



Notes on feeding, locomotor activity rhythms and orientation in the pygmy mole cricket *Afrotridactylus cf. usambaricus* in Kenya (Orthoptera: Tridactyloidea)

ALBERTO UGOLINI Dipartimento di Biologia, Università di Firenze, Via Romana 17–19, 50125 Firenze, Italy; e-mail: alberto.ugolini@unifi.it

Key words. Orthoptera, Tridactylidae, *Afrotridactylus cf. usambaricus*, behaviour, activity rhythms, feeding, orientation, Kenya

Abstract. Immature individuals of *Afrotridactylus cf. usambaricus* (Sjöstedt, 1910) were recorded on a marine sandy beach probably feeding on bacteria, microalgae and mesopsammic organisms. The larvae of this pygmy mole cricket probably obtain these organisms by manipulating grains of sand with their buccal apparatus during the excavation of tunnels close to the surface of the sand. This occurs in daytime during the ebb tide while direct migration to the sea is in progress. Therefore, the migration occurs according to a diurnal-tidal rhythm having been detected only in correspondence with the low diurnal tides. This rhythmic activity remains in phase with the diurnal-tidal periodicity even far from the sea, in a confined environment. Individuals tested in a transparent Plexiglas bowl are able to assume and maintain the sea-land direction of the beach constant throughout the day in the absence of the landscape vision.

INTRODUCTION

Tridactylidae is a group of Orthoptera, which strongly resemble tiny mole-crickets (also called Pigmy mole crickets). They are quite well known from a systematic and zoogeographic point of view (e.g. see Günther, 1975, 1977), but many aspects of their behavioural ecology are still poorly known. This information generally consists of brief notes in some of the many works published on the taxonomy and systematics of this group (e.g. see La Rivers, 1956; Deyrup & Eisner, 1996; Deyrup, 2005). Research on the behaviour and/or ecology of pigmy mole crickets is very rare. Burrows & Picker (2010) present a careful analysis of the jumping ability of *Xya capensis* var *capensis* (Saussure, 1877) with brief notes on its ecology. Moriya & Ichinose (1988) report that when *Tridactylus japonicus* (De Haan, 1842) is attacked by lycosid spiders or ants it produces a secretion that it uses to protect itself. The relationship between jaw morphology and dietary preferences in *Xya pfaendleri* Harz, 1970 and *Xya variegata* (Latreille, 1809) is described by Kuravova & Kocarek (2016) along with a few hints on their ecology (for the morphology of the mouth parts see also Gangwere, 1965). Deyrup & Eisner (1996) for *Neotridactylus archboldi* Deyrup & Eisner, 1996; Deyrup (2005) for *Ellipes eisneri* Deyrup, 2005 and Woo (2020) for *Ellipes monticolus* Günther, 1977 report interesting but qualitative observations on habitat and digging behaviour of these species. Bastow et al. (2002) highlight the importance of tridactylids in the energy exchange

between rivers and riparian food webs. The paucity of research on the behaviour of tridactylids stimulated me to propose some observations made many years ago thinking of providing a contribution which I hope will be useful to little known behaviour of a species of this family.

MATERIALS AND METHODS

Immature individuals of *Afrotridactylus cf. usambaricus* (Sjöstedt, 1910) were observed and collected on a sandy beach at Malindi, Kenya, in January 1994. The beach is located between Malindi (3°12'41S, 40°07'24"E) and the Sabaki (Galana) river mouth (3°10'25"S, 40°08'30"E). In particular, the observations in nature were made on the marine beach, about 200 m from the mouth of the river. The insects were filmed with a video-camera (Sony Handycam Vision Hi8XR CCD-TRV87E) both in the field and in confined conditions under natural or infrared light.

Feeding

Feeding behaviour was observed on the beach during the digging of galleries and then filmed by a video camera in an insectarium. The handling of sand grains and the time spent handling was recorded. Drawing (Fig. 1) was made observing several series of freeze-frames.

