

# The Biology, Nymphal Stages, and Life Habits of the Endemic Sand Dune Cricket *Schizodactylus inexpectatus* (Werner, 1901) (Orthoptera: Schizodactylidae)

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**Abstract:** The biology, nymphal stages, and life habits of the endemic dune cricket *Schizodactylus inexpectatus* (Werner, 1901) (Orthoptera: Schizodactylidae) were investigated in this study carried out between 2000 and 2007 in the Çukurova delta (Adana province) and in Alata (Mersin province), Turkey. The study showed that *S. inexpectatus*, which is a nocturnal insect, passes through 9 nymphal stages, each characterised by its own body size. The present study showed that certain properties of burrows, such as their depths, do not depend on either adult or immature stages of the insect. Food preferences of cannibalistic species of *S. inexpectatus* were also investigated under field conditions. *S. inexpectatus* is at risk of extinction and therefore the establishment of conservation programmes aimed at preserving sand dunes, which serve as the only natural habitat of this species, is advised.

**Key Words:** Dune cricket, endemic, *Schizodactylus inexpectatus*, biology, behaviour, life habits

## Endemik Kum Kriketi *Schizodactylus inexpectatus* (Werner, 1901) (Orthoptera: Schizodactylidae)'un Biyolojisi, Nimf Evreleri ve Yaşam Alışkanlıkları

**Özet:** Bu çalışma Çukurova Deltası (Adana) ve Alata (Mersin)'da 2000-2007 tarihleri arasında yürütülmüş ve ülkemiz için endemik olan kum kriketi *Schizodactylus inexpectatus* (Werner, 1901) (Orthoptera: Schizodactylidae)'un biyolojisi ve yaşam şekli araştırılmıştır. Araştırma sonuçlarına göre gece aktif *S. inexpectatus*'un 9 nimf dönemi geçirdiği yapılan ölçümlerle belirlenmiştir. Her döneme ait ölçüm sonuçları LSD testine göre istatistik açıdan önemli farklılıklar göstermiş, her dönemin kendine has vücut büyüklüğü olduğu ortaya çıkarılmıştır. Yuva özelliklerinin de verildiği çalışmada yuva derinliklerinin ergin ve ergin öncesi dönemlere göre değişmediği, tamamen yuva için seçilen bölgenin nem durumu ile ilgili olduğu ortaya çıkarılmıştır. Kannibalist özellik gösteren *Schizodactylus inexpectatus*'un besin tercihleri de doğa koşullarında araştırılmıştır. *S. inexpectatus* yok olma riski altındadır ve bu yüzden bu türün tek doğal habitatı olarak hizmet eden kumul alanların korunmasını amaçlayan programlarının oluşturulması önerilmektedir.

**Anahtar Sözcükler:** Kum kriketi, endemik, *Schizodactylus inexpectatus*, biyoloji, davranış, yaşam şekli

## Introduction

The first individual of *Schizodactylus inexpectatus* (Werner, 1901) (Orthoptera: Schizodactylidae) was accidentally found in the Cilician Taurus mountains near Gülek in Turkey by Martin Holtz in 1897. Werner described it as *Comicus inexpectatus* in 1901 (Uvarov, 1952; Ramme, 1931). Later, Ramme decided that this species did not belong to the genus *Comicus*, and so he formally transferred it to the genus *Schizodactylus* in 1931 (Uvarov, 1952). This was the first time that designated differences between the genera *Comicus* and

*Schizodactylus* (Ramme, 1931) were described. Karabağ (1958) found another adult individual *S. inexpectatus* with a specimen in Alata (Mersin province). Subsequently, Max Beier of the Vienna Museum also verified this same specimen as *S. inexpectatus*. This species was generally thought to be extinct because no further records had been made public (Demirsoy, 1999).

In 1950, however, there was yet another record of its finding, when *S. inexpectatus* was discovered in undisturbed sand dune complexes in the Çukurova delta as well as in Alata. However, this species could not be

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found in the Gülek area, where it had been originally recorded in 1897 (Aydın, 2005). Its distribution and habitat preferences were studied by Aydın (2005); however, there has been no further information available on the biology and life habits of the endemic sand dune cricket.

In the present study, we describe the biology, life habits, and body size differences between nymph and adult stages of the endemic species *S. inexpectatus*. Our main objective is to gather sufficient information about the endemic sand dune cricket, so that it can be included in the IUCN's (World Conservation Union's) Red Data Book under the category of "critically endangered species" (CR).

