Background information to the National Recovery Plan for the Gove Crow Butterfly, *Euploea alcathoe enastri* Fenner, 1991 (Lepidoptera: Nymphalidae)

Michael F. Braby

Biodiversity Conservation Division, Department of Natural Resources, Environment and the Arts, PO Box 496, PALMERSTON NT 0831

Identification

The Gove Crow, *Euploea alcathoe enastri* Fenner, 1991 (Fig. 1), is a large butterfly with the fore wing ranging from 41mm to 46mm in length for both sexes. It is distinguished from other butterflies in being almost wholly dark black-brown, usually with a few small white spots near the wing margins. The males (Fig. 1) are velvet-black on the upperside of the fore wing, with a few small white terminal spots; the upperside of the hind wing is blackish-brown, but is paler brown towards the tornal area, with a variable series of white subterminal and terminal spots. The underside ground colour of both wings is blackish-brown, but is paler chocolate brown towards the wing margins, with several white central spots, and a variable series of white subterminal and terminal spots. The females are similar to males but are distinguished in having a straighter dorsum of the fore wing. The females have the upperside of both wings blackish-brown, with the margins broadly paler brown; the underside ground colour is dark brown, with the margins broadly paler brown, and a series of white central spots. Like the males, there is a variable series of small white subterminal and terminal spots on both the upper and undersides.

Taxonomic status

E. a. enastri is a subspecies of the No-brand Crow, *Euploea alcathoe* (Godart [1819]), and was described by Fenner (1991) about 3.5 years after its initial discovery from Rocky Bay (type locality) in July 1988 by Geoff Martin. *E. alcathoe* is a polytypic species, with several subspecies currently recognised throughout its broad geographical range (Ackery & Vane-Wright 1984). Three of these subspecies, all of which are allopatric, occur within Australian limits: *E. a. eichhorni* Staudinger, 1884; *E. a. misenus* Miskin, 1890; and *E. a. enastri* Fenner, 1991. The first mentioned of these subspecies differs quite markedly in adult wing shape and pattern from undisputed *E. alcathoe.* It is considerably smaller, with a series of large white postmedian spots that form a broad broken band on the hind wing, and a series of small white subterminal spots on both wings; the fore wing has the termen less rounded and the apex more pointed compared with *E. a. misenus* and *E. a. enastri*. Indeed, for many years *E. a. eichhorni* was treated as a separate species endemic to the Australian mainland (Common & Waterhouse 1981; Waterhouse & Lyell 1914). Ackery and Vane-Wright (1984), following Corbet (1943), however, treated *eichhorni* as a subspecies of *E. alcatho*e on the basis that apparently no unique structural characters could be found to separate the two, a view tentatively adopted by Braby (2000) and Edwards *et al.* (2001). This view, however, is not universally accepted, and recent evidence on larval morphology presented by Lambkin (2005) suggests that *eichhorni* is probably specifically distinct from *E. alcathoe*.

Despite taxonomic uncertainty, the three taxa differ substantially with respect to their distribution and ecology, and therefore different conservation management requirements. *E. a. misenus* and *E. a. enastri* both have a very limited extent of occurrence, each being confined to the northern most latitudes of Australia, whereas *eichhorni* is more widespread on the mainland, though still restricted to the tropics of north-eastern Australia. In other words, the species *E. alcathoe sensu stricto* has an exceedingly limited distribution within Australia.

The subspecies *E. a. enastri* is very similar to *E. a. misenus*, from which it differs principally in the extent and size of the white spots. Males of *E. a. misenus* are usually devoid of white spots on the upperside and show little variation, although occasionally there is a white subapical spot on the fore wing, and a series of white subterminal and terminal spots on the upper and underside of the hind wing (Braby 2000). In contrast, males of *E. a. enastri* usually have a series of 1–4 white subapical spots and a few smaller terminal spots (between veins M_3 and tornus) on the upperside of the fore wing, and a series of up to nine white obscure, sometimes elongate subterminal spots, followed by a series of 1–13 smaller white terminal spots (Fenner 1991). However, a small proportion of males, which lack the white spots, are indistinguishable from those of *E. a. misenus*. Females of *E. a. misenus* vary considerably in the extent of white spots on the upperside of the fore wing and upper and underside of the hind wing. Within female *E. a. misenus*, Lambkin (2005) recognised four morphotypes, ranging from those with no white spots to those with 3–4 white subapical spots on the upperside of the fore wing and a series of white subterminal and terminal spots on the hind wing. Females of *E. a. enastri* usually have four small white subapical spots on the upperside of the fore wing, and a series of 4–11 white, sometimes elongate and often obscure subterminal spots, followed by a series of 2–11 smaller white and often obscure terminal spots on the hind wing. In some specimens of *E. a. enastri*, the white spots on the hind wing are considerably larger and more elongate than those of *E. a. misenus* but, in general, the majority of *E. a. enastri* females are indistinguishable from those of *E. a. misenus* due to the extent of variation.

