# Mammals with fluorescent fur: Observations from the Wet Tropics

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## Abstract

Wild mammals at a nocturnal feeding station near Lake Eacham in the Wet Tropics were observed variously by the viewing platform lights, by regular torchlight and by 395 nm ultraviolet torchlight. The fluorescence of two species of native rodent, two species of marsupial (one species of possum and one species of glider) is described, as well as further notes on fluorescence in one species of bandicoot. This doubles the number of published Australian mammal species with known fluorescent fur from four to eight. Additionally, an introduced species of rat in suburban Cairns was found to fluoresce.



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## Introduction

Fluorescence is a type of *photo*luminescence and is governed by physics, as opposed to *chemi*luminescence whereby cold light is produced by means of a chemical reaction. Fluorescent objects only “glow” back under the excitation of a light source. They stop glowing immediately when the light source is switched off (if they kept glowing, this would be called phosphorescence, such as in plastic glow-in-the-dark stars) (Johnsen 2012). Fluorescence is also sometimes called *bio*fluorescence when it occurs in biological organisms. It is common in the oceans but the most well-known terrestrial example is scorpions. Fluorescence is only visible to the human eye when the ambient levels of visible light are low in comparison to ultraviolet light, otherwise the subtle effect gets washed out. It is most easily stimulated by use of an ultraviolet torch, but it can also occur naturally in twilight and under the ultraviolet rays of moonlight (Walker, quoted in Heathcote 2017).

In practical terms, when a torch emitting purple ultraviolet light is shone onto the brown fur of an animal, if the fur changes colour and appears to glow brighter than it would with a regular torch (and brightly in relation to its background), then the fur is *fluorescing*. An animal does not need to change from its intrinsic colour to fluoresce, however, as it may glow in a brighter form of its regular colour. If the animal’s pelage turns purple (i.e. the same colour as emitted from the torch), the same as much of the background, then the animal is *reflecting* (otherwise known as scattering) ultraviolet light. If the animal remains the same colour as it was when it was viewed with a regular torch, then it is *absorbing* the ultraviolet light. Animals, and indeed any objects, react in one or a combination of these ways under ultraviolet light (Johnsen 2012). Fluorescence is usually thought of as being stimulated by ultraviolet light and turning into visible colours, but it can be stimulated and emitted entirely within the ultraviolet or entirely within the visible part of the spectrum (Johnsen 2012; Marshall & Johnsen 2017).

Fluorescent molecules are reasonably common in biology, and include chlorophyll, flavins, collagen, elastin, chitin, enamel, guanine, pterins, some vitamins and coenzymes (Johnsen 2012; Marshall

& Johnsen 2017; Jeng 2019). Animals which display externally visible biofluorescence do so by pigments called fluorophores which absorb some light but emit the rest as photons which usually have a longer wavelength than the light shone on them, hence changing colour and fluorescing (Johnsen 2012). The growing list of known fluorophores in vertebrates includes fulvins, carotenoids, proteins, spheniscin, hyloins and pheophorbides (Weagle *et al*. 1988; Lagorio *et al*. 2015; Marshall & Johnsen 2017; Taboada *et al*. 2017). These fluorophores variously facilitate the claws, nails, hairs, scales, skin, teeth and bones of vertebrates to fluoresce under ultraviolet light (Jeng 2019).

In the emerging field of fluorescence zoology there has been a flurry of research into tetrapods (Arnold *et al*. 2002; Lagorio *et al*. 2015; Jeng 2019; Lamb & Davis 2020), but relatively little interest in this phenomenon in mammals. In Australia there has been more emphasis studying the fluorescent urine trails that small mammals leave behind than in studying the fluorescence of the mammals themselves (Kellie *et al*. 2004).

Fluorescence in the fur of marsupials was first discovered in American opossums in 1983 and has been found in 23 out of 31 species of these didelphids (Meisner 1983; Pine *et al*. 1985). It was only recently recorded in rodents, in three species of American flying squirrels (Kohler *et al*. 2019). Fluorescence has also been noted in the keratin scales of Chinese Pangolins and the setae of Coxing's White Bellied Rat in a museum in Taiwan (Jeng 2019).

The first records of fluorescent marsupials in Australia were made of an Antechinus (*Antechinus stuartii* or *A. adustus*), Northern Brown Bandicoots (*Isoodon macrourus*) and Long-nosed Bandicoots (*Perameles nasuta*) (Reinhold 2020). Mild green fluorescence in the fur of a monotreme, a roadkill Platypus (*Ornithorynchus anatinus*) was also described (Reinhold 2020). Fluorescence in Platypus has further been investigated from specimens in North American museums (Anich *et al*. in press). Reinhold (2020) also made incidental sightings of a rodent and several microbats which did not fluoresce in 395 nm ultraviolet light.

