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Short communication

DIFFERENTIAL SUSCEPTIBILITY OF *LOCUSTA MIGRATORIA* AND *SCHISTOCERCA GREGARIA* (ORTHOPTERA: ACRIDIDAE) TO INFECTION WITH ENTOMOPATHOGENIC FUNGI

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The migratory locust *Locusta migratoria* and the desert locust *Schistocerca gregaria* are widespread species deleterious for agriculture and numerous efforts are aimed at development of effective and ecologically safe means to control these pests. Testing conidial suspension of entomopathogenic fungi *Beauveria bassiana, Beauveria brongniartii* and *Metarhizium robertsii* showed high mortality of both locust species reaching 95–100 % in 5 and 11 days post treatment in first and third instar nymphs, respectively. The dynamics of mortality caused by the three fungal strains differed between *L. migratoria* and *Sch. gregaria*, demonstrating lower levels of susceptibility of the former species as compared to the latter one. Since desert locust inhabits arid, dry biotopes where probability of contacts with fungal pathogens should be lower, it is hypothesized can be assumed that higher vulnerability in this species would be substantiated by the absence of natural selection for resistance to fungal parasite.

Keywords: *Beauveria*, *Metarhizium*, Acrididae, infection, resistance

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Locusts are notorious agricultural pests around the world (Latchininsky et al., 2011). Biological means are being extensively developing for locust control as an alternative to chemical pesticide application (Lomer et al., 2001). Ascomycetes of the genera *Metarhizium* and *Beauveria* are the most important agents of locust biocontrol (Faria, Wright, 2007). Interactions of insect parasitic fungi with Acrididae is therefore of great interest for understanding of the mechanisms underlying efficacy of microbial formulations. Susceptibility of target insects to the agents of fungal diseases may significantly vary depending upon numerous factors affecting the efficacy of biological control. In the present paper, we compared susceptibility of two species of acridid locusts to the three species of entomopathogenic fungi at different fungal conidia dosage and insect age.

Pure cultures of *Beauveria bassiana* BBK-1 isolated from *Calliptamus italicus* (Novosibirsk region, Russia 2000), *Beauveria brongniartii* BT-86 – from *Dociostaurus maroccanus* (Karakalpakstan, Uzbekistan, 1986) and *Metarhizium anisopliae* MAK-1 – from *C. italicus* (Novosibirsk region, 2000) were grown on solid Sabouraud agar until mass conidial sporulation and conidial suspensions in distilled water were adjusted to 5×10^6, 10^7 or 5×10^7 conidia/mL. Laboratory cultures of *Locusta migratoria* and *Schistocerca gregaria* (Orthoptera, Acrididae) were maintained continuously for about a hundred and thirty generations, respectively, at the Department of Entomology at the Moscow Zoo (Russia). Fresh egg masses were transported from Moscow to the laboratory in St. Petersburg and kept at 30–35 °C until hatching. Newly hatched locust nymphs were fed with fresh wheat and a mixture of wheat bran and powder milk provided *ad libitum*. Two-three days after hatching, first instar nymphs were infected by immersion for 5 sec into the suspension of fungal conidia (Tokarev et al., 2011) transferred to plastic containers and fed with fresh wheat. Suspensions of 5×10^6 and 10^7 conidia/mL were used for the first instar nymphs. Additionally, third instar nymphs (2–3 days after the second molt) were infected as above using the suspensions of 5×10^6, 10^7 and 5×10^7 conidia/mL. Distilled water was used as control. Treated nymphs were maintained in 0.5 L plastic cages, 5 insects per cage, at 30 °C and constant light. Each treatment included 4 replicates, i.e. 20 insects per treatment. Locust mortality was checked daily until 95–100 % level was reached in fungi-treated groups, perished nymphs were placed on a glass slide in a Petri Dish with a moistened filter paper to observe fungal sporulation on cadaver surface. Least significant difference was estimated using one way ANOVA analyses (t-tesn and limit significant difference $LSD_{.05}$)

Fungi killed 85–100 % of the first instar locust nymphs within first 5 days and 7 days post treatment (d.p.t.), mortality reached 100 % in all fungi-treated groups. However, there was a difference in mortality dynamics between the locust species, most notable at 4 d.p.t. By that time, mortality was lower in *L. migratoria* as compared to *Sch. gregaria* in all the treatments. The most prominent difference was between the two species treated with the fungi at the concentration of 5×10^6 conidia/mL: 25.0 ± 9.6 % (mean ± standard error) vs 80.0 ± 8.2 % in BBK-1, 20.0 ± 8.2 % vs 75.0 ± 12.6 % in BT-86 and 25.0 ± 9.6 % vs 65.0 ± 15.0 % in MAK-1 treatment. Mortality in desert locust was 2.6–3.7 times as high as compared to migratory locust and all the differences were significant at $p<0.05$. In 10^7 conidia/mL treatment, mortality from three fungal species in desert locust was only ~1.5 times higher than in migratory locust (Table 1) and the difference was significant ($p<0.05$) only in the case of the BBK-1 application.

