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Is *Manica rubida* (Hymenoptera: Formicidae) a potential host of the *Maculinea alcon* (Lepidoptera: Lycaenidae) group?

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Abstract

The caterpillars of *Maculinea* butterflies are obligate parasites of nests of *Myrmica* (or in certain cases *Aphaenogaster*) ants during most of their development. *Manica rubida* (LATREILLE, 1802) is closely related to ants of the genus *Myrmica*, and can occur on *Maculinea* sites. Laboratory colonies of *M. rubida* were therefore tested for their ability to raise caterpillars of *Maculinea rebeli* (HIRSCHKE, 1904) and *M. alcon* (DENIS & SCHIFFERMÜLLER, 1775). After introduction into the foraging arenas of these colonies, all caterpillars were taken into the nest by worker ants, where they were often carried and licked. Several caterpillars of both butterflies survived and increased in size for a number of weeks, up to one and a half months. These results suggest that *M. rubida* could potentially act as a host for *Maculinea* caterpillars, although whether any local populations have evolved to specialise on this potential host remains to be demonstrated in the fields.

Key words: *Manica*, *Maculinea*, host specificity, myrmecophily

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Introduction

Myrmecophily is a well-known phenomenon among several insect taxa (HÖLLDOBLER & WILSON 1990). The lycaenid butterflies are particularly interesting in this respect, because the larvae of most species studied are associated with ants. Facultative and obligate myrmecophily and the entire range from mutualism to parasitism can be observed among these butterflies (FIEDLER 1991, PIERCE & al. 2002). The best-known example of obligate parasitism is the genus *Maculinea*, where after feeding on a host plant for the first three larval instars, the fourth instar larva must complete its development in a host ant nest. Knowledge of the host ant species has been shown to be crucial for the protection of these endangered butterflies (e.g., ELMES & THOMAS 1992). Ants from only two genera are recorded as hosts of these butterflies: The vast majority of *Maculinea* use hosts from the genus *Myrmica* (e.g., THOMAS & al. 1989, ALS & al. 2002, STEINER & al. 2003) but *Maculinea teleius* (BERGSTRÄSSER, 1779) and especially *M. arionides* (STAUDINGER, 1887) have also been recorded as using *Aphaenogaster japonica* FOREL, 1911 in Japan (YAMAGUCHI 1988, PIERCE & al. 2002).

Manica rubida (LATREILLE, 1802) is quite closely related to ants in the genus *Myrmica* (e.g., ASTRUC & al. 2004), and was classified as a member of this genus by FOREL (1915). This ant occurs in mountains at altitudes of 500 - 2000 m in Asia Minor, the Caucasus, Central Europe, the Crimea and parts of Southern Europe (CZECHOWSKI & al. 2002). All five European species of *Maculinea* occur in some of these regions. Moreover, *M. arion* (LINNAEUS, 1758), *M. alcon* (DENIS & SCHIFFERMÜLLER, 1775) and *M. rebeli* (HIRSCHKE, 1904) populations are known from the same altitudes (e.g., WYNHOFF 1998). The co-occurrence of *Manica rubida*, *M. rebeli* and host gentians with eggs was observed at the same site near Lacul Roşu (Romania: Hargita County; S. Csősz, pers. comm.).

Based on this distribution, the question arose as to whether *Manica rubida* could potentially be a host ant of *Maculinea* butterflies. This ant has never been observed in association with any myrmecophilous lycaenid so far (FIEDLER 2001). Hence I tested the ability of laboratory colonies of this ant to adopt and raise caterpillars of *M. rebeli* and *M. alcon*.

Material and methods

Although the level of genetic (ALS & al. 2004; J. Bereczki, K. Pecsenye & Z.S. Varga, pers. comm.) and morphologic (PECH & al. 2004) differentiation between the traditional species *M. alcon* and *M. rebeli* is rather low, I differentiate "*M. rebeli*" from *M. alcon* here mostly for physiological and ecological reasons, and because sympatric populations usually have different host ant species in the same region. In Western Europe, *M. rebeli* primarily uses *Myrmica schencki* VIERECK, 1903 (THOMAS & al. 1989) but *M. alcon* mainly uses *Myrmica scabrinodis* NYLANDER, 1846, *M. rubra* (LINNAEUS, 1758) or *M.*

Tab. 1: The number of introduced (*) and surviving *Maculinea alcon* and *M. rebeli* caterpillars in *Manica rubida* colonies from week to week.