## Observations

In June of 2020, I returned to the Atherton Tablelands for two nights for a chance to see Striped Possums (*Dactylopsila trivirgata*) at the nocturnal wildlife viewing platform at Chambers Wildlife Lodge in the rainforest near Lake Eacham (17°17'10"S, 145°38'11"E). Each evening, staff paint honey on two feeding trees which wild Krefft's Gliders (*Petaurus notatus*) then glide in to lick off. The honey that drips down to the base of the trees is licked up by bandicoots and rodents. Striped Possums get the honey from both places. The honey mildly fluoresced green. On the first of two nights (23 June 2020), the viewing lights only remained on until 2020 hrs, so I used both a regular torch (Companion white 30 lumen (~3 watts), 2xAA cell LED) and an ultraviolet torch (unbranded 395 nm, 20 – 22 lumen (~2 watts), 3xAA cell 51 LED) to observe animals for the next couple of hours. White lights emit photons at both ultraviolet and visible wavelengths, but the ultraviolet portion is dwarfed by more dominant wavelengths. The ultraviolet torch had a limited wavelength, giving out a purple beam of light. The torches were not at their maximum intensity, as the batteries were partially used. On the next night, the viewing lights stayed on for several hours, but were dim enough for the ultraviolet torch to still excite visible fluorescence in the animals. All the animals are wild but are accustomed to coming in for their nightly honey and can be watched a couple of metres from the viewing platform. The feeding stations and platform gave me good viewings of preoccupied mammals, which means I could describe their fluorescence closer and in better detail than I could with the fleeting sightings of mammals around Lake Eacham itself.

I generally observed the Chambers Lodge animals with the ultraviolet torch for a few seconds at a time, alternating with checking their fur colour under the constant platform lighting or regular torchlight. The fur colour of each of the species is described in van Dyke & Strahan 2008 (for Krefft's Glider, see "Sugar Glider (*Petaurus breviceps*)"). When taking paired photos I had to switch torches quickly before the animal moved position too much from the previous frame. Photographs were handheld, taken with a Panasonic Lumix TZ80 camera on "intelligent auto" mode, with exposures of less than one second as the animals were moving. The fact that most other fluorescence photography requires long exposures on a tripod attests to the brightness of mammalian fluorescence. The fluorescence photo of the severed rat head in suburban Cairns had an exposure time of five seconds and was taken from a distance of approximately 10 cm, angled very slightly down with the camera still. The fluorescence photos of the Striped Possum, the Long-nosed Bandicoot, the Fawn-footed Mosaic-tailed Rat and the Bush Rat were taken two metres from the animal, looking down at an angle of approximately 40 degrees. The photos of the Krefft's Glider were taken 2.5 metres away from the animal, looking slightly up at an angle of approximately 20 degrees. The ultraviolet torch was shone from a similar position. The photos of the Striped Possum, Long-nosed Bandicoot and Bush Rat were taken with background illumination from the platform lights. Fluorescence photos of the Krefft's Glider, Fawn-footed Mosaic-tailed Rat and Black Rat were taken with sole illumination from the ultraviolet torch. There were no non-fluorescent mammal species observed at the viewing platform.

### *Striped Possum (Dactylopsila trivirgata), Diprotodontia*

This was the first of the visiting animals to be observed fluorescing, at 2006 hrs on 23 June 2020. Three individuals (identifiable by stripe patterns) were observed over the two nights. The Striped Possums had a strong aversion to the ultraviolet torch which wasn't evident in the other species. Subsequent views under ultraviolet were therefore had while the possums were going in for the honey with their heads inside the hollow base of the tree. Under ultraviolet illumination, the black stripes remained black, absorbing the light. The white stripes glowed a bright bluish neon white (Fig. 1b). The undersides of the possums glowed a similar neon white. The white fur over the legs and tail also glowed white, although this glow wasn't as neon bright as the glow of the stripes themselves. This fur was longer, sparser and fluffier than the fur of the stripes, so the density and direction of fur may have contributed to this difference. One possum bounded off to a log pile and the glow of its white tail tip could still be seen six metres away. Fluorescence was determined because the animals appeared to "glow" relative to the dark background, which did not occur under regular light, although the black and white stripes were striking. No part of the possums appeared purple in the purple beam of the ultraviolet torch, meaning there was no reflectance.

Another Striped Possum observed in the wild at Jum Rum Creek in Kuranda (16°49'29"S, 145°38'00"E) on 5 October 2020 glowed similarly to the ones at Chambers Lodge. I had been using my ultraviolet torch to look for frogs, and shone it up at the trees above the creek upon hearing a noise. The end of the tail glowed white, as did other parts down its body. Its belly glowed light yellow from a distance of about five metres. None of the background forest glowed. In regular torchlight it was the same black and white colouration as the Chambers Lodge Striped Possums.