Further taxonomic appraisal of *E. a. enastri* and *E. a. misenus* is clearly warranted. In particular, a genetic analysis and quantitative morphological study of the size and extent of spots of both sexes between populations of these two currently recognised subspecies from Australia are needed, supplemented with comparative ecological and behavioural data. The results of such a study would confirm if the population from north-eastern Arnhem Land, NT (*E. a. enastri*), is genetically and taxonomically distinct from that in the Torres Strait Islands, Qld (*E. a. misenus*). At the time of description of *enastri*, very little material was available of the Queensland subspecies, which was then known under the name of *E. a. monilifera* (Moore, 1883). The type locality of *E. a. monilifera*, a female purportedly collected from Thursday Island, Torres Strait, has recently been shown to be in error such that *E. a. monilifera* is a junior synonym of either *E. a. nox* Butler, 1866 from Aru Island, Indonesia, or *E. a. occulta* Butler, 1877, from eastern Papua New Guinea (Lambkin 2005). Fenner's (1991) comparison of *enastri* with the Torres Strait subspecies was based chiefly on the erroneously labelled female syntype of *monilifera*.

Ecology

Larval food plants

The larval food plants of *E. alcathoe sensu stricto* are poorly recorded in the literature. The food plant of *E. a. misenus* in the northern Torres Strait Islands, Qld, is *Gymnanthera oblonga* (Burm.f.) P.S.Green (Lambkin 2001), but adults have also been reared from pupae collected from the ornamental Oleander, *Nerium oleander* L. (Johnson & Valentine 1997). Both *G. oblonga* and *N. oleander* belong to the milkweed family Apocynaceae. The larval food plant(s) of *E. a. enastri* has not been documented. Fenner (1991) observed a female apparently ovipositing on the young shoots of a vine, tentatively identified as *Tylophora benthamii* Tsiang (Apocynaceae) growing along the forest edge about 5 m above ground level. Subsequently, eggs, assumed to be those of *E. a. enastri*, were found on the underside of leaves of *T. benthamii* growing in swampland at the margin of monsoon forest at Gurrumuru in April 2003 (R.P. Weir and C. Wilson, pers. comm.), but the larvae failed to hatch.

At Rocky Bay, L. Wilson (pers. comm.) observed a female of *E. a. enastri* ovipositing on *Gymnanthera oblonga* growing in standing water in mixed tall paperbark swampland adjacent to monsoon forest in August 2005. The larvae from these eggs were reared to adult, indicating successful development on this plant species. Additional observations were made at this site in March and July 2006 by L. Wilson and M.F. Braby. In late March, several eggs and early instar larvae were collected on *Parsonsia alboflavescens* (Dennst.) Mabb. (Apocynaceae) (Fig. 2); the early stages were subsequently reared in captivity on this plant to final instar/pupa, with one completing development and emerging as an adult. In early July, a female was observed at 11.30 am to deposit a single egg on the upperside of a young soft leaf of a large vine of *P. alboflavescens*, the plant of which grew at the base of a *Melaleuca leucadendra* (L.) L. tree within the paperbark swamp. A second female was observed at 12.15 pm to lay an egg on a different plant of the same species, and a third female was noticed at 12.30 pm inspecting another plant of *P. alboflavescens* for suitability.

These observations indicate that *E. a. enastri* utilises at least two native food plants, one of which is shared with *E. a. misenus*. Further work is needed to determine if *T. benthamii* or other plants are used, and the relative frequency of usage of *G. oblonga* over *P. alboflavescens*. *G. oblonga* is a widespread tropical woody scrambler or liana that occurs in wet coastal areas, such as in or near mangroves or along watercourses, throughout northern Australia (Forster *et al*. 1996). *T. benthamii* also grows as a woody liana and is reasonably widespread in vine-forests in the Top End; it also occurs patchily in coastal rainforest areas of Queensland (Forster *et al*. 1996). In contrast, *P. alboflavescens*, within Australian limits, is restricted to north-eastern Arnhem Land, NT (Forster & Williams 1996); at Rocky Bay it grows abundantly as a climber with twining stems in the swamplands where *E. a. enastri* occurs. If *P. alboflavescens* proves to be the primary food plant of *E. a. enastri*, its limited occurrence in the Top End may partly explain the restricted occurrence of the butterfly to north-eastern Arnhem Land.

Immature stages

The life history and early stages of *E. a. enastri* have not been reported, although they have been recorded in detail for the closely related *E. a. misenus* from the Torres Strait Islands

(Lambkin 2001). The following descriptions and illustrations are based on material collected and reared from Rocky Bay in July 2006.

Egg (Fig. 3). Pale yellow; elongate and barrel-shaped, with apex somewhat flattened, and a series of approximately 20 longitudinal ribs and finer transverse lines.

Final instar larva (Figs 4–8). Head black, with a white transverse band, and a white inverted Y-shaped mark on adfrontal suture; prothorax orange, with a black subdorsal patch; meso- and metathorax each with a long black dorsolateral fleshy filament, and a series of narrow purplish-black transverse bands broadly edged with orange, the middle orange transverse band white in lateral area; abdominal segments 1-7 each with an alternating series of six purplish-black and five white transverse dorsal bands, with the middle white transverse band extending to ventrolateral region, white transverse bands frequently orange or suffused with orange in middorsal area particularly on segments 1 and 2, a broad broken and irregular orange lateral band, and a black dorsolateral fleshy filament on segment 2; abdominal segment 8 orange, edged posteriorly with a narrow white transverse band and then a purplish-black transverse band, and with a black dorsolateral fleshy filament; abdominal segment 9 predominantly orange, narrowly edged with purplish-black transverse bands; abdominal segment 10 orange, with anal plate black; ventral surface black; legs and prolegs black, with basal area orange; spiracles black.

