Historical Biology

An International Journal of Paleobiology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ghbi20

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To cite this article: Christopher M Stimpson, Advait M Jukar, Amelia Bonea, Susan Newell & Eliza Howlett (2022): A 'large and valuable' Siwalik fossil collection in the archives of the Oxford University Museum of Natural History, Historical Biology, DOI: 10.1080/08912963.2022.2070017

To link to this article: https://doi.org/10.1080/08912963.2022.2070017

Published online: 06 May 2022.

HISTORICAL BIOLOGY
https://doi.org/10.1080/08912963.2022.2070017

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A 'large and valuable' Siwalik fossil collection in the archives of the Oxford University Museum of Natural History

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ABSTRACT

This article describes results from a review of South Asian fossils in the Oxford University Museum of Natural History. These materials include two early 19th century collections of fossils from the Siwalik Hills in India. While this assemblage was summarised in 1837 by William Buckland as 'large and valuable collections of fossil bones', it has remained largely unstudied and unpublished in any detail since collection. Here, as a precursor to a comprehensive re-evaluation, we establish a chronological and geographical context of one collection event, provide details of its donor, and outline its history after arrival in Oxford. We then describe select taxa in the collection, including a well-preserved maxilla and toothrow of the large extinct giraffid, *Sivatherium giganteum*, as a basis to justify our current understanding of the biostratigraphic affinity of the assemblage. Conservatively, the collection is a 'classic' Upper Siwalik Plio-Pleistocene fauna, possibly the first to be transported to the UK. While further analyses will realise the scientific potential of the fossils, the narrative of their journey from India to Oxford remains incomplete. Further investigation of the hidden history of the collection is warranted.

ARTICLE HISTORY
Received 25 February 2022
Accepted 20 April 2022

KEYWORDS
India; Palaeontology; Sivatherium; Hexaprotodon; Stegodon

Introduction

As the East India Company (EIC) expanded its influence on the Indian subcontinent, the beginning of the 19th century saw the burgeoning of palaeontological investigations in the foothills of the Himalaya, commonly referred to as the Siwalik Hills (Figure 1).

Highly mobile officers of the EIC's army were involved in the collection of fossils in connection with two activities designed to serve British imperial interests: comprehensive surveys that sought to map the natural, socio-economic, and cultural landscape of South Asia, and the construction of public works, especially canals and roads (Edney 1999; Nair 2005). The resources and labour that went into these works were overwhelmingly Indian, who, in addition to acting as interpreters, guides, guards, and providing essential logistical support, played a critical role in the identification of fossil localities and the excavation of specimens (Nair 2005). Scientific knowledge emerged in these 'contact zones' between South Asians and Europeans, shaped both by institutional structures like the army and the judiciary, and by individual relationships, such as those established between British officers and their local collectors of natural history specimens (Nair 2005; Kumar 2006).

The most widely known and celebrated fossils from the Siwalik Hills were collected by Dr Hugh Falconer, then superintendent of the Saharanpur Botanical Garden, Captain Proby T. Cautley, an engineer for the EIC assigned to the Doab Canal Project, and three other military officers, Henry Marion Durand, William Erskine Baker, and John Colvin (Murchison 1868; Lydekker 1880). Falconer and Cautley published their work in a series of articles and books between 1834 and 1865 (e.g., Falconer and Cautley 1836; 1846; see also Murchison 1868 for a compilation of Falconer's works). This material was not unique, however. As was common in the wider extractive processes of European colonialism in the development of the natural sciences (Raja et al. 2021), specimens collected by colonial officials in the Siwalik Hills were routinely transported to private collections and museums in Britain, India and elsewhere in the world (Lydekker 1884, 1885; Colbert 1935; Pilgrim 1939; MacGregor 2018; Jukar and Brinkman 2021). This study considers one such collection.

A recent review of fossils in the Oxford University Museum of Natural History (OUMNH) by one of us (CMS) has identified 19th century collections from various geographical locales and stratigraphic horizons in the Indian subcontinent and Burma (Table 1). Two of these collections derived from the Siwalik Hills (Figure 1). While selected elements were displayed for a time in the OUMNH, to our knowledge, the assemblages have not been the subject of detailed study, nor publication.

In this article, we focus on the largest (numerically) assemblage of Siwalik fossils in the OUMNH, which we term 'the S collection'. We provide details of the donor of the fossils, an officer in the Bengal Native Infantry named Lewis Robert Stacy, and consider the chronological and geographical context of the collection. We then provide a brief history of the fossils after their arrival in Oxford and in the OUMNH. Finally, we present the results of an examination of select mammalian taxa from the S collection, as the current basis of inference for the biostratigraphic affinity of the assemblage.

Lewis Robert Stacy and the S collection

Lewis Robert Stacy was born 11 December 1787 in Oxford, the son of Anne Keele and Rev. Henry Peter Stacy (Karttunen 2021). While his older brother Daniel George Stacy matriculated from Pembroke College and followed their father into the clergy (Foster 1888),

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Published online 06 May 2022

