

# Oldest fossil avian remains from the Indian subcontinental plate

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**We describe the oldest fossil avian remains of the Indian subcontinental plate, from the early Eocene of the Vastan Lignite Mine in Gujarat, India. Three incomplete coracoids and two scapulae are assigned to the new taxon *Vastanavis eocaena*, gen. et sp. nov. The coracoids resemble the corresponding bone of bustards (Otididae), but a reliable assignment is not possible without additional bones. Independent of their phylogenetic affinities the fossils are of potential biogeographic significance, because similar species are unknown from the well-studied Palaeogene avifaunas of Europe and North America.**

**Keywords:** Avian, early Eocene, fossils, *Vastanavis eocaena*.

AN extensive Palaeogene avian fossil record exists from Europe<sup>1</sup>, but few pre-Oligocene taxa have been discovered in Asia, and most of these come from China and the area of the former Soviet Union<sup>2-4</sup>. In addition to several taxa of uncertain affinities<sup>4-6</sup>, the Eogruidae were reported from the late Eocene of China and Mongolia<sup>7,8</sup>, putative Grues from the late Eocene of Uzbekistan, putative Geranoididae from the middle to late Eocene of Kazakhstan<sup>2</sup>, and Gastornithidae, Charadriiformes and putative Ciconiidae and Threskiornithidae from the Eocene of China<sup>3,9,10</sup>. A distal tibiotarsus of an ibis-like bird was recently reported from the middle Eocene of Myanmar<sup>10</sup>, and from Sumatra a skeleton of an aninga-like bird is known from deposits of uncertain, possibly Palaeocene, age<sup>10</sup>.

Here we report avian remains from the early Eocene of India, which are the first Palaeogene avian specimens to be described from the Indian subcontinent. The fossils were obtained from the Vastan Lignite Mine (Gujarat, India) and were found in continental lens deposits yielding the remains of aquatic and terrestrial vertebrates in well-constrained stratigraphic sections of middle to late Ypresian age (about 52 mya)<sup>11,12</sup>.

The fossil specimens are deposited in the Department of Geology of H.N.B. Garhwal University, Uttarakhand, India (GU/RSR/VAS – Garhwal University/R. S. Rana/

Vastan). Osteological terminology follows Baumel and Witmer<sup>13</sup>, measurements are in millimetres.

The fossils are clearly distinguished from any other Palaeogene avian taxon and classified into the new genus and species *Vastanavis eocaena*.

Diagnosis: *V. eocaena*, gen. et sp. nov. can be diagnosed as a medium-sized bird with a coracoid characterized by the combination of a cup-like cotyla scapularis with the absence of a foramen nervi supracoracoidei, facies articularis clavicularis small, medial margin of extremitas sternalis irregularly notched, angulus medialis pointed and strongly protruding.

Holotype: Left coracoid lacking the lateral portion of the extremitas sternalis (GU/RSR/VAS 441; Figure 1 a–c).

Type locality and horizon: Vastan Lignite Mine, northeast of Surat, Gujarat; early Eocene (Ypresian) Cambay Formation<sup>12</sup>.

The etymology of the genus derives from *avis* (Latin), bird, and the name of the type locality; the species name refers to the Eocene age of the bird.

The referred specimens include a left coracoid lacking the extremitas sternalis (GU/RSR/VAS 442; Figure 1 d–f), a left coracoid lacking the lateral portion of the extremitas sternalis (GU/RSR/VAS 647; Figure 1 g–i), a left scapula lacking the caudal end (GU/RSR/VAS 443; Figure 1 m, n), and the extremitas cranialis of a left scapula (GU/RSR/VAS 444; Figure 1 o, p); all are from the type locality and horizon.

Measurements (length in mm as preserved): Holotype, 39.0; GU/RSR/VAS 442, 27.3; GU/RSR/VAS 647, 35.7; GU/RSR/VAS 443, 40.3.

Description and comparison: The coracoid exhibits a distinctive morphology and is distinguished from the corresponding bone of any other Eocene taxon known to us. The cotyla scapularis is circular and cup-like, a foramen nervi supracoracoidei absent. The processus acrocoracoideus is straight and the impressio ligamenti acrocoracoideus shallow; the tuberculum brachiale and facies articularis clavicularis are poorly developed. The processus procoracoideus is short. The medial margin of the extremitas sternalis is irregularly notched, and the angulus medialis is pointed. The processus lateralis is broken in all specimens.

