A Green Morph of the Migratory Locust, Locusta migratoria L. (Orthoptera: Acrididae) that Occurred After Inbreeding

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A green morph of the migratory locust, *Locusta migratoria* L. (Orthoptera: Acrididae) that occurred after inbreeding

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Abstract

Green-colored hatchlings appeared in the 2nd generation of inbred family lines in *Locusta migratoria* L. Female adults collected in Tsukuba, Japan were kept individually and eggs collected from them. Locusts of the first generation from each female were reared in a group and eggs of the 2nd generation obtained from them. Green and normal-colored (fawn) hatchlings appeared together from the same egg pods, originating from 2 of the 34 family lines established. When they were reared together in the same cage, the green morph suffered from a high rate of mortality. A few green-morph female individuals attained the adult stage with light body coloration, but died without producing any eggs. Although no information is available about their genetic background, it seems likely these green morphs represent a recessive, semilethal trait that appeared after inbreeding of wild-caught female adults. Photographs of hatchlings, nymphs and adults are presented.

Key words

body color, eye color, inbreeding, *Locusta migratoria*

Introduction

The migratory locust, *Locusta migratoria* L., is widely distributed in the Old World (Uvarov 1966, 1977). This locust feeds on grass and often causes serious damage to agricultural crops. It exhibits remarkable phenotypic plasticity called density-dependent polyphenism and has attracted much attention from many researchers (Pener 1991, Pener & Yerushalmi 1998, Pener & Simpson 2009). It occurs usually in the solitarious phase at low population densities and does not cause any economic problem. Nymphs display various cryptic body colors. As population densities increase under favorable conditions, nymphs start aggregating and develop black patterns with a dirty orange color. Hatchling body color is also different between the solitarious and gregarious phases and depends on parental crowding conditions. Eggs laid by solitarious females give rise to pale-colored hatchlings, whereas those laid by gregarious females produce dark-colored hatchlings (Hunter-Jones 1958). During a study on phase polyphenism in *L. migratoria*, we obtained hatchlings with unusual body coloration in inbred colonies and reared them in the laboratory. This paper describes their body coloration and development.

Materials and methods

Approximately 40 adult females were collected in grassland in Tsukuba, Ibaraki, Japan in October, 2010. They were apparently in the solitarious phase, at a population density < $1/100m^2$. They were individually reared in small screen cages (28 × 15 × 28 cm) at 30°C with a LD 12:12 hour photoperiod, by a method described previously (Hakomori & Tanaka 1992). Locusts were fed bran and leaves of *Bromus catharticus* grass or sorghum grown at a research plot at the National Institute of Agro-biological Sciences at Ohwashi in Tsukuba. They laid several egg pods over a month's interval. These eggs were incubated at 20°C for a month before being chilled at 5°C for 3 months to terminate embryonic diapause (Tanaka 1992). Eggs chilled were then incubated at 30°C for hatching. Approximately 100 nymphs, derived from 3 to 4 egg pods laid by the same female, were reared in a large cage (42 × 42 × 24 cm) and 34 family lines were thus obtained. More than 15 egg pods were collected from each family line and exposed to a series of temperature regimes to terminate diapause as described above. Green hatchlings appeared within two such family lines when a total of 12 egg pods were incubated at 30°C for hatching. Unfortunately, the incidence of green hatchlings for each egg pod was not recorded accurately, but they appeared together with normal-colored individuals from the same egg pods. Green and normal-colored nymphs were reared together in a large cage under the same conditions as above.

Results

As mentioned above, 2 out of 34 family lines produced green hatchlings in the 2nd generation. Fig. 1a shows newly hatched nymphs obtained from one egg pod. Two types of hatchlings could be recognized: one type had a light-brown body color with black eyes shortly after hatching (Fig. 1d): the body turned dark brown several hours later (Fig. 1e); the other type exhibited a yellow-green body color with reddish eyes in the beginning (Fig. 1b) and developed a darker body color later (Fig. 1c). (The latter type will be called a 'green morph'.) After ecdysis to the 2nd instar, green morphs assumed a light body color (Fig. 1f) compared with normal locusts (Fig. 1g).

