

Biological data on *Holaspis guentheri laevis* Werner, 1895 obtained from vivarium keeping

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INTRODUCTION

Within the family Lacertidae the genus *Holaspis* represents one of the most aberrant forms. It used to be very rare in museum collections and live animals hardly ever reached Europe. It was therefore exciting to obtain several specimens in June 1996 through the attentiveness of Andreas Helmdag (Duisburg). Our lizards probably hail from the Usambara Mountains in northeastern Tanzania. Remarkably enough the first specimen to be described also came from this region (see below: WERNER, 1895).

This species is unique among lacertids as it is said to fly: i.e. can jump between branches or even trees and glide for considerable distances (e.g. BRANCH, 1988; Ionides, 1951 in: LOVERIDGE, 1955). ARNOLD (1989) stated that glides of up to 30 meters have been observed in the wild, and SCHIØTZ & VOLSØE (1959) even reported direction changes during such flights.

DESCRIPTION



Male *Holaspis guentheri laevis*.

Photo: H.A.J. in den Bosch

Holaspis guentheri is a small, arboreal lacertid. The maximum total length is 12-13 cm; the head-body length is maximally 51 mm and the tail length is 72 mm (BOULENGER, 1921; pers. obs.). The maximum weight of non-gravid animals is 3.12 g, but commonly adult animals weigh 2.1-2.5 g.

The lizard has an extremely flattened body shape. Adult males, which apart from the better-developed femoral pores can be recognised by their larger heads, measure at the most 4 mm in height at the highest part of their skull. The lizards can spread their ribs in such a way that they become very flat (too mm) and over three cm wide. Literature reports (e.g. DUNGER, 1967) have compared basking specimens with coins. Equally, the tail is much flattened dorso-ventrally.

The lateral borders of the tail consist of wide, somewhat pointed scales, increasing the tail width still further. The pointed, relatively small head is another remarkable feature. Two longitudinal rows of large dorsals are found on the back. The characteristic lacertid collar is clearly recognisable.

Dorsally the ground colour is black. From the tip of the snout to the nape of the neck a yellow greenish median line is found. A dorsolateral band starts above the eye, coloured similarly to the median stripe. It follows the outside of the large dorsals and changes its colour from turquoise to sky blue at the point where the dorsolateral stripes fuse above the tail base. From here it travels as a wide, partly interrupted, clear blue stripe onto the tail tip. A yellowish brown to red brown, but usually beige, lateral stripe runs from the tip of the snout to the hind limb. After that the widened orange tail scales are found. Ventrally the lizards are orange to greenish orange, partly with a mother-of-pearl shimmer. Thus, when MATSCHIE (1893) described "*Holaspis guentheri* (A. Sm)" from Sierra Leone and Cameroon as a small brown lizard with three white longitudinal lines along each flank, he obviously dealt with a preservational artefact.

DISTRIBUTION AND TAXONOMY

Holaspis guentheri is found in tropical Africa. Usually the species is considered to contain two subspecies. *Holaspis guentheri guentheri* lives in the Central African countries of Sierra Leone, Ghana, Nigeria, Cameroon, Gabon, Equatorial Guinea, Zaire, Uganda, and Angola. *Holaspis guentheri laevis* occurs in the eastern African countries of Tanzania, Malawi, and Mozambique (e.g. BISCHOFF, 1991). Not much literature has been published on *Holaspis*, and the older papers give rather fragmented information. MATSCHIE (1892) reported that *Holaspis guentheri* (Gray) lived in Gabon, Sierra Leone, Congo, Bukoba on Victoria Njansa, and mentioned two new specimens from Derema, located on the eastern side of the Usambara highland at around 850 m in a forested region.

For East Africa WERNER (1895) described the subspecies *Holaspis guentheri laevis*, of which he thought the following traits were characteristic: collar with 15 very small scales, smooth dorsoventral scales, 22-23 preanal pores (sic; meant are probably the femoral pores). The body is a bright green (sea green) with three black longitudinal stripes of which the middle one occupies the inner half of both dorsal scale rows; head and body have four longitudinal stripes, in which the middle black stripe is dissected by a thin bright line. The tail is black with a longitudinal series of bright green spots and the lateral denticulation is yellow both dorsally and ventrally. The total length of the lizard is 128 mm and the tail length is 76 mm. Except for the coloration, most of these characteristics do not seem to be restricted to the East African form. For instance, DUNGER (1967) gives 19-24 femoral pores for *Holaspis guentheri guentheri*. SCHMIDT (1919) saw no reason to retain *Holaspis guentheri laevis*. ARNOLD (1989) considered LOVERIDGE'S (1953) revival of Werner's subspecies justified and expressed it as follows in his key:

A dark vertebral stripe on the body and three dark stripes on each side: *Holaspis guentheri guentheri*. A dark vertebral stripe on the body and two dark stripes on each side: *Holaspis guentheri laevis*. Recently BROADLEY (2000) treated the *Holaspis* subspecies as being two species (*H. guentheri* and *H. laevis*), but we are unsure if he is the first one to do so. He felt they could be distinguished on the basis of the following key:

Pale paravertebral stripes confined to the paired rows of enlarged paravertebral scales: *Holaspis guentheri*.

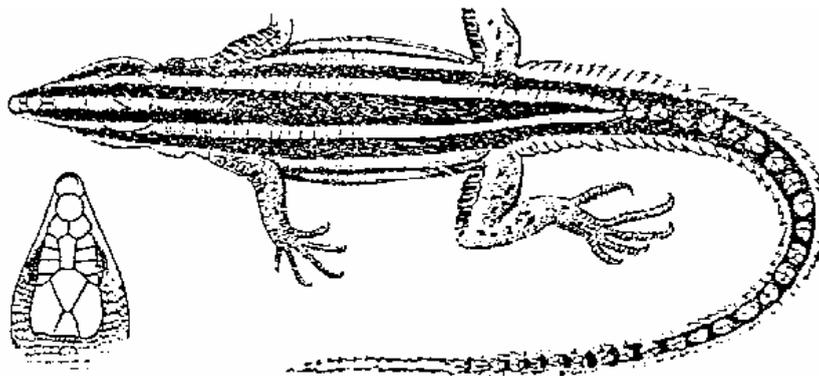
Pale paravertebral stripes not confined to the paired rows of enlarged paravertebral scales, extending onto (or even restricted to) adjacent rows of small scales: *Holaspis laevis*.

One of us (MK) recently examined two specimens in the ZMFK collection in Bonn, one of *Holaspis guentheri guentheri* (ZMFK 7887) from Cameroon and one of *Holaspis guentheri laevis* (ZMFK 73615). No obvious differences in pholidosis were seen.



The different striping of the two subspecies: *Holaspis guentheri guentheri* (above) and *Holaspis guentheri laevis* (below) (ZMFK collection, Bonn).

Photo: M. Kroniger



Drawings that accompanied the original description of *Holaspis guentheri laevis* (from: WERNER, 1895).

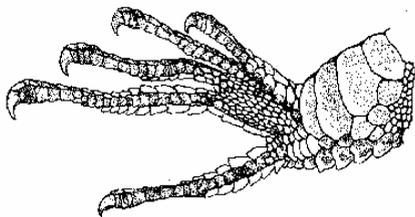
HABITAT

In its area of distribution *Holaspis* occupies a fairly wide array of habitats, ranging from primary forest to man-influenced areas and even dry (very much secondary) *Eucalyptus* forests (DUNGER, 1967; STEVENS, 1974). The lizards live on larger trees at least 15 m above the forest floor (DUNGER, 1967). It is not found in the closed forest, but only in clearings where the sun can penetrate (DUNGER, 1967; SCHIØTZ & VOLSØE, 1959). STEVENS (1974) remarked that it is uncommon for a tree lizard to also live on smooth barked species such as *Eucalyptus*.

In the field the animals become active after sunrise and start the day with extensive basking. Hunting for food comes next, and data from the wild suggest that ants, grasshoppers and spiders form the main part of their diet (BRANCH, 1988; DUNGER, 1967). At night the animals hide under loose parts of bark on the trees (SCHMIDT, 1919). Obviously it is difficult to observe the animals in their natural habitat as they live quite high up the trees, and also because they seem to be very shy. In case of danger they retreat to the other side of the trunk, or hide in the canopy (BRANCH, 1988). It is said that these lizards never come to the ground.

Even though *Holaspis* is distributed in tropical Africa, this does not necessarily mean that they live in areas with a continuous high temperature. A typical temperature range can be 15-30°C, with an average in the high twenties.