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**Figure 1.** *a-c*, *Vastanavis eocaena*, gen. et sp. nov., left coracoid, holotype (GU/RSR/VAS 441) in (*a*) dorsal, (*b*) medial and (*c*) ventral view. *d-f*, *V. eocaena*, gen. et sp. nov., left coracoid, referred specimen (GU/RSR/VAS 442) in (*d*) dorsal, (*e*) medial and (*f*) ventral view. *g-i*, *V. eocaena*, gen. et sp. nov., left coracoid, referred specimen (GU/RSR/VAS 647) in (*g*) dorsal, (*h*) medial and (*i*) ventral view. *j-l*, Extant Great Bustard, *Otis tarda* (Otidae), left coracoid in (*j*) dorsal, (*k*) medial and (*l*) ventral view. *m, n*, *V. eocaena*, gen. et sp. nov., left scapula (GU/RSR/VAS 443) in (*m*) lateral and (*n*) medial view. *o, p*, *V. eocaena*, gen. et sp. nov., extremitas cranialis of a left scapula (GU/RSR/VAS 444) in (*o*) lateral and (*p*) medial view. *q-s*, cf. *Vastanavis* sp., right coracoid (GU/RSR/VAS 445) in (*q*) dorsal, (*r*) medial and (*s*) ventral view. Fossil specimens are coated with ammonium chloride. Same scale bar for *a-i* and *m-s*.

The coracoids GU/RSR/VAS 647 and GU/RSR/VAS 442 are smaller than the holotype, but the size difference is within the range of individual variation of extant birds, especially if *Vastanavis* was sexually dimorphic in size.

The tip of the processus acrocoracoideus of GU/RSR/VAS 442 is somewhat wider than that of the holotype (compare Figure 1 *b* and *e*). Although this specimen may represent a second species of *Vastanavis*, we tentatively

assign it to *V. eocaena* pending discovery of more material of this taxon.

The coracoid of *Vastanavis* differs from that of the late Eocene to Miocene Eogruidae Wetmore, 1934, in lacking a foramen nervi supracoracoidei and in having a shallower impressio ligamenti acroracohumeralis<sup>14</sup>. In addition to the absence of a foramen nervi supracoracoidei, *Vastanavis* is further distinguished from the superficially similar early Eocene *Calcardea* Gingerich, 1987, in that the crista articularis sternalis extends perpendicular to the longitudinal axis of the coracoid (much more oblique in *Calcardea*)<sup>15</sup>.

The scapulae are assigned to the same taxon as the coracoids because they represent the only type of this bone so far found at the locality and correspond well in size with the coracoids. The acromion is pointed and there is a well-developed tuberculum coracoideum. The shaft of the bone is fairly straight; the caudal tip is not preserved.

We tentatively refer to cf. *Vastanavis* sp. a right coracoid lacking the tip of the extremitas omalis (GU/RSR/VAS 445, Figure 1 *q-s*), which also comes from the type locality and horizon.

Measurement: Length as preserved, 30.5 mm.

Description and comparison: This specimen resembles the coracoid of *V. eocaena* and corresponds in size to GU/RSR/VAS 647 and GU/RSR/VAS 442. However, in contrast to the coracoids assigned to *V. eocaena*, there are several small spiny protrusions along the medial margin of the extremitas sternalis. Also in contrast to the above specimens of *V. eocaena*, there is a pneumatic foramen below the processus procoracoideus on the medial margin of the bone. The base of the processus procoracoideus, just medial to this foramen, bears another distally protruding projection. The processus lateralis is long and narrow, and with regard to this feature the specimen resembles the coracoid of the palaeognathous Lithornithidae, which are fairly abundant in the Palaeocene and early Eocene of Europe and North America<sup>16</sup>. In lithornithids the cotyla scapularis is, however, not as circular and the foramen nervi supracoracoidei larger.