Mortality was considerably higher among green morphs and only 7 of the 22 individuals reared (32%) reached the last nymphal instar, whereas more than 70% developed to the same stage among normal-colored locusts reared in the same cage (total N = 25). Last instar nymphs of the green morph were slightly greenish with light-colored compound eyes (Fig. 1h).

Two females and two males of this morph emerged as adults and were transferred to another cage. Of these, one female and one male died a few days after adult emergence. The surviving two individuals still remained whitish two weeks after adult emergence (Fig. 1j). This 'pair' started mating in two weeks, but the female died without producing any eggs. The male survivor was then kept with two normal female adults (Fig. 1k) to obtain eggs. Mating was witnessed a few times, but no viable eggs were obtained from these females.

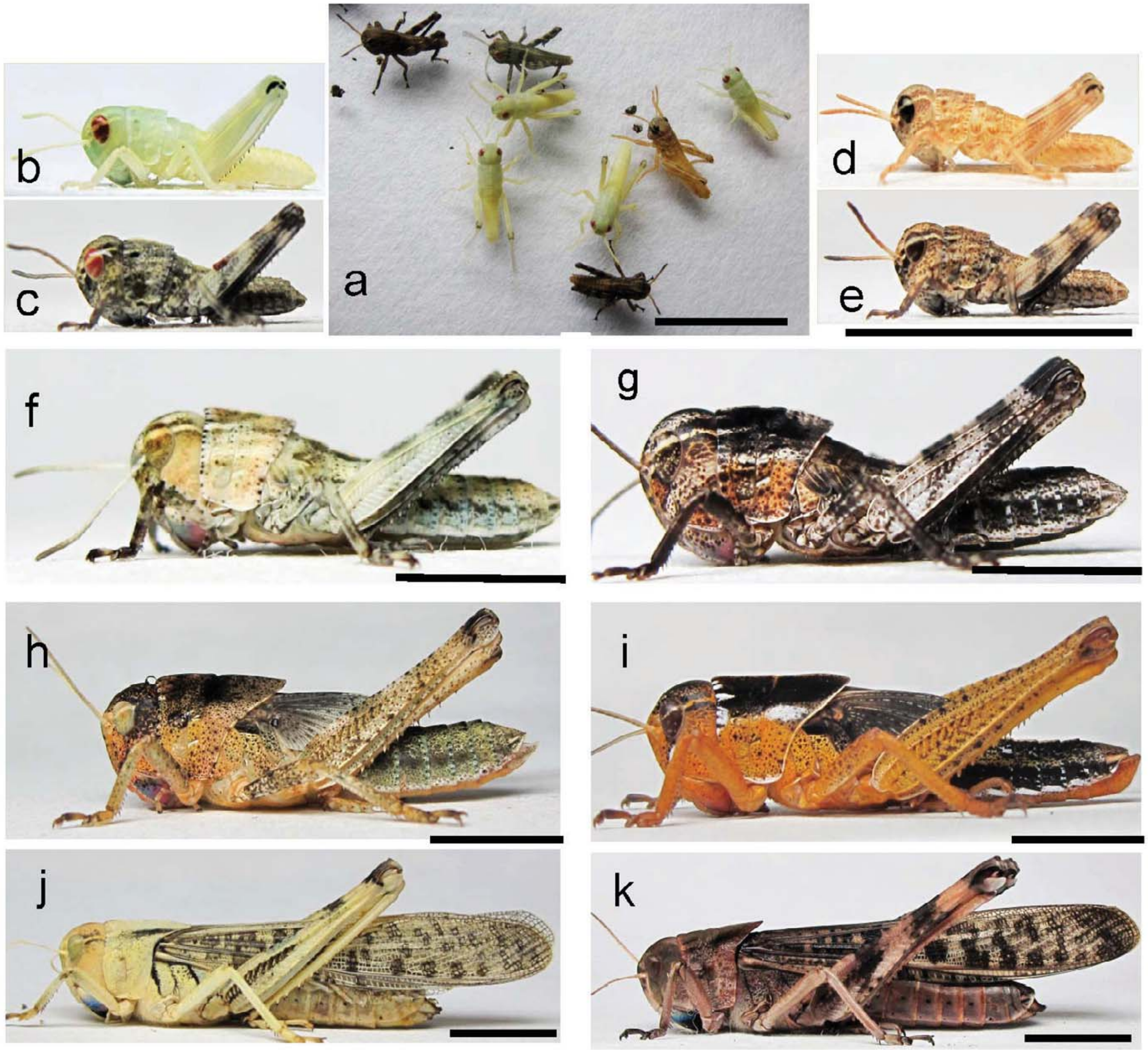

Fig. 1. Photographs showing green and normal morphs of *L. migratoria*. **a.** Hatchlings of green and normal morph. **b.** Less than hour-old green hatchling. **c.** Green hatchling a few hours old. **d.** Less than hour-old normal hatchling. **e.** Normal hatchling a few hours old. **f.** 2nd instar green nymph. **g.** 2nd instar normal nymph. **h.** Last (5th) instar green nymph. **i.** Last (5th) instar normal nymph displaying a typical gregarious color. **j.** Green morph adult. **k.** Normal morph adult. Horizontal bars indicate 1cm. For color version, see Plate II.

Discussion

The green morphs observed in the present study exhibited body coloration distinctly different from that of their normal-colored counterparts reared in the same cage. Green hatchlings are common among locusts and grasshoppers (Uvarov 1977). In *L. migratoria*, hatchling body color shows some variation, depending on the parental phase or crowding conditions (Hunter-Jones 1958), but green-colored hatchlings are not known. *L. migratoria* albinism has been reported from different laboratories (Faure 1932, Verdier 1965, Nolte 1969, Hasegawa & Tanaka 1996).The albino strain from Okinawa is controlled by a single recessive Mendelian unit and deficient in the dark-color inducing hormone (Tanaka 1993, Tanaka & Pener 1994) now known as [His^7]-corazonin (Tawfik *et al.