MORPHOLOGY



Fusion of toes on the forefoot of *Holaspis guentheri* illustrated (after: SCHMIDT 1919).

External sexual differences are slight. As is usual in lacertids, male femoral pores are more highly developed and more visible than those of the female. The pores in the males may exude a yellowish waxy substance. Further their tail base is wider, and they have a larger and broader head than the females.

The slightly enlarged and widened scales under the toes of *Holaspis guentheri* led MERTENS (1948: 92) to suggest they may be seen as precursors to adhesive pads as found in geckoes. Though the idea seems

attractive, there is little evidence to support this hypothesis, and in real life it is difficult to discern the peculiarities on the underside of *Holaspis* feet.

A very peculiar character in *Holaspis* is the fusion of the third and fourth finger for nearly their entire joint (see Discussion). The lateral expansion of the tail is another development very atypical of lacertids.

VIVARIUM



One of the more furnished vivaria.

Photo: M. Kroniger

In a sense *Holaspis* live in a specialised habitat, high up on tree stems, but as long as the lizards have a vertical surface to climb, and hiding places, they seem to be satisfied and thus can be kept in relatively simple vivaria.

A terrarium of 40x40x50 cm (lxwxh) suffices for one pair. Of course larger ones are better because the animals are considerably more agile in those. Any thicker branch that increases the possibility to climb seems to be appreciated, as well as anything that can be crawled into. The back of the terrarium can be furnished with cork plates. However, be sure that these do not consist of glued cork parts, as the chemicals in the adhesive may be hazardous under terrarium conditions of increased heat and humidity.

Cork plates that were hot-pressed together without the addition of glue are to be preferred. These plates can be stuck to the back and/or side walls with silicon cement.

On the floor a mixture of unfertilised potting soil and sand (2:1) is used: it is important that this substrate stores humidity. To aid in this, place a three cm layer of hydro pellets („Seramis“), as used in potting plants underneath the substrate. About half of the pellet layer can be kept constantly under water (providing the terrarium is made of glass glued with silicon cement!) without the soil degrading or becoming mouldy. Because the *Holaspis* reside in comparatively vegetated habitats, their housing could be furnished with plants. The following species do well: *Spathiphyllum wallisii*, *Ficus pumila*, *Scindapsus aureus*, *Chlorophytum comosum*, and *Saintpaulia ionantha*. The plants are simply stuck into the substrate and usually grow very well.

In the terrarium, spotlights of 25 and 40 W are used to give certain areas a temperature of about 40°C. This gives the animals a possibility to warm quickly. Further light comes from Neon- or HQL-lamps. In our opinion one should not be miserly with light intensity, because only then can the fabulous coloration of the lizards be appreciated to its fullest extent. A 50 W HQL-lamp is the minimum for the previously described smaller terrarium. This appears to approximate the natural conditions in forest clearings. Of course there always should be cooler spots available to the animals. A thermal safety switch should be included in the power circuitry of the higher-powered lamps to avoid any accidental overheating of the vivarium. In general the lizards should be able to choose any temperature between 25-40°C. At night the temperature may drop to 20°C and in winter to 10°C. Humidity can fluctuate, but is usually 60-80%.

The second author (HidB) kept specimens in a much simpler terrarium, with peat as floor covering, and stones and branches for climbing and hiding. Initially, a simple container with moist potting soil, covered with a few flat stones was provided for egg laying (see below).

The first author (MK) also offers the animals the possibility to oviposit in a plastic container, but sealed with a lid in which an opening provides entrance to the female. The substrate is the mixture of sand and soil as described, or consists of humid Vermiculite® or potting soil. The container is placed on top of a transformer (powering the tube lights) which means temperatures of 28-32°C are reached. Only half of the container is filled with substrate, on top of which one or more pieces of (cork) bark are placed. The second author now also uses this method with a partly closed container.

FOOD

We feed the animals every two or three days. Only insects and their larvae are accepted. About fifty percent of the diet consists of crickets (*Acheta domestica*), followed by cockroaches (*Nauphoeta cinerea*) in the vivaria of MK, larvae of beetles (*Alphitobius diaperinus*, *Tenebrio molitor*) and waxmoths (*Galleria mellonella*). All prey animals are dusted with a calcium/mineral preparation. MK also adds vitamin AD₃ to the water that is sprayed on the plants, HB only uses vitamin AD₃ in the drinking water (20.000 i.u. A, 40.000 i.u. D₃ /litre). Occasionally other prey like spiders or flies are offered, and it is thrilling to watch the *Holaspis* catch the more mobile ones from the air as the lizards are dextrous jumpers. Even when very ripe, fruits are never acknowledged as food.

