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Weather conditions during nuptial flight of *Manica rubida* (LATREILLE, 1802) (Hymenoptera: Formicidae) in southern Poland

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Abstract

Nuptial flight of many ant species occurs when weather conditions are appropriate; defined weather parameters may even initiate it. Various ant species have different seasons of nuptial flight but in Poland most of them take place in summer. Nuptial flights of *Manica rubida* (LATREILLE, 1802) were observed in Piekary Śląskie (Upper Silesia, Poland) in May 2004 and 2005, and also in April and May 2006. Obtained data suggest that appropriate weather conditions may be necessary for alate sexuals of this species to begin their nuptial flight.

The question of reliability of literature data on nuptial flight dates is highlighted. According to literature, nuptial flight of *M. rubida* has a broad time range (from April to September). Overall, weather and climatic conditions, also in context with the semi-claustral mode of colony founding in this species may serve as an explanation of such discrepant reports.

Key words: *Manica rubida*, nuptial flight, mating, swarming, phenology.

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Introduction

Nuptial flight has tremendous importance for ants. Not only does it facilitate copulating by unrelated sexuals, but it also allows young gynes to disperse and to find new localities for nesting. During appropriate weather alate gynes may even pass mountain barriers and settle down on territories beyond the continuous ranges of their species. A worker of *Messor structor* (LATREILLE, 1798) found in Poland (KRZYSZTOFIAK 1984) is a prime example of this phenomenon. This species is distributed from Southern Europe to Central Asia and although it is a permanent inhabitant of Central Europe, it appears in Poland only occasionally, when young gynes manage to pass the Carpathians and establish a colony before winter comes. It may be assumed that in Poland such colonies do not survive winter (SEIFERT 1996, CZECHOWSKI & al. 2002).

The occurrence of nuptial flight is affected by the weather in two different ways. First, the local climatic conditions (depending on altitude and latitude), especially the period over which temperatures are sufficiently high for a proper development of the sexual brood, may influence the date when alates emerge. Second, appropriate weather during the nuptial flight is required. It often happens that the nuptial flight of some species takes place on the same day over a very vast area. It is believed that highly specific weather conditions may act as the trigger to start nuptial flight (SUDD 1967). It is also known that different ant species have different requirements concerning the weather to begin nuptial flight (BOOMSMA & LEUSINK 1981). In the temperate climatic zone most ant species have their nuptial flights during the summer months, especially from June to August, rarely in May or September (see CZECHOWSKI & al. 2002).

Manica rubida (LATREILLE, 1802) is distributed in Europe, Asia Minor and the Caucasus, where it occurs mainly in the mountains (PISARSKI 1975, CZECHOWSKI & al. 2002), reaching 2400 m a.s.l. (KUTTER 1977). In Poland it often inhabits uplands; it is also common in cities in the southern part of the country, e.g., it is very abundant in Piekary Śląskie (Upper Silesia) (Ł. Depa, unpubl). *Manica rubida* builds nests in the ground, often under stones or flagstones, in dry sunny areas, sparsely overgrown by xerophilous vegetation (PISARSKI 1975, CZECHOWSKI & al. 2002).

Sexuals of *M. rubida* appear in the nests at the end of July and in August (WOYCIECHOWSKI 1985). The same is observed in Upper Silesia, but in autumn no nuptial flights have ever been noticed (see CZECHOWSKI & al. 2002).

The mode of colony founding is semi-claustral (WILSON 1971), which means that young gynes are isolated in their chambers but occasionally leave them to find food for their growing brood.

The aim of this study was to define weather conditions during the nuptial flight of *Manica rubida* and to attempt to establish precisely what weather parameters are required to initiate it.

Material and methods

The research was carried out in Piekary Śląskie (18° 58' E, 50° 24' N). Observations were conducted every day from 15 April to 4 June in 2004 and in the same period in 2005 and 2006. The periods were chosen deliberately so that they spanned the earlier observed dates of nuptial flight (DEPA 2004). The study area was about 2000 m^2, covered by hard soil, at a housing estate's outskirts, surrounded in the west by a row of high trees. The choice of the place was deliberate, as in the earlier years it was observed to be a landing area of alate gynes of *M. rubida* after swarming.

