The tick associated encyrtid wasp *Ixodiphagus hookeri* (Howard, 1908) (Hymenoptera, Chalcidoidea, Encyrtidae) in Norway – expanding or overlooked?

LARS OVE HANSEN & OVE SØRLIBRÅTEN

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The tiny encyrtid wasp *Ixodiphagus hookeri* (Howard, 1908) has been recorded from Norway. A single female was sweep-netted at Kjøkøy in Fredrikstad municipality [**Ø**] by the junior author in 2021. The wasp is a parasitoid attacking various species of hard ticks, including the castor bean tick *Ixodes ricinus* (Linnaeus, 1758) (Ixodida, Ixodidae). *I. ricinus* is most probably the main host in Norway, and this species is very abundant in coastal areas of southern Norway, including the collecting site. The distribution and biology of *I. hookeri* are briefly discussed together with a short note about previous attempts on using the species in biological control of ticks. *I. hookeri* is most probably not a novel immigrant to Norway, even though the distribution and abundance of *I. ricinus* and the tick-borne disease Lyme borreliosis (*Borrelia* spp.) are increasing because of climate changes. However, this tiny wasp may easily be overlooked, and a record from Finland 1950 indicates that the species has been present in Northern Europe before the climate changes took place. Thus, it seems more likely that it has been overlooked.

Key words: Hymenoptera, Chalcidoidea, Encyrtidae, *Ixodiphagus hookeri*, Ixodida, Ixodidae, Argasidae, *Ixodes ricinus*, Norway, Finland, Europe, Parasitoid, biological control, biocontrol, ticks, *Borrelia*.

Lars Ove Hansen, Natural History Museum, University of Oslo, P.O. Box 1172 Blindern, NO-0318 Oslo, Norway. E-mail: l.o.hansen@nhm.uio.no

Ove Sørlibråten, Åssvingen 3, NO-1852 Mysen, Norway, Norway. E-mail: osoerlib@online.no

Introduction

The genus *Ixodiphagus* Howard, 1907 belongs to the family Encyrtidae (Hymenoptera, Chalcidoidea) and comprises of 15 extant species worldwide (Noyes 2024). Those with known biology are all found parasitizing hard ticks (Ixodida, Ixodidae), except *I. mysorensis* Mani, 1941, which also has been observed attacking soft ticks (Ixodida, Argasidae) (Noyes 2024). The behaviour of this genus represents an exception among parasitic Hymenoptera, because these are the only known representatives to parasitize the order Ixodida (e.g. Noyes & Hayat 1994, Hu *et al.* 1998, Noyes 2024). The biology of *Ixodiphagus hookeri* Howard, 1908 is well investigated, and hosts are found among the following genera: *Amblyomma* Koch, 1844, *Dermacentor* Koch, 1844, *Haemaphysalis* Koch, 1844, *Hyalomma* Koch, 1844, *Ixodes* Latreille, 1795 and *Rhipicephalus* Koch, 1844 (Ixodidae) (Howard 1908, Hu *et al.* 1998, Takasu & Nakamura 2008, Noyes 2024). The European castor bean tick *Ixodes ricinus* (Linnaeus, 1758) appears to be the preferred host in Europe (Collatz *et al.* 2010, Sormunen *et al.* 2019, Noyes 2024).

The distribution and abundance of *I. ricinus*, the tick-borne disease Lyme borreliosis (*Borrelia* spp.) and the lethal tick-borne encephalitis (TBE) are all increasing in Northern Europe, most probably due to climate changes (Gray *et al.* 2009, Jore *et al.* 2011, 2014, Jaenson *et al.* 2012, Hvidsten *et al.* 2014, Ocampo *et al.* 2015). Because of the potential of *I. hookeri* as a natural enemy of ticks and subsequently tick-borne diseases, the species has been investigated and introduced to new areas for use in biocontrol (Hu *et al.* 1998, Collatz *et al.* 2010, Ramos *et al.* 2023). Unfortunately, the results have been quite modest apart from a few exceptions.

I. hookeri is not reported from Sweden, Denmark nor the Baltic countries, but some records are present from Southern Finland. The oldest is from Lohja municipality 1950, and then there are several records from the island of Seili in Pargas municipality 2013–17 (Koponen & Vikberg 2015, Sormunen *et al.* 2019).

This article presents the first record of *I. hookeri* in Norway. The aim of this study is to highlight the distribution of the chalcid family Encyrtidae in Norway, to produce a complete list of the Norwegian species of the family, and finally provide a catalogue of Norwegian Chalcidoidea (Hansen & Japoshvili 2018).