COURTSHIP



An introductory mating bite in *Holaspis guentheri laevis*.

Photo: M. Kroniger

Copulations can be seen throughout the year, except for October-December, when the temperature in the terraria is fairly low. Courtship has already been described (in German) in previous notes on the species (KRONIGER, 1998a, b). Here we summarise those descriptions and add our own observations.

Courtship commences with the male chasing the female. If the female is receptive, that is she does not reject the male with frontleg and tail movements, she allows him to bite her tail and, usually following this tail bite, to bite the side of her neck.

Commonly a mating march of one or more minutes follows, though this phase may be skipped, especially in cases where the female appears at ease. Next the male clasps the pelvic region of the female with his hind limbs.

He then shifts his bite grip to her flank, immediately in front of one of her hind limbs. The female then raises her tail base and intromission is accomplished. At the same time the male clasps one front leg over the middle of the female's dorsum; his ipsilateral hind limb rests on her tailbase and seems to grasp the lower hind limb on her other side. This hold on the female's hind limb loosens slowly after a duration of about two-thirds of the copulation. During the copulation the female makes jerky movements with her hind limbs. Copulations take approximately 5-8 minutes and are terminated when the male opens his mouth or when the female bites the male, after which he lets her go. However, certainly in the first approx. 90 seconds afterward, the male closely follows the female and later commonly basks next to her.

Courtship and copulation may occur on either horizontal or vertical surfaces. In the latter case the pair may fall to the ground without this causing them to separate.



Copulation in *Holaspis guentheri laevis*.

Photo: M. Kroniger

REPRODUCTION

In the terraria of MK oviposition always occurs late at night or during the night in the containers as described above. The eggs are oviposited on the bark. It appears that only when under stress (e.g. two females in the container) or a low humidity in the container, that the eggs are deposited under the bark. None of the approx. 20 clutches discovered by MK were buried. It is unknown where the lizards deposit their eggs in nature; one might suspect in nooks and crannies up in the tree where moist debris has accumulated.

The containers with potting soil covered with stones in HidB's terraria, while accepted by many West-Palearctic lacertids, were never used by *H. guentheri laevis*. The first eggs were found scattered and desiccated in the terrarium. Consequently the peat floor covering was moistened. This led to oviposition in this substrate, about one centimetre deep, under a flat stone heated from above by a 40 W spotlight.

The clutch almost always consists of two eggs. Rarely is just one egg deposited; usually only in very young or poorly nourished animals. Females produce a clutch every four to six weeks. Clutches are taken out of the terrarium for incubation at temperatures between 22-30°C. At temperatures outside this range eggs either fail to hatch, are weak, or deformed young are produced.

Of two clutches laid by the same female (which was hatched in 1999 by MK) at HidB's the following data were obtained (averages): At oviposition eggs measure 6.8 ± 0.5 (6.0-7.2) x 12.0 ± 0.8 (11.3-12.9) mm and weigh 0.33 ± 0.03 (0.30-0.38) g (n=4). Three of these eggs developed and grew to a size of 9.8 ± 0.2 (9.6-10.0) x 18.8 ± 2.6 (17.2-21.9) mm and 1.08 ± 0.15 (0.95-1.25) g (n=3). At 29°C incubation takes 55-57 days (n=3). At hatching the young measure (HB+T) 22.3 ± 1.5 (21-24) + 32.0 ± 2.6 (30-35) mm and weigh 0.24 ± 0.1 (0.23-0.25) g (n=3). Unfortunately, most eggs were not measured.

JUVENILES



A one-day old juvenile of *Holaspis guentheri laevis*.

Photo: H.A.J. in den Bosch

The juveniles resemble their parents but the coloured stripes, especially the dorsal ones, appear narrower and less intensely coloured. The lateral band is usually cream-coloured, not beige as in the adults. The legs are dark grey with black reticulation. Ventrally, in contrast to the adults, the juveniles are pitch-black.

Change into adult coloration occurs when the young have a head-body length of approx. 27 mm and commonly starts ventrally. The bellies first turn into a cream-coloured, yellow hue, and the throats become white or reddish-grey, or even salmon. This

coloration is sex-independent. At 35 mm the young look similar to the adults.