Observations of males and gynes flying up in the air from the nests situated near the study area and alate gynes landing on the study area were taken as indicators of nuptial flight. Alate gynes appearing on the ground in the

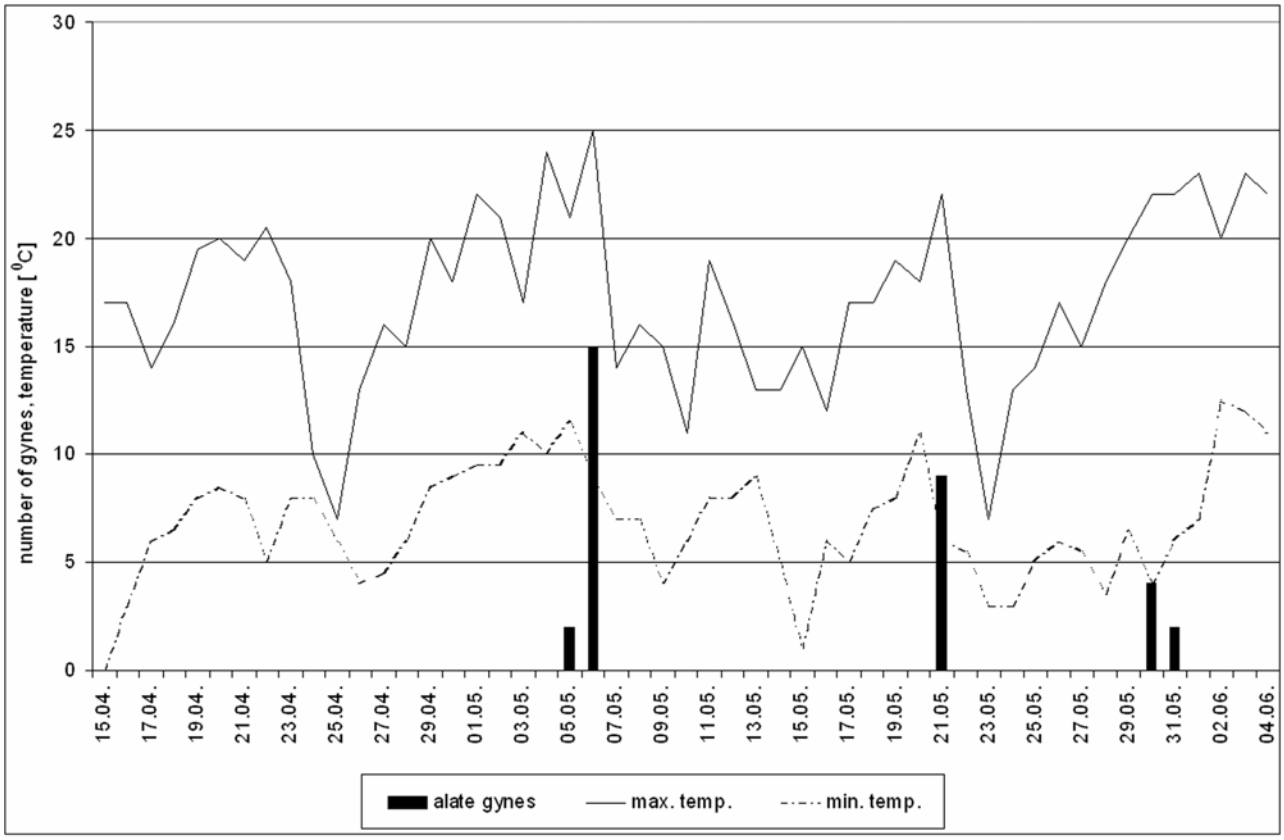

Fig. 1: Weather parameters (maximum and minimum temperature) and the number of alate gynes counted in the study area during the research period in 2004.

study area between 9:00 and 12:00 AM GMT were counted. Meteorological data (temperature, wind velocity, air pressure, relative humidity – each measured 2 m above soil surface) were obtained from a meteorological station at the nearby Pyrzowice airport, which is situated 11 km north-east of Piekary Śląskie. Standard deviation was calculated for days with and without nuptial flight. Student's t-test was used to analyse the differences in mean temperature, humidity, wind velocity and air pressure values for days with and without nuptial flight.

Results

During the research, a total of 113 alate gynes were counted (32 in 2004, 38 in 2005 and 43 in 2006). The numbers of recorded gynes and the weather conditions (maximum and minimum temperature) are presented in Figures 1, 2, and 3. Table 1 presents average, minimum and maximum weather parameters for days with and without nuptial flight.