Material and method

The specimen was sweep netted on the location, transferred to 75% ethanol, and then processed and dried with Hexamethyldisilazane according to Noyes (2024). The specimen was card mounted, pinned, labelled, and deposited in the collection at the Natural History Museum of Oslo, Norway. The taxonomy follows Noyes (2024), the faunistic divisions in Norway are written in **bold** and given in accordance with Økland (1981), and the coordinates are given in decimal degrees (Grid: Lat/Lon hddd.dddd°; datum: WGS84). The data on biology and distribution are mainly extracted from Noyes (2024).

The Norwegian record

***Ixodiphagus hookeri* (Howard, 1908)**
[Syn.: *Hunterellus hookeri* Howard, 1908]
[Syn.: *Ixodiphagus caucurtei* Buysson, 1912]

Material. Viken county [Østfold **Ø**] Fredrikstad: Kjøkøy, Skams klove [59.136383N 10.948311E ±25m, 66 m a.s.l.] 1♀ sweep netted at one of several visits to the locality in the period 23 June–18 July 2021, leg. Ove Sørlibråten. The specimen was netted in a mixed forest patch with oak (*Quercus* sp.), less than 400 m from the seashore. The European castor bean tick *Ixodes ricinus* was very common at the locality and may represent the host. The specimen is illustrated in Figure 1.

Distribution. EUROPE: Czech Republic, England, Finland, France, Germany, Hungary, Moldova, Norway [this record], Portugal, Russia (Adygey AO, Novgorod oblast), Slovakia, Spain and Ukraine; AFRICA: Angola, Ivory Coast, Kenya, Mozambique, Madeira, Nigeria, Senegal, South Africa, Tanzania and Uganda; ASIA: India, Indonesia, Kazakhstan, Malaysia, Russia (Primor'ye Kray, Khabarovskiy Kray); Singapore, Uzbekistan, Vietnam; AMERICA: Argentina, Brazil, Canada, Cuba, Guadeloupe, Mexico, Puerto Rico, Trinidad & Tobago and United States of America; AUSTRALIA: Australia; (Kopponen & Vikberg 2015, Gaye 2020, Noyes 2024).

Morphology and biology

Ixodiphagus hookeri is a tiny wasp with a slightly atypical morphology compared with typical encyrtid wasps, which makes it easy to recognize in samples. It is almost black, measuring 0.8 –0.9 mm in length, and the wingspan around 1.5 mm (Figure 1). The head and thorax are flattened dorsally and the compound eyes are large. The females have club shaped antennae with eleven segments, while males have thread-like antennae with ten segments (Figure 2) (Howard 1908, Buysson 1912, Trjapitzin 1989).

The flight period is usually short in Europe. In Finland the wasp has been collected from mid-July through August (Kopponen & Vikberg 2015,

FIGURE 1. *Ixodiphagus hookeri* (Howard, 1908) ♀ from Skams Klove, Kjøkøy, Fredrikstad. Scale 0.1 mm. Photo: Geir Søli.

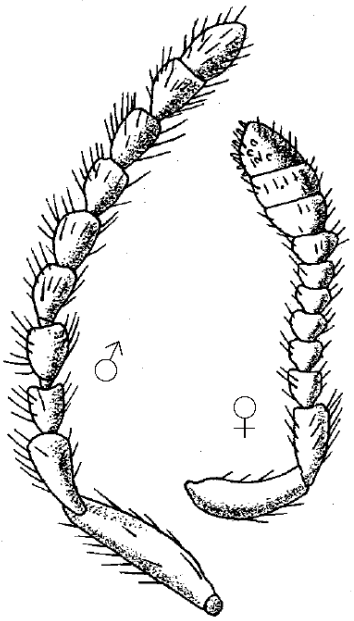

FIGURE 2. Antennae of *Ixodiphagus caucurtei* Buysson, 1912 [= *Ixodiphagus hookeri*], modified after Buysson (1912).

Sormunen *et al.* 2019), and it is assumed that the flight period is similar in southern Norway due to almost similar latitude and altitude.

