Bol. San. Veg. Plagas, 36: 149-155, 2010

A preliminary study of the biology of the grasshopper *Calliptamus wattenwylianus* (Orthoptera; Acrididae)

M. M. COCA-ABIA, I. TENAS-PÉREZ, S. GIMÉNEZ-LEGARRE, E. GARCÍA-MUÑOZ

Calliptamus wattenwylianus is an important pest grasshopper in the North East of Spain, causing substantial economical losses every year. A study was conducted to determine, for the first time, the biology of this grasshopper. Adult, nymphs and eggs were collected from the field in several locations from Zaragoza (Spain) and reared under different climate conditions. The results indicate that *C. wattenwylianus* is a univoltine species with embryonic anatrepsis, diapause and catatrepsis. Embryonic development under laboratory conditions was achieved between 83 and 134 days.

Climatic requirements for *C. wattenwylianus* are consistent with those found in other *Calliptamus* species such as *C. abbreviatus* from Inner Mongolia steppe. This could be the result of a common phylogenetic pattern. From an environmental viewpoint, *C. wattenwylianus*, *C. barbarus* and *Dociostaurus maroccanus* share ecological niches in the North East of Spain, and hatch at the same temperature range. It could be the result of an adaptation of both species to the same environment.

M. M. COCA-ABIA, I. TENAS-PÉREZ, E. GARCÍA-MUÑOZ. Centro de Investigación y Tecnología Agroalimentaria (CITA). Unidad de Sanidad Vegetal. Diputación General de Aragón. Avda. Montañana, 930, 50059 Zaragoza. Tel: + 34 976 716323, Fax: + 34 976 716335, mcoca@aragon.es

S. GIMÉNEZ-LEGARRE. Centro de Protección Vegetal. Diputación General de Aragón. Avda. Montañana, 930, 50059 Zaragoza. Tel: +34 976 71385, Fax: +34 976 716388.

Key words: Anatrepsis, catatrepsis, diapause, grasshopper, pest.

INTRODUCTION

The genus *Calliptamus* Serville (1831) is worldwide distributed across the Palaearctic Region (Mediterranean Area, Central and East Europe, Near East, North Africa), Oriental Region, Canary Islands and Madeira (KLAUS-GERHARD, 2004). Some species, such as *Calliptamus italicus* (Linnaeus, 1758), *Calliptamus barbarus* (COSTA, 1836) and *Calliptamus wattenwylianus* (Pantel, 1896) are potentially serious pests in several West and East European Countries with a regular occurrence reported from long time ago (CAÑIZO, 1939; LOUVEAUX *et al.*, 1986; LOUVEAUX, 1991; STOLYAROV, 2000).

Climatic factors are very important for the population dynamics of *Calliptamus*. In fact, outbreaks of *C. italicus* in southern Russia revealed a certain rhythm depending on the cycles of solar activity and changes in climatic conditions, favouring that the populations of Italian locust increase when the temperature rises and the precipitation falls (STOLYAROV, 2000). On the other hand, xerophyte habitats and anthropogenic landscapes, such as fallow lands, are favourable environments for *C. italicus* in West Siberian Plain (SERGEEV & VAN'KOVA, 2008). Likewise, the populations dynamics of other Palearctic acridids, such as *Dociostaurus maroccanus* (Thunberg, 1815), are dependent of climatic and anthropogenic factors as well, colonizing semi-desert areas where deforestation, scrub destruction and overgrazing

have occurred, modifying the vegetation structure and compacting the soil (LATCHININSKY, 1998). In addition to that, studies carried out in Western European countries pointed out that, the phenological parameters of density for Gomphocerinae species and *C. italicus* seem to be similar under analogous climatic conditions and variable in different habitats (BADENHAUSSER, *et al.*, 2009).