## Materials and Methods

This study was performed between 2000 and 2007 in southern Turkey: in the Çukurova delta (Universal Transverse Mercator Projection-(UTM)~36S 733753 4057039) and in Alata (UTM~36S 570159 4063205).

### Habitat preferences and distribution

In order to discover the habitat preferences of *S. inexpectatus*, the following habitats were observed in both the Çukurova delta, which with an area of more than 110 km<sup>2</sup> is the largest lagoon and sand dune area on the Turkish Mediterranean coast and represents one of the most important moist biotope systems of the entire region (Yılmaz et al., 2003), and Alata, in sand dune and beach areas.

### Descriptions of *S. inexpectatus* and nymphal stages

The specimens of both adult and immature stages of *S. inexpectatus* were sampled from burrows at night. The body sizes of *S. inexpectatus* were measured from the cranial vertex to the tip of the abdomen by length and thus each immature stage of the cricket was identified. The burrows were investigated further to understand whether there were any depth differences related to both adult and immature stages found in these burrows. In order to determine the shape of each burrow, we used gypsum plaster (mix of powdered gypsum with water) that was poured into an empty burrow and left there until it dried. In order to measure the speed of insects, we used chronometers; however, such measurements were not all performed on the same dates. The speed

measurements were obtained occasionally from 30 individuals (nearest approximation).

### Burrow excavating behaviour

The burrows of insects were dug with a single long stick. The stick was put inside each burrow until it touched the end of it (small insect room). Then the digging would start tenderly with the upper part of the stick while being directed towards the end of each burrow, so as to avoid any insect injuries. The variances between nymphal stages and burrow depths were compared using the "Mstat-C" program with "ANOVA-1", and variation was tested using LSD (1%) (Cochran and Cox, 1957; Karman, 1971).

### Food and feeding behaviour

The food preferences of *S. inexpectatus* were observed in both field and laboratory conditions. The size of the insectarium used in laboratory conditions was approximately 50 × 50 × 50 cm. *S. inexpectatus* was given food consisting of primarily ground darkling and dung beetles collected from sand dune habitats. The burrows were inspected for insect parts, such as elytrae and wings, in order to determine the food preferences of *S. inexpectatus*.

## Results and Discussion

### Habitat preferences and distribution

Similarly to the other 4 species of the genus *Schizodactylus* (*S. monstrosus* (Drury, 1773), *S. burmanus* (Uvarov, 1935), *S. minor* (Ander, 1938), and *S. tuberculatus* (Ander, 1938)), *S. inexpectatus* prefers to live in sand dune habitats (Aydın, 2005). Field surveys were carried out in sand dune and beach habitats in the Çukurova delta and in Alata. The investigated endemic species, however, was found only in the sand dune habitats. It was not observed in sand dunes that turned into afforestation areas due to changes in soil properties of the habitat, making burrowing activity much more difficult.

There is a question though whether this species may be found in the Göksu delta (80 km west of Mersin among Atakent, Silifke, Taşucu, and Mediterranean Sea on a total area of 23,600 ha), since the habitat types there are very similar to the Çukurova delta (Dönmez, 1995). The habitat determined by us as the preferred one for this species is consistent with the IUCN habitat

classification list: "10. Coastline 10.2. Sand, Shingle or Pebble Shores - includes sand bars, spits, sandy islets, dune systems".

#### Description of the adult and nymphal stages of *S. inexpectatus*

Body sizes of both adult and immature stages of *S. inexpectatus* were determined. The adult body sizes average  $4.1 \pm 0.033$  cm in length ( $n = 10$ ). The adult is robustly built. Compared to the nymphal stages, its cephalon and pronotum are larger than the abdomen (Figure 1). The cephalon is quite large with an evident facet and filiform antennae that are longer than the body (approximately 8-9 cm in adults). The mandibula and maxilla are developed, and the labrum covers the mouth parts. The labrum is separated by the mandibula and maxilla during feeding in order to help get the larger parts of food to fit inside the mouth. The maxilla is used both for breaking food into pieces and for tunnelling. The sand coming through the mouth part during burrowing is pushed back by the hind tarsus. Palpi are quite developed in adults, being approximately 1.5 cm in length. The general body colour is yellowish with black patches dorsally. These black patches on the pronotum resemble a butterfly shape (Figure 2).