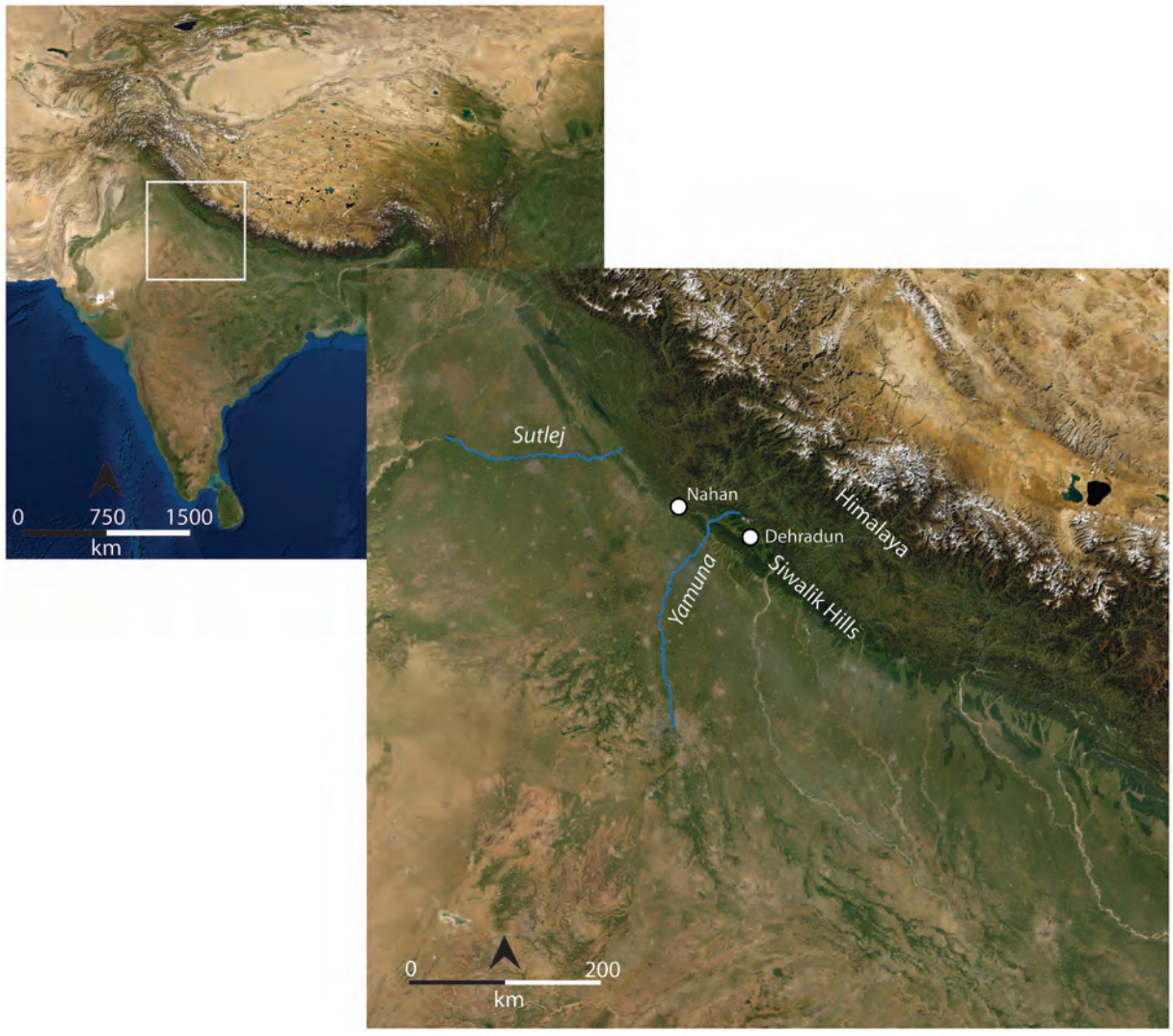

Figure 1. Siwalik Hills in northern India, showing locations referred to in the text.

Lewis Robert joined a unit of the EIC' s army, the Bengal Native Infantry, in 1804 (Dodwell and Miles 1838, p. 240). Stacy remained in India for the rest of his life (*Allen's Indian Mail* 1848, p. 548). He had an active military career and lead the typical peripatetic life of many British officers stationed in the subcontinent. The subscription lists to the *Journal of the Asiatic Society of Bengal*, the premier publication of colonial science at the time, suggest that he moved from Nasirabad to Aligarh to Dacca (Dhaka) between 1833 and 1837 (*Journal of the Asiatic Society of Bengal* 1833–1837), eventually serving in the First Afghan War (Stacy 1848) and attaining the rank of Brigadier by the time of his death on 18 July 1848, in Neemuch (*Allen's Indian Mail* 1848, p. 548).

Stacy's scientific and antiquarian preoccupations likely originated from his strong family ties with Oxford and developed in India by his interactions with the Asiatic Society of Bengal, whose member he became in 1836. While not a prominent member of the Society, he seems to have had a keen interest in natural history and archaeology and contributed occasional notes on coins from his own cabinet and the discovery of a sculpture with Greek influences in Upper India (Stacy 1834, 1836a). Stacy also demonstrated an active interest in agriculture. He collected samples of seeds and cotton (Wallich 1834), published in the *Transactions of the Agricultural and Horticultural Society of India* (Stacy 1836b) and attempted to establish an experimental garden in Dacca, where he was stationed from 1837. Stacy was elected as a member of the Agricultural Society of India in 1838 (*Transactions* 1839: 53). Stacy also had a long association with the Ashmolean Society and Museum at Oxford, becoming one of its most prolific donors of zoological specimens from the British colonies in the Indian Subcontinent (MacGregor and Headon 2000). For example, in 1829, he donated 57 bird specimens to the museum. The Ashmolean Society (AS) inducted him as an honorary member in 1834 (AS 1834).

The 1830′s saw remarkable developments in the palaeontological investigation of the wider Indian Subcontinent (e.g., Prinsep 1832; von Hügel and Fulljames 1836) and the Siwalik Hills. Cautley's discovery of fossils near Dehradun in 1831 (Falconer 1832; Royle 1832), Baker and Durand's fortuitous discovery of the fossil deposit near the town of Nahan in 1834 (Baker 1834; Cautley 1834a), followed by Falconer and Cautley's collections in the same region, and further west to the Sutlej river and east to the Yamuna (Jumna) river (Cautley 1834b, 1835; Falconer 1835), were the highlight of scientific establishments, both in the colonies and in Britain (Corbyn 1837; Lyell 1837). Ultimately, Falconer and Cautley were awarded the Wollaston Medal for their achievements in 1837 (Lyell 1837; Royle 1837).

