THE DECLINE AND CURRENT STATUS OF THE CHRISTMAS ISLAND SHREW CROCIDURA ATTENUATA TRICHURA ON CHRISTMAS ISLAND, INDIAN OCEAN.

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The Christmas Island shrew (Crocidura attenuata trichura) is listed as an endangered species in Australian legislation. The cause of decline and its current status are unknown. In 1997-98 surveys were conducted at 15 sites on Christmas Island to determine the status of C. a. trichura. During 17 months, 4,150 trap nights of surveys were conducted using Longworth traps, hair tubes and pitfall traps. The surveys were hampered by non-target species interference and C. a. trichura were not trapped. Due to the interference of traps by terrestrial crabs and yellow crazy ants (Anoplolepis gracilipes) it was not possible to determine if C. a. trichura is extant on Christmas Island. This paper describes the surveys undertaken, future management and discusses the theories for the cause of decline of the species.

Key words: Christmas Island shrew, Crocidura attenuata trichura, decline, extinct, endangered.

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CROCIDIURINE shrews are similar in appearance to the Australian Sminthopsis spp. and Pseudalopex spp. and occupy a similar niche (Eisenberg 1981). There are 335 species of shrew in 23 genera world-wide, with the majority of species in the genera Crocidura (Wolmar and Hutterer 1998). Crocidurine shrews from tropical climates reach sexual maturity within a couple of months of weaning and become reproductively active and able to breed in the same year they were born (Churchfield 1990). Breeding can be continuous, but is often interrupted by the dry season (Medway 1978). Gestation lasts 30 days (Churchfield 1990; range 28 - 33 days, Vogel 1972), litters of less than five young are produced and weaned after 22 - 25 days. Most shrews live for one year (Churchfield 1990) although Crocidurine shrews have been reported to live for two years in the wild (Vogel 1972).

Crocidurine shrews are insectivorous and depend mostly on olfactory, auditory and tactile senses when foraging as eye sight is poor. There is evidence of echolocation in Sorex (Buchler 1976) and Ilarina (Tomasi 1979), although it is not believed to be an important foraging tool and the signals have not been recorded as a survey method in wild populations. Hunting mostly involves foraging using the sensitive snout to probe the litter layer and low plant substrate. In the absence of scientific data describing C. a. trichura habitat, extrapolations based on studies suggest that primary rainforest with a dense cover of leaf litter is ideal habitat for Crocidura species (Dickman 1995).

Crocidura attenuata trichura is the only shrew recorded in an Australian territory. It is a subspecies of the gray shrew Crocidura attenuata, also known as the long-tailed shrew (Davison 1984). These are widespread throughout China, Burma, Thailand (Hutterer 1993) and Malaysia including Tioman Island (Davison 1984), Vietnam (Heaney and Timm 1983), and the Chinese Island of Hainan (Allen 1938). The holotype for C. attenuata was collected from China where the species was reported as common (Allen 1938). It is uncertain how C. a. trichura arrived on Christmas Island although dispersal of the common shrews is often attributed to sea-faring humans (Lekagul and McNeely 1988). C. a. trichura was originally thought to be a relative of the southeast Asian white-toothed shrew Crocidura fuliginosa (Thomas 1888) until Jenkins (1976) redescribed the species as C. a. trichura based on morphological features. Genetic tests are required to confirm the taxonomy of the species as using morphological assessments to confirm a species can be flawed (Ruedi 1995).

Crocidura attenuata trichura (Fig. 1) is described as light or reddish brown in colour. The skull is typically shrew-shaped with low but evident
lamboid crests that meet at the occiput. The ratio of tail length to upper tooth row length is 7.7 - 9.2 :1 (Jenkins 1982). Records of museum specimens of *C. a. trichura* record a weight range between 4.5 - 6 g. Data published by Thomas (1888) on four *C. a. trichura* specimens recorded the following body measurements: head and body length of 70 mm, tail 80 mm (sparsely covered in long fine hairs), a large manus of 16.6 mm, lower leg 20.5 mm and a forearm and pes of 21 mm.