Date (2003)	Colony 1	Colony 2	Colony 3	Colony 4	Colony 5	
	M. rebeli	*M. rebeli*	*M. alcon*	*M. alcon*	*M. rebeli*	*M. alcon*
15 July	10*	10*	-	-	-	-
22 July	4	9	-	-	-	-
29 July	2	8	-	-	3*	-
05 August	2	5	10*	10*	2	1*
12 August	1	4	10	7	2	1
19 August	0	3	7	6	2	1
26 August	0	1	6	3	1	1
02 September	0	0	4	3	1	0
09 September	0	0	1	1	0	0
16 September	0	0	1	0	0	0
23 September	0	0	0	0	0	0

ruginodis NYLANDER, 1846 (THOMAS & al. 1989, ELMES & al. 1994, ALS & al. 2002) host ants. However, in Central Europe *M. alcon* is almost always found in colonies of *M. scabrinodis* (SIELEZNIEW & STANKIEWICZ 2002, HÖTTINGER & al. 2003, TARTALLY & CSŐSZ in press), and *M. rebeli* is mostly found in nests of *Myrmica sabuleti* MEINERT, 1861, *M. schencki* and *M. scabrinodis* (STEINER & al. 2003, TARTALLY & CSŐSZ in press).

In the summer of 2003, I introduced 21 caterpillars of *M. alcon* from Mátraszentimre (Hungary: Heves County) and 23 caterpillars of *M. rebeli* from Bükkszentkereszt (Hungary: Borsod-Abaúj-Zemplén County) into five artificial colonies of *Manica rubida* (Tab. 1). It should be noted that all the caterpillars were from mountains where *M. rubida* has not been recorded (SOMFAI 1959; pers. observ.). The same methods were used in the collection and introduction of the caterpillars and in the keeping of the *M. rubida* colonies as had previously been used for culturing *Maculinea alcon* and *M. rebeli* caterpillars in artificial *Myrmica* colonies (TARTALLY in press).

The *Manica rubida* colonies were collected from Sovata (Rumania: Mureş County) in March of 2003. Colonies 1 - 4 (Tab. 1) contained one queen, brood, and at least 150 workers, while Colony 5 contained one queen, brood, and only 50 workers. This last colony was used primarily for making a video record of the interaction, because smaller caterpillars in a dense colony are not easily visible. Colony 5 was videotaped on 5 August 2003 when a freshly adopted *M. alcon* caterpillar and two *M. rebeli* caterpillars (introduced one week before) were present. Discrimination between the two *Maculinea* species after adoption based on size was not difficult because *M. rebeli* caterpillars grow much quicker than those of *M. alcon* in the Hungarian populations in late summer (TARTALLY in press and unpublished data). Similar phenomena are also known from other countries (e.g., SCHÖNROGGE & al. 2000).

The caterpillars of each butterfly species were introduced to the foraging arena of the same colony together at the same time. Colonies were then checked for surviving caterpillars once per week (Tab. 1). Before introduction, the length of each caterpillar was measured with a ruler. Caterpillars were remeasured after one month by putting the ruler to the glass which covered the artificial nests. This allowed the survival and growth of the caterpillars to be recorded while causing the minimum of disturbance.

Results

After introduction the *Manica rubida* workers carried each caterpillar from the foraging arena to the nest within one hour. Several caterpillars of both *M. alcon* and *M. rebeli* survived in the nests for a number of weeks, up to one and a half months (Tab. 1). The remains of dead caterpillars were often found in the arena among the rubbish.

Both *M. alcon* and *M. rebeli* caterpillars were about 3 mm long on introduction, and a month later the former had grown to about 5 mm while the latter had grown to about 10 mm. The workers antennated, licked and carried the caterpillars within the nest (Fig. 1; see the MPEG files showing extracts of the videotape at http://www.zool.klte.hu/macman or http://www.oegef.at/). I observed caterpillars eating ant brood, but it was not clear if the caterpillars were also fed directly by the worker ants.

