

Ethogram of courtship and mating behaviour of garden lizard, *Calotes versicolor*

Bhagyarekha N. Pandav, Bhagyashri A. Shanbhag* and Srinivas K. Saidapur

Department of Zoology, Karnatak University, Dharwad 580 003, India

An ethogram of courtship and mating in the garden lizard, *Calotes versicolor* was prepared by recording these behaviours in outdoor terraria. Courtship behaviour was recorded by video camera and handwritten notes of direct observations in nine encounters. A behaviour inventory defining 25 distinctive postures/gestures, orientations and simple movements is presented, and these units are grouped into functional categories. The courtship behaviour was divided into three distinguished patterns – orientation, persuasion and copulation. This study describes the ethogram of courtship and mating behaviour in an agamid lizard in captivity and correlates the function and form of behavioural units in an agamid lizard.

Keywords: Behaviour, *Calotes versicolor*, courtship, ethogram, mating.

CHEMICAL, auditory and visual cues are known to play key roles in courtship patterns in lizards^{1,2}. Diurnal lizards

primarily communicate using movement-based visual signals often delivered in a predictable sequence, together with characteristic postures and changes in body coloration³, while nocturnal lizards like geckos mainly rely either on vocal/auditory¹ or chemical cues⁴ for courtship acts. Despite some studies on courtship behaviour in iguanid and scincid lizards^{3,5-9} careful descriptions of the sequence of events in courtship and mating behaviour in agamid lizards are rare¹⁰. Interestingly, the agamid lizards exhibit complex and colourful visual displays. The present study describes the catalogue of behaviours (ethogram) during courtship and mating in an agamid, *Calotes versicolor* in an outdoor terrarium and their organization into functional categories.

The courtship and mating behaviour in *C. versicolor* was studied in individuals that were laboratory-born and raised in outdoor terrarium (150 cm × 120 cm × 120 cm). The terrarium was made of wire mesh on two opposite sides (for ventilation) and the remaining two sides with transparent acrylic sheet (for light). The bottom of the terrarium contained sand-mixed soil bed, 30 cm in depth. The terrarium was provided with potted plants, hiding sites using broken pots, perch stand and a water bowl. The lizards were maintained on a variety of diet consisting of insects like silkworm, grasshopper, silk moth and cockroach.

When six months old, both the sexes developed black patches ventro-laterally in the neck region, a sign of attainment of sexual maturity. The sexually matured males measured 9.4 ± 0.02 cm in snout vent length (SVL) and weighed 20 ± 5 g in body mass. The SVL of females was 8.3 ± 0.13 cm and body mass was 10.7 ± 0.71 g. Males exhibited red coloured hues on their head and gular areas. The courtship and mating behaviour in these lizards was generally observed from the last week of May to the second week of August, which coincides with the breeding season of the garden lizards in nature¹¹. The courtship behaviour was mainly encountered between 0900 and 1200 as well as 1600 and 1800 h. Observations were made on a total of nine courtship and mating encounters. The sequence of events of courtship and mating was video-recorded using a Sony handycam in four cases, while hand-written notes were based on observations in five cases.

The terminologies used for behaviour of lizards are mostly after Carpenter and Ferguson³. A total of 25 types of behaviour associated with courtship and mating were recorded. Using the recorded observations and video analyses, the ethogram of courtship and mating was prepared and is described below:

Aggression – Agonistic or dominating actions performed by male.

Approach – Male's approach towards female.

Body wrap – Male with neck-bite hold and tail twist, body arched over female with fore-leg hold on female's trunk and hind-leg hold on the base of female's tail.

*For correspondence. (e-mail: bhagyashrishanbhag@gmail.com)

Chase – Rapid pursuit of one individual by another that is retreating from the former.

Circling – Male approaches female with lateral orientation facing-off the female in a circular or semicircular path.

Colour change – Red colour develops at the head or antero-dorsal region of the body and around the eyes (especially in male) or at the head region in females.

Copulation – Intromission of hemipenis into the vent of the female, stationary for 5–9 s and withdrawal of hemipenis.

Dewlap – Rapid extension of gular flap due to muscular movement of the hyoid apparatus.

Flee – Rapid retreat by a lizard on approach of another lizard.

Follow – Male follows the retreating female.

Four-leg push-up – Rapid raising and lowering the body on all four legs.

Grip release – Male releases the neck bite and leg hold on female.