Everything seems to indicate that climatic and anthropogenic factors such as the rise in temperature, drought, deforestation and overgrazing, could favour the post-embryonic development and outbreaks of acridid species. However, these same conditions in excess could be unfavourable for the embryonic development. In fact, there are evidences indicating that overgrazing could destroy the egg-pods and that extreme moist or drought in the spring provokes fungal and bacteria epizootics or egg dehydration (LATCHININSKY, 1998). Hence, climatic factors are keys to carry on the life cycle of acridid species. Specially, the optimal ranges of temperature and, to a lesser extent, humidity, allow to complete the embryonic development and to hatch at the season when climatic conditions are optimal to start post-embryonic development. Indeed, recent researches have carried out studies about temperature effects on the embryonic development, diapause termination and hatching time in several grasshopper species (HAO & KANG, 2004) and other acridid species such as *D. maroccanus* (QUESADA-MORAGA & SANTIAGO-ÁLVAREZ, 1999; QUESADA-MORAGA & SANTIAGO-ÁLVAREZ, 2000; SANTIAGO-ÁLVAREZ, *et al.*, 2003). This knowledge is essential to know the adaptation of life-cycle to environmental condition of those acridid species that, as *C. wattenwylianus*, show high population levels in the North East of Spain (COCA-ABIA *et al.*, 2007). In this way, it will be possible to carry on rearing under laboratory conditions to understand their biology, never studied before.

Thus, the aim of the present study is to describe, for the first time, the embryonic and post-embryonic development of *C. wattenwylianus* under controlled conditions providing a first step towards the development of a rearing method.

MATERIALS AND METHODS

Collection of living specimens and egg-pods

Adult and nymphs of *C. wattenwylianus* were collected from the field in several locations from Zaragoza (Spain) specified below. The collection date is shown in brackets.

Alhama de Aragón (14/06/06). Caspe-Chiprana (23/06/05, 11/05/06, 22/05/06, 01/06/06, 07/06/06). Cervera de la Cañada (10/05/05, 24/05/05, 01/07/05). Épila (17/06/05, 19/05/06). Torralba de Ribota (10/05/05). Zuera (21/06/06, 07/07/06, 12/07/06, 14/07/06, 17/07/06, 20/07/06, 25/07/06).

Forty-one egg-pods were collected from the field at Zuera and Caspe and one hundred and ninety nine egg-pods were obtained from oviposition pots in rearing cages.

Rearing cages and climatic room for nymphs and adults

Rearing was carried out in 50x50x50 cm metallic cages with all walls made of metallic mesh except the bottom and the ceiling that were made of PVC. A 60W bulb of incandescent light hangs from the ceiling with a string strip to facilitate vertical movement of the insects for the temperature gradient. All cages were identical, but adults and nymphs were placed into different cages. Two pots (d=12cm, h=6cm) with sterile and sifted sand were placed at the bottom of adult cages for oviposition.

Rearing cages were put into a climatic room at 25 ºC-23 ºC (12:12h), and 71-30% relative humidity

The study of adults' behaviour was carried out by direct observation of the specimens into the rearing cages.

Feeding and nursing of adults and nymphs

Adults and nymphs were fed with fresh wheat and dry wheat bran, following the method to rear *D. maroccanus* (SANTIAGO-ÁLVAREZ & QUESADA-MORAGA, 1999; QUESADA-MORAGA & SANTIAGO-ÁLVAREZ, 2001).

The cages were cleaned once every two days, excrements and dead grasshoppers were removed replacing the bottom of the cage by a clean one. Leftover food was removed from the ceiling when required.

Climate camera for egg-pods and embryo incubation

Two hundred and forty egg-pods were used to study the embryonic development. Anatrepsis, diapause and catatrepsis temperatures were established on the basis of the report on *D. maroccanus* (QUESADA-MORAGA & SANTIAGO-ÁLVAREZ, 2000) and *Calliptamus abbreviatus* Ikonnikov, 1913 (HAO & KANG, 2004).

Anatrepsis development

Egg-pods were placed in Petri dishes cups and transferred to incubation cameras at 60% RH and two constant temperatures, 30 ºC (40 egg-pods) and 25 ºC (200 egg-pods), of the five considered for *D. maroccanus* by QUESADA-MORAGA & SANTIAGO-ÁLVAREZ (2000).

Diapause and Catatrepsis development

After finishing the anatrepsis, egg-pods were subjected to diapause for 40 days. The established temperature was 10 ºC according to QUESADA-MORAGA & SANTIAGO-ÁLVAREZ (2000) for *D. maroccanus*. After this period, the egg-pods were warmed to 30 ºC because this is the temperature with maximal hatch ability in species such as *C. abbreviatus* (HAO & KANG, 2004) and the shortest number of days to hatch in *C. barbarus* (FABRY *et al*., 1987) and *D. maroccanus* (QUESADA-MORAGA & SANTIAGO-ÁLVAREZ, 2000).