### *Krefft's Glider (Petaurus notatus), Diprotodontia*

Multiple individuals of this species were observed over the two nights. The ultraviolet "glow" was somewhat milder compared to the other species. Their dorsal surfaces did not noticeably react, and mostly absorbed the ultraviolet light, remaining the same colour but faintly flooded with purple. The cream-white strips between their dorsal and ventral surfaces appeared a little brighter. When the ventral fur caught the ultraviolet light, it glowed slightly bluish white (Fig. 1d). This "glow" was not just absorbing the light, as it turned a slightly different colour and stood out from the rest of the animal and the background, thus it was fluorescing. Nor was it reflecting, as it did not turn purple (some lichen on a nearby tree did turn purple).

### *Long-nosed Bandicoot (Perameles nasuta), Peramelemorphia*

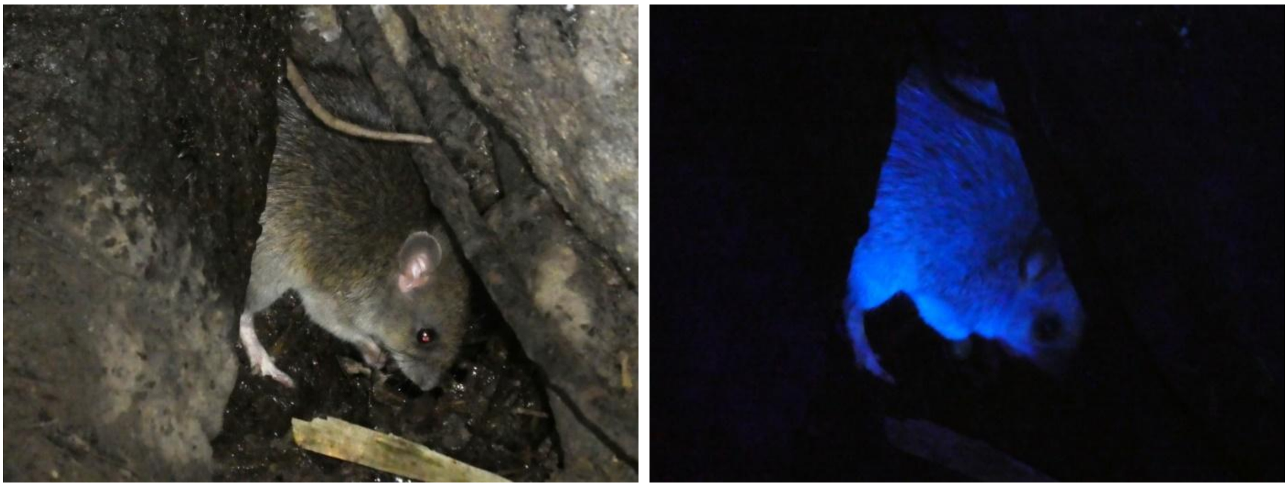
Several individuals of differing sizes were observed and all fluoresced the same colour. Under ultraviolet light, the animals appeared bright pink (Fig. 2b). The black strands of fur remained black, but there was a mottling of brown and yellow with a dominant colour of pink over the dorsal surface. The finer whiter fur down the legs and feet glowed white, with the pink skin toes either fluorescing a light coppery colour or remaining pink. When viewed from behind, the scrotum remained dark and the belly fur fluoresced uniformly a lighter shade of bright pink. The tail did not fluoresce. If the fur had remained its same brindled brown colour under ultraviolet illumination, it would have been absorbing the light. If it shone back purple

a,b. Striped Possum. In b., the head is inside the hollow base of the tree.

c,d. Krefft's Glider.

**Figure 1. Photos of Striped Possum and Krefft's Glider in regular light (left of pair) and in 395 nm ultraviolet torchlight (right of pair).**

a,b. Long-nosed Bandicoot. In b. the beam of the UV torch does not cover the whole animal.



c.d. Fawn-footed Mosaic-tailed Rat.

e.f. Bush Rat. In e., illumination is by UV torchlight together with the camera flash.

**Figure 2. Photos of Long-hosed Bandicoot and two native species of rat in regular light (left of pair) and in 395 nm ultraviolet torchlight (right of pair).**

**Figure 3. Photos of Black Rat head in regular light (left, a) and in 395 nm ultraviolet torchlight (right, b).**

photons it would have been reflecting. The observation that the animals not only turned a different colour that wasn't purple, but appeared to "glow" in relation to the background (whereas they appeared quite camouflaged in regular light), means their fur was reacting to the light by fluorescing.