We keep the young *Holaspis* in the same manner as the adults. It is very important to use vivaria from which they cannot flee, as a small slit of less than one millimetre could be enough for escape. In the first two to three months one rarely sees the young. Most of the time they hide in between cracks in the bark and even to bask they rarely show themselves. At a length of 30 mm the young become less shy, bask openly and can sometimes even be fed by pincer. We feed them tiny crickets and *Drosophila* initially. Aphids are accepted as well.

Sexual maturity is reached after 1.5-2 years and seems to depend primarily on size.

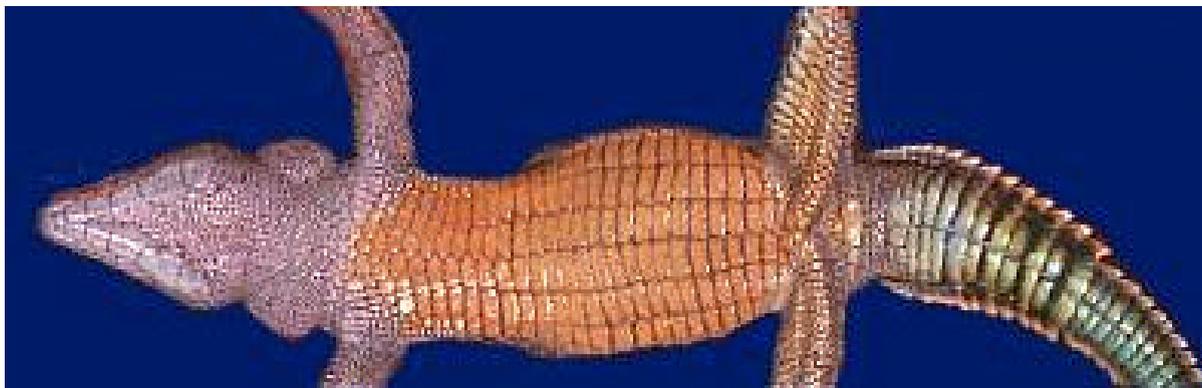
DISCUSSION

It is amazing on how little evidence subspecies can be elevated to species status. Recently BROADLEY (2000) merely stated that *H. laevis* seems to be a good evolutionary species, and proceeded with a key in which only the extension of the paravertebral stripes distinguishes this form from *Holaspis guentheri*. It may very well be that the genus *Holaspis* consists of two (or more?) species. With such a large range from West to East Africa this is almost obligatory since one expects the development of differences, but whether the described variation in banding leads to a biological segregation seems as yet very much unverified.

As mentioned above, cursory examination of specimens in the Bonn museum collection revealed no differences in pholidosis between the two described forms. If this holds true for larger series, then indeed only the slightly different striping pattern constitutes the distinguishing feature in the two forms. This seems a weak basis for species characterization. We therefore remain conservative in this paper, retain the subspecies status of the two forms, and refer to our animals as *Holaspis guentheri laevis*.

The proximal fusion of the third and fourth finger in *Holaspis* is almost always mentioned in any paper on the genus, but has never been explained functionally. We think it may be related to their flying abilities and provide the following hypothesis. The impact after gliding, certainly after substantial distances, must be considerable. Professional volleyball players often tape some of their fingers (frequently their third and fourth finger) together to avoid injury when catching the ball at higher velocities. It does not seem to be too far-fetched to assume that nature developed a similar mechanism to dampen impact in *Holaspis*. Of course one is immediately reminded of the other famous flying lizards in the genus *Draco* in which all toes are free. However, these lizards show a much more controlled flight and moreover brake their speed to a large extent by spreading the flying skin before landing, so perhaps they do not need additional precautions. Nevertheless, making muscle groups work together where large impacts are expected might be a more general solution in the animal world. The old example of digit reduction in the horse comes to mind, where only one finger is left (for the moment disregarding the remnants on each side).

Some see the lateral expansion of the tail as a help in flying, and then even as a steering mechanism (e.g. BÖHME, 1994). In a more day-to-day use this would be considered as an additional tree-climbing adaptation, as already proposed by SCHMIDT (1919) to increase grip, especially as the denticulation is directed downward. It can be readily observed in captive specimens that they run along branches with body and tail pressed closely to the surface. When handling the animals it also becomes clear that the tail especially provides a good hold and prevents them from slipping backwards.