For the study of embryos, the eggs were removed from the egg-pods and immersed in 5% sodium hypochloride solution to make the chorion transparent. The stage of the eggs was established on the basis of the report by BODENHEIMER & SHULOV (1951) on *D. maroccanus* and by FABRY *et al*., (1987) on *C. barbarus*.

RESULTS AND DISCUSSION

Embryonic development

C. wattenwylianus female lays eggs in egg-pods buried several centimetres into the soil. Eggs are brownish and have a hard cell-like chorion texture (Fig. 1). In the first stage, there is no evidence of embryo and the egg is full of vitellum (Fig. 2).

Anatrepsis

The end of the anatrepsis was detected by the presence of elongated, brown-reddish eyes (Fig. 3). This phase lasted between 38 and 68 days with a mean duration of 53 days incubating egg-pods of *C. wattenwylianus* at 25 ºC and 60% humidity. Egg-pods incubated at 30 ºC and 60% humidity were discarded after 90 days without changes. Thus, it is possible to assert that 25 ºC, not 30 ºC, is a feasible temperature

Figure 1. Cell-like chorion texture of *Calliptamus wattenwylianus* eggs

for anatrepsis of *C. wattenwylianus*. Nevertheless, further research is needed to determine the optimal temperature for this phase.

Diapause and Catatrepsis

According to some authors (UVAROV, 1957; LATCHINISKY, 1998), early spring rainfall is critical for some locust development and it is considered that some contact water on the *D. maroccanus* egg-pods is needed to complete the catatrepsis (ARIAS GIRALDA *et al*., 1997; QUESADA-MORAGA & SANTIAGO-ÁLVAREZ, 1999). On the other hand, for other *Calliptamus* species such as *C. abbreviatus*, the maximal hatch occurs at 29.0 ºC (HAO & KANG, 2004) and for *C. barbarus* the best hatching rate occurs between 22 and 31 ºC (FABRY *et al*., 1987). Our results show that egg-pods of *C. wattenwylianus* subjected to 10 ºC for 40 days and sprayed with water continued the embryonic development by rising the temperature to 30 ºC, undergoing blastokinesis (Fig. 4) and grows until reaching the final egg volume (Fig. 5), hatching between 8 and 26 days (15.6 days on average). Thus, it is possible to assert that 30 ºC is a feasible temperature for catatrepsis of *C. wattenwylianus*.

This climatic requirement is consistent with *C. abbreviatus* from other geographic areas so far away from the Mediterranean area as the steppe grasslands of Inner Mongolia (HAO & KANG, 2004). This similarity in the climatic requirement between them *C. wattenwylianus* and *C. abbreviatus* could be the result of sharing a phylogenetic pattern. From an environmental viewpoint, *C. wattenwylianus*, *C. barbarus* and *D. maroccanus* share ecological niches in the North East of Spain, adapting to hatch at the same temperature range. This fact could be the result of an adaptation of these species to the same environment.

After this research, it is possible to state that the embryonic development of *C. wattenwylianus* under laboratory conditions can be achieved between 83 and 134 days. It is a univoltine species that shows four embryonic phases: phase I, anatrepsis, diapause and catatrepsis and it is similar to that described by BODENHEIMER & SHULOV (1951) for *D. maroccanus*. On the contrary, the state VI (axial turn) described by FABRY *et al*., (1987) for *C. barbarus*, has not been observed on *C. wattenwylianus*. Nevertheless, further research is needed to determine the most effi-

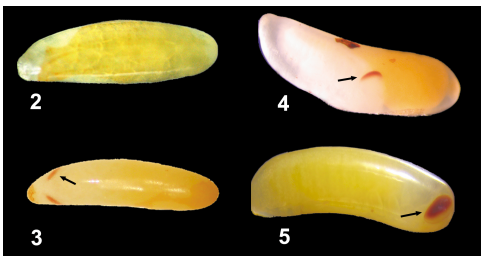

Figure 2-5. Eggs of *Calliptamus wattenwylianus* in: phase I, without evidence of embryo (2), embryo in anatrepsis (presence of elongated eyes) (3), embryo undergoing blastokinesis (4), embryo in catatrepsis (5). Arrows show the eyes

cient temperatures for anatrepsis and catatrepsis, and the shortest time for diapause.