### *Fawn-footed Mosaic-tailed Rat (Melomys cervinipes), Rodentia*

This was the first species of rodent recorded fluorescing, at 2127 hrs on 23 June 2020. In the light of the ultraviolet torch, the animal appeared to glow bright bluish white (Fig. 2d). The white glow was more prominent along the lower parts of the animal. The blue/white glow over the back and flanks was peppered with black strands of fur. The black whiskers did not glow. Neither the pinnae nor the tail glowed. The feet, although with a thin covering of glowing fur, mostly remained the pinkish colour of skin. Again, the fur of this species neither remained brown nor turned purple under the purple beam of the ultraviolet torch, so the observation that it turned white-blue and "glowed" against its otherwise dark background means that it was fluorescing.

### *Bush Rat (Rattus fuscipes), Rodentia*

The second species of rodent was recorded fluorescing at 2139 hrs on 24 June 2020. It was a native Bush Rat (*Rattus fuscipes*) (the length of the tail in relation to the head-body was not long enough for it to be an introduced Black Rat *(Rattus rattus*)). Rats were photographed brightly fluorescing three times over the course of that night, but I could not verify whether the other two sightings were of Bush Rats or of Black Rats. These rats had not been observed on the first night. Under ultraviolet light, the animal glowed bright bluish white (Fig. 2f), much the same as the Fawn-footed Mosaic-tailed Rat. The strands of blackish fur remained black. The whiskers remained black. The "glow" was bluish over the body and brighter white towards the underparts of the animal. The nose, ears and feet remained skin pink. The urogenital skin did not glow. The tail did not glow. As for the Fawn-footed Mosaic-tailed Rat, fluorescence was established because of the startling "glow" compared to the background.

### *Black Rat (Rattus rattus), Rodentia*

On the morning of 20 November 2020, a Black Rat (*Rattus rattus*) was retrieved in the southern Cairns suburb of Mount Sheridan (16°58'37"S, 145°44'12"E). Under 395 nm ultraviolet light, the nose and pinnae remained skin-coloured and the eyes remained black. The fur of the muzzle remained pale grey and the whiskers black. The fur over the rest of the head fluoresced bright cyan. To the naked eye the colour was green, but the camera interpreted it as blue (Fig. 3b). Some parts of the fur, particularly around the eye, appeared reddish. The blackish strands of fur remained dark. Fluorescence of the fur was established because the photons from the torchlight went about 200 nm up the spectrum and because it stood out so brightly under ultraviolet illumination both in relation to its appearance under regular light and to the other features that did not fluoresce.

I preserved the skin of the Black Rat by salting and drying, and it retained its fluorescence after taxidermy. The saliva of neither the rat nor the neighbour's cat that caught it noticeably fluoresced. The cat itself, a Russian Blue, did not fluoresce. Under ultraviolet light, his fur appeared dark grey with a purple tinge.

## Discussion

Brushtail Possums (*Trichosurus vulpecula*) in New Zealand have been observed to have faint green fluorescence in some strands of fur, but researchers could not discount the possibility of contamination with fluorescent green urine (Zero Invasive Predators 2018). The mammals at Lake Eacham were not particularly fluorescent around the urogenital region or around the mouth, or on the paws, meaning the fluorescence of the fluorophores in the fur was not necessarily enhanced by either urine or saliva. The fluorophores of the Lake Eacham mammals were restricted to the fur (but not the whiskers). A multitude of organisms in the rainforest fluoresce: Plants, some lichen, fungi and various invertebrates (which can be very bright but also very small). None stand out for brightness combined with size as much as mammals.

The species described here represent two marsupial orders, Diprotodontia and Peramelemorphia, and the placental order Rodentia. This hints that fluorescence in fur may be widespread phylogenetically among the mammals. The addition of the introduced Black Rat, which has a widespread distribution, gives a global connection to the pocket of native mammals fluorescing in Queensland's tropical rainforests.

These observations of rainforest mammals fluorescing under ultraviolet light generate a lot of questions regarding the physics, chemistry and biology of this phenomenon. Which animals can see this fluorescence as it is excited by twilight or moonlight, and whether it has any adaptive function, is as yet unknown. My observations have been opportunistic, initially discovered serendipitously while out looking for fluorescent mushrooms at night. They have so far been limited to wild animals in the Wet Tropics region of Far North Queensland. I am now enrolled in post-graduate research on "Fluorescence in mammals: prevalence and causes" to find some answers.

**Eds note:** These observations will be used to further our understanding of animal behaviour, however, we do not encourage the use of strong lights or UV light to observe wildlife.

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