POLISH HYPERBARIC RESEARCH 4(73)2020
Journal of Polish Hyperbaric Medicine and Technology Society

MASS OCCURRENCES OF MILLIPEDES IN TIMES OF GLOBAL CLIMATE CHANGE

Barbara Nieradko-Iwanicka[1)], Monika Jung[2)]

[1)] Chair and Department of Hygiene and Epidemiology, Medical University in Lublin, Poland
[2)] Chair of Pharmacology and Biology, Medical University in Lublin, Poland

ABSTRACT

There had been recorded a rise in global average temperature by 1.5°C since pre-industrial times. It promotes the spread of diseases carried by vectors and mass occurrence of arthropods. Millipede can carry infectious agents, invade homes and farms, cause skin irritation in case of exposure to their excretions.The aim of the study was to find information about mass appearances of millipedes and identify the places and periods where it happens.
A systematic review of publications available in online scientific databases and the library of the Medical University of Lublin was performed.
As many as 5 reports about mass occurrence of millipede were from Japan, 3 from Brazil, 3 from Australia 2 from Germany and Hungary, and single publications from Romania, Norway, Poland and Madagascar. In Japan the 8-year periodicity of millipede outbreaks was observed. Japan and Australia encounter problems at railway due to these organisms. In other countries they are nuisance to people when they enter their dwellings and pose a burden in farming and gardening therefore mechanical, chemical and biological methods of millipede control are tested. On the other hand millipede help in composting organic waste. In conclusion: global climate change is accompanied by an increase in frequency of mass occurrences of millipedes.
Keywords: Arthropods, climate change, biology, millipedes.

ARTICLE INFO

PolHypRes 2020 Vol. 73 Issue 4 pp. 81 – 88
ISSN: 1734-7009 **eISSN:** 2084-0535
DOI: 10.2478/phr-2020-0025
Pages: 8, figures: 1, tables: 1
page www of the periodical: www.phr.net.pl

Publisher
Polish Hyperbaric Medicine and Technology Society

Review article

Submission date: 15.08.2020 r.
Acceptance for print: 07.10.2020 r.

INTRODUCTION

There had been recorded a rise in global average temperature by 1.5°C since pre-industrial times [1]. Climate change has an impact on human health, extreme weather conditions, floods, droughts, tornadoes and storms. It promotes the spread of diseases carried by vectors and mass occurrence of arthropods. An example is the spread of malaria carried by mosquitoes [2,3]. Researchers recorded the increased occurrence of Lyme disease and other tick-borne diseases in the moderate climate zone [4,5]. Massive appearances of millipedes are also observed invasions of homes and farms. Millipede passively transport diseases, direct impact involve skin irritation in case of exposure to their excretions.

A characteristic feature of millipedes that distinguishes them from other arthropods is that their body is made of diplosomites, identical segments. Millipedes have a single pair of legs per segment hence their name Diplopoda. Fossilized millipedes were found. They exhibit secretive, nocturnal lifestyle. In a stressful situation, they curl into a ball or spiral fashion. They have a few natural enemies. When irritated produce defense secretions. Their composition (quinazolinone alkaloids - glomerine, homoglomerine, alkaloids, nitropolizonamines, spirolizidines, terpenes, limonene, benzoquinones, jest hydroquinolones hydroquinones) is specific for the order [6]. They are not poisonous but belong to toxic animals. They emit a smelling odour, which can sting or burn. Some members can shoot their excretions for several feet away. Majority feed on decaying plant matter [7].

Mass occurrences of millipedes are not a recent phenomenon (Fig. 1.). For example in Japan and Australia, the mass appearances of millipedes pose a problem for the endurance of train traffic. Numerous millipedes make the tracks slimy. The train loses traction and slips [8-13].

While most millipedes in the world are harmless to humans, some can vector plant and animal diseases caused by bacteria such as Citrobacter, Enterobacter, Salmonella, and Raoultella species [14].

AIM

The aim of the study was to find information about mass appearances of millipedes and identify the places and periods where it happens.