Hatching, nymphs and adult's behaviour

The well-developed embryo breaks the chorion and emerges from the egg. Immediately after hatching, the hoppers undergo a first moult. Nymphs (Fig. 6) moult five times (N1-N5), growing in size and developing the wings and tegmina until becoming functional wings in adults.

When males and females become sexually mature, they can copulate. Sexual excitement of males is evident when the last abdominal terguites are swollen up and the cerci are lifted (Fig. 7). Copulation behaviour is characteristic; the males twist the abdomen 90º laterally and approach the female back to try the copula. During copulation, the males hold females with their cerci.

Figure 6. Nymph of *Calliptamus wattenwylianus* in advanced state

Figure 7. Swollen 9th and 10th abdominal terguites of a male specimen of *Calliptamus*

After the copula, and to lay the eggs, the females explore the soil surface with the valves located at the rear of their abdomens. After finding an adequate place, females bore into the ground by opening and closing the valves and lay the eggs. These are protected with sand and froth, produced by their accessory glands (SNODGRASS, 1935). When the egg-pods are finished these are closed with a soft plug of froth.

Although the identification of an appropriate nourishment to successfully develop *C. wattenwylianus* will require undoubtedly further work, the data we present herein particularly on the embryonic development, provides a first step towards the reconstruction of the life cycle of *C. wattenwylianus* under laboratory conditions.

ACKNOWLEDGEMENTS

Ángel Guerrero (Instituto de Investigaciones Químicas y Ambientales-CSIC) provided comments on the manuscript. This work was supported by the project RTA2006-00110-C02-01 funded by Instituto Nacional de Investigaciones Agroalimentarias (INIA) Spanish Government and a predoctoral grant from Training of Researchers Program (INIA) to E. G.-M.

RESUMEN

COCA-ABIA, M. M., I. TENAS-PÉREZ, S. GIMÉNEZ-LEGARRE, E. GARCÍA-MUÑOZ. 2010. Estudio preliminar sobre la biología del saltamontes *Calliptamus wattenwylianus* (Orthoptera; Acrididae). *Bol. San. Veg. Plagas,* **36:** 149-155**.**

Calliptamus wattenwylianus es responsable de severas plagas en cultivos agrícolas del noreste de España, causando perdidas económicas sustanciales todos los años. Este trabajo describe, por primera vez, la biología de *C. wattenwylianus* en cautividad. Adultos y ninfas fueron recolectados en diferentes localidades de Zaragoza (España) y criados en cautividad bajo distintas condiciones climáticas. Los resultados indican que *C. wattenwylianus* es una especie univoltina, con un desarrollo embrionario que presenta anatrepsis, diapausa y catatrepsis. La duración del desarrollo embrionario bajo condiciones climáticas controladas fue entre 83 y 134 días.

Los requerimientos climáticos de *C. wattenwylianus* son consistentes con los de otras especies como *C. abbreviatus* de las estepas de Mongolia. Esto podría ser debido a que ambas especies comparten el mismo linaje filogenético. Desde un punto de vista ambiental *C. wattenwylianus*, *C. barbarus* y *Dociostaurus maroccanus* comparten el mismo nicho ecológico en el noreste de España y avivan dentro del mismo rango de temperaturas. Esto podría ser el resultado de la adaptación de ambas especies al mismo ambiente.

Palabras clave: Anatrepsis, catatrepsis, diapausa, saltamontes, plaga.

REFERENCES

ARIAS GIRALDA, A., JIMÉNEZ VIÑUELAS, J., PÉREZ ROMERO A. 1997. Observaciones sobre el desarrollo embrionario y el avivamiento de Dociostaurus maroccanus (Thunb) en una finca de "La Serena" (Extremadura). *Boletín de Sanidad Vegetal. Plagas*, **23**: 113-132.

BADENHAUSSER, I., AMOUROUX, P., LERIN, J., BRETAGNOLLE, V. 2009. Acridid (Orthoptera: Acrididae) abundance in Western European Grasslands: sampling methodology and temporal fluctuations. *Journal of Applied Entomology*, **133**: 720-732.

BODENHEIMER, F. S., SHULOV, A. 1951. Egg development and diapause in the Moroccan locust, *Dociostaurus maroccanus* (Thunberg). *Bulletin of the Research Council of Israel*, **1**: 59-75.

CAÑIZO J. 1939. Las plagas de langosta en España. *Boletín de Patología Vegetal. Entomología Agrícola*, **8**: 27-48.