In contrast with *S. monstrosus*, *S. inexpectatus*' tegmina are not developed, brachypterous, approximately 1 cm in length, and cover just 1/3 of the abdomen. The inferior wings are not developed. The wings of the last

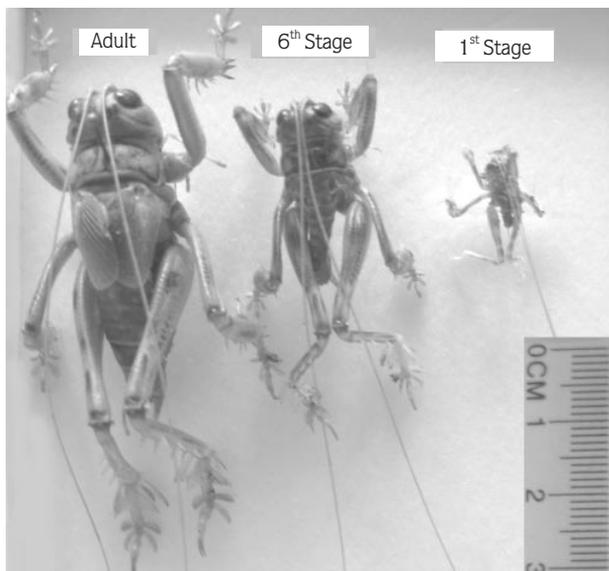


Figure 1. Adult and immature stages of *Schizodactylus inexpectatus*.



Figure 2. Black patches on the pronotum of *Schizodactylus inexpectatus* resemble a butterfly in shape.

larval stages are smaller than those of the adult stage. Insects of both adult and immature stages are unable to fly. The veins of the tegmina are obvious. We think that *S. inexpectatus* has no sound organ on the tegmina because this species is brachypterous. Both hind tibia and tarsi are more developed compared to either the front and middle tibia or tarsi. There are spines on the tibia (dorsolateral spines = 7). The triangular plates are present only on hind tarsi. There are 6 apical spurs, and there are 4 euplantulae (tarsal segments) under the triangular plates. A claw is present on the end of the leg (Figure 3).

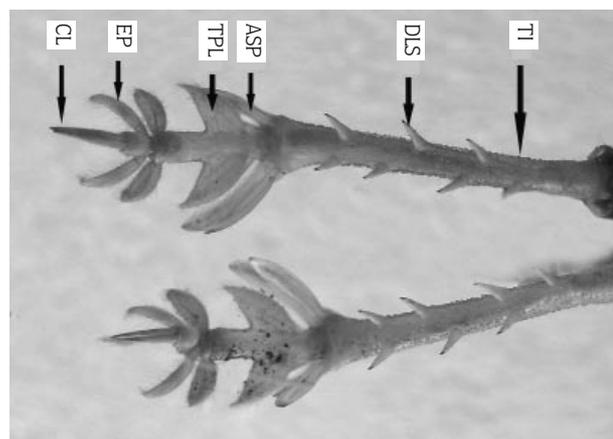


Figure 3. Hind tibia and tarsus of *Schizodactylus inexpectatus*: dorsal view (CL: claw; EP: euplantulae; TPL: triangular plate; ASP: apical spurs; DLS: dorsolateral spines; TI: tibia) (G. Aydin, 2007).

The triangular plate has a very important role during tunnelling. Hazra and Tandon (1991) noted that *S. monstrosus*, which has a similar leg structure, can run fast. According to our observation, *S. inexpectatus* runs at 1/2 m/s on sand (n~30). The unsegmented cerci are well developed and flexible. It is interesting that all the sampled specimens in our study, extending over 7 years, had an ovipositor. The mentioned species may have growth parthenogenesis because no males were found during the study.

The results of measurements of adult and immature stage also showed that *S. inexpectatus*, which belongs to the same genus as *S. monstrosus*, has 9 nymphal stages (Khatkar, 1972). Each immature stage has a body size that is distinct from all other stages. These results are statistically important (Table). Naturally, when the species reaches the next level of nymphal stage, its body size is bigger and reaches the size that is characteristic for the next nymphal stage. This study provided a basis for understanding of nymphal stages of immature insects by measuring body sizes.

Our study shows that the body sizes of the adult stage and of each nymphal stage of *S. inexpectatus* are similar to the body size of *S. monstrosus* (Khatkar, 1972).