Pupa (Figs 9–11). Shining silver, with dark brown markings on wing cases and abdomen; antennae and cremaster dark brown; spiracles black.

The early stages of *E. a. enastri* are similar to the general descriptions and illustrations given for *E. a. misenus* by Lambkin (2001). The egg and final instar larva are identical in colour pattern and form, but the pupa appears to differ slightly in that the abdomen is gold and pink in *E. a. misenus* but silver in *E. a. enastri*. However, since very few individuals of either subspecies have been reared, the extent of variation in pupal colour within each taxon is not known. The early stages of *E. a. enastri* and *E. a. misenus* appear to differ considerably from those of *E. a. eichhorni*. Lambkin (2001) noted several differences between the final instar larvae, particularly in the body colour, pattern of transverse bands, relative length of the black fleshy filaments on the metathorax and abdominal segments 2 and 8, and presence of a white lateral band (absent in *E. alcathoe sensu stricto*).

The early stages of *E. a. enastri* are similar to those of *E. core corinna* (W.S. Macleay, 1826) and *E. sylvester pelor* Doubleday, 1847, two species which breed on the same larval food plants in the same habitat as *E. a. enastri* in north-eastern Arnhem Land (Braby, unpublished data). However, there are several noticeable differences in the final instar larva and pupa among these species. The larva of *E. core corinna* has a narrow but conspicuous white lateral band along the length of the body (sometimes this band is broken into a series of spots), whereas in *E. a. enastri* this band is absent. In *E. a. enastri*, the middle white transverse dorsal band, of the five bands on each body segment (from the mesothorax to abdominal segment 7), extends to the ventrolateral region, whereas in *E. core corinna*, this band stops well before the broad orange lateral band. In *E. core corinna*, the pair of black fleshy filaments on the mesothorax, metathorax and abdominal segments 2 and 8 arise from a white patch and/or the basal area of the filaments is white, whereas in *E. a. enastri* the basal area of the filaments is generally pale orange and the filaments arise from an orange coloured portion of the segment. The pupa of *E. a. enastri* is larger, with the markings darker brown, than that of *E. core corinna*.

Life cycle and biology

Little information on the ecology, behaviour, adult longevity and reproductive biology of *E. a. enastri* has been recorded, although some details have been documented for the closely related *E. a. misenus* from the Torres Strait Islands (Lambkin 2001). Adults of several other species of *Euploea* and the related *Tirumala* are known to migrate and/or aggregate in large numbers during the winter-dry season in northern Australia (Kitching & Scheermeyer 1993; Scheermeyer 1993, 1999). Many of these species, including *E. sylvester* (Fabricius, 1793), *E. tulliolus* (Fabricius, 1793), *E. core* (Cramer, [1780]) and probably *E. darchia* (W.S. Macleay, 1826), stop breeding during the dry season. It is not known if breeding in *E. alcathoe* is also seasonal, and that females enter reproductive diapause during the late dry season. Lambkin (2001) noted that adults of *E. a. misenus* were most abundant during the wet season, from December to May, and suggested that breeding is limited to this period. He observed that the early instar larvae were dependent upon the young, soft foliage of the larval food plant (*Gymnanthera oblonga*), which is seasonally available in the late wet season. The life cycle of *E. a. misenus*, from egg to adult, was completed in approximately four weeks during March (Lambkin 2001).

At Rocky Bay, *E. a. enastri* females were observed to lay eggs (Fig. 3) singly on the new soft growth of the larval food plant. Potential host suitability by ovipositing females involved a slow, hovering flight around the foliage, followed by alighting on the upper surface of the leaves. This behaviour would be repeated many times until a leaf was eventually found suitable on which to lay an egg. Such behaviour suggests visual and tactile cues are used to determine host suitability. Prior to pupation, the final instar larva (Figs 4–8) spun on the underside of a leaf a silken platform to which the pupa (Figs 9–11) was attached by the cremaster and suspended upside down. Adults (Fig. 1) did not appear to venture far from the monsoon forest-mixed paperbark swampland patches, although they probably disperse occasionally between the patches. Males were commonly found within the forest or near its edge; they flew within 3 m of ground level in sunny glades or rested on twigs or the upper surface of large leaves, as previously noted by Fenner (1991). Females were more usually observed flying slowly near vegetation, settling frequently but for short periods. They have mostly been encountered up to 20 m of the edge of the monsoon forest, often feeding high up from paperbark (*Melaleuca*) flowers (Fenner 1991). It is not known if sexual activity is partitioned by habitat, with males utilising the non-breeding areas (interior of monsoon forest), perhaps to establish mating territories, while females reside mainly in the breeding areas (edge of monsoon forest adjoining mixed paperbark swampland) to seek out larval food plants and nectar of flowers of tall paperbark trees.