* 1999). Hatchlings of this albino mutant are, however, indistinguishable from normal hatchlings by either body color or eye color: they have a fawn body color and black eyes (Tanaka S., unpub. obs.). In the desert locust *Schistocerca gregaria* Forskål, an albino strain controlled by a simple recessive Mendelian unit is also known (Hunter-Jones 1957). Yerushalmi *et al.* (2000) obtained a "dark-adult" mutant in this same locust that is also recessive to the normal phenotype. Nymphs of this "dark-adult" strain look the same as normal hoppers, but develop a black pigment in the body and wings after adult emergence.

The green morph of *L. migratoria* suffered from a high rate of mortality in the laboratory compared with normal-colored individuals from the same egg pods. Although no genetic studies have been performed, it seems likely that the green morphs carried a semilethal gene. As mentioned earlier, the incidence of green hatchlings was not recorded accurately; however, they always appeared together with normal phenotypes from the same egg pods. These observations, together with the fact that they did not appear until the 2nd generation in inbred family lines, might suggest that the green-morph phenotype was controlled by a recessive, possibly semilethal gene.

Recently we obtained a short-winged morph of *L. migratoria* in a similar way (Tanaka & Nishide 2012): several short-winged individuals appeared in the 2nd generation of inbred family lines originating from Tsushima Island, Japan. The short-winged phenotype is controlled by a single recessive Mendelian unit. Although the possibility that these unexpected morphs have occurred by mutation in the laboratory cannot be excluded, inbreeding wild-caught insects in the laboratory may be an interesting way of finding recessive phenotypes that are normally unexpressed in the field.

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