When third instar nymphs were assayed, 80–100 % and 95–100 % mortality levels were reached at 9 and 11 d.p.t., respectively, reflecting lower susceptibility to fungal pathogens in elder instars. As in first instar nymphs, before reaching the maximal level, mortality was higher in desert locust as compared to the migratory locust. In particular, at minimal concentration used (5×10^6 conidia/mL), all three fungal species caused significantly higher mortality ($p<0.05$) in desert locust at 7 d.p.t. At higher concentrations, significant differences in locust species susceptibility were also observed, including BBK-1 with concentration of 5×10^7 conidia/mL at

3 d.p.t., BT-86 with concentration of 5×10^7 conidia/mL at 3–7 d.p.t. and MAK-1 with concentration of 10^7 conidia/mL at 3–7 d.p.t. In all the cases, higher mortality was observed in *Sch. gregaria.* (Table 2)

Natural conditions of preferable habitats of *L. migratoria* and *Sch. gregaria* are remarkably different. The migratory locust prefers reed stands on the sides of large water bodies, such as the delta of the river Volga at the Caspian Sea in Russia or Lake Balkhash in Kazakhstan. The temperature optimum for the development of this species is about 26−28 °C. These conditions are optimal for fungi development. It can be therefore expected that probability of locust contact with fungi under such conditions is high substantiating selection for resistance. Conversely, desert locust is known to occur in more arid biotopes, such as deserts, and optimal temperature for its development is 30 °C (Gündüz and Gülel, 2002). We therefore assume that natural contacts of this species with entomopathogenic fungi are less frequent and selection for resistance is less probable as compared to migratory locust. This may explain the difference in susceptibility to fungal infection found in the present study.

Table 1. Mortality of first instar nymphs of *Locusta migratoria* and *Schistocerca gregaria* treated with *Beauveria bassiana* (BBK-1), *Beauveria brongniartii* (BT-86) and *Metharizium anisopliae* (MAK-1)

Treatment	Dosage, conidia/mL	Insect species	Mortality, %±SE, days post treatment				
			3	4	5	6	7
BBK-1	5×10^6	*L. migratoria*	25.0±9.6	25.0±9.6*	85.0±5.0	95.0±5.0	100
		Sch. gregaria	25.0±5.0	80.0±8.2	100	100	100
	1×10^7	*L. migratoria*	30.0±12.9	60.0±8.2*	100	100	100
		Sch. gregaria	35.0±15.0	90.0±5.8	100	100	100
BT-86	5×10^6	*L. migratoria*	15.0±5.0*	20.0±8.2*	85.0±9.6	100	100
		Sch. gregaria	40.0±21.6	75.0±12.6	100	100	100
	1×10^7	*L. migratoria*	50.0±23.8	55.0±22.2	90.0±5.8	100	100
		Sch. gregaria	35.0±9.6	85.0±9.6	100	100	100
MAK-1	5×10^6	*L. migratoria*	10.0±2.5	25.0±5.0*	85.0±9.6	85.0±9.6	100
		Sch. gregaria	10.0±5.8	65.0±15.0	90.0±5.8	95.0±5.0	100
	1×10^7	*L. migratoria*	20.0±20.0	55.0±15.0	85.0±15.0	95.0±5.0	100
		Sch. gregaria	40.0±23.1	75.0±9.6	100	100	100
Control		*L. migratoria*	0.0	0.0	0.0	5.0±5.0	10.0±5.8
		Sch. gregaria	0.0	0.0	0.0	0.0	5.0±5.0
$LSD_{.05}$			20.12	30.07	20.11	30.03	17.52

SE – standard error; LSD – least significant difference. Asterisks indicate mortality values significantly different between two host species.