However, the wing structure of the adult *S. inexpectatus* is very different from that of *S. monstrosus*. Both the tegmina and wings of *S. monstrosus* are long, while tapering posteriorly and rolling into a spiral that lies over the cerci. The tegmina sides turn down abruptly and cover the lateral sides of the abdomen, while *S. inexpectatus* has undeveloped (brachypterous) wings that cover only 1/3 of the abdomen. Uvarov (1952), Ramme (1931), and Mason (1961) presented results similar to ours while also mentioning that *S. inexpectatus* is brachypterous unlike the following species: *S. monstrosus* (Drury, 1773), *S. burmanus* Uvarov, 1935, *S. minor* Ander, 1938, and *S. tuberculatus* Ander, 1938. According to Uvarov's (1952) study, the specimen, which was sent from Turkey by T. Karabağ (2nd time), was 32 mm in length. If we compare his result with the results of our study, that specimen could be an 8th nymphal stage.

#### Description of the burrow excavating behaviour

Both adult and nymph stages of *S. inexpectatus* are burrow makers. The adults and nymphs were found in the following types of dunes: *shifting dunes* along the shoreline (so-called *white dunes*, which are higher than

usual (1-3 m) yet still movable with the vegetation cover represented by *Imperata cylindrical* and *Medicago marina*); *fixed grey dunes* (dune areas that are characterised by shrubs, grasses, and low lignified species such as *Polygonum equisetiforme*, *Bromus* spp., *Trachomitum venetum*, *Helianthemum stipulatum*, *Rubus sanctus*, and *Vitex agnus-castus*); *maquis dunes* (dunes colonised by typical higher maquis species such as *Myrtus communis*, *Pistacia terebinthus*, *Nerium oleander*, and *Verbascum sinuatum*), and *secondary shifting dunes* (dunes along the shoreline, which are not connected to the beach as well and have poor vegetation; these dunes are also movable as a result of overgrazing, cutting, and strong winds) (Altan and Tischew, 2002; Habitats Directive 92/43/EEC).

The adult stage prefers to make burrows in higher sand dune areas than the nymphal stages. The burrows that were made by the first nymphal stages were especially observed in low altitudes and located close to lagoons and river banks. Both adults and nymphs live as single individuals inside their burrows. The diameters of burrows increase from one nymphal stage to another, while the depths of burrows do not show any statistically significant correlation with body size (Table).

The depths of burrows are dependent upon soil properties. Generally, the burrows are made with one small chamber until the specimen finds humid places. This small chamber enables the specimen to rest during the day and to consume its food during the night (Figure 4). Nearly all the burrows we checked out had one small chamber at the end of the burrow. During the daytime, burrows are mostly closed due to the high temperatures.

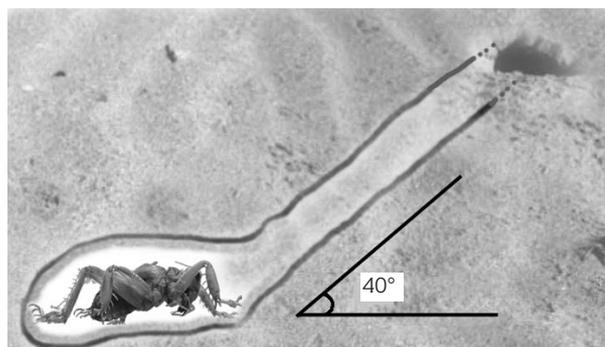


Figure 4. The burrow excavating behaviour of *Schizodactylus inexpectatus*.

Table. Average of the body sizes and burrow depths of adult and nymphal stages of *Schizodactylus inexpectatus*.

	n	Body Size (cm)		min-max	Borrow Depth (cm)		min-max
Adult	10	4.10 ± 0.033*	A**	3.98-4.25	81.3 ± 15.379	A	35-160
9 <sup>th</sup> nymphal stage	10	3.80 ± 0.008	B	3.75-3.85	78.2 ± 4.054	A	39-140
8 <sup>th</sup> nymphal stage	10	2.95 ± 0.004	C	2.87-3.05	71.8 ± 3.946	AB	29-115
7 <sup>th</sup> nymphal stage	10	2.70 ± 0.014	D	2.65-2.75	70.1 ± 6.142	AB	39-98
6 <sup>th</sup> nymphal stage	10	2.49 ± 0.008	E	2.45-2.55	64.3 ± 6.538	ABC	35-105
5 <sup>th</sup> nymphal stage	10	2.27 ± 0.007	F	2.20-2.30	62.7 ± 5.608	ABC	35-90
4 <sup>th</sup> nymphal stage	10	1.68 ± 0.009	G	1.64-1.71	59.1 ± 4.900	ABC	25-90
3 <sup>rd</sup> nymphal stage	10	1.46 ± 0.013	H	1.40-1.48	54.2 ± 6.626	ABC	35-88
2 <sup>nd</sup> nymphal stage	10	1.12 ± 0.010	I	1.00-1.19	45.2 ± 8.025	BC	34-72
1 <sup>st</sup> nymphal stage	10	0.70 ± 0.017	J	0.68-0.72	38.6 ± 8.434	C	28-46

\* Mean ± Standard Error

\*\*The letters indicate a significant difference ( $P < 0.01$ ) according to the LSD test.

