Colour changes induced by pairing and painting in the male rainbow lizard, *Agama agama agama*[1]

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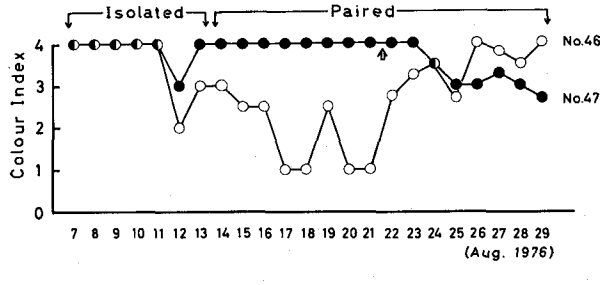
Summary. The brilliant red-orange colour of the head changed to dark brown, if a male rainbow lizard was paired with a stronger male. However, after the latter was painted green on the head, which might imitate the female or juvenile male coloration, the former recovered its brilliant colour.

The adult male rainbow lizard, *Agama agama agama*, which governs its own territory, displays a brilliant red-orange head and tail with a blue-black body in the sunny daytime. Such a male is called 'cock lizard'[3]. Females and juvenile males surrounding a cock lizard have a green head and a brownish body and tail. All lizards turn dark brown in the evening when they come to their roosting place. A number of cock lizards, together with females and young males, can sleep in the same place as long as they show such night coloration. However, after leaving the sleeping place, a cock lizard does not allow another cock to penetrate its territory, challenging and threatening by special postures as described by Harris[3], then pursuing and attacking the penetrator. During the fight, the whole body colour of both lizards becomes rather pale, and the defeated one sometimes shows a chocolate-brown head. Similar coloration is easily observed immediately after handling. This report deals with an analysis of the significance of colour changes in the social life of the rainbow lizard.

Changes in colour scores of paired rainbow lizards before and after painting one of the cage mates green

Pair No.	Painted partners		Nonpainted partners	
	Before*	After*	Before*	After*
1	3.4	3.2	3.0	3.9
2**	4.0	3.3	1.8	3.4
3	3.8	2.5	1.6	2.6
4	3.4	2.3	3.0	3.3
5	3.3	2.8	3.2	2.5
6	3.4	2.7	2.6	3.1
7	3.7	3.6	2.3	2.9
8	3.8	3.3	2.1	2.9
9	3.5	3.0	3.2	3.4
10	3.4	2.8	3.2	2.9
Mean ± SE	3.6 ± 0.2	3.0 ± 0.4	2.6 ± 0.6	3.1 ± 0.4
Statistical difference		$p < 0.001$		$p > 0.05$

* Each value equals the average of daily scores in 7–8 days.
** The time course of changes in this pair is shown in the figure.



Daily changes in colour index in 2 cock lizards (No. 46 and 47). Before pairing, both lizards exhibited high scores. After pairing No. 47 was apparently dominant to No. 46. But painting No. 47 green on the head (arrow between 21st and 22nd days) gradually resulted in a reversal of the situation, although the score difference were not so great as before.

Materials and methods. 20 'cock lizards' were collected at the University of Ife Campus. They were numbered for identification by blue spots of magic ink on the back skin according to the 7–4–2–1 coding method[4], measured for the body and tail length and weighed. 6 lizards were individually kept for 7 days and then paired. 14 others were paired on the next day of capture. Cages of metal wire mesh (30 × 30 × 50 cm) were separately placed inside a large outdoor enclosure of metal wire mesh (5 × 5 × 2 m), in which females and juvenile males were kept. This enclosure prevented free cock lizards from approaching and threatening the captured animals. Panels between the cages eliminated visual interference. Sections of black polyvinylchloride pipe and a dish were placed in each cage for hiding and water supply, respectively. Living insects were supplied as food. Pieces of biscuit inside the cage attracted many ants which also served as food.

The coloration was classified as follows. Grade 4: red-orange head with blue-black body. Grade 3: dark orange head with white patterns on dark grey body. Grade 2: light brown head with dark brown uniform spots or patterns on grey body. Grade 1: dark brown head with brown-black uniform spots and white specks on grey body. Grade 0: dark brown head with dark brown body. Grades 4, 1 and 0 may equal the reproductive, the fear and the dark reticulate colour phase, respectively, of Harris[3]. Observations of skin colour were done 1–5 times per day (8–18 h). Daily scores were obtained by averaging the numerical values of the grades. After 7–8 days of pairing, dominant lizards which had won a larger total score than their cage mates were painted green with magic ink on the head including the whole gular fold and, in some cases, on the red-orange part of the tail. Scoring was then mainly based on the coloration of the body. After 7–8 days of observation, the animals were released to their natural habitat.