COCA-ABIA, M., QUERO-LÓPEZ, C., SOPEÑA-MAÑAS, J. M., MARTÍN-BERNAL, E., GUERRERO A. 2007. Contribución al conocimiento de los Ortopteros de la Península Ibérica. *Boletín de Sanidad Vegetal. Plagas*, **33**: 79-86.

FABRY, M. H., LOUVEAUX, A., CHOISNEL, E., PAYEN, D. 1987. Environnement thermique à l'interface air-sol. Application à la simulation de la durée du développement des oeufs de *Calliptamus barbarus* (Costa, 1836) (Orthoptère, Acrididae). *Acta Oecologica. Oecologia Applicata*, **8** (1): 53-65.

HAO, S. G., KANG, L. 2004. Effects of temperature on the post-diapause embryonic development and the hatching time in three grasshopper species (Orth., Acrididae). *Journal of Applied Entomology*, **128**: 95-101.

KLAUS-GERHARD, H. 2004. Fauna Europaea: Acrididae. Fauna Europaea Versión 1.1, available on line at http://www.faunaeur.org. Last update 3 June 2010.

LATCHINISKY, A. V. 1998. Moroccan locust *Dociostarurus maroccanus* (Thunberg, 1815): a faunistic rarity or an important economic pest? *Journal of Insect Conservation*, **2**: 167-178.

LOUVEAUX, A. 1991. Population upsurges and dispersion strategy of acridoids: an example in the Calliptaminae subfamily. *Bulletin de la Societe Zoologique de France*, **116** (3-4): 243-251.

LOUVEAUX, A., PAYEN, D., FABRY, M. H. 1986. Variabilité climatique et Déstabilisation Démographique de *Calliptamus italicus* (L.) (Orthoptères, Acrididae). *Coll. Nat. CNRS, Biologie des Populations*, **20**: 569-757.

QUESADA-MORAGA, E., SANTIAGO-ÁLVAREZ, C. 1999. Inducción de salida de la diapausa en la langosta Mediterránea *Dociostaurus maroccanus* (Thunberg) (Orthoptera: Acrididae). *Journal of Orthoptera Research*, **8**: 13-16.

QUESADA-MORAGA, E., SANTIAGO-ÁLVAREZ, C. 2000. Temperature related effects on embryonic development of the Mediterranean locust, *Dociostaurus maroccanus*. *Physiological Entomology*, **25**: 191-195.

QUESADA-MORAGA, E., SANTIAGO-ÁLVAREZ, C. 2001. Rearing and breeding of the Moroccan locust *Dociostarurus maroccanus* (Thunberg) (Orthop., Acrididae) under laboratory conditions. *Journal of Applied Entomology*, **125**: 121-124.

SANTIAGO-ÁLVAREZ, C., QUESADA-MORAGA, E. 1999. Manipulación del desarrollo embrionario y cría en laboratorio de la langosta mediterránea *Dociostaurus maroccanus* (Thunberg). *Boletín de Sanidad Vegetal. Plagas*, **25**: 469-474.

SANTIAGO-ÁLVAREZ, C., QUESADA-MORAGA, E., HERNÁNDEZ-CRESPO, P. 2003. Diapause termination and post-diapause development in the Mediterranean locust *Dociostaurus maroccanus* (Orth., Acrididae) under field conditions. *Journal of Applied Entomology*, **127**: 369-373.

SERGEEV, M. G., VAN'KOVA, I. A. 2008. Dynamics of the Italian locust *Calliptamus italicus* L. Population in the Southeast of the West Siberian Pain. *Contemporary Problems of Ecology*, **1** (2): 204-209.

SNODGRASS, R. E. 1935. *Principles of Insect Morphology*. Electronic edition. McGraw-Hill, New York and London.

STOLYAROV, M. V. 2000. Cyclicity and some characteristics of mass reproduction of *Calliptamus italicus* L. in southern Russia. *Russian Journal of Ecology*, **31** (1): 43-48.

UVAROV, B. P. 1957. *The aridity factor in the ecology of locusts and grasshoppers of the Old World*, pp. 164-198. In: Arid Zone Research VIII. Human and Animal Ecology, (UNESCO Reviews of Research Eds): Paris, France.

(Recepción: 25 marzo 2010)
(Aceptación: 21 junio 2010)