NEW EVIDENCE CONCERNING THE EXTINCTION OF THE ENDEMIC MURID *RATTUS MACLEARI* FROM CHRISTMAS ISLAND, INDIAN OCEAN

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Recently rediscovered material from the collections and archives of the Oxford University Museum throws new light on the disappearance of the endemic rat *Rattus macleari* from Christmas Island (Indian Ocean), thought to have gone extinct between 1898 and 1908 as a result of diseases introduced by infected individuals of *R. rattus*. A collection of rats made by H.E. Durham in 1901-1902 reveals that *R. macleari* was present on Christmas Island at this time, although in lesser numbers than had been the case when the species was described in 1887. Also present in the collection are specimens of *R. rattus*, together with a number of rats which exhibit a mixture of characters from both *R. rattus* and *R. macleari*. Durham's notes on blood parasites in the Christmas Island rats reveal that in 1901-1902 both *R. rattus* and some specimens of *R. macleari* were heavily infested with trypanosomes. Notes deposited in the University Museum archives by Hanitsch (1923) show that *R. macleari* was no longer present on Christmas Island after 1904. As a result of the authors' observations on the Durham collection and the Hanitsch manuscript, it is proposed that the extinction of *R. macleari* occurred between 1901 and 1904. During this period, there is evidence for extensive interspecific hybridisation between *R. macleari* and *R. rattus*. The selective pressure for such hybridisation may have been parasitisation, resulting from the introduction of trypanosome-infected individuals of *R. rattus* in a cargo of hay in 1899.

Key words: Christmas Island, *R. macleari*, *R. rattus*, extinction, hybridisation, trypanosomes

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CHRISTMAS Island is an outcrop of coralline limestone of 13,470 hectares which lies 320 km south of Java. Until comparatively recently, the Island's fauna contained two endemic species of rat: Maclear's rat (*Rattus macleari*), a lightly built, semi-arboreal species and the bulldog rat (*Rattus nativitatis*), a robust, burrowing animal. The taxonomic distinctiveness of these rats has been discussed by a number of authors, notably Thomas (1888), Ellerman (1949) and Musser & Newcomb (1983). The two species are known to have become extinct at some point during the first decade of the twentieth century.

The extinction of *R. macleari* and *R. nativitatis* happened over a very short time. The reports on the two visits to the Island, by the naturalist C.W. Andrews of the British Museum (Natural History) in 1897-8 and 1908, document the startling change in the rat populations between those two dates. On his first visit Andrews saw "swarms" of *R. macleari* (Andrews 1900) whilst in 1908 he reported that the two native species were almost certainly extinct (Andrews 1909). The arrival of the species *Rattus rattus* on the island in 1899 on the S.S. *Hindustan*, in a cargo of hay (Durham 1908) is a key event, since it is hypothesised that the ship rat brought disease to the Island which wiped out the indigenous rats (Andrews 1909). Until now there has been no evidence from the crucial period 1898-1908 (apart from anecdotal remarks from the island's inhabitants reported in Andrews, 1909) to support this hypothesis. However, recent discoveries in the zoological collections and archives of the Oxford University Museum may provide such evidence. The collection of rats described here was made between November 1901 and March 1902 (after the introduction of the ship rat) by a pathologist, Herbert Durham. In addition, documentary evidence, from a visit to the Island by K.R. Hanitsch of the Raffles Museum, Singapore, suggests that by 1904 there were no recognisable individuals of *R. macleari* present on Christmas Island.

COLLECTING ON CHRISTMAS ISLAND PRIOR TO 1899

The history of Christmas Island can be divided into three distinct phases (Gibson-Hill 1949). From its discovery in 1643 to 1888 it was seldom visited. In 1888 a small colony was founded in Flying Fish Cove, by the Clunies Ross family from the Cocos Islands, who cultivated coffee and coco-nuts, and finally in 1897 the colony was enlarged and paths were cut to further parts of the Island. Singapore became the principal outside contact. From 1899 until 1985 the island was the site of large-scale phosphate mining.

