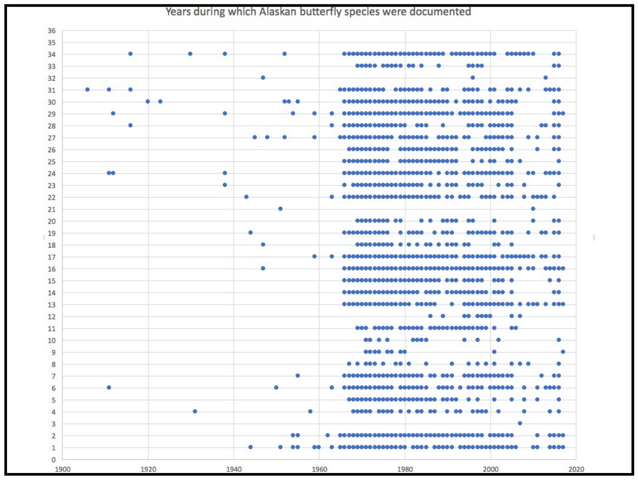
Distribution. To date, known only from Alaska, found only along the Richardson and Alaska Highways, and just south of Tok.
Habitat. Open grassy areas in boreal forest.
Biology. Hibernation as larva with two-year life cycle in Alaska. Larval hosts are grasses.
Flight period. Mid-June into early July. Odd-number years only.
Diagnostic characters. Expanse: 46 mm. Some sexual dimorphism: females larger and brighter/paler than males. Both sexes have a diffuse submarginal orange-brown band (paler ventrally) with two FW pronounced and separated black spots. This band is penetrated along its inner margin by a narrow horizontal "V" below the top-most black spot.
Field notes. As in the previous species, these butterflies tend to be rather sedentary in vegetation or on open ground, and when disturbed, they usually fly close to the ground in straight line paths, circling before they alight. They laterally bask with the wings placed broadside to the sun.
Taxonomic note. The original description of this species is published in: Warren, A. D. et al., 2016. *The Journal of Research on the Lepidoptera*, vol. 49:1–20.

Male V Male D

Female V Female D

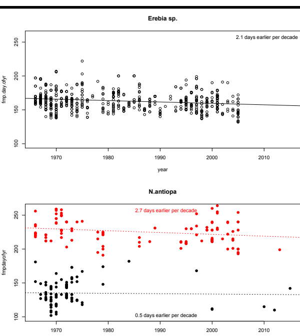
98

Philip, K.W., Ferris, C.D. 2016. Butterflies of Alaska: A Field Guide. 2nd ed. Alaska Entomological Society. 110 pp. ISBN 978-1-945170-60-7.

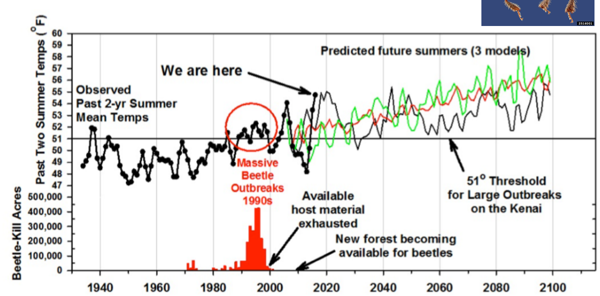


Kathryn Daly, MS student

Photo © D. Sikes

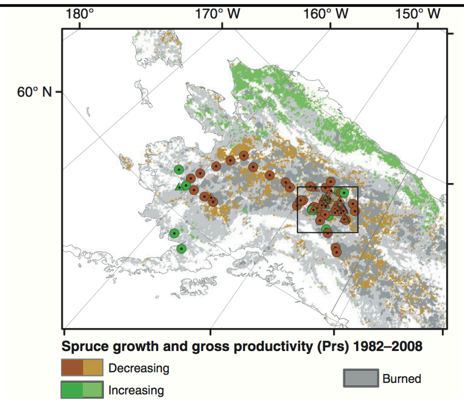


Thesis data – publication in prep
- winglength changes
- phenology changes



Global climate models from Germany (green), Canada (red) and USA (black) scaled to the Kenai predict that post-2030 mean summer temperatures will always be above the threshold for spruce bark beetle outbreaks. Observed temperatures are from the Homer airport since 1932. Lower bar graph shows annual beetle-kill for southern Kenai since aerial surveys began in 1971 (US Forest Service). Ed Berg graphic.

