

## Insight into hemipenial morphology of five species of *Hemidactylus* Oken, 1817 (Reptilia: Gekkonidae) of Guwahati, Assam, India

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**ABSTRACT.**– In this paper we present comparative hemipenial morphology of five *Hemidactylus* species, namely *Hemidactylus aquilonius*, *H. brookii*, *H. frenatus*, *H. flaviviridis* and *H. platyurus* of Guwahati city of Assam, India

**KEYWORDS.**– *Hemidactylus*, Hemipenis, Assam, India

### Introduction

The morphology of the copulatory organ in the reptiles is of great interest both taxonomically as well as in reproductive biology (Dowling 1967; Arnold 1986a; Zhang 1986; Malnate 1990). Male squamates have a pair of such intromittant copulatory organs, the hemipenes (Eberhard 1985; Arnold 1986a; Arnold 1986b). These are pocket like structures that are stored retracted in an inside out position at the base of the tail. When everted, a groove on one of its surface, the sulcus spermaticus, can be observed. This groove transports sperm from the cloaca of the male to the female. The hemipenis also shows different ornamentation in different species. In retracted state, the sulcus spermaticus and the ornamentation of the hemipenis is in the inner side of the blind tube (Cope 1896).

Hemipenis structures serve as indicator of taxonomic identity of squamate reptiles (Keogh 1999). As hemipenis morphology has no correlation with diet, ecology, etc. (Dowling 1967; Böhme 1971; Arnold 1986b; Branch 1986; Klaver & Böhme 1986; Böhme 1988), it is believed to be an excellent tool for studying phylogenetic relationships.

Earlier work on hemipenis morphology was carried out for several families of lizards (e.g. Cope 1896; Rosenberg 1967; Böhme 1971; Presch 1978; Branch 1982; Klaver & Böhme 1986; Böhme 1988; Card & Kluge 1995; Glaw et al. 2006; Rösler & Böhme 2006; Maduwage et al., 2008) and snakes (e.g. Pope & Pope 1933; Pope 1935; Smith 1943; Mao et al. 1984; Guo et al. 1999; Keogh 1999; Guo 2000; Guo & Zhang 2001).

Hemipenis morphology of gekkonids in general is characterized as having a more or less club-shaped trunk, a pedicel, and a voluminous apex. In several geckos the apex has two lobes (Böhme 1988; Rösler 1998). Although previous work on the hemipenis morphology of several gekkonid genera has been carried out (Glaw et al. 2006; Rösler & Böhme 2006), there are relatively few studies focused on the hemipenial morphology of the genus *Hemidactylus* Oken, 1817. In India, prior to this study, the courtship, mating behaviour, and hemipenis structure of *Hemidactylus flaviviridis* has been investigated (Mahendra 1953).

The genus *Hemidactylus* is represented by five species in Assam: *H. frenatus* Schlegel, 1836; *H. aquilonius* McMahon and Zug, 2007;

*H. flaviviridis* Rüppell, 1835; *H. brookii* Gray, 1845 and *H. platyurus* (Schneider, 1792). Although they are one of the most common types of lizards found in the region, this genus has been little studied. In this paper we present a preliminary comparative study of the hemipenis morphology of species in the genus *Hemidactylus* found in Assam.

### Materials and Methods

This study was conducted in Guwahati (26°11'9"N, 91°44'51"E), Assam, India. The adult male specimens of *Hemidactylus* were collected for this study. The lizards were euthanized and their hemipenes fully everted by injecting water through the tail, eight subcaudals away from the base. The measurements on the everted hemipenis were taken immediately, prior to fixing the specimen. The specimen were fixed and stored in 10% formaldehyde. Measurements of different parameters (in mm) were taken using Mitutoyo dial calliper (0.02mm precision). The fully everted hemipenis, the asulcal surface, and sulcal surface were photographed. The following morphometric measurements were taken for comparison: HPL= hemipenis length, HPW= hemipenis width, LL= lobe length, LW= lobe width, ROB= region of bifurcation, SVL= snout to vent length of the specimen, TL= tail length. The characteristic features and classification of the hemipenes were done as per Dowling and Savage (1960).