Locomotor activity rhythm and orientation

During the observations in the wild, a count was made of the individuals seen, every hour traveling along transects orthogonal to the shoreline of about 3 m wide in the intertidal belt starting from the limit of the previous high tide. The observations carried out in a confined environment were made in a terrarium, a transparent Plexiglas box (20 × 50 cm) with 3–4 cm of damp sand

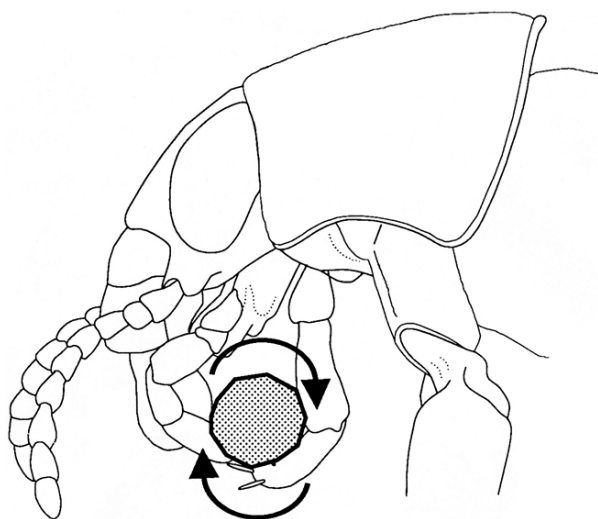


Fig. 1. Schematic representation of the feeding behaviour of an immature individual of *Afrotrydactylus* cf. *usambaricus*. In grey a grain of sand. The arrows indicate the direction of rotation of the grain.

collected from the same beach. Thirty individuals were placed in the box kept under natural conditions of illumination. Every hour from 5 a.m. till midnight the number of individuals active on the surface of the sand was recorded. The capacity for spatial orientation was tested in a confined environment on 15 January 1994. For this a transparent Plexiglas bowl (diameter = 14 cm) surrounded by a white Plexiglas cylinder was used, which prevented the animal inside the bowl from viewing the surrounding landscape but allowed it to see the sun and the clear sky. The bowl had a lid of transparent acetate, which prevented the pygmy mole crickets from escaping. Thirty directions were recorded for each individual by a video-camera placed under the bowl. The experiments were carried out when the azimuthal variation was less than $15^\circ/\text{h}$ (in the morning and afternoon), and when the speed of the sun was 20° to $24^\circ/\text{h}$ (central part of the day). Circular distributions were analysed using the methods proposed by Batschelet (1981). For each individual distribution the mean vector length (r) and mean angle (α) were calculated. To test if the distributions differed from uniformity Rao's test was used ($P < 0.05$ at least). In the case of bimodality, the two modes were neither symmetrical or similar for the number of directions or dispersion, so they were analysed separately. It is therefore obvious that a second order analysis cannot be used. To test the non-uniformity of the second order distribution the G test (Zar, 1984) was applied counting the mean angles of the first order distributions falling in to the sea – land quadrants and in the 2 orthogonal quadrants (1 point for each unimodal distribution, 0.5 point for each mode of the bimodal distributions).

RESULTS AND DISCUSSION

Feeding

The individuals seem to feed on bacteria and, perhaps, on mesopsammic organisms present on the surface of sand grains, which they roll in front of their mouth (Fig. 1). The grains seem actively selected from those available during the digging of the galleries, dug by the individuals very superficially into the substrate using the first pair of legs duly modified. The manipulation of sand grain is very fast, in 60 seconds they can handle 80 grains ($n = 87$) with an average time per grain of 0.41 seconds (minimum time 0.12