METHOD

A systematic review was performed. On January 15 2022 PubMed, and Google Scholar databases was searched for open access full texts with use of the following key words: 'millipede' and 'mass appearances'. An additional source was the library of the Medical University of Lublin. In Google Scholar 4370 publications were found (no time limit, any language). After skimming the titles 90 articles were selected. The PubMed database was searched for open access full texts with use of the following key words: 'millipede' and 'mass appearances'. From last 5 years 4 results were found, from last 10 years 8 and from the years 1900-2022 it was 12. After elimination of duplicates 50 articles were chosen. After scanning the abstracts 22 full texts were selected. Three of them were from the XIX century, 9 from the XX, and 10 from the first 22 years of the XXI century.

RESULTS AND DISCUSSION

The oldest report about mass occurrence of millipede are from Hungary [15,16] and Germany [17].There are also reports from the XX century from England [18], Romania [19], Norway [20], Brazil [21]. In the XXI century the number of such reports increased. They describe mass occurrence of millipedes in Brazil [22], England [23], Germany [24], Poland [25], Madagascar [26], Australia, [8,27] and Austria [28]. In Japan, outbreaks of train millipedes have been reported since 1920 [9,10,11]. The 8-year millipede outbreak periodicity was noticed. It recurred in the summer.

The name 'train millipede' is derived from the frequent train obstructions during 1920–1984 period caused by Parafontaria laminata armigera Verhoeff 1936 (Diplopoda: Polydesmida: Xystodesmidae) (P. l. a.). Most likely, millipedes lived there before the tracks were laid, and because they do not like to travel too far, they stay close to where they were born. Similar findings come from Australia where millipedes cause train accidents [8,12,13]. Meyer-Rochow in 2015 published his own new observations of a mass migration of Chamberlinius hualienensis Wang 1956 on Japanese Izu Island [27]. Boccardo et al. described mass appearance of millipedes in coffee plantations in Brazil [22]. It was accompanied by millipede spread over dwelling houses, gardens, orchards. There was a hypothesis that it happened due to irrigation in the coffee crop and accumulation of large amount of organic materials in the area, which was a perfect feed for the millipede [21]. They can be a domestic nuisance when they invade homes and gardens in thousands. Some of them are attracted by lights at night and that is why they invade homes.

Reducing the area covered with organic matter around the house helps to prevent millipedes mass occurrence as it diminishes their food supply and shelter. Smooth barriers of glass, vinyl, teflon or propylene prevent millipedes from entering houses. Sticky aluminium tape around the house charged with small electric current is very effective too. A moat and trap systems mounted around the dwellings are also used. Millipedes fall in there and cannot come out. Light traps are also useful. Niijima et al. suggest that an outbreak of Parafontaria laminata armigera Verhoeff (Diplopoda: Xystodesmidae) in Japan helped in litter decomposition, as these organisms are known to turn organic waste into millicompost [9]. Scott described mass occurrences of millipedes that they entered human houses in the period from 1953 till 1957 [18]. At that time people used to eliminate millipedes with lime. Later Fontanetti et al described millipede outbreaks giving a nuisance to people so that a pesticides 2,3 isopropylidene-dioxy phenyl methylcarbamate had to be used for their eradication [29]. The methods of millipede management in agriculture are: use occasional tillage (every other year), varying planting date by a few weeks (either early or late), an increased seeding rate but consider economics or application of insecticides, including organophosphates and pyrethroids, but only if they can contact the pests. Carbaryl (of carbamate group), bendiocarb (carbamate ester) and cyfluthrin (pyrethroid) are used.

At present there are trials to use Bacillus thuringiensis for these organisms control [30] or nematodes Rhabditis necromena in Australia. When

a millipede infestation occurs –the nematode population grows to affect the millipede numbers. These nematodes should be released in Australian conditions through April-June and it is expected that they reduce the millipedes population in the area within 1-2 years. The nematodes reproduce inside corps of millipede and then return to the soil to start another infestation cycle during the winter months. This method is selective the particular type of nematode that invades specific millipedes. They do not harm other animals, plants nor insects [31]. Commercial formulas for millipedes control based on nematodes are available on the market nowadays.

The reasons of mass occurrences in Diplopoda include: lack of food and for reproduction that urge relocation for suitable oviposition sites. Population increase beyond sustainable levels increases the chance for the individual to find overwintering or aestivation sites and survival of the species in turn [27].