Discussion

My results show that laboratory *Manica rubida* colonies readily adopted *Maculinea* caterpillars, some of which survived for up to six weeks, during which they

grew considerably. This contrasts with the field observations of THOMAS & al. (1989) on another ant of the subfamily Myrmicinae, *Tetramorium caespitum* (LINNAEUS, 1758). They noted that "... several young *M. rebeli* larvae were seen being taken by *Tetramorium caespitum* L. soon after leaving their foodplant, but these were presumably taken as food by this voracious predator, for no trace of them was found in the nests soon afterwards." (THOMAS & al. 1989: 453). Similarly, ELFFERICH (1988) did not observe adoption of *M. alcon* caterpillars by *T. caespitum* nor by *Lasius flavus* (FABRICIUS, 1781), *L. niger* (LINNAEUS, 1758), *Formica fusca* LINNAEUS, 1758 and *F. sanguinea* LATREILLE, 1798 under artificial conditions. The caterpillars were often carried or tapped by the workers after the introduction but each of them was dead the next day or was carried out of the nest. However, he observed successful adoption and rearing by *Myrmica ruginodis* and this was the only ant species which licked the caterpillars. ELFFERICH (1988) considered this behaviour as obligatory for the survival of caterpillars. Similarly, in my experiments the caterpillars not only survived and grew but also were licked by the workers of *Manica rubida* (Fig. 1B). These phenomena show the potential suitability of *M. rubida* as a host for *Maculinea*. It is therefore possible that caterpillars of some *Maculinea* populations could fully develop in *M. rubida* nests at high altitudes.

It is important to emphasize that we cannot predict the host ant species used by a particular population of *Maculinea* butterflies using the data recorded from other populations. Different populations of these butterflies have evolved to use different hosts in different parts of their geographical ranges (ELMES & al. 1994, ALS & al. 2002). Moreover, within the islands of Japan *M. teleius* has been recorded as using hosts from two different ant genera: a *Myrmica* species (*M. ruginodis*) and an *Aphaenogaster* species (*A. japonica*) (YAMAGUCHI 1988).

Manica rubida is remarkably open in its social structure, even allowing for heterospecific colonies (with *Formica selysi* BONDROIT, 1918) to be established in the laboratory (ERRARD & JALLON 1987). This could potentially increase the suitability of this ant as a host of myrmecophilous insects. Additionally MALICKY (1969) reported experimental observations that *Manica* ants show standard, non-aggressive (but rather unspecific) tending behaviour to a range of (unspecified) lycaenid species. Whether the potential of *M. rubida* as a host of *Maculinea* butterflies that I have shown in the laboratory is realized in the field remains to be demonstrated. As far as I know there are no records of *Maculinea* pupae, caterpillars or exuvia from nests of *M. rubida* in the wild, but this may also reflect lack of search effort. On the other hand it has also been shown that a *Myrmica* species that does not act as a host to *Maculinea* from a particular population in the wild can be a good