*Crocidura attenuata trichura* was recorded as widespread and abundant on Christmas Island in 1900 (Andrews 1900). Within eight years there was no sign of the species nor the two endemic rats *Rattus nativitatis* and *Rattus macleari* (Andrews 1909). By 1908 the species was believed to be extinct (Andrews 1909), however two specimens were found during rainforest clearing at South Point in 1938 (David Powell 1997, pers. comm.). Two more specimens were found in 1985 at Hughes Dale and LB4 (Hugh Yorkston 1997, pers. comm.). The cause of decline of *C. a. trichura* was initially linked to the extinction of the two endemic rat species which disappeared following the introduction of a rodent borne pathogen (*Trypanosoma sp.*) in *R. rattratus* (Andrews 1909; Pickering and Norris 1996).

There have been some anecdotal sightings of *C. a. trichura* since 1996 although efforts to trap the species have been unsuccessful (Tidemann 1989) and remains have not been found in cat (*Felis catus*) scats (Tidemann 1994). It is currently listed as endangered on Schedule 1 of the Endangered Species Protection Act 1992 and a recovery plan has been prepared (Meek 1997). In 1997-98 surveys were implemented across Christmas Island habitats to determine the current status of *C. a. trichura*. This paper presents the findings of the survey and discusses the possible reasons for the species' decline.

**METHODS**

**Study Site**

Christmas Island is located in the Indian Ocean at 10°25'S and 105°40'E (Fig. 2). It is approximately 2,600 km west of Darwin, 2,600 km north-west of Perth and 360 km south of Java. The island is 135 km² of which approximately 85 km² (63%) is Christmas Island National Park (Fig. 3). The Island is volcanic in origin and has undergone a series of uplifts and subsidence during the last 80 million years. Primarily underlying a tropical rainforest is a substrate of limestone and basaltic rocks that are rich with phosphate deposits. DuPuy (1988) categorises the habitats of Christmas Island into primary rainforest, marginal rainforest, areas with surface water, open - scrubby forest, coastal fringe, shore cliffs and disturbed habitat. Primary rainforest occurs on deeper soils and is dominated by emergent trees to 50 m including broad buttress species such as *Planchonella nitida*, *Syzygium nervosum*, *Tristichopectus acutangula* and *Inocarpus fagifer*. Marginal rainforest is more open with trees from 20 - 30 m growing along the lower terraces including *Pisonia grandis*, *Gyrocarpus americanus* and *Erythrina variegata*. The lowest terraces are low structure (5 - 10 m) scrubby understorey habitat with spiny and scrambling shrub vines and the trees (*Columbiana pedunculata*) are mostly deciduous. There is a high degree of species endemism on the Island including 16 species of flora, 3 mammal species (excluding
two extinct rats), 2 terrestrial crab, 5 reptile and 7 terrestrial bird species and 3 species of seabirds.

Census methods

Several methods were deployed to survey for C. a. trichura (Table 1); trials were conducted at two sites to record ultra-sonic signals using an ANABAT® detector. ANABAT® equipment was placed in plastic containers with the microphone protruding from one side of the box. The box was mounted on a steel frame one metre from the ground to preclude rubber crabs (Hiruges latro) from tampering with the equipment. Ultra-sonic call surveys were attempted in two sites over many weeks and were ceased due to constant disturbance and triggering of the ANABAT® detector by B. latro. This species is inquisitive and would spend hours at the site scratching at the device stand with their claws which triggered the device to record incidental signals. On one occasion a B. latro found a way to climb the smooth surface of the box and removed the external microphone from the ANABAT®. Following these difficulties it was decided to be an ineffective method of sampling.

Longworth traps®, hair tubes (designs by State Forests NSW and Sackling 1978) and pitfall traps were also used. Pitfall trap lines (25 m x 12 pit) were constructed in the forest and along a watercourse in the Dales. Pits of varying diameters (250 mm and 80 mm) were used, smaller diameters were preferred to prevent visitation by red crabs (Gecarcoidea natalis) and blue crabs (Cardisoma hirtipes). Rolls of rigid underground powerline cable cover (300 mm x 4 mm) were used as a pitfall drift fence to prevent destruction of the drift fence by B. latro. Pieces of PVC tubing (100 mm x 40 mm) were placed in the pits as refuge to protect any captured animals from B. latro predation.