Table 2. Mortality of third instar nymphs of *Locusta migratoria* and *Schistocerca gregaria* treated with *Beauveria bassiana* (BBK-1), *Beauveria brongniartii* (BT-86) and *Metharizium anisopliae* (MAK-1)

Treatment	Dosage, conidia/mL	Insect species	Mortality, %±SE, days post treatment				
			3	5	7	9	11
BBK-1	$5x10^6$	*L.migratoria*	0.0	25.0±9.6	55.0±9.6*	85.0±15	95.0±5.0
		Sch. gregaria	10.0±5.8	40.0±8.2	80.0	85.0±5.0	100
	$1x10^7$	*L. migratoria*	5.0±5.0	20.0±0.0	75.0±15.0	95.0±5.0	100
		Sch. gregaria	0.0	30.0±5.8	70.0±5.8	100	100
	$5x10^7$	*L. migratoria*	0.0*	40.0±8.2	80.0±11.5	95.0±5.0	100
		Sch. gregaria	15.0±9.6	55.0±5.0	95.0±5.0	100	100
BT-86	$5x10^6$	*L. migratoria*	0.0	25.0±9.6	75.0±5.0*	85.0±5.0	100
		Sch. gregaria	5.0±5.0	45.0±9.6	95.0±5.0	100	100
	$1x10^7$	*L. migratoria*	0.0*	45.0±9.6	70.0±12.9*	90.0±5.8	100
		Sch. gregaria	35.0±5.0	70.0±12.9	85.0±9.6	100	100
	$5x10^7$	*L. migratoria*	0.0	30.0±10.0*	70.0±5.8*	100	100
		Sch. gregaria	20.0±8.2	60.0±8.2	100	100	100
MAK-1	$5x10^6$	*L. migratoria*	15.0±5.0	20.0±8.2	25.0±5.0*	80±8.2	95.0±11.5
		Sch. gregaria	5.0±5.0	30.0±15.0	60.0±8.2	100	100
	$1x10^7$	*L.migratoria*	5.0±5.0*	45.0±15.0*	85.0±15.0*	100	100
		Sch. gregaria	20.0±8.2	85.0±9.6	100	100	100
	$5x10^7$	*L. migratoria*	0.0	55.0±9.6*	90.0±5.8	100	100
		Sch. gregaria	10.0±10.0	95.0±5	100	100	100
Control		*L. migratoria*	0.0	0.0	5.0±5.0	25.0±5.0	35.0±5.0
		Sch. gregaria	0.0	0.0	10.0±5.8	25.0±5.0	30.0±5.8
$LSD_{.05}$			14.26*	20.88	14.26	20.88	22.36

Abbreviations and indications as in Table 1.

The data obtained are in accordance with the preliminary studies of Kassa et al. (2004) which assayed another ascomycete fungus, *Metarhizium acridum,* against two locust hosts: *L. migratoria* and *Cryptocatantops haemorrhoidalis* (Krauss). The latter species, which also prefers arid biotopes (similarly to *Sch. gregaria)*, displayed significantly higher susceptibility to the fungus, and this observation is in agreement with our hypothesis.

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Краткое сообщение

ДИФФЕРЕНЦИАЛЬНАЯ ВОСПРИИМЧИВОСТЬ *LOCUSTA MIGRATORIA* И *SCHISTOCERCA GREG*ARIA (ORTHOPTERA: ACRIDIDAE) К ЗАРАЖЕНИЮ ЭНТОМОПАТОГЕННЫМИ ГРИБАМИ

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Перелетная *Locusta migratoria* и пустынная *Schistocerca gregaria* саранча являются широко распространенными вредителями сельскохозяйственных культур. Разработка эффективных и экологически безопасных средств борьбы с ними является весьма перспективным направлением. Оценка биологической активности конидиальных суспензий энтомопатогенных грибов *Beauveria bassiana*, *Beauveria brongniartii* и *Metarhizium robertsii* показала высокую смертность у обоих видов саранчи – 95–100% через 5 и 11 дней после обработки у личинок первого и третьего возраста соответственно. Динамика смертности, вызванной тремя штаммами грибов существенно различалась у *L. migratoria* и *Sh. gregaria*, восприимчивости первого вида на более низкие уровни по сравнению со вторым. Поскольку пустынная саранча обитает в ксерофитных биотопах, где вероятность контактов с грибными патогенами может быть ниже, предполагается, что более высокая восприимчивость у этого вида будет подтверждена отсутствием естественного отбора на устойчивость к грибам.

Ключевые слова: *Beauveria*, *Metarhizium*, Acrididae, инфекция, устойчивость

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