Adults of *E. a. enastri* have been recorded from February to April, June to August, October and December. They almost certainly occur throughout the year and, like other danaines, are probably long-lived, possibly up to 12 months or more (G. Martin, pers. comm.). Limited observations on ovipositing females suggest that breeding occurs from at least the late wet season (March) to the early dry season (August). However, from a sample of females (n = 5) collected from various populations on Gove Peninsula (Baralminar River, Gurrumuru, Rocky Bay) in June 2006 and dissected in the laboratory to ascertain the number of eggs and extent of fat bodies, three individuals (60%) contained no eggs while two (40%) had only small numbers of eggs (1–2) present in their ovaries. Moreover, the body cavity of all individuals contained large amounts of yellow fat bodies, and each specimen contained several large intact spermatophores. These observations suggest that females greatly reduce their rate of egg production and may stop breeding with the onset of the dry season. During the dry season they do not seem to form large overwintering clusters but limited observations made at several sites suggest that they aggregate in small numbers within or close to the breeding areas (i.e. paperbark swamps and edges of monsoon forest).

An egg laid in early July 2006 was reared to adult in captivity at Darwin on *G. oblonga*, with the life cycle being completed in four weeks: the egg hatched two days after being laid, the larva pupated after a period of 16 days feeding, and then emerged as an adult after a pupal duration of 10 days.

Distribution

E. alcathoe occurs from southern Maluku (Buru) and the Aru Archipelago (Kai, Aru, Numfoor, Japen islands), through mainland New Guinea and its adjacent islands, including Fergusson, to northern Australia (Ackery & Vane-Wright 1984). The subspecies *E. a. enastri* and *E. a. misenus* and the distinct taxon *E. a. eichhorni* are all endemic to Australia (Braby 2000). *E. a. enastri* occurs in the Top End, NT, where it is currently known only from the Gove Peninsula in north-eastern Arnhem Land. *E. a. misenus* is restricted to the Torres Strait islands, Qld: most specimens have been collected from the northern islands (Boigu, Duaun, Saibai) where evidence of breeding has been reported (Johnson & Valentine 1997; Lambkin 2001). This subspecies is not established on the Australian mainland although a single specimen, the male syntype, was collected from the tip of Cape York late in the nineteenth century. This specimen and the few others from the eastern Torres Strait islands (Campbell, Darnley and Murray) are believed to represent southern vagrants from northern Torres Strait. *E. a. eichhorni* occurs in mainland north-eastern Qld and is more widely distributed than the two other subspecies, occurring from Cape York Peninsula (Cape York) to the Wet Tropics (Ingham).

E. a. enastri has a very patchy occurrence, previously known from only four discrete, widely spaced populations (Fenner 1991, 1992; Wilson 2003). Surveys carried out by Dhimurru Land Management Aboriginal Corporation (DLMAC) in conjunction with Parks and Wildlife Service of the Northern Territory (P&WS) during 2002–04 confirmed the presence of *E. a. enastri* at three of the known populations, *viz*: near Mt Bonner (1 survey), Mosquito Creek Port Bradshaw (5 surveys), and Gurrumuru (3 surveys). The fourth population (Rocky Bay near Yirrkala), was not relocated despite 10 surveys, but in 2005 L. Wilson (pers. comm.) discovered two breeding sites, one of which was close to where adults were originally collected by G. Martin in 1988. During discussions, consultations and surveys held in 2006 three new populations were identified. These new populations were located along a creek near the Gapuwiyak airstrip, the Baralminar River (listed incorrectly as the Habgood River on topographic maps) to the east and south of Gapuwiyak, and Yanungbi. These new populations together with the four previously known populations are listed in Table 1. In addition, P. Wise and B. Marika (pers. comm.) recorded a single specimen of *E. a. enastri* at Galaru near Nhulunbuy (12°09’52”S, 136°46’02”E) at 11.30 am on 17 August 2006. The specimen was observed flying in a north-westerly direction in an open area near the beach and was heading out over the ocean towards Bonner Rocks (Site 4), some 20 km distant. The population from which this specimen originated has not been determined and is therefore not listed in Table 1. GPS coordinate data collected at each site show that the general coordinates given by Fenner (1991, 1992) for Rocky Bay (Site 7: 12°16’S, 136°54’E) and Gurrumuru (Site 3: 12°37’S, 136°13’E) are too imprecise and therefore are not given in Table 1.

Available data suggests *E. a. enastri* has a very limited spatial distribution, with an extremely restricted geographical range (Fig. 12). The extent of occurrence is approximately 2,200 km^2, but the area of occupancy of most sites comprises only a few hectares. An exception is population 2, which appears to be distributed over a much larger area, with three sites recorded approximately 15 km apart along the Baralminar River and its tributaries – as suitable habitat occurs between these localities it is assumed the butterfly is also patchily distributed between these areas. Because the preferred habitat of *E. a. enastri* occurs patchily in the landscape of north-eastern Arnhem Land, the butterfly has a very patchy distribution, occurring in widely dispersed areas.

All populations are situated in lowland areas close to the coast (Fig. 12). Of the extant populations, three (populations 1-3) are situated along permanent creeks and rivers that drain into Arnhem Bay of the Arafura Sea, one (population 5) is located along a creek which drains into Melville Bay, while a further two are situated along creeks which drain into the bays of Port Bradshaw (population 6) and Rocky Bay (population 7) of the Gulf of Carpentaria.