A male *Holaspis guentheri laevis* with an orange belly.

Photo: M. Kroniger

BRANCH (1988) stated that the belly of *Holaspis guentheri laevis* is orange. HERRMANN (1998) considered ventral body coloration to be sexually dimorphic, with males having a bright orange belly and females a faint grey orange one. This cannot be fully confirmed in our samples, where both males and females may have yellow bellies, though in males indeed they are more brightly coloured, reaching an orange coloration. Perhaps, like in some amphibians (e.g. *Bombina*) this may be food dependent?

Copulation in *Holaspis guentheri laevis* lasts 5-8 minutes and involves a flankbite. This is a fairly average length of time for lacertids (HidB pers. obs.); the male clasping the female with his hind limbs during most of this time is, however, less common.

SCHMIDT (1919), giving data from the wild collected in June, already reported that apparently only two eggs reach full development in this species. The larger sizes he mentioned (6.3x12 and 5x11 mm) are close to few measurements on freshly laid eggs we reported above (avg. 6.8-12.0 mm). BRANCH (1988) gave similar data (5-6 x 9-11 mm), and he, DUNGER (1967) and HERRMANN (1998) describe a clutch of two eggs. In our experience a clutch of two eggs is indeed the rule, with only very young or infirm animals producing just a single egg.

Females can produce a clutch every 4-6 weeks, which in theory could result in an astonishing 17-26 young per year. The lower temperatures may very well induce the winter pause in our terraria during our cold season.

HERRMANN (1998) hatched one egg after 54 days, unfortunately without stating at what incubation temperature. Since this period is almost identical to the data we presented above for 29°C (55-57 days), a similar temperature is suspected. The measurements of his single hatchling fall within our data of 22+33 mm (HB+T). Data published by MK for 27-29°C (KRONIGER, 1998) suggest 76, 80 and 87 days at those temperatures. However, it later turned out that the average temperatures were considerably lower, more likely around 25°C.

After hatching, *Holaspis* egg shells more or less retain their form (in contrast to many European lacertids), and this could perhaps indicate a firmer structure, adapted to the possibly more exposed oviposition sites (under bark on the tree) in the wild.



Detail head male *Holaspis guentheri laevis*.

Photo: H.A.J. in den Bosch

Though the natural habitat is impossible to reproduce exactly, especially the altitude of 15 m or more high up on trees, *Holaspis guentheri laevis* appears to do well in vivaria bearing a slight resemblance to the African forest. Even in fairly Spartan vivaria with a peat floor covering, some stones and branches, the species will reproduce provided a suitable oviposition spot with pieces of bark on a humid substrate is available. It is surprising that temperatures as low as 10°C at night for longer periods have no adverse effects on these tropical lacertids, though it must be noted that egg production stops.

Even though in the wild prey items are reported to be mainly ants and spiders, in captivity the animals are not picky and seem to accept any arthropod they can swallow. In fact, H. Lang (in SCHMIDT, 1919) mentioned that next to ants, they also eat earwigs, small beetles and their larvae. In that respect *Holaspis guentheri laevis* seems to be just an average lacertid.

ACKNOWLEDGEMENTS

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SUMMARY

Two types of vivaria are described for *Holaspis guentheri laevis*, one an approximation of the natural habitat and the other a more spartan design. In both the lizards do well, though we prefer the former design.

Courtship lasts 5-8 minutes and involves a flankbite and the male clasping the female with his hind legs. For oviposition the lizards must be provided with a humid substrate on which pieces of bark are deposited, preferably in a partly closed container, the substrate if possible being around 30°C. Oviposition of the clutch of two occurs at night. At oviposition eggs measure 6.8x12.0±0.8 mm and weigh 0.33 g. These eggs develop to 9.8x18.8 mm and 1.08 g. At 29°C incubation takes 55-57 days. Juveniles measure (HB+T) 22+33 mm and weigh 0.24 g, and resemble their parents, though less intensely coloured. In contrast to the adults' ventral colour the juveniles are ventrally pitch-black. At a head-body length of approx. 27 mm, the change into adult coloration begins, and is completed when the animal reaches 35 mm in length. Sexual maturity is reached after 1.5-2 years.

The proximal fusion of the third and fourth finger in *Holaspis* is hypothesised to dampen the impact after gliding flights.

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