Nuptial flights began in morning hours, between 7:30 and 10 AM GMT, most often from 8:30 to 9:30 AM GMT, during sunny, warm days, when clouds did not diminish the sunshine. Alate sexuals (males and alate gynes at the same time) were flying in the air either after climbing grass blades or directly from the ground. First alate gynes were recorded in the study area about 10:00 AM GMT, which means that they were landing at least one hour after the nuptial flight began. The most preferable days were of lower than average humidity and higher than average day temperature (Tab. 1). The standard deviation (SD) values for temperature and humidity were significantly lower for days with nuptial flight than for days without it. This means that those two weather parameters tended to be more stable on days with nuptial flight. Also, Student's t-tests indicated that the differences in mean values of temperature and humidity for days with and without nuptial flight were statistically significant ($P < 0.001$ for both parameters). The average atmospheric pressure and average wind velocity during the nuptial flight did not differ significantly from the average for days without nuptial flight. Mean values of those two weather parameters for days with nuptial flight were close to the average for days without nuptial flight and SD values did not show consistent and significant differences.

Swarming usually took place when the "warm sector" of the low-pressure area was over the study area, when warm air masses flowed in, preceding the cold atmospheric front. Nuptial flights were also undertaken when the anticyclonal weather was established and strong convection was developing. In all years ample rain was normally observed later on the same day or on the next day after the nuptial flight. This is illustrated in Figures 1, 2, and 3 by the significant decline in maximum temperature directly after flights.

In the course of this study, no males were observed in the study area where alate gynes were counted. 15 - 30 minutes after landing alate gynes shed their wings and started digging chambers, often in short distances from each other, sometimes < 1 m.