The findings from our systematic review are summarized in table 1 (Tab. 1). Unfortunately many reports about mass occurrence of millipedes are written in national languages and they are published in local newspapers so they are not recorded in scientific databases. Another drwaback of a systematic review analysing publications from over one hundred years ago is that in the past there was much less scientific papers than in the XXI century.

There is also a Polish part of the millipede story that deserves attention. A famous Polish scientist Hieronim Jawlowski in 1945 obtained his habilitation on the basis of the work 'Millipedes in south-eastern Poland'. He was an outstanding expert on millipedes and the author of 22 publications in this field. He also described 21 species and subspecies new to science; Brachyiulus jawlowskii Lohmander 1928 was also named in his honor. After world war II he settled in Lublin. From 1945 he headed the chair and the Department of General Biology at the Faculty of Medicine at the Maria Curie-Sklodowska University, and in 1950-1962 at the Medical Academy [32].

CONCLUSION

Global climate change is accompanied by an increase in frequency of mass occurrences of millipedes.

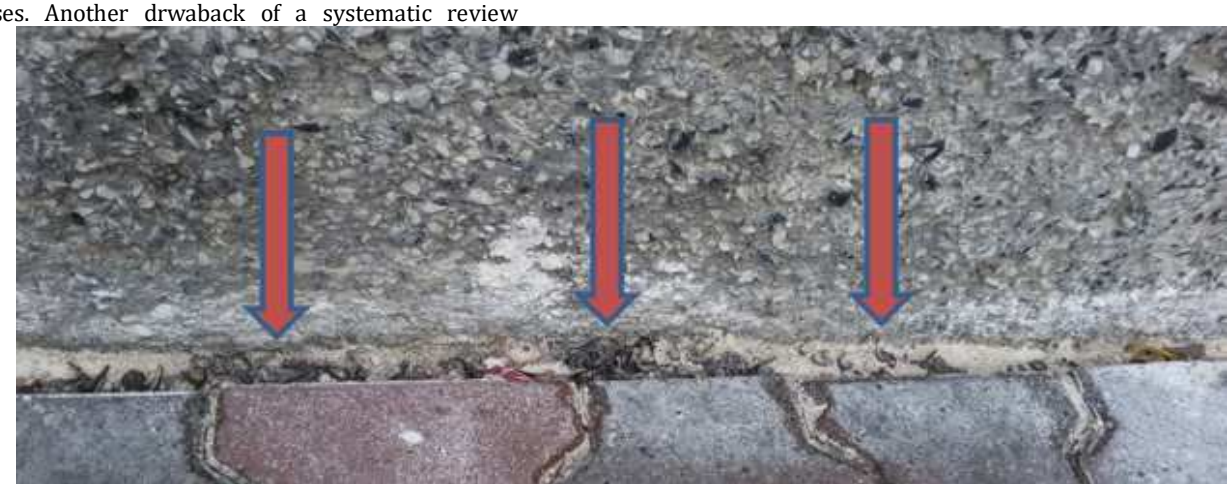

Fig. 1 Cylindroiulus caeruleocinctus (Wood, 1864) millipedes (red arrows), during seasonal migrations in Lublin (Poland), trapped on the building facades. Photo Monika Jung.

Tab. 1

The summary of the systematic review on mass occurrence of millipedes from 1878-2021.

No	Source	Date	Country	Observation
1	Tömösváry Ö, 1878	1878	Hungary	Mass appearances
2	Brade-Birks SG, 1922	1879	Hungary	Migration from oats fields to pasture land (*Brachyiulus unilineatus*)
3	Verhoeff KW, 1900	1900	Germany	Mass appearance and migration
4	Esaki T, 1934	1934	Japan	Disturbance of train movement
5	Scott H, 1958	1953-1957	England	Mass appearances, entering human homes
6	Baker GH, 1978	1978	Australia	Mass appearances (*Ommatoiulus moreletii*)
7	Ceuca T, 1984	1984	Romania	Mass appearances
8	Koch L, 1985	1985	Australia	Mass appearances (pincushion