### Results

The structure of the hemipenis in the genus *Hemidactylus* is bilobed and cylindrical. The organ is stout, and is comprised of a base, pedicel (stalk), and head. Bilobed organs are formed when the hemipenis is divided, at the apex only, and for a distance which is lesser than the undivided basal segment. The lobes are, in most cases, a distinguished portion of the trunk which is

more swollen. Presence of ornamentation at the apex is limited to *H. aquilonius* and *H. brookii*. In most cases the entire organ is also devoid of any ornamentation. The sulcus spermaticus is a longitudinal groove, present on the outer surface of the hemipenis. The sulcus spermaticus bifurcates in all the five species we examined. However, the route of entry of the sulcus to the lobe head shows some variation in these five species.

### A summary of hemipenial morphology of five species of *Hemidactylus* of the study area

1)– *Hemidactylus aquilonius* McMahan and Zug, 2007

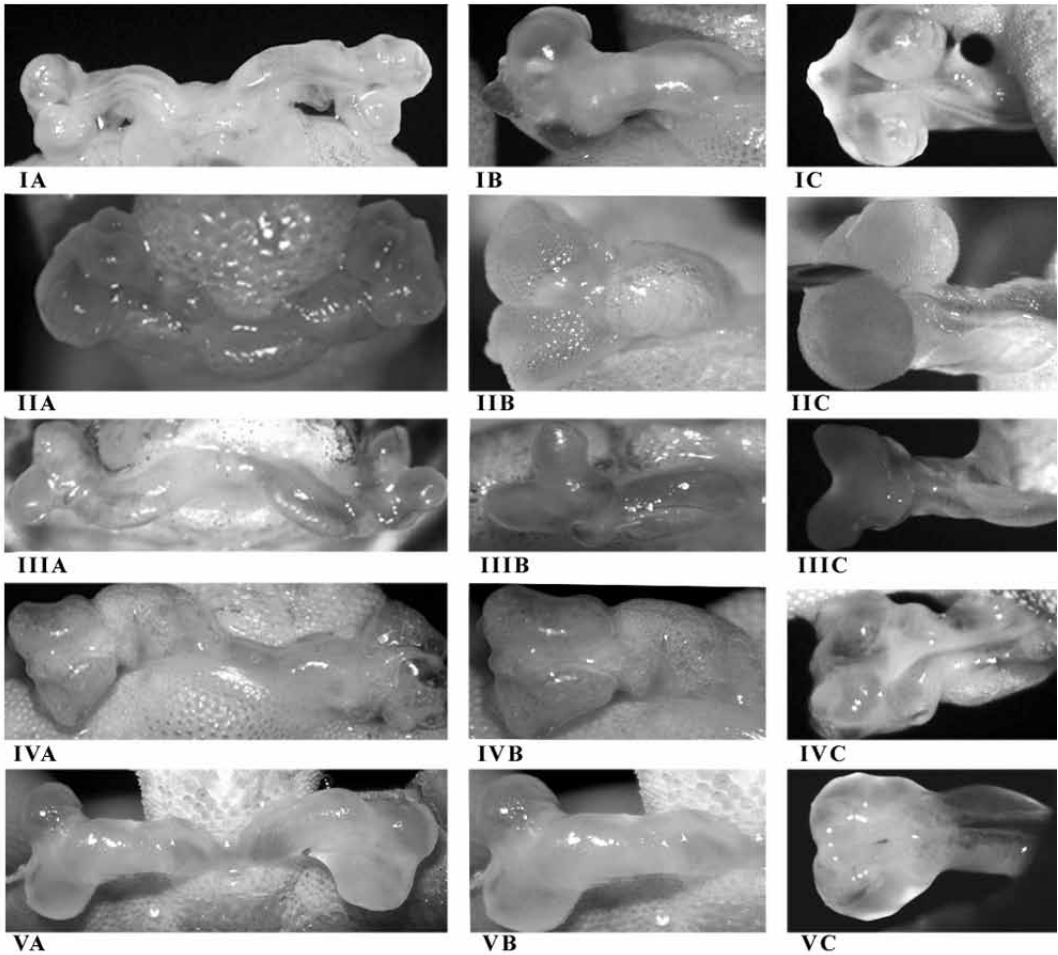
The hemipenis of *H. aquilonius* is bilobed, elongated, and almost bow shaped. Its trunk or pedicel is long and ends in a voluminous bilobed head covered with numerous small papillae. The width of the lobe is more than half of its length. The sulcus spermaticus is bifurcated and passes around to the asulcal surface before entering the head of the lobes. The region of bifurcation of the sulcus spermaticus is almost one third of the total length of the hemipenis, the width is more than half of its length. The sulcus spermaticus also shows a branching pattern at the lobe head. An unusual feature observed in case of *H. aquilonius* is the presence of a tissue joint in between the two lobe heads. In a fully everted hemipenis this tissue joint assumes a conical shape. The organ is totally devoid of any other ornamentation on its trunk or pedicel (see Table 1, Fig. 1 [IA, IB, IC]).