Berg, E. 2015. Warm summers prepare for spruce bark beetle return. USFWS Kenai National Wildlife Refuge Notebook 17(37)



Beck, Juday et al. 2011. Changes in forest productivity across Alaska consistent with biome shift. Ecology Letters (2011) 14: 373–379

Yellowjacket Related Deaths in Alaska

Demain, J. G. & Gessner, B. D. Increasing incidence of medical visits due to insect stings in Alaska. *Alaska Epidemiology Bulletin* **13** (2008)

Increase in sting reports

Region	Largest Community	Annual temperature Increase*	Winter temperature Increase*	average 1999-2001 insect sting incidence†	average 2004-2006 insect sting incidence†	Percent change in insect sting incidence (X^2 for trend, p-value)‡
Northern	Barrow	3.8	6.1	16	119	626% (13, p<0.001)
Southwest	Bethel	3.7	6.9	62	133	114% (8, p=0.005)
Interior	Fairbanks	3.6	8.1	333	509	53% (28, p<0.001)
Southcentral	Anchorage	3.4	7.2	276	405	47% (22, p<0.001)
Southeast	Juneau	3.6	6.8	221	279	27% (22, p<0.001)
Gulf	Kodiak	1.5	1.5	437	487	11% (0.1, p=0.75)
Statewide		**3.4**	**6.3**	**254**	**364**	**43% (54, p<0.001)**

Demain, J.G., Gessner, B.D., McLaughlin, J.B., Sikes, D.S., Foote, J.T. 2009. Increasing insect reactions in Alaska: Is this related to changing climate? Allergy & Asthma Proceedings 30: 238-243. http://www.ncbi.nlm.nih.gov/pubmed/19549424

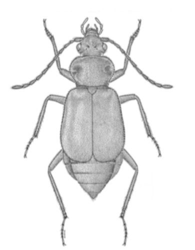
Taxonomic Revision of the Rove Beetle Genus *Phlaeopterus* Motschulsky, 1853 (Coleoptera: Staphylinidae: Omaliinae: Anthophagini)

Logan J. Mullen
University of Alaska Museum
University of Alaska Fairbanks
Fairbanks, AK, USA
ljmullen2@alaska.edu

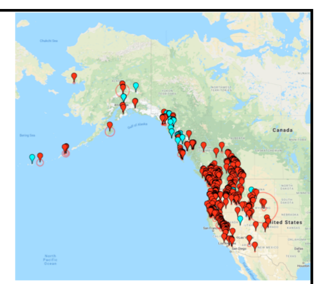
J. M. Campbell
Canadian National Collection of Insects, Arachnids, and Nematodes
Ottawa, ON, CANADA

and

Derek S. Sikes
University of Alaska Museum
University of Alaska Fairbanks
Fairbanks, AK, USA
dssikes@alaska.edu



The Coleopterists Society
Patricia Vaurie Series * Monograph 16



18 species

http://bugguide.net/node/view/498139

Habitat and Ecology

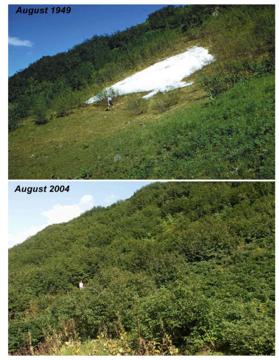
Hatcher Pass, Talkeetna Mountains

"Phlaeopterus Creek", Denali National Park

Heintzleman Ridge, North of Juneau, AK

Phlaeopterus feeding on arthropod fallout

Shrubification



Nature of Southeast Alaska: A Guide to Plants, Animals, and Habitats

"Climate change has already reduced snow cover in the Rockies by 20 percent since 1980,"

https://insideclimatenews.org/news/07062016/unabated-global-warming-threatens-west-snowpack-water-rocky-mountains-sierra-nevada-drought

Scalzitti, J., Strong, C. and Kochanski, A., 2016. Climate change impact on the roles of temperature and precipitation in western US snowpack variability. Geophysical Research Letters, 43(10), pp.5361-5369.

Alpine snowpatches

Arctic and Alpine Research, Vol. 8, No. 3, 1976, pp. 237-245

ARTHROPOD FALLOUT AND NUTRIENT TRANSPORT: A QUANTITATIVE STUDY OF ALASKAN SNOWPATCHES

JOHN S. EDWARDS* AND PAUL C. BANKO†
Institute of Arctic Biology
University of Alaska
Fairbanks, Alaska 99701

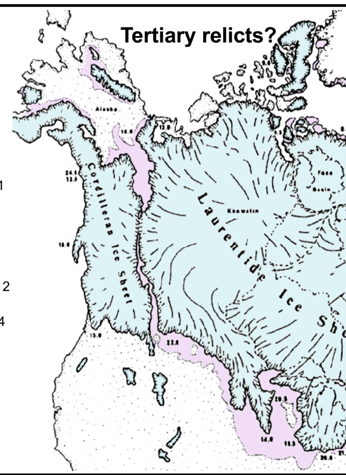
"The unique snowfield and high-elevation stream habitat association of most *Phlaeopterus* species may render these beetles at risk of extirpation, or even extinction, by a warming climate. Two species, described here … have not been collected since 1979 and 1984."