In 1887, H.M.S. *Flying Fish* visited Christmas Island for the purpose of collecting samples of rock and coral from the foreshore, together with other specimens of scientific interest. The material collected included the holotype of *R. macleari*, an adult female preserved in spirit, which was described by Thomas (1887). The Captain of the ship, Maclear, mentioned that "Rat-holes were numerous" (however, it should be noted here that Christmas Island has abundant land crabs, which also make burrows: these are approximately the same size as a rat hole).

In 1887, J.J. Lister collected on Christmas Island. He described *R. macleari* as follows:

"This Rat abounds all over the island. From dusk till daylight they swarmed about the tents on shore, and Captain Aldrich, who, with his party, spent a night on the high part of the island, found them equally abundant there. They generally keep to the ground, but are able to climb trees." (Lister, 1888)

Lister collected seven more specimens of *R. macleari* which were described and measured by Thomas (1888). He also collected 2 specimens of a larger rat, described as a new species, *R. nativitatis* (Thomas, 1888).

In 1888 the Island was annexed by the British Government and, in 1899, the Christmas Island Phosphate Company began mining the extensive phosphate deposits (Burstyn, 1975). A study of the Island's natural history was commissioned by the Company's founder, Sir John Murray, to be carried out by Charles W. Andrews. Andrews left England in May 1897 to stay on the Island for ten months. The result was "A Monograph of Christmas Island" (Andrews, 1900). He collected 14 specimens of *R. macleari* and describes the rat as being "by far the commonest of the mammals found in the island; in every part I visited, it occurred in swarms." He saw it at night, when the rats would come to the settlement to scavenge food. Andrews also collected 9 specimens of *R. nativitatis*, which, although much less common than *R. macleari*, was numerous in places such as Phosphate Hill. It too was strictly nocturnal.

In August 1890, H.M.S. *Redpole* had visited Christmas Island with the naturalist Henry M.Ridley, (Ridley 1891) who was the Director of Gardens and Forests for the Straits Settlements. Unfortunately Ridley was only on the Island for a day; he left before sunset and did not secure any rat specimens.

THE DURHAM COLLECTION

The Durham collection is split between the Zoological Collections, University Museum, Oxford and the University Museum of Zoology, Cambridge. Dr. Herbert Durham, a pathologist and pioneer in tropical medicine, worked principally on bacteria. He was on the London School of Tropical Medicine's "Beri-beri Expedition", which arrived on Christmas Island on November 25 1901. The expedition was supported by the Christmas Island Phosphate Company to investigate outbreaks of the disease amongst the Company's workers. Durham believed that the cause of the disease was nutrition (Durham 1902, 1903). He mentions rats twice in his official expedition reports, both times in relation to attempts to grow vegetables to feed the mine workers.

"It may be said that no really serious attempt at gardening had been made at the time of my visit. Complaints were made that the rats destroyed everything, but no steps were taken to prevent them." (Durham, 1902)

"I went over the gardening area with Mr Macphearson and pointed out that many useful things escaped the attacks of the rats." (Durham, 1903)

Durham was told by the manager of the Phosphate Company, Captain Vincent, that *R. rattus* had been introduced to the island in 1899 by the S.S. *Hindustan*, in a cargo of hay. By his visit in 1901/2 they had multiplied to huge numbers. In considering Durham's observations, it should be noted that he did not stray far from the settlement.

i) Specimens of rat collected by Durham

In all, Durham collected 19 specimens of rat on Christmas Island. He was unable to obtain any fresh or recently killed *R. nativitatis* because

"the large *Mus nativitatis* had already become so rare about the settlement at the time of my visits and I was unable to obtain either a freshly killed or a living specimen although a reward was offered" (Durham, 1908)