				millipedes (Diplopoda: Polyxenida))
9	Meidell B, et al., 1985	1985	Norway	Mass appearances (*Cylindroiulus londinensis* (Leach, 1815))
10	Niijima K, et.al., 1988	1988	Japan	Mass appearances (*Parafontaria laminate* group (Diplopoda: Xystodesmidae))
11	Boccardo L, et al., 1997	1977	Brazil	Mass appearance (*Plusioporus setiger*)
12	Niijima K, 1998	1998	Japan	Mass appearance (*Parafontaria laminata armigera* Verhoeff (Diplopoda: Xystodesmidae))
13	Boccardo L, et al., 2002	2022	Brazil	Mass appearance (*Cylindroiulus londinensis*)
14	Chater A, 2004	2004	England	Mass appearance
15	Voigtländer K, 2005	2005	Germany	Mass appearances
16	Kania G, et al., 2005	2005	Poland	Mass appearances
17	Fontanetti CS, et al, 2010	2005-2007	Brazil	Mass appearances (*Urostreptus atrobrunneus*)
18	Wesener T, et al., 2010	9 appearances	Madagascar	Mass appearance (*Zoosphaerium neptunus*)
19	Zimmermann K, 2013	2004-2011	Austria	Mass occurrence (*Cylindroiulus caeruleocinctus* Wood 1864)
20	Anonymous, 2013	2013	Australia	Mass appearance caused train crash
21	Meyer-Rochow VB, 2015	2014	Japan (Izu Island)	Mass migration (*Chamberlinius hualienensis* Wang 1956)
22	Niijima K, et al., 2021	1920-2016	Japan	Mass appearances every 8 years caused train crashes (train millipede (*Parafontaria laminata armigera* Verhoeff 1936 (Diplopoda: Polydesmida: Xystodesmidae))