Table 1. Provenance, current estimates of geological age, and number of reviewed specimens (*n*) of five different collections of South Asian fossils that are included in the collections of the OUMNH. [1]Specimen counts at time of writing should not be regarded as final or definitive.

Collection	Donor/Collector	Date of collection	Location of collection	Geological age		*n*[1]
'S'	Lieutenant Colonel Lewis Robert Stacy	Late 1834–1835	Siwalik Hills	Upper Siwaliks	Plio-Pleistocene	175
'K'	Colonel Charles Pratt Kennedy	Late 1834–1835	Siwalik Hills	Upper Siwaliks	To be confirmed (cf. Plio-Pleistocene)	29
'Ava – Irawadi'	Dr John Crawfurd	1826	Burma: 'halfway between Ava and Prome. . .little north of Wetmasot'	Irrawddy Gravels	Middle Miocene to Pliocene	3
'Nerbudda'	To be determined	To be determined	Narmada river Central India	/	Middle to Upper Pleistocene	8
Piram (Perim) Island	To be determined	To be determined	Piram (Perim) Island India		Late Miocene	3
(Unannotated/to be determined)						(191)
					TOTAL	409

Figure 2. Annotated specimens from the 'S' and 'K' collections; left: mandibular canine fragment of *Hexaprotodon* (OUMNH PAL-QY.16); right: Cervidae antler fragment (OUMNH PAL-QY.26). Scale bars = 20 mm.

As a subscriber to the *Journal* (and apparently a friend of Cautley, below) Stacy was undoubtedly influenced by these discoveries; as a newly inducted member of the Ashmolean Society, he likely wanted the museum to have a collection of fossils from the Indian Subcontinent (AS 1835). The Ashmolean was an obvious choice not only because of his personal connection to Oxford, but also because it was the best known of the newly formed natural history societies in Britain around that time (Allen 1994); the geological collections, presided over by Professor of Geology and Mineralogy William Buckland had achieved considerable celebrity. It is also highly likely that Buckland would have known Stacy's brother and would have asked Daniel to mediate in the acquisition of fossils for the museum. In a letter that reached Oxford in May 1835, Stacy explained that he had sent out a local Indian collector to do just that (AS 1835). This eventually led to the collection of seven boxes of fossils (AS p. 1837a), which were duly shipped back to Oxford.

The fossils had arrived in Oxford by 1836 and were examined by Buckland that same year: 'In 1836 Dr. Buckland examined a number of fossils from the hill-slopes and ravines that traverse that part of the Siwalik Sub-Himalayan range of hills which lies between the Jumna and the Sutlej rivers' (Gordon 1894, p. 179). Buckland's correspondence indicated that he believed that these were the first Siwalik fossils 'ever brought thence to this country' (Gordon 1894, p. 179). The collection was the subject of an address to the Ashmolean Society on 5 June 1837, where he described two donations. The first of these was, according to him, 'a large and valuable collection of fossil bones' donated by Stacy (AS 1837b). The second collection was mentioned in a more off-hand manner at the end of the summary: 'another magnificent present of bones has been made to the collection of the University of Oxford by Colonel Kennedy' (AS 1837b), specifically, Colonel Charles Pratt Kennedy of the then Bengal Artillery (later Royal Artillery).

Specimens from both these collections were annotated with capital letters; those from the collection donated by Stacy with an 'S' (hence 'S collection') and those from Kennedy, with a 'K' (Figure 2; Table 1). The annotations were most likely applied by Mary Buckland (née Morland). Mary was intimately involved in the curation of the university's Geological Museum and her eldest son reminds us that among many tasks 'It was her occupation also to label the specimens, which she did in a particularly neat way; and there is hardly a fossil or bone in the Oxford Museum which has not her handwriting upon it'. (Buckland 1858, p. xxxvi).

A brief history of the S collection in Oxford

Following their arrival in Oxford and inspection by Buckland in 1836, the Stacy fossils eventually made their way into the University Museum collections. Between 1830 and 1832 the geological collections from the Old Ashmolean Museum were moved, together with their professor, into more spacious quarters in the adjacent Clarendon Building. The Stacy fossils do not appear on a list of baskets, boxes, etc. of surplus specimens that were moved from Buckland's lecture room to the upper floor of the Clarendon Building in 1843 (Oxford University Museum 1843), so presumably they were still being used for teaching. Indeed, early museum guides indicate that the Siwalik fossils were highly valued as exciting recent discoveries and were selected for display when the OUMNH was

Table 2. Measurements in mm and characteristics (after Maglio 1973; Lister and Sher 2015) of dental remains of three specimens of Proboscidea in the S collection.