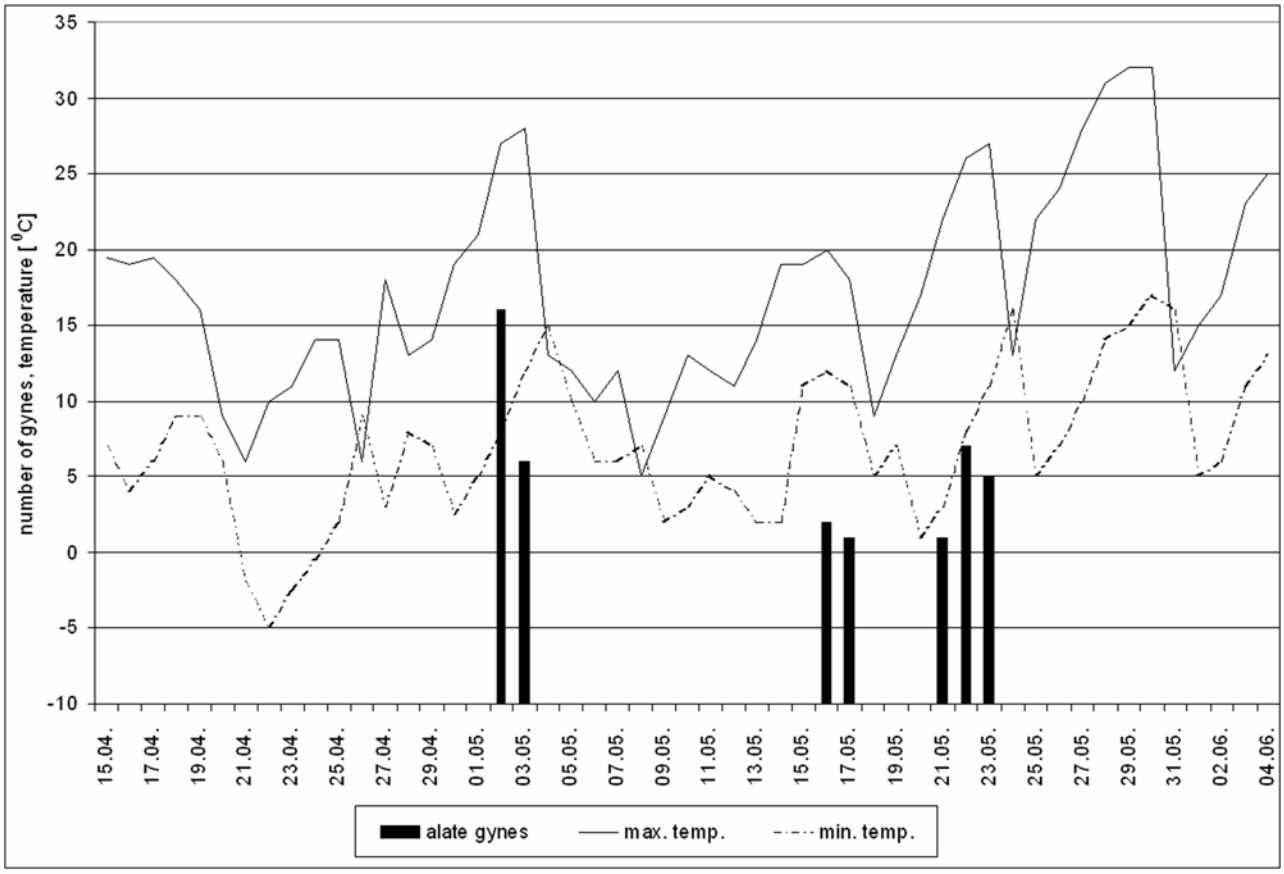

Fig. 2: Weather parameters (maximum and minimum temperature) and the number of alate gynes counted in the study area during the research period in 2005.

Tab. 1: Daily weather parameters (day temperature, air pressure, relative humidity, wind velocity) on days with nuptial flights and on days without nuptial flights, measured over the study period (n – number of days, SD – standard deviation).

		2004				2005				2006			
		days with nuptial flight (n = 5)		days without nuptial flight (n = 46)		days with nuptial flight (n = 7)		days without nuptial flight (n = 44)		days with nuptial flight (n = 7)		days without nuptial flight (n = 44)	
temperature [°C]	average ⎮ SD	22.40	1.52	16.61	3.91	24.00	3.96	16.11	6.69	21.14	1.75	16.58	3.94
	maximum	25		24		28		32		24		25	
	minimum	21		7		18		5		19		7	
air pressure [hPa]	average ⎮ SD	1010.00	14.82	1013.96	7.31	1015.14	3.39	1014.45	7.41	1019.86	4.85	1015.68	4.87
	maximum	1026		1026		1021		1027		1028		1028	
	minimum	993		995		1010		996		1015		1005	
relative humidity [%]	average ⎮ SD	61.00	4.38	69.00	10.53	62.00	7.99	68.00	13.00	51.29	5.31	69.00	9.83
	maximum	68		94		76		99		60		92	
	minimum	56		46		51		40		44		53	
wind velocity [m/s]	average ⎮ SD	2.23	1.48	2.62	1.39	1.90	1.02	2.18	1.73	3.96	0.78	3.70	1.63
	maximum	3.90		5.80		3.06		6.39		4.72		7.72	
	minimum	0.55		0		0.83		0		2.58		1.03	