Logan, Campbell, Sikes (2018)

YUKON GEOLOGICAL SURVEY

373
species
AK
only

Acari -11
Crustacea - 2
Archaeognatha -1
Diplopoda – 1
Chilopoda - 13
Coleoptera - 44
Collembola - 2
Diptera – 137
Ephemeroptera - 2
Hemiptera - 28
Hymenoptera - 84
Mecoptera – 5
Orthoptera - 1
Pauropoda - 9
Phthiraptera - 2
Plecoptera - 2
Protura - 15
Siphonaptera – 1
Trichoptera - 2



Nouv. Revue Ent. (N.S.) | T. 3 | Fasc. 2 | p. 171-187 | Paris, avril-juin 1986

Chionotyphlus alaskensis n.g., n.sp.,
a Tertiary relict
from unglaciated interior Alaska
(_Coleoptera, Staphylinidae_) (*)

A. SMETANA
Biosystematics Research Institute, Agriculture Canada, Ottawa KIA 0C6. Canada.

Résumé. – L'auteur décrit *Chionotyphlus alaskensis* n.g., n.sp., staphylinide leptotyphline aveugle dont les adultes ont été récoltés aux environs de Fairbanks, dans la zone intérieure de l'Alaska non érodée lors des dernières glaciations. Ce nouveau taxon est placé dans la tribu des *Neotyphlini*, surtout représentée dans le Nouveau Monde ; il est comparé à tous les autres genres connus de cette tribu et ses relations phylogénétiques possibles à l'intérieur de la tribu sont brièvement discutées.

Il semble que cette espèce soit une relique du Tertiaire. L'auteur émet des hypothèses sur son histoire en se basant sur les changements climatiques et floristiques survenus en Alaska. On présume que cette espèce est adaptée aux sols loessiques. On discute aussi des habitats passés probables et des habitats actuels. Cette espèce est vraisemblablement plus largement répartie dans la zone intérieure de l'Alaska non érodée lors des dernières glaciations et dans les Territoires du Yukon.

L'auteur mentionne aussi diverses implications liées à la découverte de ce staphylinide aveugle dans la zone intérieure de l'Alaska, en particulier la possibilité que d'autres populations semblables de *Leptotyphlinae* survivent aussi dans le nord-est de la Sibérie, dont le passé géologique est similaire.

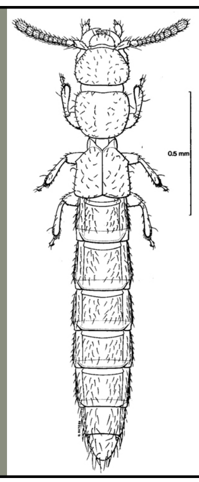
Summary. – *Chionotyphlus alaskensis* n.g. n.sp., a blind leptotyphline staphylinid, is described from adults taken in the unglaciated interior Alaska in the vicinity of Fairbanks. It is assigned to the predominantly New World tribe *Neotyphlini*, compared to all known genera of the tribe and its possible phylogenetic relationships within the tribe are briefly discussed.

The species is considered a Tertiary relict. Its past history, based on climatic and vegetational changes in Alaska, is postulated. It is presumed to be adapted to loess soils. The possible past habitats and the present habitats are discussed. The species is likely more widely distributed in unglaciated interior Alaska and Yukon Territory.

Several implications resulting from the discovery of this blind staphylinid in interior Alaska are mentioned, particularly the possibility that similar leptotyphline populations may also exist today in northeastern Siberia, which had, in general, a similar past history.

Mots-clés. – *Coleoptera, Staphylinidae, Leptotyphlinae, Chionotyphlus*, nouveau genre, nouvelle espèce, Alaska.

(*) 31st contribution to the knowledge of *Staphylinidae*.



3 sites

Chena
Ridge

Chatanika

Nenana

Summary

1) Many examples of probable climate change impacts on invertebrates globally
 - range shifts (*Bombus*, butterflies, etc.)
 - biomass declines (causes ?)

2) Alaska's fauna is becoming better known but we lack a good pre-warming baseline for most taxa
 - non-native species (ticks, earthworms)
 - threatened species (alpine & spruce associates)
 - insect outbreaks (bark beetles, wasps)
 - winglength & phenology changes (b'flies)