ACC	Element	Taxon	ET	H	HI	L	LF	P	W
OUMNH PAL-QY.20	mand. frag/molar (dm3/4?)	*Elephas hysudricus*	1.5	95	171.48	>120	~8	>9?	55.4
OUMNH PAL-QY.19	mand. frag/ tooth (m2?)	*Stegodon* sp.	p7 = 4.96 (*n* = 4)	p1 = 44.28	65.991	>165	5	8	p3 = 67.1
01682 PAL-QY.21	jaw with molar fragment	*Elephas planifrons*	na	110	124.63	>125	5	X5X	88.26

Figure 3. Left mandible fragment with molar (likely m2) of *Stegodon* sp. (OUMNH PAL-QY.19) in the S collection; upper: lateral view; lower: occlusal view. Scale bar = 50 mm.

established in 1860. The museum guides by John Phillips and Joseph Prestwich mention Siwalik fossils in wall cases on the south and west corridors although, confusingly, they state that these were presented by Falconer and Cautley (Phillips 1860, p. 78; Prestwich 1881, p. 60); it is most likely that taxonomic authorities were misinterpreted as donors. At least one of the Stacy specimens, a partial horn core from a large bovid, was part of a display of Siwalik fossils installed in the time of Professor WJ Sollas (1897–1936). This display was dismantled in 1975. According to former museum staff, other specimens were stored on open shelves above the display cases in the east corridor and in cupboards under the display cases in the west corridor (WJ Kennedy and HP Powell, *pers. comm*. to EH 2020). In 1992–93 all the Siwalik Hills material was boxed up and transferred to an off-site store in Nuneham Courtenay, about 8 km southeast of Oxford, due to lack of suitable on-site storage for large geological specimens (WJ Kennedy, *pers. comm*. to EH 2020). In 2018 this store was emptied, and the Siwalik material was transferred to an interim store elsewhere in Oxfordshire, where it is in the process of being curated.

Select taxa in the S collection

To date, a total of 175 annotated S specimens have been noted (this excludes any potential specimens from a collection of isolated cervid and equid teeth that have yet to be examined in detail). The collection comprises of cranial and post-cranial elements and is biased towards specimens from larger taxa, most likely as a function of surface prospecting by Stacy's agent. The assemblage includes fossils of the Proboscidea, Perissodactyla, Artiodactyla and Reptilia; only specimens from mammalian taxa have been examined in any detail, to date.

Here, measurements of fossil specimens were taken with a single set of analogue dial callipers by a single observer. Measurements are shown in mm, throughout. Taxonomic identifications and confirmations were aided using vertebrate zoological collections of the OUMNH and published descriptions and data from Siwalik fossils; these works are cited where they are employed.

Proboscidea

Specimens of the Proboscidea are relatively abundant in the collection and include crania, post-crania, and tusk fragments. Distinct ridged molars, together with low relative crown height (H) and high relative enamel thickness (ET), separate teeth of the Stegodontidae from the Elephantidae (Table 2; Figure 3). In terms of dental remains, specimens from the Stegodontidae appear to be more abundant than those of the Elephantidae. Though relatively infrequent in number, an initial assessment of the Elephantidae fossils indicates the presence of least two species of *Elephas*: a Plio-Pleistocene species, *E. planifrons* and a Pleistocene species *E. hysudricus* (Table 2; Figure 4).

At least three species of Stegodon are reported from the Siwalik Hills, but the specific taxonomy of the genus is contentious (Saegusa et al. 2005). Briefly, Falconer named the species *Stegodon insignis* and *Stegodon ganesa* seemingly based on dental remains (Murchison 1868). Falconer's notes on various Stegodontid crania collected from the Siwalik Hills, however, indicated that the dentition of skulls referred to *Stegodon insignis* were indistinguishable from the dentition from the then only known skull of *Stegodon ganesa* (Murchison 1868). Furthermore, Falconer did not assign any holotypes so it's hard to tell exactly which teeth he was talking about.

Lydekker assigned crania as lectotypes for *S. insignis* and *S. ganesa* (Lydekker 1886) and in 1876 assigned a new cranium from Hoshiarpur as a female *S. ganesa* (Lydekker 1876). Later, when describing the Barnum Brown collection, Osborn (1942)

Figure 4. Top: mandible fragment and deciduous molar of *Elephas hysudricus* (OUMNH PAL-QY.20) from the S collection; Bottom: jaw fragment and broken molar of *Elephas planifrons* (OUMNH PAL-QY.21) from the S collection. Scale bars = 50 mm.

incorrectly (considering Lydekker's work) determined the first teeth Falconer figured in the *Fauna Antiqua Sivalensis* as the lectotypes and went on to argue that perhaps *S. ganesa* and *S. insignis* represent sexual morphs (male and female, respectively) of the same species, uniting the specific epithets to *insignis-ganesa*.

Critically, Falconer's specimens come from unknown stratigraphic levels in the Plio-Pleistocene and until new stratigraphically provenanced crania are recovered, it's nearly impossible to assign *Stegodon* teeth to one of these species. Several specimens in the S collection had previously been referred to '*Elephas insignis*' and all examined fossils, to date, appear to correspond

Table 3. Measurements (after Bernor et al. 1997) of maxillary teeth (mm) of *Equus sivalensis* (OUMNH PAL-QY.22).

Measurement (mm)	P4	M1	M2	M3
length (occlusal)	32.08	29.78	30.16	~32.00
width (occlusal)	28.66	31.76	30.7	27.04
protocone length	/	13.68	/	11.89
protocone width	/	4.62	/	3.88

to 'derived' or 'Group 4' *Stegodon* of Saegusa (1996; Saegusa et al. 2005). Given the unresolved and muddy taxonomy, however, we refer the specimens to *Stegodon* sp. (Table 2). In the Siwalik Hills, the temporal range of the genus extends from the Pliocene, from c. 3.4 Ma to the end of the Middle Pleistocene, 0.78 Ma (Patnaik 2013).

Perissodactyla

Specimens from the Perissodactyla appear to be relatively rare in the S collection. The Rhinocerotidae are represented by infrequent jaw fragments with worn teeth. Given that the taxonomy of extinct rhinoceros, generally, and from the Siwalik Hills specifically, is complex, these specimens have not been identified beyond family at present.

Specimens from the Equidae are also relatively rare but include a maxillary fragment (OUMNH PAL-QY.22), including P4 to M3 (Table 3; Figure 5). While portions of the teeth are partially obscured by matrix or have been damaged, pli caballin (enamel folds) are present on all teeth. The fossettes are plicated, with between one to three folds present on each anterior and posterior face. Overall, protocones are elongate; the buccal side is rounded whereas the lingual side is indented but straighter and the mesial and distal ends are angular (Figure 5).