The female wasp normally injects an egg into the body of an unfed nymph or occasionally an adult of the tick, but the nymph seems to be the preferred instar (Takasu and Nakamura 2008, Collatz *et al.* 2011, Ramos *et al.* 2023). *I. hookeri* lays between 120 and 200 eggs. They stay in diapause until the tick engorges of blood from a vertebrate. Some eggs may be rejected, as the immune system of the tick may incapsulate them. The wasp larvae stay as koinobiont parasitoids in the tick from 28 to 70 days before emerging (Ramos *et al.* 2023). The bacteria *Wolbachia* is symbiotic with the wasp, and the presence in the tick is a possible indicator of infestation by *Ixodiphagus* (Plantard *et al.* 2012, Ramos *et al.* 2023). *Wolbachia* may have a role in suppressing the immune system of the tick, but also plays a role in the parthenogenesis of the wasp.

I. ricinus is annoying and may transmit diseases such as Lyme borreliosis (*Borrelia* spp.)

and the lethal tick-borne encephalitis (TBE). Shortly after the description of *I. hookeri* in 1908, the species was included in biocontrol programs of ticks and tick-borne diseases (Ramos *et al.* 2023). Breeding programs were established and parasitized nymphs were shipped and released in areas inside and outside the US, including Europe, Africa and the Far East (Hu *et al.* 1998, Collatz *et al.* 2010, Ramos *et al.* 2023). All attempts failed, and if there were any effect, it must have been very modest.

At least 33 species of Ixodidae have been reported as hosts of *I. hookeri* (Noyes 2024). The wasp is also able to attack different hosts on the same locality (Buczek *et al.* 2021).

Discussion

It is to be assumed that *Ixodiphagus hookeri* is established in Norway, and the species may have been present for a longer period like in Finland, even though it is reported for the first time from Norway here. Thus, it is hard to be conclusive based on one record. However, *Ixodes ricinus* has obviously become more widespread and common in northern Europe both northwards and in the inland in recent decades due to climate changes (Hvidsten *et al.* 2014, Ocampo *et al.* 2016), and the wasp may have had a similar expansion. Further investigations are needed to clarify the presence and distribution of *I. hookeri* in Norway. Preferable monitoring methods are hatching, use of chemical attractants and sweep-netting, but malaise traps are not recommended (Sormunen *et al.* 2019, Ramos *et al.* 2023, pers. obs.).

No biocontrol programs based on *I. hookeri* have hitherto been carried out in Northern Europe, and it is not recommended until further. The chances of failure are still too great, and new knowledge must be acquired before such kind of programs can be initiated on freeland.

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References

Buczek, A., Buczek, W., Bartosik, K., Kulisz, J., & Stanko, M. 2021. *Ixodiphagus hookeri* wasps (Hymenoptera: Encyrtidae) in two sympatric tick species *Ixodes ricinus* and *Haemaphysalis concinna* (Ixodida: Ixodidae) in the Slovak Karst (Slovakia): ecological and biological considerations. *Scientific Reports* 2021 (11), 11310. 10 pp.

Buysson, R. du. 1912. Un Hyménoptere parasite des Ixodes. *Archives de Parasitologie* 15, 246.

Collatz, J., Selzer, P., Fuhrmann, A., Oehme, R., Mackenstedt, U., Kahl, O. & Steidle, J.L.M. 2010. A hidden beneficial: Biology of the tick-wasp *Ixodiphagus hookeri* in Germany. *Journal of Applied Entomology* 135(5), 351–358.

Gaye, M., Amanzougaghenem, N., Laidoudi, Y., Niang, E.H.A., Sekeyová Z., Laroche, M., Bérenger, J.-M., Raoult, D., Kazimírová, M., Fenollar, F. & Mediannikov, O. 2020. Hymenopteran Parasitoids of Hard Ticks in Western Africa and the Russian Far East *Microorganisms* 8, 1992, 1–13.

Gray, J.S., Dautel, H., Estrada-Peña, A., Kahl, O. & Lindgren, E. 2009. Effects of climate change on ticks and tick-borne diseases in Europe. *Interdisciplinary Perspectives on Infectious Diseases.* Volume 2009 (593232), 1–12 pp.

Hansen, L.O. & Japoshvili, G. 2018. New records of Encyrtidae (Hymenoptera, Chalcidoidea) from Norway VII. *Norwegian Journal of Entomology* 65, 101–107.

Howard, L.O. 1908. Another chalcidoid parasite of a tick. *The Canadian Entomologist*. 40 (7), 239–241.

Hu, R., Hyland, K.E., & Oliver, J.H., 1998. A review on the use of *Ixodiphagus* wasps (Hymenoptera: Encyrtidae) as natural enemies for the control of ticks (Acari: Ixodidae). *Systematic and Applied Acarology* 3, 19–28.