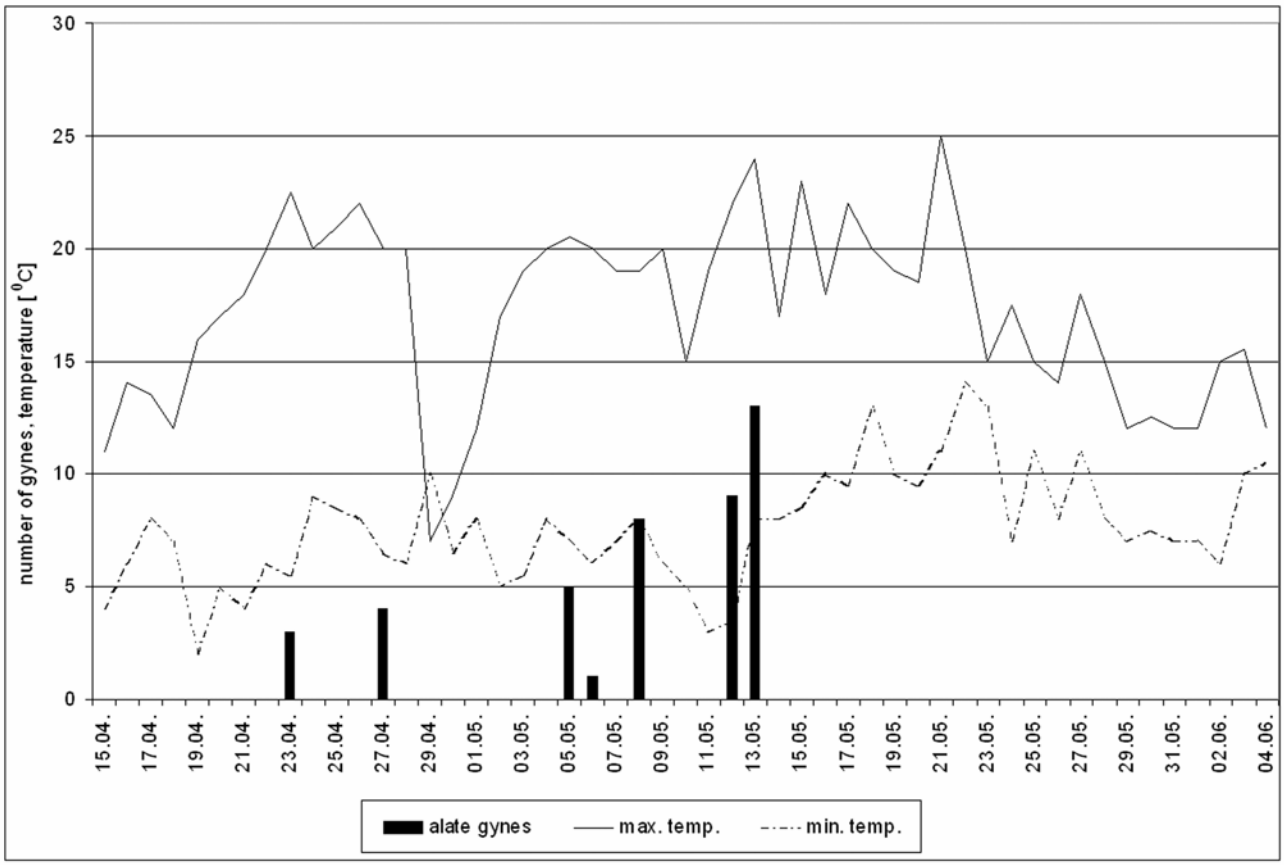

Fig. 3: Weather parameters (maximum and minimum temperature) and the number of alate gynes counted in the study area during the research period in 2006.

Discussion

This study shows that appropriate weather conditions may act as a trigger for the nuptial flight of *M. rubida*. Swarming did not take place until specific weather parameters had been established (see differences in SD values for days with and without nuptial flight), especially with regard to temperature. Swarming was observed on days when maximum day temperature reached at least 18 °C, but preferably exceeded 20 °C, and when relative humidity was not higher than 76 %, preferably about 60 %.

Interestingly, not always all sexuals took advantage of the very first acceptable day: While in 2004 and 2005 the first acceptable day, which was already a very warm one, was chosen by the highest number of alate gynes, in 2006 many alate gynes did not swarm on a series of acceptable but only moderately warm days but performed their nuptial flight on the very warmest day, which was at the end of the nuptial flight period. This is remarkable because the brood of gynes choosing the first day suitable for a nuptial flight may be about 2 - 3 weeks ahead in development compared to brood of gynes copulating at a later time. Since young gynes land on the same area in great numbers, there must exist a severe intraspecific competition among them, and later among developing incipient colonies. In view of this, the earlier young workers emerge, the greater chance they stand of eliminating neighbouring nests.

If nuptial flight, in the extreme, occurs in late summer or autumn, young queens may not manage to rear workers before winter. If this is the case, they have to overwinter with their brood (KIPYATKOV 1993), or wait with laying the eggs until spring. Probably, overwintering without workers is more risky for them than overwintering in the parental nest. And indeed, it has been observed in Upper Silesia that although young sexuals appear in July and August (Ł. Depa, unpubl.; similarly in mountainous areas: WOYCIECHOWSKI 1985) they do not swarm the same year although the likelihood of similar weather conditions in September and in May is high for most parameters, the average September temperature in Upper Silesia even being about 0.5 °C higher than the May temperature; only insolation is weaker in September. In mountainous areas, where *M. rubida* mainly occurs, nuptial flight may be postponed to June or even July of the year after sexuals emerged.

Weather conditions during the nuptial flight, especially temperature and sunlight, are important for sexuals to reach sufficient body temperature to fly into the air. Because gynes of *M. rubida* are big and massive, heat makes the flying easier. BOOMSMA & LEUSINK (1981) show that bigger gynes of *Lasius niger* (LINNAEUS, 1758) and *L. flavus* (FABRICIUS, 1782) need higher air temperature to fly than smaller ones of *Myrmica scabrinodis* NYLANDER, 1846 and *M. rubra* (LINNAEUS, 1758). Probably, the same rule also concerns gynes of *M. rubida*, but this needs further investigation.

It is interesting that *M. rubida* swarms mainly during dry and hot weather, when the soil is hard, which makes digging the chamber difficult. *Manica rubida* is a species inhabiting dry and sunlit places and such species often have their nuptial flight after rainfall, when the soil is moistened,

so that it is easier to excavate (HÖLLDOBLER & WILSON 1990). In this study, however, there never was rainfall in the 24 hours preceding flight but was often registered after the flight, either on the same or on the next day. Perhaps such a sequence of weather events in some way enables young gynes to find an appropriate locality to found the nest.