At present, there is one generally accepted equid from the Siwaliks Hills, *Equus sivalensis*. The stratigraphic range of this Pleistocene taxon (Bernor et al. 2019) has also yielded evidence of a possible second, smaller equid (Gaur and Chopra 1984) but this has yet to be confirmed (Bernor et al. 2019). Dental metrics (Table 3) indicate that there are no grounds to suspect the smaller taxon here and the morphology and metrics of PAL-QY.00022 is consistent with *Equus sivalensis* (Lydekker 1882; Bernor et al. 2019).

Artiodactyla

A particularly noteworthy specimen in the S collection is a left maxilla and toothrow of the large extinct giraffid *Sivatherium giganteum* (Figure 6); OUMNH PAL-QY.23. While Buckland's address in 1837 confusingly referred to 'a lower jaw' from this taxon (AS 1837, p. 3), a letter from Proby T. Cautley to Lord Northampton stated that 'a colonel Stacy a friend of mine has sent home a lot/amongst them a line of molars upper jaw *Sivatherium*/ to the Ashmolean Museum in Oxford' (Cautley, 31 May 1836; letter transcribed by Philip Compton).

In addition to the post-cranial specimens in the collection, OUMNH PAL-QY.23 is a particularly valuable contribution to the record of *S. giganteum*. Despite being something of a totem of Siwalik fossils, these enormous extinct mammals are still poorly known (e.g., Basu et al. 2016). The maxilla was formerly on display in the museum and comprises of an upper left toothrow, P2-M3, partially encased in matrix. From the labial aspect, the distinctive anterior and posterior columns characteristic of the Giraffidae are preserved best in the P3 and P4 (Figure 6).

The ventral surface and thus the occlusal surface of the toothrow was, at some point, sectioned and polished and clearly shows the rugose enamel of the broad, triangular-shaped cusps. While the shape and limits of the fossettes have been affected by the section,

Figure 5. Lateral (top) and occlusal (bottom) views of left maxillary fragment from *Equus sivalensis* from the S collection (OUMNH PAL-QY.22). Scale bar = 20 mm.

Figure 6. Lateral (top) and occlusal (bottom) views of left maxillary fragment from *Sivatherium giganteum* from the S collection (OUMNH PAL-QY.23). Scale bar = 50 mm.

overall, the teeth are sufficiently preserved to permit measurement of most dimensions. Although comparative data are slight, the measurements from this specimen correspond well with those of Falconer and Cautley's type and specimens reported in Colbert (1935) (Table 4). The temporal range of *Sivatherium giganteum* in the Siwalik Hills is generally held to extend from the Pliocene, c. 2.7 Ma, to the end of the Middle Pleistocene, 0.78 Ma (Patnaik 2013). Excavations in the Pabbi Hills, Pakistan, however, have indicated that this latest occurrence of this taxon may have been restricted to the lower Pleistocene, >1.8 Ma (Dennell 2004).

Specimens from the Hippopotamidae are relatively common in the collection. All examined fossils where incisors/alveoli were present are hexaprotodont and thus attributable to *Hexaprotodon* (Figure 7).

South Asian *Hexaprotodon* ranges from the Pliocene, surviving into the closing stages of the Upper Pleistocene (Jukar et al. 2019). The genus is represented by a single species in the Siwaliks, *Hexaprotodon sivalensis*. While earlier authorities expressed misgivings ('I cannot imagine that full species would show so much intergradation as *H. sivalensis, H. namadicus, H. palaeindicus* and the Javan forms do'; Hooijer 1950, p. 32), workers have formed *Hexaprotodon* fossils into chronospecies, from older to younger, as follows: *H. sivalensis*, (Pliocene to Lower Pleistocene) *Hexaprotodon namadicus* (Middle Pleistocene) and *Hexaprotodon palaeindicus* (Upper Pleistocene). In the case of the latter two 'species', however,

Table 4. Measurements of maxillary teeth (mm) of *Sivatherium giganteum* (OUMNH PAL-QY.23) from the S collection with equivalent data from specimens in the Natural History Museum (UK) and American Museum of Natural History. [1]Measurements based on Falconer & Cautley 1836; [2]Female - measurements estimated from cast. [3]Measurements from Colbert 1935. M-D: Mesial-distal; B-L: Buccal-lingual.

	P2		P3		P4		M1		M2		M3	
Specimen	M-D	B-L	M-D	B-L	M-D	B-L	M-D	B-L	M-D	B-L	M-D	B-L
PAL-QY.23	42.24	/	39.4	49.7	37.06	44.93	46.58	47.3	54.94	/	54.24	/
NHMUK 15283[1]	43.18	48.26	43.18	49.53	39.37	56.9	42.67	55.88	55.88	60.45	/	59.69
NHMUK 39523[2]	37	38	38	38	38	40	43	41	45	44	45	41
AMNH 19883[3]	39	44	39	47	38	49	45	52	56	56	53	50
AMNH 29805[3]	/	/	/	/	/	/	50	50	55	52	50	46