While new populations almost certainly remain to be discovered, there has been reasonable survey effort in the Top End to discount the possibility that *E. a. enastri* occurs outside the Gove Peninsula. Appendix I summarises sites with potentially suitable patches surveyed on Gove Peninsula in which *E. a. enastri* was not detected. Dunn *et al*. (1994 p. 70) statement that the butterfly is probably widespread in north-eastern Arnhem Land and that many sites remain to be discovered is clearly erroneous; these authors did not consider that *E. a. enastri* is extremely limited in extent within the landscape because of its specialised habitat requirements. Fenner (1991) suggested the geographic range of the butterfly may be constrained by the prevailing climate of the Gove Peninsula and nearby areas. Although the climate is strongly monsoonal with most of the rain falling between November and April, the dry season from May to October of north-eastern Arnhem Land is less pronounced and severe, being characterised by cooler and more humid conditions compared with the rest of the Top End.

Population size

There have been no quantitative estimates of population size of *E. a. enastri*. Within habitat patches, adults are very local, residing within or close to the putative breeding areas where they are generally encountered in small numbers. Typically no more than 10 individuals are recorded at each site, but some surveys carried out by DLMAC and the author yielded only 2-4 adults (e.g. population 6). The maximum number of individuals recorded at any one site was 15 (Table 1). In contrast, adults of two sympatric species of *Euploea* (*E. sylvester*, *E. darchia*), which occur in the same habitat patches as *E. a. enastri*, were encountered more abundantly (typically > 100). These observations suggest *E. a. enastri* is rare in terms of its relative abundance, rare in habitat preference and rare in spatial distribution.

The population of *E. a. enastri* has probably always been naturally patchy, comprising a number of local subpopulations, at least since the last glacial period. There is no information on the population dynamics, including population size and how numbers change seasonally in relation to breeding phenology, if the subspecies is more abundant during the wet season than in the dry season, whether adults aggregate during the non-breeding period, and if the spatial distribution changes (contracts/expands) seasonally. *E. a. enastri* probably has a metapopulation structure in which there is limited interchange of individuals between subpopulations of each habitat patch. The observation of a single adult flying in a constant direction well outside its preferred habitat near the sea at Galaru would tend to support this hypothesis.

Habitat

Most specimens of *E. a. enastri* have been collected from within or near the edge of relatively small pockets of monsoon forest (evergreen vine-forest, known as 'retja' by the Yolngu Aboriginal community) growing in wet lowland coastal areas (Fenner 1991) that are surrounded by the more extensive savannah woodland and tall open-woodland dominated by *Eucalyptus tetrodonta* F.Muell. and *E. miniata* A.Cunn. ex Schauer. These rainforest patches (Fig. 13) comprise mostly evergreen plants and are associated with perennial groundwater seepages, which typically consist of springs or creeks which have permanently flowing water that may eventually drain into rivers. The population at Rocky Bay differs from the other populations in that the groundwater seepage occurs at the bottom of an escarpment adjacent to low coastal sand dunes.

Preliminary surveys carried out in March-July 2006 indicated that *E. a. enastri* also occurs in more open habitats (projected foliage cover < 70%), including mixed paperbark open swampland (Fig. 14) and mixed tall paperbark swampland (Fig. 15), usually with rainforest elements in the understorey, in juxtaposition to the patches of monsoon forest. For example, at Rocky Bay (site 7a), the subspecies was found in both monsoon forest and the adjacent mixed tall paperbark swampland (dominated by *Melaleuca leucadendra*) with extensive rainforest elements in the understorey. The swampland habitat at this site (Figs 2, 15) occurred patchily along the edge of the monsoon forest, and during the wet season the area was inundated with water, which in places was up to 0.5 m deep. On the Baralminar River, loose aggregations of *E. a. enastri* were found in paperbark swampland (dominated by *Melaleuca nervosa* (Lindl.) Cheel, with *Pandanus spiralis* R.Br.) immediately adjacent to rainforest areas along the banks of the Baralminar River (site 2a), or in mixed paperbark open swampland (dominated by *Melaleuca cajuputi* Powell) with rainforest elements in the understorey growing on peat bog of a permanent spring (site 2c) (Fig. 14).

The breeding habitat of *E. a. enastri* and the dependency on wet monsoon forest verses mixed paperbark swampland is imprecisely known. The single factor that both of these habitats have in common is that they are restricted to perennial groundwater seepages. Evidence of breeding and the larval food plants of *E. a. enastri* have only been found at Rocky Bay (site 7a). At this site, the larval food plants, female oviposition behaviour and the presence of early stages were recorded in the mixed tall paperbark swampland growing immediately adjacent to the more extensive monsoon forest. However, the larval food plants are absent from monsoon forest. These observations indicate that breeding probably occurs in mixed paperbark swampland but in juxtaposition to monsoon forest. Further study is required to determine the ecological requirements of *E. a. enastri*, particularly its dependency on monsoon forest. The breeding habitat of *E. a. enastri* contrasts with the habitat of *E. a. misenus* in the northern Torres Strait Islands, which breeds in vine-thickets, mangroves and in the transitional zone between these two habitats where the larval food plant grows (Lambkin 2001).