The Cambridge collection of rats was presented to the Zoology Museum in June 1910. There were 9

skins with skulls (the skulls are now missing). According to the accessions catalogue they were presented for comparison with some white-tailed *M. rattus* (sic) from Bombay, which were also presented at the same time by a Captain R.E.Lloyd. The collection in Oxford was presented by Dr. Durham in May 1938, on the advice of Dr. R Parrington of Cambridge. It comprises 3 skins, 2 skeletons and 4 skulls from *Pteropus natalis*, 1 skin of *Zosterops natalis* and some insects, as well as 3 skins of *R. rattus* and 6 skins (2 with skulls) and one skull of *R. macleari*. Of these, one (OUM 18842) is mentioned as being a possible hybrid between *R. rattus* and *R. macleari*. For details of the specimens see the Appendix. Durham also collected some fleas from the skins which are described below.

Viewed as a whole, the Durham rats exhibit three distinct morphologies:

1. OUM 18841, 18843-6. Rats exhibiting the characteristics of *R. macleari*, as described by Thomas (1887). They are large (mean adult head and body length [HBL] 206mm) with a pelage that is cream ventrally and distinctively chestnut brown dorsally: the dorsal fur is punctuated by long, dark guard hairs. The ear pinnae are relatively small. The facial vibrissidae are coarse and dark. The tail is bicoloured, being dark proximally, but white distally. The hind foot is elongate.

2. E 2072-3, 2076-80. Rats exhibiting the characteristics of the ship rat *R. rattus* These are smaller rats (mean adult HBL 163mm) with a pelage that is dark grey brown dorsally and pale grey ventrally. There are a small number of pale guard hairs concentrated laterally and caudally. The ear pinnae are relatively large. The facial vibrissidae are very fine. The tail is uniformly dark.

3. OUM 18606-8, 18842; E 2074-5. These are large rats (mean adult HBL 203mm), with a variable pelage: cream or grey ventrally; dorsally ranging from mid to dark brown with some chestnut (most clearly in E2075 and OUM 18842); many long pale guard hairs dorsally. The ear pinnae are relatively large. The facial vibrissidae are coarse and dark. The tail is uniformly coloured, but the scales are generally paler than those of type 2 rats. The hind foot is relatively short.

The identification of the third class of rat is problematic. This is reflected in the comments made on the original museum labels at both Oxford and Cambridge, which are written by Durham. These appear to show a degree of confusion as to what exactly was being collected. For example E 2072 (one of the type 2 specimens) is described as "half breed *M. decumanus* and *Mus macleari*", although it is not noticeably different from the other skins in this group. A number of specimens are simply described as "? halfbreed." Three of the type 3 rats (OUM 18606-8) are described as *M. rattus*. In the case of OUM 18842 Durham's label notes that -

"This had a divergent coat colour and I thought possible a cross between M. rattus and M. macleari."

This particular specimen was kept in captivity by Durham, presumably giving him the opportunity for a longer period of observation. It is the only type 3 rat for which a skull is available. The skull possesses characters used by Thomas (1888) in his definition of *R. macleari*, in that the front edge of the anterior zygoma root is projecting and very convex and the palatal foramina are elongated. Unlike *R. macleari*, however, the auditory bullae are large, a character frequently cited for *R. rattus* (eg Laurie & Hill, 1954).

ii) Parasite infections in *R. macleari*

Durham published some notes (1908) on blood parasites in Christmas Island rats, bats and the small ground pigeon *Chalcophaps natalis*. He observed that the *R. macleari* collected around the settlement had "abundant trypanosomes" whilst those captured at the top of Phosphate Hill were free from infection. He also collected a number of *R. rattus* and found that they harboured a similar trypanosome to *R. macleari*. Durham proposed, as did Andrews (1909), that the infections in *R. macleari* had been introduced by the ship rats.