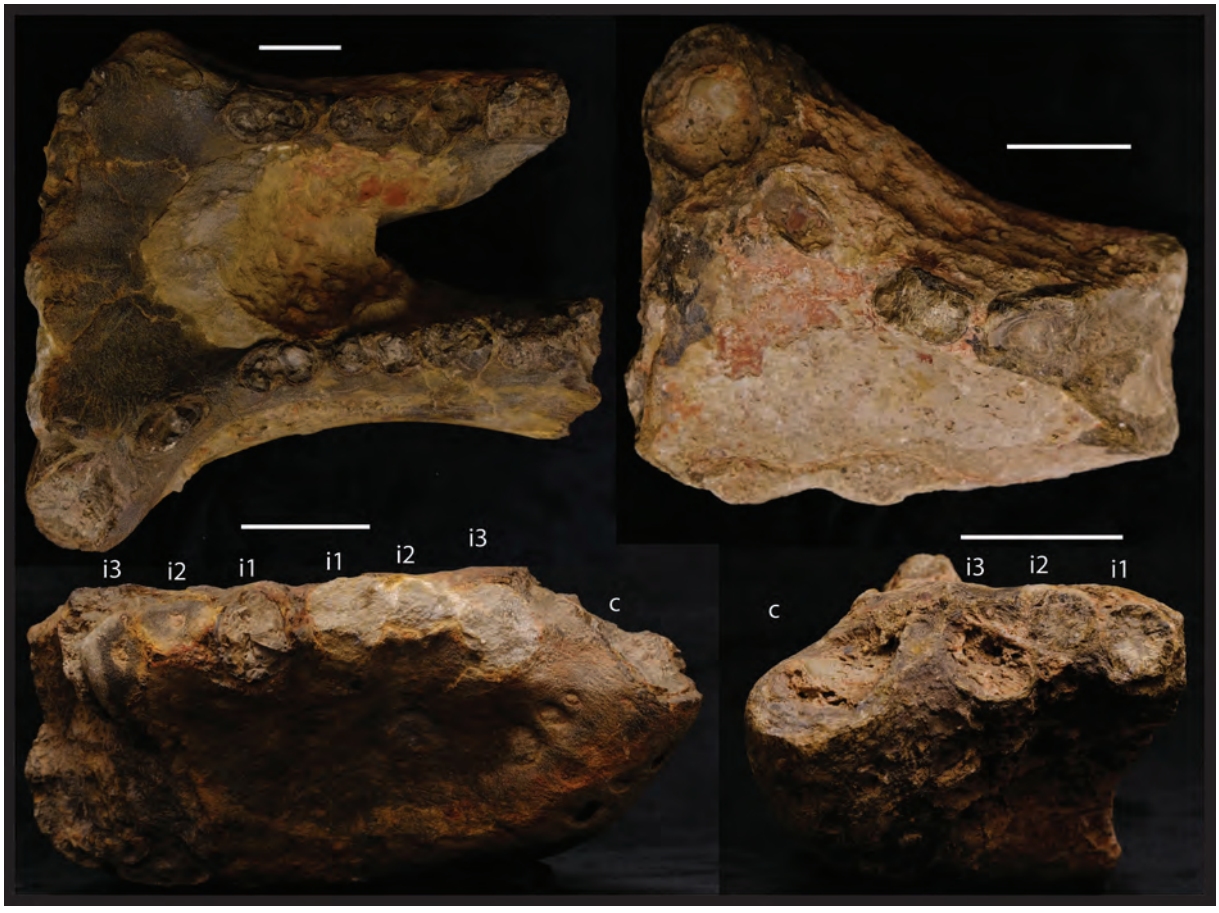

Figure 7. Top: occlusal views of *Hexaprotodon* mandibles from the S collection, OUMNH PAL-QY.17 (left) and OUMNH PAL-QY.18 (right); Bottom: anterior views of mandibular symphysis of OUMNH PAL-QY.17 (left) and OUMNH PAL-QY.18 (right) showing alveoli of canines (c) and incisors (i#). Scale = 50 mm.

there are contentions that they represent different morphs of a single, sexually dimorphic species, are two distinct taxa, or indeed the sequence should in fact should be treated as chronospecies (Jukar et al. 2019).

Reported morphological trends through time include an increase in the diameter of the third incisor relative to the other incisors (Boisserie 2005) and a reduction in size and elevation of the position of the second incisor in relation to the first and third (Salahuddin 1989; Jukar et al. 2021).

Table 5. Metric characteristics (following Hooijer 1950; Boisserie and White 2004; Boisserie 2005) of two *Hexaprotodon* mandibles from the S collection. Measurements are shown in mm.

Measurements (mm)/Indices	OUMNH PAL-QY.17	OUMNH PAL-QY.18
Length of symphysis	165	170
Interval between canines	190	(190)
L/W index – symphysis	86.84	89.47
Height symphysis	90	100
H/L index symphysis	54.55	58.82
i1 ML (alveolus)	28.84	28.18
i1 DV (alveolus)	32.67	30.02
i2 ML (alveolus)	22.45	26.82
i2 DV (alveolus)	20.8	21.82
i3 ML (alveolus)	28.98	30.10
i3 DV (alveolus)	33.36	31.92
ratio MD i2: i1 (alveolus)	0.69	0.89
ratio MD i3: i1 (alveolus)	1.02	1.06

Metrics derived from examination of alveoli suggest that the characteristics of the third incisors of two *Hexaprotodon* specimens from the S collection (OUMNH PAL-QY.17 and OUMNH PAL-QY.18); (Table 5) are consistent with data from Pleistocene-age specimens. Metric comparisons indicate that the diameter of third incisors is relatively large in comparison to equivalent data from *H. sivalensis* and approach the size of the intermediate chronological form, '*namadicus*' (Figure 8), which in central India is regarded as an index fossil of the Middle Pleistocene (Badam 2007). Furthermore, the second incisor is the smallest in size of all the incisors, in both cases and is elevated, relative to the other two incisors (Figure 7).