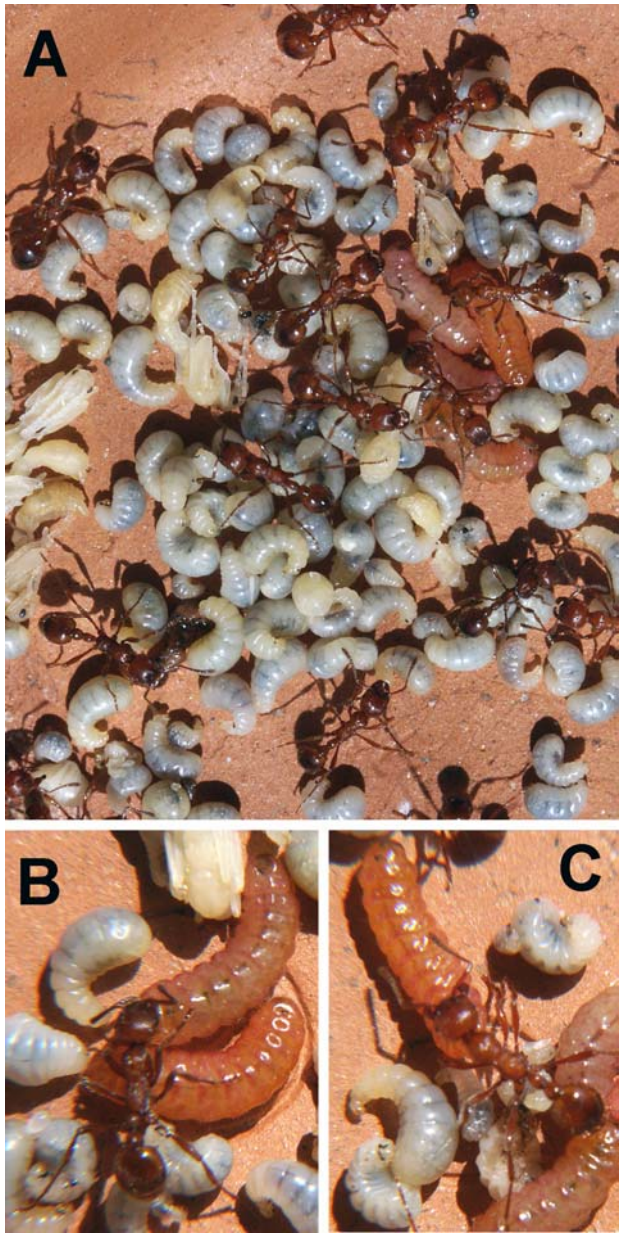

Fig. 1: These well-fed *Maculinea rebeli* caterpillars were not only at peace among the *Manica rubida* brood (A) but the workers often licked (B) and carried (C) them (photos by Péter Kozma of Colony 2 on 12 August 2003).

host in the laboratory when well-fed and not subject to stress (ELMES & al. 2004, SCHÖNROGGE & al. 2004).

It has been shown that the primary means of gaining entry to and surviving in *Myrmica* host ant nests is mimicry, whether it be of acoustic signals (DEVRIES & al. 1993) or of brood or colony odours (AKINO & al. 1999, ELMES & al. 2002, SCHLICK-STEINER & al. 2004, SCHÖNROGGE & al. 2004). My results suggest that the signals of caterpillars matched the template of *Manica rubida* sufficiently, well enough to induce adoption and to some degree acceptance in the nest – which is not surprising considering the close phylogenetic proximity of the genera

Manica and *Myrmica* (ASTRUC & al. 2004). However, the caterpillars in this study were from sites where the *Manica rubida* did not occur. Whether better mimicry of *M. rubida* can evolve in areas where it is found on *Maculinea* sites remains to be seen. In any case it would be interesting to compare the acoustical and chemical signatures of *M. rubida* with those of *Myrmica* species and to *Maculinea* caterpillars from *M. rubida* sites. In addition, it would be interesting to further test whether caterpillars of *M. alcon* and *M. rebeli* in *M. rubida* colonies get all their nutrition by eating the ant brood (which is not an unfamiliar food of "cuckoo-feeder" caterpillars; e.g., ELFFERICH 1988), or whether they can also be fed by trophallaxis by the worker ants as they are in *Myrmica* host nests.

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Zusammenfassung

Die Larven von *Maculinea*-Bläulingen leben den Großteil ihrer Entwicklung als obligate Parasiten in Nestern von *Myrmica*-Ameisen (oder in Einzelfällen von *Aphaenogaster*). *Manica rubida* (LATREILLE, 1802) ist der Gattung *Myrmica* nahe verwandt und kommt unter anderem auch in Lebensräumen von *Maculinea* vor. Ich testete daher im Laborversuch, ob *M. rubida* Larven von *Maculinea rebeli* (HIRSCHKE, 1904) und *M. alcon* (DENIS & SCHIFFERMÜLLER, 1775) großziehen kann. Nach dem Einsetzen der *Maculinea*-Larven in die Arenen der Laborkolonien wurden alle Larven von Ameisenarbeiterinnen ins Nest gebracht, wo sie häufig umgelagert und beleckt wurden. Einige Larven beider Schmetterlingsarten überlebten und wuchsen einige Wochen, maximal eineinhalb Monate lang. Diese Ergebnisse legen nahe, dass *M. rubida* ein potentieller Wirt von *Maculinea*-Larven sein könnte. Ob sich tatsächlich lokale *Maculinea*-Populationen auf diesen potentiellen Wirten spezialisiert haben, muss allerdings im Freiland überprüft werden.