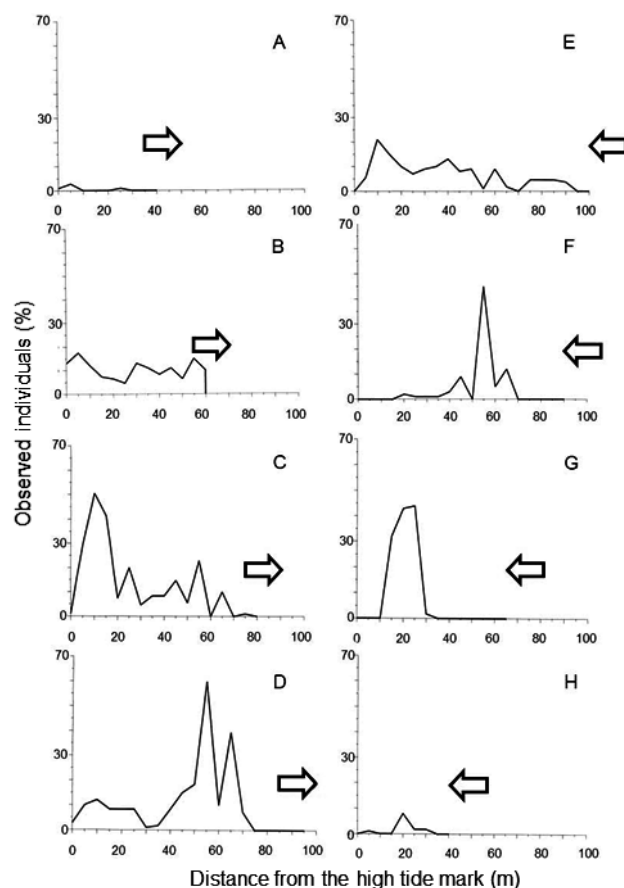


Fig. 2. Locomotor activity of *Afrotrydactylus* cf. *usambaricus* recorded in the field during a tidal cycle (A–H). Each figure shows the percentage of active individuals out of the general total of individuals seen in activity ($n = 192$), at different distances from the water indicated by the tip of the black arrows.

seconds, maximum recorded time 0.58). It is likely that the organic material adhering to the sand granules is removed by rubbing against the buccal parts provided with numerous bristles. Once handled, the granules are not used for the tunnel but are discarded. The scant beached material does not seem to be attractive to individuals.

Locomotor activity rhythm and orientation

The pygmy mole crickets begin to be active moving down the beach orthogonally to the shore line as the tide starts to ebb (Fig. 2A, B). The highest number of active individuals are especially observed in the strip of sand also frequented by the sand bubbler crab, *Dotilla fenestrata* Hilgendorf, 1899 just before the tide reaches its lowest point (Fig. 2D). During the rising tide they move landward, and is followed by a reduction in locomotor activity, which ceases when the high tide is about its maximum (Fig. 2H) and resumes about 2 h after the peak of the high tide (Fig. 3A). The maximum number of active individuals is recorded 1–2 h before the minimum of the low tide (Fig. 3A). My observations do not allow to identify what is/are the external (and/or internal) stimuli that regulate the activity rhythm. However, since no nocturnal migrations were observed, and the migration begins and ends in a temporal “window” related to the tidal rhythm (Fig. 3B) it is reasonable to infer