Large bovids are represented by crania and horncores and have not yet been subject of detailed study. One a specimen, OUMNH PAL-QY.25, has previously been referred to *Bubalus* sp. by CN Norris in 1998 (*unpublished*) (Figure 9). The horncore in this specimen is elevated at a shallow angle and orientated posteriorly. It is angular in cross section with defined keels on the anterior and posterior edges; the posterior keel is particularly well defined. A Pleistocene species, *Bubalus platyceros*, is reported from the Siwalik Hills (Pilgrim 1939).

A notable specimen, OUMNH PAL-QY.24, derives from a small bovid and comprises of a fragment of frontal, the medial suture and basal horncore. A portion of the supraorbital foramen is also preserved (Figure 9). The horn core has a rounded, elliptical cross section (basal measurements: anterior-

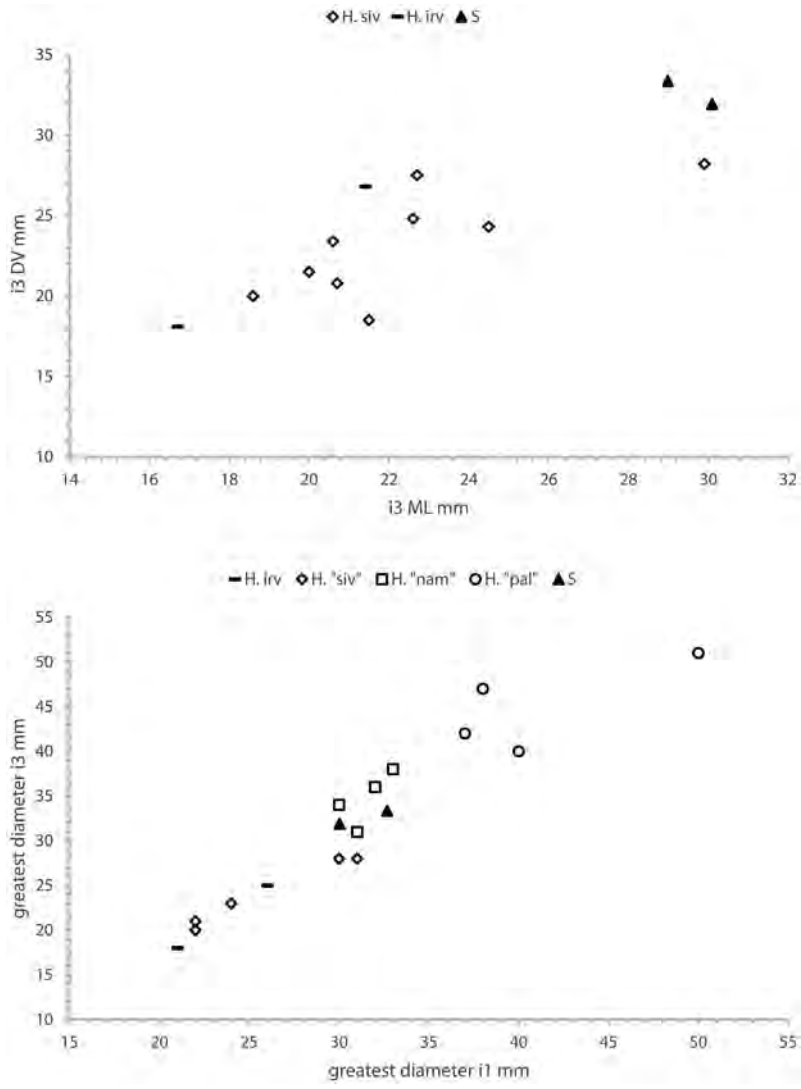

Figure 8. Top: Medio-lateral (M-L) and dorso-ventral (D-V) diameter of third lower incisors (i3) from *Hexaprotodon irvaticus* (H. irv), *Hex*. sivalensis (H. siv) and two specimens from the S collection ('S': OUMNH PAL-QY.17 and OUMNH PAL-QY.18); Bottom: greatest diameter of first lower incisor (i1) versus third lower incisor (i3) of *Hexaprotodon irvaticus* (H. irv) and *Hexaprotodon* chrono-species 'sivalensis' (H. 'siv'), 'namadicus' (H. 'nam') and 'palaeindicus' (H. 'pal') and two specimens from the S collection ('S': OUMNH PAL-QY.17 and OUMNH PAL-QY.18). Comparative data from Boisserie and White (2004) and Hooijer (1950), respectively.

posterior = 39.95 mm; medial-lateral = 34.25 mm; Figure 9) and relatively deep, coarse longitudinal stria; much more so than in extant and Pleistocene *Oryx* specimens (Stimpson et al. 2016), which, while superficially similar, are larger, more robust and taper more markedly. There is no indication of torsion and the distance between horncores can be estimated at c. 20 mm, with a divergence of 30 degrees and an acute backward sweep of c. 60 degrees. These characters are consistent with *Gazella* sp. (cf. Kahn et al. 2016).

Two species from the genus have been proposed from the Siwalik Hills; *Gazella lydekkeri* and a larger more robust form, *Gazella superba*, which was tentatively proposed by Pilgrim (1939) and subsequently upheld by Kahn et al. (2016). The horncores of the two taxa reportedly display very similar morphologies and are largely differentiated by size (Figure 10). OUMNH PAL-QY.24 is relatively large and robust, and measurements of the horn core are consistent with those reported for the larger taxon, *G. superba* (Figure 10).