Twenty five Longworth traps and twenty hair tubes were baited with a standard mammal mixture of rolled oats, peanut butter and honey. A shrew-specific mixture of ikan billis (fish) soup powder, flour and water, as well as mealworms were also used in devices (P. Vogle 1997, pers. comm.). Hair tube and trap transsects (n = 15) were located across the range of rainforest habitats, exposed pinnacles mine fields and karst. Survey site selection was based on age-class of rainforest, proximity to previously recorded shrew sites, anecdotal sightings, free surface water and in areas of low crab density (Fig. 3). One exposed pinnacle field (ex-mine Field 25) was surveyed because crab density at this site was very low and visitation to the devices by crabs was less likely. The devices were placed under rock piles, on vines, on Pandanus sp. fronds, on large buttress trees (Planchonella niuia, Syzygium nervosum, Inocarpus fagifer, Tristaniopsis acutangula) in old logs and on exposed surfaces to maximize capture success. Devices were spaced randomly within 10 m along the transect. Surveys were conducted over 17 months at 15 sites with a total of 4,150 trap nights (Table 1). Devices were checked and cleared early each day. In areas where ants were abundant, rings of Vaseline were used to discourage visitation to traps and hair tubes.

RESULTS

There were no successful captures or records of C. a. trichura using any of the devices. Eight R. ratti, 186 G. natalis, 15 B. latro, 10 C. hirtipes, five giant geckos (Cystodactylus sp.), two yellow nipple crabs (Geograpsus crinites) and one tawny hermit crab (Coenobita rugosus) were collected during this survey. A range of invertebrates was also collected including the yellow crazy ant Anoplolepis gracilipes, land snails, centipedes and millipedes. Gumphilus beetles Carcinops sp. and Aphiolobus laevigatus were collected in traps and hair tubes in Daniel Roux Cave.

Terrestrial crabs and A. gracilipes complicated survey efforts. Excessive measures were needed to stop crabs destroying the survey devices; Longworth traps were placed inside crab excluding devices, on trees and under rocks. A. gracilipes also removed baits and fouled sticky tapes in hair tubes rendering
Fig. 3. Christmas Island showing key land features and the trapping sites (●).

<table>
<thead>
<tr>
<th>Transect</th>
<th>Habitat</th>
<th>Hair tube (m)</th>
<th>Longworth (n)</th>
<th>Pitfall (n)</th>
<th>Anahat (n)</th>
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<tr>
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<td>LB4</td>
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<td>140</td>
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<td>Plateau rainforest</td>
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<td>Krist</td>
<td>108</td>
<td>24</td>
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<td>Exposed mine field</td>
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<td><strong>Trap nights</strong></td>
<td></td>
<td><strong>2,164</strong></td>
<td><strong>1,156</strong></td>
<td><strong>820</strong></td>
<td><strong>10</strong></td>
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</table>

Table 1. Christmas Island shrew survey sites and device effort during 1997-98. n = trap nights. * two sites at Margaret Knoll.
thorn without any attractant and inactive. Constant efforts to preclude the ants from devices by smearing Vaseline across entrances to the devices usually failed although piping Vaseline was sometimes successful.

DISCUSSION

There is conclusive evidence that C. a. trichura has declined dramatically since 1900. Andrews (1900) referred to the shrilling calls of C. a. trichura around the settlement in his early surveys indicating that at that time they were an abundant species. By his return in 1908 they had disappeared (Andrews 1909). The reasons for the decline of C. a. trichura within this eight-year period are not known. It is unlikely that Felsis catus contributed to their decline as cats were not present on Christmas Island until approximately 1904 (Tidemann 1989) and even to this day are not distributed across all habitats (pers. obs.), being most abundant in regrowth and urban areas (Tidemann 1989). Tidemann (1994) believes that F. catus predation was an unlikely cause of the decline of C. a. trichura. This argument has some merit given the low densities (0.3 cats km⁻²) (Tidemann 1989), restricted distribution of F. catus across Christmas Island and that dietary analysis has not detected C. a. trichura.

Durham (1908) and Pickering and Norris (1996) reported that the decline of the two endemic rats may be attributed to Naganu infection caused by Trypanosoma sp. and there is some belief by local researchers that this parasite may have also infected the C. a. trichura population. Durham (1908) speculated that Trypanosoma levinsi was the species recovered from museum rat specimens collected on Christmas Island. Some species of Trypanosoma have a wide host range and T. levinsi may occur in many mammal species (David Spratt 1999, pers. comm.), so it is possible the parasite infected C. a. trichura, although this is unproven.