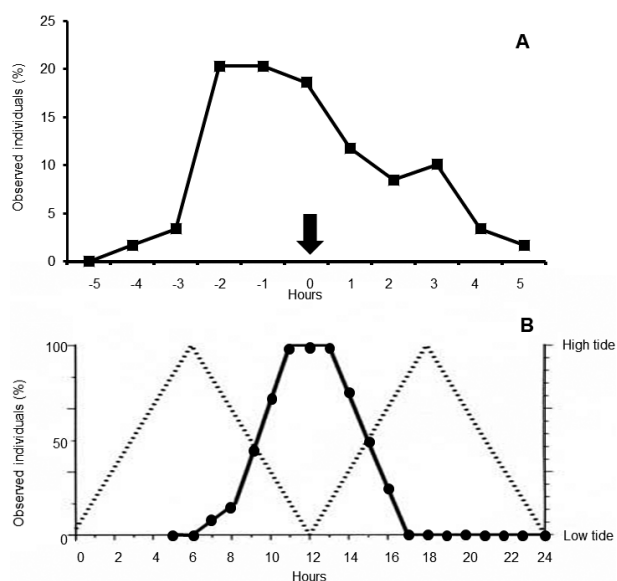


Fig. 3. A, locomotor activity of *Afrotrydactilus* cf. *usambaricus* recorded in the field. Relationship between number of active individuals (%; $n = 192$) times (in hours) after low tide (low tide corresponds to 0, black arrow). B, Locomotor activity recorded in confined conditions far from the sea over a period of 24 h (from 5 a.m. to 24 p.m. local time). The black line indicates the percentage of active individuals recorded every hour out of the total of individuals ($n = 30$). The dashed lines represent the tidal cycle.

that it shows a diurnal-tidal rhythm, which they also exhibit in confined conditions far from the sea (Fig. 3B).

These migrations seem performed mainly, if not entirely, in order to feed. Cicindelid beetles (*Lophyra somalia* Fairmaire, 1882) and small riparian birds, prey on individuals during these migrations (personal observations).

This species of pygmy mole cricket is able to maintain the direction of the sea-land axis of the beach without the landscape vision (Fig. 4) as the mean angles of the first order analyses of individual circular distributions are well clustered around the sea-land axis of the beach ($G = 19.833$, $df = 1$, $P < 0.001$, G test). Unfortunately, the small number of individuals tested and not being able to manipulate some of the possible orienting factors allow only some considerations and hypotheses. Although it is not possible to exclude the possibility that this species uses the natural magnetic field as a compass, as demonstrated for the Equatorial sandhopper *Talorchestia martensii* Weber, 1892 living in the same ecosystem, i.e. East African sandy beaches, (Ugolini, 2001; Ugolini et al., 2021) it is possible that the orientation along the sea-land axis of the beach is maintained constant and independent of the variation in the solar azimuth as demonstrated in other species of Orthoptera (e.g. see Felicioni & Ugolini, 1991; Ugolini & Felicioni, 1991). Moreover, it is also noteworthy that most of the directions recorded in the morning (during ebb tide) are directed towards the sea, whilst those recorded in the afternoon (rising tide) are landward and therefore, in accordance with the tidal rhythm.

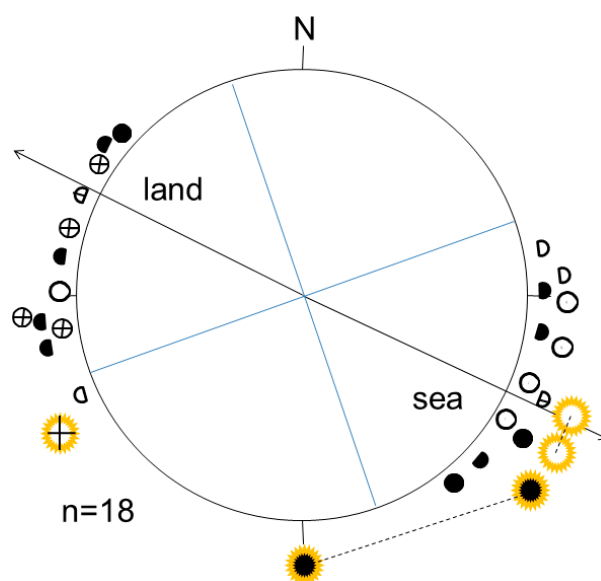


Fig. 4. Solar orientation of *Afrotrydactilus* cf. *usambaricus* recorded in confined conditions far from the sea. Each symbol indicates the mean angle calculated for each individual tested. Open symbols – morning releases; black symbols – mid-day releases; symbols with a cross – afternoon releases. The half symbols indicate mean angles for bimodal distributions. N – north; n – sample size. The symbols of the sun indicate variations in the azimuth at different times during the tests. The sea-land axis of the home beach is also shown. The directions are well clustered around the sea-land axis.