REFERENCES

1. Capon A, Corvalan C. Climate change and health: global issue, local responses. Public Health Res Pract. 2018;28(4):2841823. doi: 10.17061/phrp2841823. PMID: 30652183;
2. Ogden NH, Gachon P. Climate change and infectious diseases: What can we expect? Can Commun Dis Rep. 2019 ;45(4):76-80;
3. Kumar A. Some considerable issues concerning malaria elimination in India. J Vector Borne Dis. 2019;56(1):25-31;
4. Rochlin I, Toledo A. Emerging tick-borne pathogens of public health importance: a mini-review. J Med Microbiol. 2020;69(6):781-791;
5. Semenza JC, Suk JE. Vector-borne diseases and climate change: a European perspective. FEMS Microbiol Lett. 2018;365(2):fnx244. doi: 10.1093/femsle/fnx244. PMID: 29149298; PMCID: PMC5812531;
6. Ilić B, Unković N,, Knežević A,Savković Z,, Ljaljević Grbić M, Vukojević J, Jovanović Z, Makarov S,Lučić L 2019 Multifaceted activity of millipede secretions: Antioxidant, antineurodegenerative, and anti-Fusarium effects of the defensive secretions of Pachyiulus hungaricus (Karsch, 1881) and Megaphyllum unilineatum (C. L. Koch, 1838) (Diplopoda: Julida) PLOS ONE Published: January 3, 2019 https://doi.org/10.1371/journal.pone.0209999;
7. Hopkin SP, Read HJ.1992. The Biology of Millipedes. Oxford: Oxford University Press;
8. Anonymous.Millipedes suspected in Clarkson train crash. Railway Digest (Australia),November 2013: 24;
9. Niijima K, Shinohara K.Outbreaks of the Parafontaria laminate group (Diplopoda: Xystodesmidae).Japanese Journal of Ecology,1988; 38: 257-268 (in Japanese with English summary);
10. Niijima K, Nii M, Yoshimura J. Eight-year periodical outbreaks of the train millipede. R Soc Open Sci. 2021;8(1):201399;
11. Esaki T.Diplopoda that disturb the movement of trains.Shokubutsu oyobi Dobutsu, 1934;2: 821-833 (in Japanese);
12. Baker GH.The distribution and dispersal of the introduced millipede Ommatoiulus moreletii (Diplopoda: Julidae) in Australia.Journal of Zoology (London),1978 185(1): 1-11;
13. Koch LE. Pincushion millipedes (Diplopoda: Polyxenida): their aggregations and identity in Western Australia.Western Australian Naturalist,1985; 16(2-3): 30-32;
14. Kania G., and Klapeć T.Seasonal activity of millipedes (Diplopoda) – their economic and medical significance. Annals of Agricultural and Environmental Medicine 2012;19: 649–650;
15. Tömösváry Ö. A százlábúak vándorlásához.Természettudományi Közlemények, 1878;10: 365-366 (in Hungarian);
16. Brade-Birks SG. Notes on myriapoda, 27. Wandering millipeds.Annals and Magazine of Natural History 1922; 9(9): 208-212;
17. Verhoeff KW.Wandernde Doppelfüßler, Eisenbahnzüge hemmend.Zoologischer Anzeiger.1900; 23: 465-473 (in German);
18. Scott H.Migrant millipedes and entering houses 1953-1957.The Entomologist's Monthly Magazine.1958; 94: 73-77;
19. Ceuca T. Migraţiile la diplopode.Nymphaea (Oradea).1984;10: 237-242 (in Romanian with English summary);
20. Meidell B, Simonsen A. A mass occurrence of Cylindroiulus londinensis (Leach, 1815) in Norway.Fauna Norvegica B.1985; 32(1): 47-48;
21. Boccardo L, Penteado CHS, Jucá-Chagas R.Swarming of millipedes, new case noticed in the district of Patrocinio, MG, Brazil. Journal of Advanced Zoology.1997; 18(1): 62-63;
22. Boccardo L, Jucá-Chagas R, Penteado CHS.. Migration and population outbreaks of millipedes in the coffee plantations, region Altoparanaíba, MG, Brazil.Holos Environment 2002;2(2): 220-223;
23. Chater A. A swarm of Cylindroiulus londinensis in Montgomeryshire.Bulletin of the British Myriapod and Isopod Group.2004; 20: 51-55;
24. Voigtländer K.Mass occurrences and swarming behaviour of millipedes (Diplopoda: Julidae) in Eastern Germany.Peckiana.2005; 4: 181-187;
25. Kania G, Tracz H. Mass occurrence and migration of Ommatoiulus sabulosus (Linnaeus, 1758) (Diplopoda, Julida: Julidae) in Poland.Peckiana.2005; 4: 57-66;
26. Wesener T, Schütte K.Swarming behaviour and mass occurrences in the world's largest giant pill-millipede species, Zoosphaerium neptunus, on Madagascar and its implication for conservation efforts (Diplopoda: Sphaerotheriida).Madagascar Conservation and Development.2010; 5(2): 89-94;
27. Meyer-Rochow VB. New observations - with older ones reviewed - on mass migrations in millipedes based on a recent outbreak on Hachijojima (Izu Islands) of the polydesmid diplopod (Chamberlinius hualienensis, Wang 1956): Nothing appears to make much sense. Dongwuxue Yanjiu. 2015 ;36(3):119-32;
28. Zimmermann K R St. Magnus und die Tausendfüßler. Naturmonografie Jagdberggemeinden. 2013: 371-386 (in German);
29. Fontanetti CS, Calligaris IB, Souza TS. A millipede infestation of an urban area of the city of Campinas, Brazil and preliminary toxicity studies of insecticide bendiocarb® to the *Urostreptus atrobrunneus* Pierozzi & Fontanetti, 2006. Arquivos do Instituto Biológico (São Paulo) 2010**;** 77(1, 165-166;
30. Roh JY, Choi JY, Li MS, Jin BR, Je YH. Bacillus thuringiensis as a specific, safe, and effective tool for insect pest control. J Microbiol Biotechnol. 2007;17(4):547-59;
31. Australian Environmental Pest Managers Association 25.08.2016 available at: https://www.aepma.com.au/News/31510/Portuguese_Millipedes_in_WA cited on Jan 16,2022;
32. Jawlowski H Krocionogi południowo-wschodniej Polski Faun. Mus. Zool. Pol.1946; 2:11-23 (in Polish).

Barbara Nieradko-Iwanicka
Katedra i Zakład Higieny i Epidemiologii
Uniwersytet Medyczny w Lublinie
20-093 Lublin, ul. Chodźki 7
e-mail: barbara.nieradko-iwanicka@umlub.pl