Conservation Status

In a preliminary assessment of the conservation status of *E. a. enastri*, Dunn *et al*. (1994 p. 70) stated that "…many other sites in this remote area await discovery. The butterfly is probably quite widespread and abundant…" Despite the authors having no direct experience of the taxon they went further and claimed that "There are no threats to this subspecies as it occurs in largely undisturbed, and extensively forested areas." and suggested that management was not necessary. Yen and Butcher (1997) listed *E. a. enastri* as having 'conservation significance', but Sands and New (2002) did not consider the taxon for discussion during extensive consultative workshops held amongst Australian lepidopterists in preparation of their review on the conservation status of Australian butterflies.

In 2002-04, some 15 years after the initial discovery of undisputed *E. alcathoe* from the Australian mainland, extensive surveys and community consultation on the Gove Peninsula were carried out by Colin Wilson in collaboration with Indigenous Rangers of DLMAC and P&WS (Wilson 2003). During these surveys, *E. a. enastri* was relocated at three of the four known populations, but no additional populations were located (S. Roeger and P. Wise, pers. comm.). The subspecies was found to occur in relatively low numbers and restricted to small areas. More significantly, a number of threatening processes impacting on the subspecies' habitat were identified (Wilson 2003.). These threats, together with its restricted geographic distribution, led the taxon being listed both locally and nationally. Currently, *E. a. enastri* is listed as Endangered in the Northern Territory under section 29 of the *Territory Parks and Wildlife Conservation Act 2000* (www.nt.gov.au/nreta/wildlife/threatened/specieslist.html) and as Endangered nationally under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as of 6 August 2003 (www.environment.gov.au/biodiversity/threatened/index.html).

Threats

There is no evidence that the geographic range of *E. a. enastri* has declined or the population has been severely fragmented. However, in terms of the size of the extant habitat patches relative to the area of savannah woodland within the wider landscape of north-eastern Arnhem Land, these patches are relatively small. Initial concerns that the population at Rocky Bay had declined or disappeared, due to invasion and predation by Yellow Crazy Ants (in September 2002), was found to be erroneous. While this tramp ant posses a serious threat in the long-term, the current area of infestation at Rocky Bay (12°16'28"S, 136°53'59"E) does not coincide with the precise location where adults currently breed (12°17'45"S, 136°54'11"E), despite the fact that the two species occur in the same monsoon forest patch. While it is true that *E. a. enastri* at present occurs in largely undisturbed, forested areas, the claim by Dunn *et al*. (1994) that there are no threats to the subspecies is erroneous. The habitat of the extant populations of *E. a. enastri* currently faces a number of potential environmental threats, which if left unabated, could lead to a significant decline in population size and eventual loss of this taxon. The most significant threats to *E. a. enastri* include: (1) habitat modification through weed invasion, especially introduced pasture grasses (i.e. Perennial Mission Grass and Gamba Grass); (2) habitat loss through altered fire regime, due to a combination of (i) loss of traditional knowledge and land management practices, and/or (ii) spread of tropical grassy weeds; (3) invasion of tramp ants, specifically predation and habitat modification by Yellow Crazy Ant; and (4) habitat disturbance by feral animals, namely water buffalo and feral pig. Several other threats, such as increased intensity of cyclones and sea-level rise due to global climate change, have been identified by DLMAC. These threatening processes, if left uncontrolled in the long-term on the Gove Peninsula, may eventually lead to complete loss of the unique wet coastal monsoon forest and mixed paperbark swampland on the Gove Peninsula in north-eastern Arnhem Land.

Habitat modification through weed invasion

The introduced Annual Mission Grass, *Pennisetum pedicellatum* (Trin) (Poaceae), is currently widespread in the towns of Gapuwiyak, Yirrkala and sporadically around Nhulunbuy. More seriously, the taller African Perennial Mission Grass, *Pennisetum polystachion* (L.) Schult., has recently become established on the Gove Peninsula: local infestations have been reported from Nhulunbuy township, Ski Beach airstrip, the crocodile farm, Garma Festival, and Dhälingbuy outstation (P. Wise, pers. comm). Infestations of Perennial Mission Grass are currently being controlled to prevent further spread on the Gove Peninsula, but they have not been eradicated. A single plant of Gamba Grass, *Andropogon gayanus* (Kunth), also originally from West Africa, found in Nhulunbuy has been eradicated.

Both Annual and Perennial Mission Grass and Gamba Grass are three grassy weed species that have been identified as posing a major threat to ecosystems in the Top End of northern Australia (Anon. 2006a; Kean & Price 2003). When left uncontrolled, these exotic grasses spread rapidly from suburban areas to natural undisturbed bushland areas, either along roadsides or through invasion by long distance dispersal from infested source areas (Kean & Price 2003). On the Gove Peninsula, these grasses have the potential to invade and spread into the mixed paperbark open swamplands; once established they may change the structure and composition of the habitat to the point that it becomes unsuitable for *E. a. enastri* and its larval food plant. In the NT, Perennial Mission Grass is currently declared as a noxious weed under the NT *Weeds Management Act 2001*, and landholders have a legal obligation to control its growth and spread (Anon. 2006a). There are currently proposals to nominate Gamba Grass as a key threatening process under the EPBC Act.