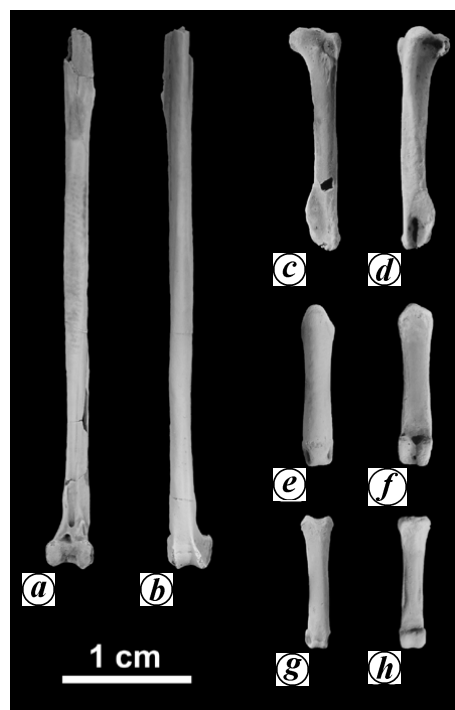
## Discussion

The specimens described here constitute the earliest fossil record of birds from the Indian subcontinental plate, from which so far only Neogene fossil avian taxa have been reported<sup>17,18</sup>. (Note that the specimen in Patnaik and Sahni<sup>18</sup> has been misidentified and is from a galliform, not strigiform bird.)

The coracoid of *V. eocaena*, gen. et sp. nov., is distinctive and unlike the corresponding bone of other taxa known to us. However, although it clearly represents a new species, a reliable phylogenetic assignment is not possible without more skeletal elements. Compared to ex-

tant birds, the coracoid of *V. eocaena* most closely resembles the corresponding bone of some taxa of the polyphyletic<sup>19</sup> 'Gruiformes', in particular bustards (Otididae) which have no Palaeogene fossil record. The coracoid of the Great Bustard, *Otis tarda* (Figure 1 *j-l*), differs from that of *Vastanavis* in having a pneumatic opening on the dorsal shaft of the bone, just below the cotyla scapularis, but such an opening is absent in other Otididae, e.g. *Ardeotis arabs*. The coracoid of *Vastanavis* also shows some overall similarity to the corresponding bone of ducks (Anatidae) in which, however, the impressio ligamenti acroracohumeralis is more marked, the facies articularis clavicularis larger, and the facies articularis humeralis more ventrally protruding. Because Galloanseres, the taxon including Anatidae, is the sister group of Neoaves, which includes Otididae<sup>19</sup>, these shared similarities are likely to be plesiomorphic for neognathous birds. Clearly, more skeletal elements are necessary to assess the phylogenetic affinities of *Vastanavis*, and if GU/RSR/VAS 445 belongs to the same group of birds, the coracoid is distinguished from that of both Otididae and Anatidae by the long processus lateralis.

A similar coracoid to that of *Vastanavis* is only known from terrestrial or aquatic birds, and despite the uncertain phylogenetic affinities of this taxon, an analogous way of living seems to be likely for *Vastanavis*.



**Figure 2.** Aves indet. *a, b*, Left tibiotarsus (GU/RSR/VAS 440) in (*a*) cranial and (*b*) caudal view. *c, d*, Left phalanx distalis digiti majoris (GU/RSR/VAS 658) in (*c*) ventral and (*d*) dorsal view. *e, f*, Pedal phalanx (GU/RSR/VAS 152) in (*e*) dorsal and (*f*) plantar view; *g, h*, Pedal phalanx (GU/RSR/VAS 153) in (*g*) dorsal and (*h*) plantar view; all coated with ammonium chloride.

There are few other avian remains in the vertebrate material from Vastan Lignite Mine. In addition to a phalanx distalis digiti majoris and two pedal phalanges, these include a long and slender left tibiotarsus which lacks the proximal end (Figure 2). The latter specimen is from a small, long-legged bird; but given its age and the poorly known Palaeogene avifauna of Asia, the phylogenetic affinities of GU/RSR/VAS 440 also cannot be determined without additional material.

*Vastanavis* is distinguished from any of the avian groups known from the Palaeogene of Europe<sup>1</sup>, which is not unexpected as Europe and Asia were still separated by the Turgai Strait in the early Eocene<sup>20</sup>. It has been suggested that the Indian subcontinental plate was the centre of origin for several mammalian taxa which abruptly arrived in Europe after the former collided with Asia<sup>21</sup>. Although distribution via the drifting Indian plate may also have played a role in the biogeography of birds, sound conclusions are hardly possible without a better knowledge of the Palaeogene avifauna of Asia in general and the phylogenetic affinities of the above taxa in particular.

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