The fleas found on *R. macleari* were of a new species, *Xenopsylla nesiotes* (Jordan & Rothschild, 1908). The material (which was incorrectly attributed to the collector, C.W. Andrews, in the original description: Hopkins & Rothschild, 1953) comprises 6 dry specimens plus 11 specimens in alcohol. *X. nesiotes* is only known from the material brought back by Durham. The fact that this is a unique species of flea means that the interchange of fleas from the ship rat was not proven. To date no other collections of this flea have been made (Lewis, pers comm).

HANITSCH EXPEDITION, 1904

Sir John Murray continued to encourage scientists to visit Christmas Island and in 1900, when passing through Singapore he suggested to the zoologist K.R. Hanitsch of the Raffles Museum that he should go and collect specimens there (Hanitsch, 1923).

Accordingly, in 1904, Hanitsch went to Christmas Island with the botanist, Ridley, who had visited the Island once before in 1890. They spent about 5 weeks on the island during September and

October. Ridley published an account of the trip (Ridley 1905), which only mentioned rats in connection with their being food for feral cats, but Hanitsch never published an account of his travels.

However, in the archives of the University Museum, there are manuscript notes for a lecture on Christmas Island which Hanitsch gave, in the Museum, to the Ashmolean Natural History Society of Oxfordshire on Tuesday May 15th, 1923. These notes give a detailed account of his trip, a list of Europeans then present on the Island, the geology and zoology of the Island, and also include a map showing the routes the expedition took. The passage on rats we quote in full:

"You will have heard of the two rats which Andrews described from Xmas I. and which at the time of his visit were common all over the island. One of them was *Mus nativitatis* which the settler called the Bull-dog rat.....very much different is, or was, the other rat, *Mus macleari*..... We naturally expected great sport from these creatures. We had provided ourselves with several dozens of traps and had quite made up our minds substantially to reduce the rat population of the island. But there were none. The rats had disappeared, at least those two species, *M. nativitatis* and *M. macleari* which Andrews had found in such abundance only 7 years before. After much trouble we secured 1 or 2 specimens of a Rat which on account of its slaty colour we called the Blue Rat, & a very few specimens of another species, possibly a Ship's rat, with whitish bellies, *Mus isabellinus* or some close ally. Andrews who visited the island again in 1908 confirmed the extinction of the original two rats. To account for this extinction is a difficult matter. The inhabitants of the island had noticed the gradual disappearance of the Rodent, but were only too grateful for this dispensation needlessly to worry their heads about it. They said there had been a great drought a few years after Andrew's visit. However as the luxuriant jungle remained practically unaffected by it and there remained abundant food for Rats in the way of roots and leaves and other vegetable matter, this could hardly have caused their total extinction. Nor could the few introduction of a few dogs and cats have been the reason. It is more likely that the accidental introduction of Ship's rats, with the germs of all sorts of diseases, must have killed them off. It is true that nobody had seen any dead Rats lying about. But the crabs of the island would probably quickly have finished them off, grateful for such a welcome change of diet."

The Raffles natural history collections, now in the Zoological Research Collection at the National University of Singapore, have no specimens from the expedition (Yang, pers comm). Although Durham had not travelled far from the settlement, Hanitsch and his party had travelled over to Middle Point on the other side of the island. Since they were intent on collecting rats, it seems likely that the two native rats were indeed extinct by the time of their visit.

ANDREWS' VISIT OF 1908

Andrews revisited Christmas Island in 1908, in the autumn, to look at how the many introduced species of fauna and flora had affected the native wildlife. He reported (Andrews, 1909) that the two species of native rat seemed to be totally extinct. A medical officer reported to him that about 1902/3 he had seen "individuals of the native species of rats crawling about the paths in the daytime, apparently in a dying condition". He concluded that the disappearance of these rats may have been the result of an epidemic of disease, possibly brought onto the Island by the ship rat. In his opinion, the newcomers had not penetrated far enough into the Island for it to be the result of direct competition.