Results. During the isolation period, all lizards showed almost constantly the bright coloration (the average score of 6 lizards in 7 days was 3.6 ± 0.4). Females inside the enclosure often approached the cages containing males in

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3 V. A. Harris, The Life of the Rainbow Lizard. Hutchinson & Co., London 1964.
4 S. Inoué, Jap. J. Anim. Reprod. *10*, 137 (1965).

the grade 4 coloration. When females demonstrated the mating posture, arching the back and raising the tail, males bobbed the head without extending the gular fold (the male courtship behaviour[3]). Soon after the animals were paired, the challenge and threat postures accompanying combats were in most pairs observed only for a short while. Then one of the cage mates would turn pale. This state usually continued until the other was painted green. The cage was so small that the 2 lizards stayed very close to each other, but no more aggressive behaviour was observed. In 10 pairs, the average score of dominant partners in 7–8 days was significantly larger than that of the subordinate (table). The size of lizards seems not to be related to the dominance in the pair. The initial body length, tail length and weight in the dominant partner group averaged 132 ± 10 mm, 180 ± 53 mm and 78.5 ± 18.4 g, respectively, while those in the subordinate mate group were 133 ± 7 mm, 174 ± 44 mm, and 83.1 ± 11.4 g, respectively.

When dominant partners were painted green, the grade of coloration continued high for a few days and then fell slightly with some ups and downs. On the other hand, the subordinate nonpainted cage mates showed a rapid rise in colour grade, which lasted until the termination of the experiment. However, individual differences in this group were so great that no statistical significance was found in difference between scores before and after painting their partners. During the observation period of 7–8 days, no distinct aggressive behaviour occurred even when both painted and nonpainted lizards exhibited the grade 4 coloration. Nonpainted lizards displayed no male courtship behaviour to their painted partners, which, of course, showed no female mating posture. However, they responded to females approaching from the outside of the cage by the head bob, which had never been seen before. The average scores of both groups after painting were almost same (table). A typical time course of the changes in a pair is shown in the figure.

Discussion. Visual information appears to play an essential role in the social life of the rainbow lizard. Like traffic signals in human society, the rainbow lizard recognizes another to be approachable or not by its coloration. The head colour seems most important to discriminate the sex, social status and psychophysiological states. A cock lizard usually displays the typical brilliant coloration as long as no disturbance exists. If a stronger male approaches, the weaker has to change its skin colour to pale or even dark to guarantee its safety. Pale or dark males are no longer attacked by the stronger males. This is also the case with the coloration for sleep.

However, if the stronger male showed a green-painted head, the weaker behaved like a dominant cock lizard, supposedly mistaking the partner for a female or a weaker male. Such a change gradually affected the psychophysiological state of the painted lizard, forcing it to resign the dominant status. It is of interest that the reversal of the status, although not well established in the 7–8 day observation period, was achieved without fights. Explanations are at present not available as to why painted lizards showed no aggression to their bright-headed cage mates.

The internal regulatory mechanism of colour change and territorial behaviour, triggered by visual inputs, is still unknown in the rainbow lizard. The fact that colour grades of cock lizards are greatly reduced by castration and restored by testosterone administration[5] may suggest an involvement of the neuroendocrine system in the control of coloration and, possibly, of behaviour.

5 K. C. Ezem, B. Sc. Dissertation at the Faculty of Health Sciences, University of Ife, Nigeria 1976.

Oriented mycelium growth of the fungus *Poria vaillantii* (DC) Sacc. in mixed culture with spruce callus

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Summary. Metabolites with inhibiting action, which are secreted into the substrate by the spruce callus, provoke in the fungus *Poria vaillantii* a subsequent production of aerial mycelium bundles. Their orientation, right-handed negative chemotropism with a certain deflection from the callus, is included in this reaction.

In many fungi, the longitudinal hyphal aggregation of surface mycelium appears[1]. In the course of time, rhizomorphes are formed from this aggregation. In nature, the rhizomorphes are common in some species of wood-destroying fungi and serve partly for the propagation of infection[2,3] and partly for the translocation of nutrients[4]. The origin and formation of longitudinal aggregations of hyphae can well be investigated in vitro in mixed culture with living spruce callus, which mostly inhibits the growth of wood-destroying fungi[5]. Under these conditions, the aggregations of hyphae originating from the surface mycelium exhibit a certain growth orientation.

In the present paper, we intend to demonstrate how this growth orientation is manifested in the fungus Poria vaillantii.

Material and methods. In 1974 the callus culture of *Picea excelsa* Link. was derived in our laboratory from the hypocotyl of a spruce seedling on the medium by Durzan et al.[6] The callus culture is maintained on Brown and Lawrence medium[7] with the addition of 5 mg α-napthylacetic acid and 0.1 mg · l^{-1} benzylaminopurine, by passaging for 4 weeks. This medium was put into Petri dishes of 9 cm in diameter. The callus, which had been grown for 3 weeks from the last passage, was inoculated in the distance of about 3 cm from the centre of each dish. The callus inoculum was placed into Petri dishes in following variants:

1. The dish contained only 1 inoculum (figure, a, b).
2. The dish contained 2 inoculi which were placed a) on radii, forming an angle of 45° (figure, c), b) on radii forming an angle of 90° (figure, d), c) on the same diameter, but on the opposite parts of the dish (figure, f).
3. The dish contained 3 inoculi placed next to each other on radii forming an angle of 45° (figure, e).

Each variant was established in 3 repeatings. After 24 days of callus growth, the fungus *Poria vaillantii* (DC)