References

AKINO, T., KNAPP, J.J., THOMAS, J.A. & ELMES, G.W. 1999: Chemical mimicry and host specificity in the butterfly *Maculinea rebeli*, a social parasite of *Myrmica* ant colonies. – Proceedings of the Royal Society of London, Series B 266: 1419-1426.

ALS, T.D., NASH, D.R. & BOOMSMA, J.J. 2002: Geographical variation in host-ant specificity of the parasitic butterfly *Maculinea alcon* in Denmark. – Ecological Entomology 27: 403-414.

ALS, T.D., VILA, R., KANDUL, N.P., NASH, D.R., YEN, S.-H., HSU, Y.F., MIGNAULT, A.A., BOOMSMA, J.J. & PIERCE, N.E. 2004: The evolution of alternative parasitic life histories in Large Blue butterflies. – Nature 432: 386-390.

ASTRUC, C., JULIEN, J.F., ERRARD, C. & LENOIR, A. 2004: Phylogeny of ants (Formicidae) based on morphology and DNA sequence data. – Molecular Phylogenetics and Evolution 31: 880-893.

CZECHOWSKI, W., RADCHENKO, A. & CZECHOWSKA, W. 2002: The ants (Hymenoptera, Formicidae) of Poland. – Studio 1, Warszawa, 200 pp.

DEVRIES, P.J., COCROFT, R.B. & THOMAS, J.A. 1993: Comparison of acoustical signals in *Maculinea* butterfly caterpillars and their obligate host *Myrmica* ants. – Biological Journal of the Linnean Society 49: 229-238.

ELFFERICH, N.W. 1988: Zuchterfahrungen mit *Maculinea alcon* (DENIS & SCHIFFERMÜLLER, 1775) (Lepidoptera, Lycaenidae). – Mitteilungen der Entomologischen Gesellschaft Basel 38: 134-150.

ELMES, G.W., AKINO, T., THOMAS, J.A., CLARKE, R.T. & KNAPP, J.J. 2002: Interspecific differences in cuticular hydrocarbon profiles of *Myrmica* ants are sufficiently consistent to explain host specificity by *Maculinea* (large blue) butterflies. – Oecologia 130: 525-535.

ELMES, G.W. & THOMAS, J.A. 1992: Complexity of species conservation in managed habitats: interaction between *Maculinea* butterflies and their ant hosts. – Biodiversity and Conservation 1: 155-169.

ELMES, G.W., THOMAS, J.A., HAMMARSTEDT, O., MUNGUIRA, M.L., MARTIN, J. & VAN DER MADE, J. 1994: Differences in host-ant specificity between Spanish, Dutch and Swedish populations of the endangered butterfly, *Maculinea alcon* (DENIS et SCHIFF.) (Lepidoptera). – Memorabilia Zoologica 48: 55-68.

ELMES, G.W., WARDLAW, J.C., SCHÖNROGGE, K. & THOMAS, J.A. 2004: Food stress causes differential survival of socially parasitic larvae of *Maculinea rebeli* (Lepidoptera, Lycaenidae) integrated in colonies of host and non-host *Myrmica* species (Hymenoptera, Formicidae). – Entomologia Experimentalis et Applicata 110: 53-63.

ERRARD, C. & JALLON, J.M. 1987: An investigation of the development of the chemical factors in ants intra-society recognition. In: EDER, J. & REMBOLD, H. (Eds.): Chemistry and biology of social insects. – Verlag J. Peperny, München, p. 478.

FIEDLER, K. 1991: Systematic, evolutionary, and ecological implications of myrmecophily within the Lycaenidae (Insecta: Lepidoptera: Papilionoidea). – Bonner Zoologische Monographien 31: 5-157.

FIEDLER, K. 2001: Ants that associate with Lycaenidae butterfly larvae: diversity, ecology and biogeography. – Diversity and Distributions 7:45-60.

FOREL, A. 1915: Fauna insectorum helvetiae. Hymenoptera. Formicidae. Die Ameisen der Schweiz. – Mitteilungen der Schweizerischen Entomologischen Gesellschaft 12 (Beilage): 1-77.