DISCUSSION

The Durham collection and Hanitsch manuscript provide new evidence which fixes the likely extinction of the rats to 1902-3. A number of new lines of evidence are established, permitting the creation of a detailed hypothesis for the process of extinction in *Rattus macleari*. This evidence can be briefly summarised as follows, with the novel information presented in this paper italicised:

1. 1897-1898. *R. macleari* is the commonest species of mammal on Christmas Island, present all over the island, including the settlement. Distribution of *R. nativitatus* patchy, but still moderately abundant (Andrews, 1900);

2. 1899. Cargo of hay from S.S. *Hindustan* introduces *R. rattus* to Christmas Island;

3. *1901-1902. H.E. Durham visits Christmas Island. Huge numbers of R. rattus reported. R. nativitatis extremely rare. R. macleari still present, but now accompanied by other rats showing combinations of macleari/rattus characters. Specimens of R. macleari from around the settlement, where the population of R. rattus is concentrated, are heavily infected with a type of trypanosome also found in the R. rattus specimens collected. Specimens of R. macleari away from the settlement are clear of this infection;*

4. 1902-1903. Sick and dying rats seen around the island (Andrews, 1909);

5. *1904. Hanitsch visits Christmas Island. Despite considerable efforts he can find no specimens of either R. macleari or R. nativitatus. The only rat specimens collected are tentatively identified as R. rattus: they are pale coloured ventrally. In addition, a second type of rat, which is slate coloured is found.*

6. 1908. Andrews visits Christmas Island for a second time and pronounces the two species of native rat to be totally extinct.

The specimens in the Durham collection suggest that the extinction of *R. macleari* was a more complex event than the simple replacement of an island endemic by an invading competitor. In particular, the existence of the type 3 group of rats suggests that extensive hybridisation may have taken place between *R. macleari* and *R. rattus* in the years following the visit of the *Hindustan*. By the time of Durham's visit in 1901, although it was still possible to distinguish specimens of *R. macleari*, the boundaries between the species were sufficiently blurred to confuse a worker whose background was in pathology. However, by 1904, there were no longer any rats recognisable as *R. macleari*. The uncertainty implicit in Hanitsch's comments about the identity of the rats collected suggests that some of them may not have been pure bred *R. rattus*, although the absence of specimens from this expedition makes it impossible to confirm this.

There are a number of caveats to this hypothesis. Firstly, with regard to the type 3 morphology, it should be noted that, as a species, *R. rattus* is notoriously variable in size and coat colour. Secondly, successful interspecific hybridisations are, by definition, rare events. In the few cases where they occur, the most likely explanation is usually selection for hybrid vigour. For example, Tegelström (1987) presents evidence from mitochondrial DNA sequences for a limited episode of hybridisation between two species of vole, *Clethrionomys glareolus* and *C. rutilis*. He concludes that this may have occurred during the postglacial recolonisation of Fennoscandia 8,000 to 13,000 years ago. Hybrids may have had a selective advantage as colonisers in the harsh environment of these times, because of the increased litter size, birth rate and growth rate which have been reported in hybrids of these two species (Zimmerman, 1965).

In the case of *Rattus macleari*, the selection pressures are likely to have been different. The major change was not in the physical environment of Christmas Island; nor is direct competition with *R. rattus* a strong probability, since this commensal species was unlikely to spread far beyond the bounds of the settlement. The most probable source of the selection pressure may have been disease introduced by the rats from the *Hindustan*, one possibility being infection with the trypanosomes identified by Durham. The endemic species may have been especially vulnerable to the arrival of a new parasite. Van Valen (1973) suggested a model of evolution known as the "Red Queen Hypothesis," whereby the probability of a species' extinction is determined by its ability to keep pace with a steadily deteriorating environment: this is, to a significant extent, dependent on the variation present within its gene pool: the more variation, the greater the potential to adapt to environmental changes, such as evolutionary changes in the parasites infecting it. Confined to an island of only 13,470 hectares, 320km from the nearest large body of land (Java) it is possible that *R. macleari* had lost much of its population heterogeneity. Given sudden environmental stress in the form of a new parasite and the low rate of accumulation of random point mutations, hybridisation with *R. rattus* may have been the only way to rapidly acquire new genomic variability.