CONCLUSIONS

These brief notes demonstrate that *A. cf. usambaricus* (1) can be found on sandy sea shores (although the area where the observations were made is located near the mouth of a river) and feeds by grazing the grains of sand; (2) it performs migrations based on a diurnal – tidal rhythm, and (3) it probably orientates by using celestial references (sun and sky) and/or the natural magnetic field (e.g. see Ugolini, 2001) during its excursions along the sea – land axis of the beach.

REFERENCES

- BASTOW J.L., SABO J.L., FINLAY J.C. & POWER M.E. 2002: A basal aquatic-terrestrial trophic link in rivers: algal subsidies via shore-dwelling grasshoppers. — *Oecologia* **131**: 261–268.
- BATSCHLET E. 1981: *Circular Statistics in Biology*. Academic Press, London, 371 pp.
- BURROWS M. & PICKER M.D. 2010: Jumping mechanisms and performance of pygmy mole crickets (Orthoptera, Tridactylidae). — *J. Exp. Biol.* **213**: 2386–2398.
- DEYRUP M. 2005: A new species of flightless pygmy mole cricket from a Florida sand ridge (Orthoptera: Tridactylidae). — *Fla Entomol.* **88**: 141–145.
- DEYRUP M. & EISNER T. 1996: Description and natural history of a new pygmy mole cricket from relict xeric uplands of Florida (Orthoptera: Tridactylidae). — *Mem. Entomol. Soc. Wash.* **17**: 59–67.
- GANGWERE S.K. 1965: The structural adaptations of mouthparts in Orthoptera and allies. — *Eos* **41**: 67–85.

- GÜNTHER K.K. 1975: Das Genus *Neotridactylus* Günther, 1972 (Saltatoria, Tridactylidae, Insecta). — *Mitt. Zool. Mus. Berlin* **51**: 305–365.
- GÜNTHER K.K. 1977: Revision der Gattung *Ellipes* Scudder, 1902 (Saltatoria, Tridactylidae). — *Dt. Entomol. Z. (N.F.)* **24**: 47–122.
- FELICIONI S. & UGOLINI A. 1991: Learning and solar orientation in the mole-cricket, *Gryllotalpa gryllotalpa*. — *J. Insect Behav.* **4**: 431–439.
- KURAVOVA K. & KOCAREK P. 2016: Mandibular morphology and dietary preferences in two pygmy mole crickets of the genus *Xya* (Orthoptera: Tridactylidae). — *Turkish J. Zool.* **40**: 720–728.
- LA RIVERS I. 1956: Chapter 5. Aquatic Orthoptera. In Usinger R.L. (ed.): *Aquatic Insects of California*. University of California Press, Berkeley, p. 154.
- MORIYA N. & ICHINOSE T. 1988: Function of the scent from the pigmy mole cricket, *Tridactylus japonicus* De Haan, Orthoptera: Tridactylidae. — *Appl. Entomol. Zool.* **23**: 321–328.
- UGOLINI A. 2001: Relationship between compass systems of orientation in equatorial sandhoppers. — *Anim. Behav.* **62**: 193–199.
- UGOLINI A. & FELICIONI S. 1991: Celestial orientation in *Gryllotalpa gryllotalpa*. — *Physiol. Entomol.* **16**: 355–360.
- UGOLINI A., NISTRI A., AGNELLI P., CIOFINI A. & WILCOCKSON D.C. 2021: The role of the antennae in the compass-based orientation of the equatorial sandhopper *Talorchestia martensii* Weber (Crustacea Amphipoda). — *Ethol. Ecol. Evol.* **33**: IN PRESS. doi10.1080/03949370.2020.1844303.
- ZAR J.H. 1984: *Biostatistical Analysis, 2nd ed.* Englewood Cliffs, NJ, Prentice Hall, 718 pp.
- WOO B. 2020: First natural history observations of the canyon pygmy mole cricket, *Ellipes monticolus* (Orthoptera: Tridactylidae). — *J. Orthopt. Res.* **29**: 1–7.

Received April 8, 2021; revised and accepted May 25, 2021
Published online July 8, 2021