Half head bob – Raising and lowering of the head above or below the axis and bringing it back to normal position with no movement of front legs.

Head bob – Raising and lowering of the head above and below the axis and bringing it back to normal position with no movement of front legs.

Head up/lift – Head tipped upwards and neck stretched at right angle to the body axis.

Limp – Submissive body condition of female dragged by the male with neck bite hold.

Neck bite hold – Male grasps on the skin of the neck of female with its jaws.

Nuchal crest – Elevated/erected ridge of scales along the back of the neck.

Push-up – Rapid raising and lowering of the anterior region of the body with fore legs.

Stand high – Stiff pose; stand high, rigidly on front legs.

Stationary – No body movements for 5–6 s when male is mounted on female, except head bobs by the female.

Straddle – Male holds female with neck grip and partly embracing with limbs, climbs onto the back of the female.

Tail up at base – Tail lifted at base, mid portion up and tip touching the substrate displayed by female.

Tail twist – Male's tail twisted under the female's tail bringing the cloaca close to that of the female.

Throat inflation – Inflates throat by puffing-up.

These behavioural units account for majority courtship activity and can be distinguished into 14 distinct functional units as described below.

Circling – As the female signals her acceptance by displaying the courtship stand, the male approaches her by circling.

Colour change – The change in body colour of the lizard is the first step towards initiating courtship. The change

in colour becomes more intense in both the male and the female, as they make the first move towards courtship.

Courtship approach – Male's approach towards female with courtship displays. Courtship response by the receptive female is associated with approach by male towards the female.

Courtship display – Male performs this with five half head bobs upwards and one full head bob followed by a push-up display and dewlap and nuchal crest, with increase in the intensity of head colour. The male becomes aggressive at this point of time.

Courtship response – Female shows two full head bobs, three half head bobs upwards and one half head bob downwards holding the head down for some time, push-up display and throat inflation to courtship display and courtship approach of male.

Courtship stand – The female stands rigid and immobile as the courting male approaches her and does not try to flee.

Display site selection – Male chooses a characteristic site, especially the top position on a perch in the cage to perform initial display.

Female acceptance – Female shows a single head bob followed by a four-leg push-up display following courtship approach by male.

Grip release – Male releases the neck bite and leg hold on female and female is released free. Then both the lizards move opposite to each other. Male withdraws the hemipenis after moving a distance from the female in opposite direction and stands on four legs holding the basal part of the tail high up and bent to one side.

Head up/lift – Head lifting behaviour is exhibited by the receptive female when the male mounts on the female.

Initial display – Six half head bobs upwards, one full head bob and one half head bob downwards and held down for some time accompanying a push-up display.

Mounting – The male assumes superior position on the female's dorsum with neck-bite hold and front-leg hold on the female's trunk.

Post-mating behaviour – The male shows one half head bob downwards, two half head bobs upwards once and four half head bobs upwards and one full head bob, while the female shows three half head bobs upwards and one full head bob, accompanying the push-up display. The body colour of both sexes changes to normal.

Submissive behaviour – The receptive female shows this behaviour with head down, back arched and cloaca attached to the substratum with tail up at base. The receptive female shows submissive behaviour in acceptance for mating as the male approaches with circling.

The sequences in courtship and mating behaviour are represented through a flow diagram in Figure 1. The courtship and mating behaviour in *C. versicolor* may be divided into three distinct phases, i.e. orientation, persuasion and copulation.

male with body wrap and tail twist (Figure 2*f*). The male attempts to maintain its position with the forelegs and brings its cloaca in contact with that of the female. This is followed by intromission of hemipenis and copulation is effected. The pair remains in this position for 5–9 s (7.66 ± 1.12 s). After copulation, the male releases the neck of the female and relinquishes contact with the anterior part of the female. Then the female crawls slowly forward and slides from beneath the male (Figure 2*g*). The male moves in opposite direction, loses contact with the female and moves away. About < 5 s after copulation, the lizards lose nuptial colouration (Figure 2*h*). The entire process of courtship and mating, beginning from the approach of the male towards the female, mating and separation of the pair takes about 3–18 min.

The ethogram associated with courtship and mating behaviour is an important first step in understanding and interpreting the courtship behaviour pattern and movement-based visual signals in *C. versicolor*. This provides a baseline for future endocrine and behavioural aspects related to mate choice.

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