There is much within this hypothesis which remains speculation. For example, the question of whether hybridisation proved to be a successful strategy is still unanswered. With the disappearance of *R. macleari* and *R. nativitatus*, the interest of biologists in the rats of Christmas Island declined: there would seem to be little merit from a taxonomic point of view in collecting specimens of a comparatively recent introduction of the ubiquitous *R. rattus*. This is unfortunate, since the development of techniques such as the polymerase chain reaction (PCR) means that the potential now exists to extract DNA from the preserved skins of specimens of *R. macleari*. Comparisons between homologous sequences from specimens collected by Andrews and Durham, together with modern "*R. rattus*" from Christmas Island, would perhaps provide evidence to support or falsify the hypothesis outlined above.

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REFERENCES

ANDREWS, C.W., 1900. *A Monograph of Christmas Island (Indian Ocean).* British Museum (Natural History): London.

ANDREWS, C.W., 1909. An account of a Visit to Christmas Island. *Proceedings of the Zoological Society* **1909**: 101-103.

BURSTYN, H.L., 1975. Science Pays Off: Sir John Murray and the Christmas Island Phosphate Industry, 1866-1914. *Social Studies of Science* **5**: 5-34.

DURHAM, H.E., 1908. Notes on Nagana and on some Haematozoa observed during my travels. *Parasitology* **1**: 227-35.

DURHAM, H.E., 1902-3. "Investigation into Beri-beri on Christmas Island-Durham's Reports". Unpublished Manuscript in Archives of London School of Hygiene & Tropical Medicine: London. MSS FA=D3 (1).

ELLERMAN, J.R., 1949. *The Families and Genera of Living Rodents.* British Museum (Natural History): London.

GIBSON-HILL, C.A., 1949. The Early History of Christmas Island. *Journal of Malayan Branch of the Royal Asiatic Society* **22 (1)**: 82-93.

HANITSCH, K. R., 1923. "A visit to Christmas Island". Unpublished Manuscript, Oxford University Museum Archives: Oxford.

HOPKINS, G.H.G. AND ROTHSCHILD, M., 1953. *An Illustrated Catalogue of the Rothschild Collection of Fleas in the British Museum. Vol I: Tungidae and Pulicidae.* British Museum (Natural History): London.

JORDAN, K. AND ROTHSCHILD N.C., 1908. Revision of the non-combed eyed Siphonaptera. *Parasitology* **1**: 1-100.

LAURIE, E.M.O. AND HILL, J.E., 1954. "Mammals of New Guinea, Celebes and adjacent islands." British Museum (Natural History): London.

LISTER, J.J., 1888. On the natural history of Christmas Island, in the Indian Ocean. *Proceedings of the Zoological Society* **1888**: 512-531.

MUSSER, G.G. AND NEWCOMB, C., 1983. Malaysian murids and the giant rat of Sumatra. *Bulletin of the American Museum of Natural History* **174 (4)**: 327-598.

RIDLEY, H.N., 1891. A Day at Christmas Island. *Journal of the Straits Branch of the Royal Asiatic Society* **23**: 123-129.

RIDLEY, H.N., 1905. An expedition to Christmas Island. *Journal of the Straits Branch of the Royal Asiatic Society* **45**: 121-155.

TEGELSTROM, H., 1987. Transfer of mtochondrial DNA from the Northern Red-backed Vole (*Clethrionomys rutilus*) to the Bank Vole (*C. glareolus*). *Journal of Molecular Evolution* **21**: 218-227.