Another theory that could explain the rapid decline of C. a. trichura relates to the demise of the endemic rats and possible inter-specific competition between G. natialis and C. a. trichura for leaf litter resources. I propose that following the extinction of the two endemic rats, a likely prey species, G. natialis, increased in abundance in response to the change in the predator prey system, e.g., rat decline, therefore displacing C. a. trichura. The pivotal point in this theory is whether the G. natialis population did increase in abundance after the rats declined. Transcripts by Lister (1888) and Andrews (1900) do not describe G. natialis as abundant. In fact, Andrews (1909) refers to the most conspicuous crab being B. latro. Given the current abundance of G. natialis, the implication is that the population has increased since 1900. Andrews (1900) states in his synopsis that R. macleari "seem to eat anything, and destroy any boots or skins incautiously left in their reach". If R. macleari were omnivorous it is likely that they would take advantage of an abundant food resource such as G. natialis. In this model, following the rats' decline G. natialis numbers may have increased significantly i.e., mesopredator release. A proportionate increase in G. natialis could have outcompeted C. a. trichura for resources and in-turn modified the niche by consuming an increasing amount of leaf litter; a critical habitat component for shrews (Dickman 1995). If leaf litter abundance decreased, the microhabitat for invertebrates would decrease and the C. a. trichura population may have crashed in response to a depleted food resource i.e., competition exclusion. The subsequent change in habitat and food supply for C. a. trichura could have either caused a rapid decline in abundance or forced animals into new habitats. Potential habitat could only have been tree canopies, or sites with low crab abundance e.g., caves. The most recent finding of a C. a. trichura in a freshly fallen birds nest fern on the central plateau and another at LB4 by Messrs Peter Goh and H‘ng Kim Chey near Hughes Dales (Fig. 3) demonstrates C. a. trichura’s propensity to live in canopy plants. The pressure on the C. a. trichura population may have been compounded by their vulnerability during weaning. Allen (1938) describes their behaviour of leaving the nest immaturesly and their predisposition for limited wandering as juveniles, which would make them vulnerable to predation by crabs. If crab population densities were high, young C. a. trichura might have been susceptible to population regulating predation during weaning. This theory is speculative but provides another possible explanation for the decline of C. a. trichura. If some individuals are trapped in the future the Recovery Plan actions (to release shrew into crab-free enclosures) should be considered to test the theory posed above (Meek 1997).

Tidemann (1989) caught 54 R. ratus and six Mus domesticus in his trapping survey (2,036 trap nights). The reason for the low capture rate of R. ratus in this study compared to Tidemann’s is puzzling although he was restricted in the areas he could set trap lines due to road closures and may have had to select more disturbed sites. In the decade since his trapping, habitat restoration and weed invasion has changed the sites substantially and this may be a factor in the different capture rates between the two surveys.

The results of this study and Tidemann’s (1989) are not conclusive evidence that C. a. trichura is extinct, although evidence suggests that if they have survived they are probably widely dispersed and in
very low numbers. Further trapping surveys are necessary, although considerable time will be needed to develop methods for excluding terrestrial crabs and *A. gracilipes*. It is unlikely that the survey design in this study was not adequate to capture *C. a. trichura*. A diverse range of habitats were sampled including sites where *C. a. trichura* has been recorded historically. The trapping techniques are proven methods for sampling small mammals including shrews (Suckling 1978; Davison et al. 1982; Cantoni and Vogel 1989; Kitchener et al. 1994; Dickman 1995). The difficulty was in presenting an undisturbed capture device when crab and *A. gracilipes* density was high. The use of pitfall traps on Christmas Island is clearly not a suitable method due to the crabs. The use of crab excluders around traps (Tildensam 1989) and hair tubes reduce device damage although in this study crab interference had many forms and more presence near some devices rendered them inactive. The persistence of *B. intro* to find food does result in significant disturbance to sites and their presence may discourage small mammals from visiting devices. Tree canopy surveys should be considered in the future, perhaps using infra-red trip line photography at bait stations rather than traps and hair tubes.

The conservation of *C. a. trichura* is dependent on the actions of the Recovery Plan. Before extensive trapping surveys are conducted it is recommended that one action—a genetic study to clarify the taxonomy of the species, should be undertaken. It is important to determine how closely related *C. a. trichura* is to *C. attenuata*. If the species are not distinctly different, consideration should be given to de-listing it from the Endangered Species Protection Act 1993. If it is a separate species, efforts should be made to either contribute resources to the recovery of the species including reintroduction or declare it extinct. Efforts to implement the recovery actions should only be carried out if there is a long-term commitment to the conservation of the species by the governing agency.

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REFERENCES