Another invasive plant on the Gove Peninsula is Candle Bush, *Senna alata* (L.) Roxb. (Fabaceae), an exotic species widely planted in the suburban gardens of Nhulunbuy. This species is currently invading natural bushland areas, including monsoon forest, around Nhulunbuy and is not being controlled (D. Hinz, pers. comm.).

Habitat loss through altered fire regime

There is widespread concern that traditional knowledge and land management practices amongst the Yolngu Aboriginal community in north-eastern Arnhem Land are not being passed on from elders to the next generation. This knowledge and management includes an understanding of traditional burning practices – the seasonal timing, patchiness, and frequency of burns – and Traditional Owners have acquired considerable expertise over the millennia. It is imperative that traditional land management practices are maintained on Gove Peninsula: incorrect (excessive) burning will ultimately reduce the extent of the monsoon forest patches.

Perennial Mission Grass and Gamba Grass, once established in savannah woodland and paperbark swampland, have the capacity to alter the fire regime, particularly the intensity and frequency of fires. In comparison with native grasses, these exotic grasses form taller, denser stands that cure later in the dry season, with higher fuel loads (3 times greater or more), yielding more intense fires that frequently reach the canopy of eucalypts (Anon. 2006a, 2006b; Kean & Price 2003). These hotter, more destructive late season fires, in turn, reduce biological diversity and abundance, and adversely affect the edge or ecotone of monsoon forest. Monsoon forests comprise a restricted vegetation type that are fire sensitive, and repeated annual burning fuelled by these grasses have the potential to result in complete loss of these habitats, as well as seriously alter the biodiversity, structure and character of tropical eucalypt savannahs. The rapid spread of Perennial Mission Grass in savannah woodland is one of the key factors implicated in the decline of a monsoon forest complex in the Darwin region, mediated through changes in the local fire regime (Panton 1993). Moreover, access to the town of Nhulunbuy has recently been upgraded, as has the local network of roads across the Gove Peninsula. The more intensive land use and greater ease of access within this previously inaccessible region increases the likelihood of these invasive grasses becoming established. That is, the potential for new outbreaks of Perennial Mission Grass and Gamba Grass to become established and spread on the Gove Peninsula through people, transportation vehicles, road building and road maintenance activities is now very high.

Invasion by tramp ants

The Yellow Crazy Ant, *Anoplolepis gracilipes* (Smith), has recently become established in the Top End of the Australian mainland. It was first reported from north-eastern Arnhem Land in May 1990, although the ant has probably been established on the Gove Peninsula for several decades (Young *et al.* 2001). Surveys in 1999 found that Yellow Crazy Ants had spread over five river drainage systems. The ant is spread by accidental transport and has now been detected at 175 sites, of which 82 have been spatially mapped in detail on the Gove Peninsula; the combined extent of these infestations is around 750 ha (B. Hoffman, pers. comm.). Yellow Crazy Ants are currently listed as a key threatening process in the loss of biodiversity and ecosystem integrity on Christmas Island, Indian Ocean, under the EPBC Act. On Christmas Island, the ants have been found to alter the structure and composition of rainforest vegetation through an association with scale insects. This association, in turn, causes increased levels of honeydew, leaf mould, tree dieback, light penetration and ultimately weed invasion on the forest floor.

The Yellow Crazy Ant poses a serious long-term threat to the invertebrate fauna of monsoon forests in northern Australia (Young *et al.* 2001). The ants do not bite or sting but spray formic acid to subdue their prey. On Christmas Island, the ants have wiped out local populations of the spectacular Christmas Island Red Land Crab, *Gecarcoidea natalis*, in areas of infestation. In other countries, there are numerous reports of Yellow Crazy Ants displacing other invertebrate species (especially ants and spiders) and altering the floral compositions of habitats (see references reviewed in Young *et al.* 2001).

Preliminary observations in areas on the Gove Peninsula occupied by Yellow Crazy Ants indicate a loss of all native ant species and a significant reduction in all other invertebrates due to predation, particularly in the shaded, moist areas provided by monsoon forest (B. Hoffman, pers. comm.). Thus, it is probable that larvae of *E. a. enastri* would not survive the impact of invasion by Yellow Crazy Ants, although experimental evidence is currently lacking. Yellow Crazy Ants have recently become established in one of the patches of monsoon forest occupied by *E. a. enastri* (northern end of Rocky Bay). Although Yellow Crazy Ant has not yet invaded the breeding area of the butterfly, if left uncontrolled it is only a matter of time before the ant sweeps through the entire forest patch. Of the mapped infestations of Yellow Crazy Ant, 80% have so far been chemically treated, but the total extent of infestation on Gove Peninsula remains to be determined (B. Hoffman, pers. comm.).

Habitat disturbance by feral animals

Feral animals, particularly water buffalo, *Bubalus bubalis*, and to a lesser extent feral pig, *Sus scrofa*, occur on the Gove Peninsula. The presence of these species, either singly or in combination, was detected at all sites. These animals are known to disturb and degrade monsoon forest patches through their effects on the soil and understorey plants, and are thus a potential threat to the integrity of the habitat of *E. a. enastri*, especially the mixed tall paperbark swampland adjacent to monsoon forest (i.e. the putative breeding areas). Water buffalo and feral pig have been present on Gove Peninsula in only the last few decades – buffalo became established in the late 1970’s – early 1980’s and pig in the 1990’s (I. Morris and D. Hinz, pers. comm.). The current population size/density of buffalo and pig appears to be relatively low, but the precise number has not been quantified and it is not known if the population of either species is increasing. A comprehensive survey of the distribution and abundance of these feral animals is needed. Feral pigs are currently listed as a key threatening process of habitat degradation under the EPBC Act.