Hvidsten, D., Stuen, S., Jenkins, A., Dienus, O., Olsen, R.S., Kristiansen, B.-E., Mehl, R. & Matussek, A. 2014. *Ixodes ricinus* and *Borrelia* prevalence at the Arctic Circle in Norway. *Ticks and Tick-borne Diseases* 5(2), 107–112.

Jaenson, T.G.T., Jaenson, D.G.E., Eisen, L., Petersson, E. & Lindgren, E. 2012. Changes in the geographical distribution and abundance of the tick *Ixodes ricinus*

during the past 30 years in Sweden. *Parasites Vectors* 5(1), 1–15

Jore, S., Viljugrein, H., Hofshagen, M., Brun-Hansen, H., Kristoffersen, A.B., Nygård, K., Brun, E., Ottesen, P., Sævik, B.K. & Ytrehus, B. 2011. Multi-source analysis reveals latitudinal and altitudinal shifts in range of *Ixodes ricinus* at its northern distribution limit. *Parasites Vectors* 4(84), 1–11.

Jore, S., Vanwambeke, S.O., Viljugrein, H., Isaksen, K., Kristoffersen, A.B., Woldehiwet, Z., Johansen, B., Brun, E., Brun-Hansen, H., Westermann, S., Larsen, I.-L., Ytrehus, B., & Hofshagen, M. 2014. Climate and environmental change drives *Ixodes ricinus* geographical expansion at the northern range margin. *Parasites Vectors* 7 (11), 1–14.

Koponen, M. & Vikberg, V. 2015. Suomen hyppykiilupistiäiset [Check list of the species of Encyrtidae in Finland] (Hymenoptera, Chalcidoidea, Encyrtidae). *Sahlbergia* 21(1), 12–43.

Noyes, J.S. 2024. Universal Chalcidoidea Database. World Wide Web electronic publication. http://www.nhm.ac.uk/chalcidoids [Last accessed: 4 May 2024].

Noyes, J.S. & Hayat, M. 1994. Oriental Mealybug Parasitoids of the Anagyrini (Hymenoptera: Encyrtidae) with a world review of Encyrtidae used in classical biological control and an index of encyrtid parasitoids of mealybugs (Homoptera: Pseudococcidae). The Natural History Museum, London. CAB international. 554 pp.

Ocampo, J.M.F., Jore, S., Andreassen, Å.K., Wiklund, B.S., Dudman, S., Ottesen, P., Sandbu, S., Soleng, A., Vainio, K., Aaberge, I. & Vold, L. 2016. Årsrapport - Flått og flåttbårne sykdommer i 2015. Nasjonalt folkehelseinstitutt. ISBN 978-82-8082-742-5. 34pp.

Økland, K.A. 1981. Inndeling av Norge til bruk ved biogeografiske oppgaver – et revidert Strand-system. *Fauna (Oslo)* 34, 167–178.

Plantard, O., Bouju-Albert, A., Malard, M-A., Hermouet, A., Gilles, C., & Verheyden, H. 2012. Detection of *Wolbachia* in the Tick *Ixodes ricinus* is Due to the Presence of the Hymenoptera Endoparasitoid *Ixodiphagus hookeri*. *PLOS ONE* 7 (1), e30692. 8 pp.

Ramos, R.A.N., de Macedo, L.O., Bezerra-Santos, M.A., de Carvalho, G.A.; Verocai, G.G., & Otranto, D. 2023. The Role of Parasitoid Wasps, *Ixodiphagus* spp. (Hymenoptera: Encyrtidae), in Tick Control. *Pathogens 2023,* 12, 676. 11 pp. https://doi.org/10.3390/pathogens12050676.

Sormunen, J.J., Sippola, E., Kaunisto, K.M., Vesterinen, E.J. & Sääksjärvi, I.E. 2019. First evidence of *Ixodiphagus hookeri* (Hymenoptera: Encyrtidae) parasitization in Finnish castor bean ticks (*Ixodes ricinus*). *Experimental and Applied Acarology* 79, 395–404.

Takasu, K. & Nakamura, S. 2008. Life history of the tick parasitoid *Ixodiphagus hookeri* (Hymenoptera: Encyrtidae) in Kenya. *Biological Control* 46, 114 –121.

Trjapitzin, V.A. 1989. *Parasitic Hymenoptera of the Fam. Encyrtidae of Palaearctics.* Opredeliteli po Faune SSSR 158: 288. Zoologicheskim Institutom Akademii Nauk SSR, Leningrad. 488 pp.

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