THOMAS, O., 1887. Mammalia *in* Gunther, A. (ed) Report on a Zoological Collection made by the Officers of H.M.S. Flying Fish at Christmas Island, Indian Ocean. *Proceedings of the Zoological Society* **1887**: 511- 514.

THOMAS, O., 1888. On the Mammals of Christmas Island. *Proceedings of the Zoological Society* **1888**: 532-534.

VAN VALEN, L., 1973. A new evolutionary law. *Evolutionary Theory* **1**: 1-30.

ZIMMERMAN, K., 1965. Art-Hybriden bei Rötelmäusen. *Zeitschrift für Säugertierkunde* **30**: 315-320.

APPENDIX

Cambridge Collection

E.2072 Skin only. Christmas Island, 13 January 1902. Collected H.E. Durham. Collector's label "Half breed M. decumanus + Mus macleari".

E.2073 Skin only. ♂. Settlement, Christmas Island. Collected H.E. Durham. Collector's label "117 x 117, Killed 5 days, Xmas Settlement".

E.2074 Skin only. ♂. Settlement, Christmas Island, 13 January 1902. Collected H.E. Durham. Collector's no. 22. Collector's label "long pile grey".

E.2075 Skin only. ♂. Christmas Island, 11 January 1902. Collected H.E. Durham. Collector's label "Grey ?Halfbreed".

E.2076 Skin only. ♂. Settlement trap, Christmas Island. Collected H.E. Durham. Collector's label "Immature _ HB 14, Tail 17, HF 3.3, Ear 2.0".

E.2077 Skin only. ♂. Christmas Island, 16 January 1902. Collected H.E.Durham. Collector's label "M. macleari".

E.2078 Skin only. ♂. Kitchen trap, Settlement, Christmas Island. Collected H.E. Durham. Collector's

label "Immature male, HB 18,Tail 23.2, HF 3.5, Ear 2.7, (word unclear - ?testicles)0.85 x 0.5".

E.2079 Skin only. ♀. Christmas Island. Collected H.E. Durham. Collector's label "?Halfbreed,_, mature HB 18.4, Tail 22, HF3.6, Ear2.3".

E.2080 Skin only. ♀. Trap, Settlement, Christmas Island, 5 January 1902. Collected H.E. Durham. Collector's label "imm. _, HB17, Tail 19.8, HF3.5, Ear 2.2".

Oxford Collection

Rattus rattus

18606 Skin only. ♂ juvenile. Christmas Island, 24 February 1902. Collected H.E. Durham. Collector's no. 40.

18607 Skin only. ♀. Christmas Island, 17 March 1902. Collected H.E. Durham. Collector's no. 47.

18608 Skin only. ♂. Christmas Island, 15 January 1902. Collected H.E. Durham. Collector's no. 25.

Rattus macleari

18841 Skin and skull with lower jaw. ♂. Christmas Island, 24 February 1902. Collected H.E. Durham,. Collector's no. 39.

18842 Skin and skull with lower jaw. ♂. Settlement, Christmas Island, 11 March 1902. Collected H.E. Durham. Collector's no. 44. Collector's note "This had a divergent coat colour and I thought possibly a cross between *M.rattus* and *M.macleari* Kept in captivity"

18843 Skin only. ♂. Phosphate Hill, Christmas Island, 16 December 1901. Collected H.E. Durham. Collector's note "Caught by Jagger with fleas and ticks".

18844 Skin only. ♀. Christmas Island, 16 February 1902. Collected H.E. Durham. Collector's no. 37.

18845 Skin only. Christmas Island. Collected H.E. Durham.

18846 Skin only. ♂ nearly adult. 3/4 up Phosphate Hill, Christmas Island, 29 December 1901. Collected H.E. Durham. Infected by trypanosomes.

18847 Skull with lower jaw. ♂. Christmas Island, 20 December 1901. Collected H.E. Durham.