Khatkar (1972) also mentioned that the burrows of both adult and immature stages of *S. inexpectatus* are closed after they are completed. In our fieldwork, the deepest burrow of an adult was recorded at 160 cm in depth; however, the shortest burrow was recorded only at 35 cm depth due to the soil moisture conditions and the low altitude. The burrows of the first nymphal stage were  $38.6 \pm 8.434$  cm in depth. The burrows of the other nymphal stages ranged in size between those of the adult stage and of the first nymphal stage (Table). There is no correlation between the sizes of burrows and the different stages of nymphs because the burrow size is dependent upon the soil moisture. We determined that the same individual (4th nymphal stage), which had been taken out from its original burrow, was not trying to create a burrow of the same size when we put it in a different place. Hazra and Tandon (1991), who examined the burrow-making behaviour of *S. monstrosus*, mentioned that burrows end when the insects arrive at moist areas. There is a striking similarity between the burrows of *S. inexpectatus* and those of crabs.

However, according to our observation, crabs make their burrows more perpendicular than *S. inexpectatus*. Both adults and nymphs of *S. inexpectatus* excavate the burrows at  $40^\circ$ . Their burrows generally appear straight and smooth. The sizes of burrows at the beginning vary because of differences in the body size of each immature stage (Figure 4) but the burrows are never directed only one way or just towards the sea, as Guichard (1961) reported.

Khatkar (1972) determined that burrows of *S. monstrosus* are excavated at  $60^\circ$ , and the diameter of the burrows can vary depending on different immature stages of the insect. Choudhuri and Bagh (1974) also found that the female of *S. monstrosus* lays eggs towards the end of the burrow; however, we could not find any eggs at the ends of burrows excavated by *S. inexpectatus*.

#### Food preferences

As a result of fieldwork observations ( $n \sim 30$ ) as well as of burrow inspections and in laboratory research ( $n \sim 10$ ), it was established that *S. inexpectatus*, which is a carnivorous insect, prefers to feed on *Gryllotalpa gryllotalpa* (L., 1758) (Orth.: Gryllotalpidae), *Scarabaeus sacer* L., 1758, *Pentodon bidens* Pallas, 1771 (Col.: Scarabaeidae), *Scaurus puncticolis dlabolai* Kaszab, 1959, *Zophosis dilatata* Deyrolle, 1867, *Erodius orientalis oblongus* Solier, 1834 (Col.: Tenebrionidae), *Blatella germanica* L., 1767 (Ort.: Blattellidae), and *Myrmeleon* spp. (Neu.: Myrmeleontidae), much like many species of the family Acrididae (Orthoptera). Both in fieldwork and under laboratory conditions, *S. inexpectatus* was observed after it attacked the prey, holding it among the strong legs and squeezing it with the abdomen. This species has also been observed when eating meat pieces given as food under laboratory conditions. Both adult and nymphal stages are cannibalistic: different individuals attack each other once they find themselves in confined places, and the stronger one eats the weaker one. Hazra and Tandon (1991) mentioned that *S. monstrosus* shows cannibalistic

behaviour also. Uvarov (1952) mentioned that *S. inexpectatus* is a carnivorous species.

The population of *S. inexpectatus* has decreased about 60% in destroyed sand dune complexes within the 7-year period (unpublished data). This species, which is endemic to Turkey and which cannot live within other geographical zones of the world, has been found only in sand dune habitats in Çukurova delta and Alata. However, these areas are being destroyed by agriculture, including cattle and goat grazing, by sand excavation, and by tourism. Carnivorous *S. inexpectatus* plays a very important role in the local food chain that prevents certain insect populations from increasing and becoming dominant in sand dune habitats, thereby protecting the insect diversity of the sand dune habitat. Besides the mentioned factors, this endemic species provides food for the reptiles in desert ecosystems.

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