2)– *Hemidactylus brookii* Gray, 1845

The hemipenis of *H. brookii* is fleshy and bilobed. The lobes are almost round in shape and clearly distinct from the pedicel. The pedicel is stout with very few transverse ridges. The length of the organ is greater than its width. The sulcus spermaticus starts from the base of the pedicel at a median point and traverses the entire

**Table 1.** A table showing comparative morphometry of hemipenis to the corresponding body size of five species of *Hemidactylus* of Assam.

Specimen	HPL	HPW	LL	LW	ROB	SVL	TL
<i>H. aquilonius</i>	5.24	3.52	2.66	1.72	2.46	48.14	52.72
<i>H. brookii</i>	7.1	3.64	2.56	2.92	2.34	56.72	73.14
<i>H. frenatus</i>	6.6	4.92	2.52	1.9	2.26	56.94	61.24
<i>H. flaviviridis</i>	7.18	4.6	4.46	3.44	0.26	75.82	93.54
<i>H. platyurus</i>	8.12	3.7	2.14	1.72	1.72	55.18	58.52



**Figure 1.** A figure showing hemipenial morphology (A: Fully everted hemipenis, B: asulcal view and C: sulcal view) of five species of *Hemidactylus* geckos (I: *Hemidactylus aquilonius*, II: *H. brookii*, III: *H. frenatus*, IV: *H. flaviviridis* and V: *H. platyurus*) of Guwahati, Assam, India.

length of the organ upto the region of bifurcation (ROB). It bifurcates from the ROB and enters the lobe head. The sulcus spermaticus does not coil as it enters the lobe head, but enters the lobe head laterally dividing each lobe into equal halves. The lobe is wider than long and spinose. Spines are present on the lobe head. The asulcal surface also displays spines and these are greater in number than on the sulcal surface (see Table 1, Fig.1 [IIA, IIB, IIC]).

### 3)– *Hemidactylus frenatus* Schlegel, 1836

The hemipenis in *H. frenatus* is bilobed and the apex of the lobes is symmetrically divided and fleshy. The apex is almost smooth with little to no spines, which become more sparse towards the base. The head of the lobe is nude (de-

void of any ornamentation). The pedicel is stout and without embellishments. There are no calyces or cardioid structures present. The length of the entire organ is greater than its width and the lobe is longer than wide, though not elongated. There are no hooks or other accessory structures towards the base. The sulcus spermaticus is bifurcated, traverses the entire length from the base, and stops a little way below the region of bifurcation. The sulcus spermaticus enters the lobe head laterally up to its tip (see Table 1, Fig.1 [IIIA, IIIB, IIIC]).

### 4)– *Hemidactylus flaviviridis* Rüppell, 1835

The hemipenis of *H. flaviviridis* is short and stout. The organ is almost a whole organ with a stout pedicel. The lobe length is very short with

an extremely small region of bifurcation, making the lobe quite undefined. The lobe is wide and fleshy. The entire organ is smooth and devoid of any kind of ornamentation. The sulcus spermaticus bifurcates at the base of the lobe and takes an almost ninety degree turn before rising up to the lobe head. The head of the lobe is nude. The sulcus spermaticus also longitudinally splits the lobe head while passing through it, thereby dividing each lobe into two equal halves (see Table 1, Fig.1 [IVA, IVB, IVC]).