Manica rubida has been reported to swarm either in early spring, i.e., in April (PARAPURA & PISARSKI 1971, CZECHOWSKI & al. 2002), or in May and June (FOREL 1915), or from May to August (EMERY 1916), or even from July to September (FOREL 1915, PARAPURA & PISARSKI 1971, CZECHOWSKI & al. 2002). CZECHOWSKA (1976) found sexuals of this species in the Pieniny Mountains in the second half of July. ARAKELIAN (1994) observed sexuals in nests in Armenia in June. It is not known whether data presented by a large number of authors are based on direct observations of nuptial flights or only on observation of dealate gynes. A. Buschinger (pers. comm.) observed freshly mated (confirmed by dissection) alate gynes of *M. rubida* running on the ground in Aosta valley, Italy, c. 1700 m a.s.l., on 6.VI.2005, and B. Seifert (pers. comm.) observed sexuals flying off from the nest in Austria, Tyrol, Landeck / Inn, on 15.V.1994. The author of this paper observed the nuptial flight of this species in the Tatra Mountains (c. 1200 m a.s.l.) in the middle of the first decade of June 1996. Cited data refer to populations in different parts of *M. rubida*'s geographic range, from moderate and Mediterranean climatic zones. In view of this, the existing inconsistencies of literature data may reflect different climatic conditions in various areas of *M. rubida*'s geographic range, which must affect the date of emerging of sexuals and the beginning of nuptial flight.

Moreover, it is possible that the time of nuptial flight was determined merely on the basis of observations of young sexuals in the nests. Doubts of this kind have already been aired in the case of a Central European *Messor* cf. *structor* (LATREILLE, 1798) population (SCHLICK-STEINER & al. 2005, 2006). It is known that sexuals of the closely related genus *Myrmica* LATREILLE, 1804 emerge in summer and start their nuptial flight in late summer and early autumn (WOYCIECHOWSKI 1987, 1990). The same situation might have been assumed for *M. rubida*. Because alate sexuals appear in summer, many authors could expect them to have their nuptial flight in late summer or in autumn.

Another source of inconsistencies of literature data on the date of nuptial flight could be the fact that young queens of *M. rubida* leave their chambers to find source of food. This means that they can be observed on the ground for 2 - 3 months after their nuptial flight, the period it takes the first workers to develop (STITZ 1939, Ł. Depa, unpubl.). Assuming that the nuptial flight in the mountains takes place in June, and that the first larvae appear one month after the flight, it is possible to find dealate gynes there outside their nests in search for food for their brood from the beginning of July to the end of August. Such observations might also have led many authors to report widely varied dates of nuptial flights. Overall, it seems that reliability of literature data on nuptial flight dates is a general problem in myrmecology raised with regard to many ant genera (e. g., *Formica* spp., B. Seifert, pers comm., *Solenopsis fugax* and *Lasius* spp., A. Buschinger, pers comm.). In the case of *M. rubida*, further systematic research needs to be conducted to determine precisely the possible impact of weather and climatic factors on its mating behaviour and dispersal strategy.

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Zusammenfassung

Bei vielen Ameisenarten findet der Hochzeitsflug nur bei passender Witterung statt, ja bestimmte Wettersituationen können den Hochzeitsflug sogar auslösen. Unterschiedliche Ameisenarten fliegen zu unterschiedlichen Zeitpunkten, aber in Polen findet der Hochzeitsflug der meisten Arten im Sommer statt. Im Rahmen dieser Studie wurden Flüge von *Manica rubida* (LATREILLE, 1802) in Piekary Śląskie (Oberschlesien, Polen) im Mai 2004 und 2005, sowie im April und Mai 2006 beobachtet. Diese Daten legen nahe, dass *M. rubida* nur bei passender Witterung Hochzeitsflüge unternimmt.

Die Frage nach der Verlässlichkeit von Literaturangaben zum Zeitpunkt von Hochzeitsflügen wird diskutiert. Publizierte Daten weisen für *M. rubida* Hochzeitsflüge während eines langen Zeitraums (April bis September) aus. Insgesamt könnten Diskrepanzen zwischen Literaturangaben auf Klima und Witterung, auch in Zusammenhang mit der semiklaustralen Nestgründung der Art, zurückzuführen sein.

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