HÖLLDOBLER, B. & WILSON, E.O. 1990: The Ants. – The Belknap Press of Harvard University Press, Cambridge, Massachusetts, 732 pp.

HÖTTINGER, H., SCHLICK-STEINER, B.C. & STEINER, F.M. 2003: The Alcon blue *Maculinea alcon* (Lepidoptera: Lycaenidae) in eastern Austria: status and conservation measures. – Ecology (Bratislava) 22: 107-118.

MALICKY, H. 1969: Versuch einer Analyse der ökologischen Beziehungen zwischen Lycaeniden (Lepidoptera) und Formiciden (Hymenoptera). – Tijdschrift voor Entomologie 112: 213-298.

PECH, P., FRIC, Z., KONVIČKA, M. & ZRAVÝ, J. 2004: Phylogeny of *Maculinea* blues (Lepidoptera: Lycaenidae) based on morphological and ecological characters: evolution of parasitic myrmecophily. – Cladistics 20: 362-375.

PIERCE, N.E., BRABY, M.F., HEATH, A., LOHMAN, D.J., MATHEW, J., RAND, D.B. & TRAVASSOS, M.A. 2002: The ecology and evolution of ant association in the Lycaenidae (Lepidoptera). – Annual Reviews of Entomology 47: 733-771.

SCHLICK-STEINER, B.C., STEINER, F.M., HÖTTINGER, H., NIKIFOROV, A., MISTRIK, R., SCHAFELLNER, C., BAIER, P. & CHRISTIAN, E. 2004: A butterfly's chemical key to various ant forts: intersection-odour or aggregate-odour multi-host mimicry? – Naturwissenschaften 91: 209-214.

SCHÖNROGGE, K., WARDLAW, J.C., THOMAS, J.A. & ELMES, G.W. 2000: Polymorphic growth rates in myrmecophilous insects. – Proceedings of the Royal Society of London, Series B 267: 771–777.

SCHÖNROGGE, K., WARDLAW, J.C, PETERS, A.J., EVERETT, S., THOMAS, J.A. & ELMES, G.W. 2004: Changes in chemical signature and host specificity from larval retrieval to full social integration in the myrmecophilous butterfly *Maculinea rebeli*. – Journal of Chemical Ecology 30: 91-107.

SIELEZNIEW, M. & STANKIEWICZ, A. 2002: First data on host-ant specificity of parasitic butterfly *Maculinea alcon* (DEN. & SCHIFF.) (Lepidoptera: Lycaenidae) in Poland and eastern Europe. – Fragmenta Faunistica 45: 123-130.

SOMFAI, E. 1959: Hangya alkatúak Formicoidea. In: SZÉKESSY, V. (Ed.): Magyarország Állatvilága (Fauna Hungariae). – Akadémiai Kiadó, Budapest 43: 79 pp.

STEINER, F.M., SIELEZNIEW, M., SCHLICK-STEINER, B.C., HÖTTINGER, H., STANKIEWICZ, A. & GÓRNICKI, A. 2003: Host specificity revisited: New data on *Myrmica* host ants of the Lycaenid butterfly *Maculinea rebeli*. – Journal of Insect Conservation 7: 1-6.

TARTALLY, A. in press: Accelerated development of *Maculinea rebeli* larvae under artificial conditions. – Nota Lepidopterologica 27.

TARTALLY, A. & CSŐSZ, S. in press: Adatok a magyarországi *Maculinea* fajok (Lepidoptera: Lycaenidae) hangyagazdáiról (Data on the ant hosts of the *Maculinea* butterflies (Lepidoptera: Lycaenidae) of Hungary). – Természetvédelmi Közlemények 11.

THOMAS, J.A., ELMES, G.W., WARDLAW, J.C. & WOYCIECHOWSKI, M. 1989: Host specificity among *Maculinea* butterflies in *Myrmica* ant nests. – Oecologia 79: 452-457.

WYNHOFF, I. 1998: The recent distribution of the European *Maculinea* species. – Journal of Insect Conservation 2: 15-27.

YAMAGUCHI, S. 1988: The life histories of five myrmecophilous lycaenid butterflies of Japan. – Kodansha, Japan.