The majority of *Gazella* sp. fossils reported from the hills tend to derive from older strata, from the Lower and Middle Siwaliks (Pilgrim 1937; Patnaik 2013; Kahn et al. 2016), although fossils from the genus do range into the Pleistocene and the Upper Siwaliks (Kumar and Gaur 2013; Patnaik 2013). *G. superba*, however, is currently reported only from the late Miocene to early Pliocene 7.0–5.0 Ma (Khan et al. 2016). The preceding taxa all are suggestive of a Plio-Pleistocene affinity; OUMNH PAL-QY.24 could suggest that the S collection is a temporally mixed assemblage. Because the exact collecting localities visited by Stacy's agent are currently unknown, a strict biostratigraphic interpretation would be ill-advised at this stage. Extant *Gazella* sp. are known to be dimorphic; in some species males display markedly larger and longer horns than females (e.g., Wronski et al. 2010) and sexual dimorphism within a single species cannot be ruled out here. OUMNH PAL-QY.24 is referred to *G.* cf. *superba* pending further investigation.

Figure 9. Left: Superior view of *Bubalus* sp. (OUMNH PAL-QY.25) cranial fragment (and horncore (scale bar = 50 mm); right: superior view of *Gazella* cf. *superba* horncore (OUMNH PAL-QY.24; scale bar = 20 mm).

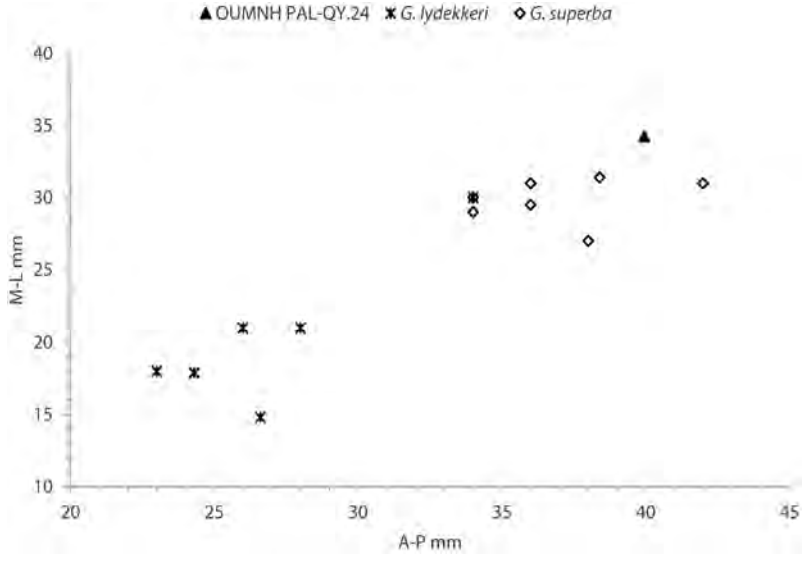

Figure 10. Bivariate comparison of basal horncore measurements of OUMNH PAL-QY.24 (A-P: anterior-posterior; M-L: medial-lateral) with equivalent data from *G. lydekkeri* and *G. superba*. Data from Khan et al. (2016).

Discussion and conclusion

The S collection is a valuable one, from both scientific and historical viewpoints. These poorly known and understudied specimens are important early collections of Siwalik fossils, which were collected at similar time to those of the celebrated works of Falconer and Cautley. Indeed, they may be among the first fossils to be transported to the UK from the Siwalik Hills.

More importantly, these fossils are valuable archives of the palaeontology of India. It has been over 180 years since first scientific descriptions of fossils from the Siwalik Hills, but, as highlighted in the summary of taxa above, the taxonomy of many extinct large mammalian taxa remains poorly resolved (e.g., Chauhan 2008; Jukar et al. 2019, 2021; Turvey et al. 2021).

While Buckland refers to the 'valley of the Markanda' in his 1837 address on the fossils (AS 1837b, p. 3), it is not possible at present to state from where the S collection derived, wholly or partially, other than at a locality, or localities, between the Yamuna and Sutlej rivers. Further work may refine the geographical context of the collection. Taken together, however, the majority of the taxa, above, parsimoniously indicate that the S collection comprises of an Upper Siwalik fauna (cf. Dennell 2004; Nanda 2013; Nanda et al. 2018).

Research on the collection is ongoing, but the S fossils have the potential to contribute to resolving a common problem in palaeontology and the fauna of the Siwalik Hills. There is no need to revisit the well-documented problem of species taxonomy here (e.g., Simpson 1951), but suffice to say is that an often cited problem is when a 'species' (essentially a population) is described on the basis

of a limited number of, or even single, specimens, which are unrepresentative of intraspecific variation as a function of cline, sexual dimorphism, etc. In this context, the availability of further specimens at the OUMNH is, potentially, a valuable resource for further taxonomic investigation of Siwalik mammals.

Equally pertinent here, however, is the hidden history of this collection. While this study has revealed details of the donor of the collection and initial results on the character of the fossils assemblage, the investigation of provenance has necessarily relied on the use of scant historical records and colonial-era archives. These records are intrinsically biased and represent incomplete narratives; the absence of references to individual local Indian actors and communities is pervasive (e.g., Nair 2005). In parallel with the further scientific exploration of the S collection, a dedicated investigation into the journey of the fossils from the Siwalik Hills and all the likely actors that were involved would not only be a fruitful and worthwhile endeavour but would be an essential step towards establishing a comprehensive and representative history of the collection.

Acknowledgments

Special thanks to the Nuneham move project team (Sue Beardmore, Peter Brown, Chantelle Dolimore, Neil Owen) for their efforts in the curation and cataloguing of the Siwalik Hills fossils. CMS thanks Neil Owen for his assistance throughout the detailed research work. Professor Sally Shuttleworth provided helpful comments about natural history societies in Britain and the Ashmolean. We thank Lord Northampton for access to the Northampton family archives at Castle Ashby and to Philip Compton for permission to quote his transcription of P.T. Cautley's private letter. We thank two referees for their time and comments on an earlier version of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Susan Newell is a Collaborative Doctoral Partnership student at the University of Leeds and Oxford University Museum of Natural History funded by UKRI, the Arts and Humanities Research Council

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