##### 5)– *Hemidactylus platyurus* (Schneider, 1792)

The hemipenis of *H. platyurus* is longer than other *Hemidactylus* species of the region, despite its size. The organ is bilobed and the lobes are very distinct. The trunk is smooth and devoid of any ornamentation. The lobe head is almost round, nude, and smooth. The width of the lobe is almost one third of its length. The ROB is adequate. The sulcus spermaticus bifurcates from the ROB and assumes a “V” shaped pattern to enter the lobe head almost directly (see Table 1, Fig. 1 [VA, VB, and VC]).

### Discussion

The hemipenis morphologies exhibited by the five species of *Hemidactylus* of Assam are similar in their basic structure. All are bilobed and possess a trunk, pedicel, and voluminous apex. The apex is bilobed and the lobe heads in all the examined species are nude. However, the head displays spines, particularly in case of *H. brookii* and *H. aquilonius*, although in *H. aquilonius* the head is more papillate. *H. flaviviridis*, despite being the largest *Hemidactylus* of the region, has an organ proportionately smaller than the others. In *H. flaviviridis* HPL/SVL is 0.0946, whereas it is 0.1088 in *H. aquilonius*, 0.1159 in *H. frenatus*, 0.1251 in *H. brookii*, and 0.1471 in *H. platyurus*. There is little to no ornamentation in all the species, though if present it is typically restricted to spines and papillae. The lobe head of *H. flaviviridis* does display a curve, though they cannot be attributed to flounces.

The sulcus spermaticus shows interesting routes to the lobe head and its tip. In *H. platyurus* it is almost a “V” shaped structure from the ROB, whereas in *H. flaviviridis* an almost ninety degree turn occurs at the entrance the lobe head. In *H. aquilonius* the sulcus spermaticus

takes a deviated path around to the asulcal surface before entering the head of the lobes. We have not observed coiling of the sulcus in the lobe head in any other species examined so far. The hemipenis of *H. aquilonius* also exhibits a cone shaped structure at the junction of the two lobe heads (see Fig.1 IB, IC). This structure has not been observed in the other species, in fully everted condition, though a rudimentary tissue patch may be seen in case of *H. brookii*. Based on hemipenial observations of these species we conclude that *H. frenatus*, *H. aquilonius* and *H. platyurus* have the most similar hemipenis morphology, which consists of the shape of the organ being elongated with a comparatively longer pedicel. *H. brookii* and *H. flaviviridis* have somewhat shorter, fleshier, and stouter hemipenes with a shorter relative pedicel length. The hemipenis of *H. brookii* differs from that of *H. flaviviridis* by having a spinose head (see Fig. 1). These results are somewhat consistent with recent phylogenetic findings for tropical Asian *Hemidactylus* (Bauer *et al.* 2010), which suggest that *H. platyurus* and *H. aquilonius*, which share similar hemipenis morphology, are indeed closely related. However, there is not a direct correlation between genetic relatedness and genital morphology for the other congeners studied.

Several authors have debated whether the copulatory organs like hemipenes differ from other organ systems in an evolutionary context. These organs seem to retain their structure through the course of evolution and thus are deemed more stable (Arnold 1986b). This may be due to the fact that these organs are located internally and are less likely to be affected by external morphological changes. Additionally, it is likely that these structures are unaffected by changes in niche (Arnold 1986b). Seasonal hemipenial variation is common among lizards, but has not yet been demonstrated for geckos; seasonal hemipenial variation is known from many lacertids, some iguanids, and some species of chameleon (Böhme 1988). Overall, hemipenial structures have proved to be an excellent indicator of relationships between various taxa (Arnold 1986a; Arnold 1986b) making detailed hemipenial studies all the more imperative and valuable.

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