Other threats

Increased intensity of cyclones due to climate change could be detrimental to the habitat of *E. a. enastri*. Cyclones cause considerable short-term structural damage to small monsoon forest patches by opening up the canopy or temporarily eliminating the vegetation. Normally, these habitat patches recover quickly, but if the patches become heavily weed infested, frequently burnt or disturbed by buffalo and pigs, recovery may be impossible. All known populations occur in coastal lowland areas and are also susceptible to any sudden rise in sea-level brought about by global climate change.

Management

The Gove Peninsula in north-eastern Arnhem Land of the Northern Territory represents a unique and remote part of Australia, an area that is still relatively pristine and rich in biodiversity and indigenous culture. Every effort should be made to preserve and maintain these natural heritage and cultural values. Perhaps the most striking natural heritage asset is the patches of wet coastal monsoon forest and mixed paperbark swampland associated with permanent ground water. These habitats are a safe haven for the Gove Crow butterfly and, accordingly, their protection and management will ensure the continued survival of *E. a. enastri* in the long term. The habitats are floristically diverse and contain a number of species not found elsewhere in the Northern Territory or indeed Australia. For example, at least 14 species of vascular plants are known only from habitats in this region, including one of the larval food plants of *E. a. enastri*, *Parsonsia alboflavescens* (Liddle *et al.* 1994). As such, the patches of monsoon forest comprise a critical ecological community for the continued survival of these plant species. Detailed surveys and inventory of the invertebrates associated with these habitats have not been undertaken, but it is likely that other endemic taxa occur in the region.

The monsoon forests on Gove Peninsula also contain a suite of resources that are of cultural significance to the Yolngu community, the indigenous Aboriginal landowners of these habitats. These resources include food, timber, fibre, medicine and spears, but the forests also comprise an important entity for stories and spirits.

Hence, protection of *E. a. enastri* as a flagship taxon will ensure conservation of the wider biodiversity associated with monsoon forests and mixed paperbark swamplands in north-eastern Arnhem Land. The butterfly also has the potential to be used as an indicator taxon through long-term monitoring programs. Although the subspecies is rare and ecologically specialised, adults are large, spectacular and readily identified in the field. Therefore, changes in its distribution and abundance may indicate adverse changes to the general health of the ecological community as a whole.

Actions that need to be implemented to achieve successful conservation management include the following components: development and involvement of local indigenous rangers, education and community awareness, monitoring to assess threats, and control of exotic species. Each of these components is discussed in detail below. In addition, further research on *E. a. enastri* is needed to fill critical information gaps, especially to determine the ecological requirements and to identify the most critical populations.

Development and involvement of local indigenous rangers

All populations of *E. a. enastri* occur on private land managed by the indigenous Aboriginal Yolngu people of north-eastern Arnhem Land. Successful conservation management of the monsoon forests and mixed paperbark swamplands will only be achieved if it involves the Yolngu landowners and local community groups. While the land of *E. a. enastri* at several populations is managed by two Aboriginal ranger groups (population 3: Yirralka Laynhapuy Rangers; populations 4–7: DLMAC), the area near Arnhem Bay that encompasses two populations (1–2) currently lacks adequate conservation management. These populations fall within responsibility of the Gapuwiyak Aboriginal Community, however, the Community has neither the resources nor rangers to implement a recovery plan to address the threatening processes outlined above. Moreover, population 2 is suspected to comprise the most important population. Therefore, a priority action is the development and establishment of a local indigenous ranger group based at Gapuwiyak, possibly through the Community Development Employment Program. Once a ranger group is established and operational, control and eradication measures of grassy weeds and feral animals can be implemented.

Education and community awareness

An important component of recovery will be increased level of education and community awareness, not just of the Gove Crow butterfly but of the wider Yolngu culture. There is an urgent need to ensure that customary knowledge is not lost but passed on from the traditional owners to the next generation. A program needs to be established in which senior elders are employed to gather, teach, disseminate and transfer cultural skills and knowledge. Such a program would include traditional burning practices, Ethnobotany, hunting techniques and traditional dances, as well as the conservation needs of *E. a. enastri*, the importance of its monsoon forest habitat and its need for on-going management. In order to raise general awareness of *E. a. enastri* effectively, the program should include media preparation (information sheets, posters, videos, talks etc) and involve input and participation from scientists from P&WS. The program could run as a series of workshops for both school children and the wider community, and could link in with established activities such as the Garma Festival, which is held annually in the region as a key forum for indigenous education and training.

Monitoring to assess threats

All known sites of *E. a. enastri* should be monitored on a regular basis to assess general environmental health, such as new outbreaks/infestations of grassy weeds, Yellow Crazy Ants and feral animals. Monitoring should include assessing annual and longer term changes in the extent and structure of rainforest habitat. This could be achieved by recording photos at several point locations. At most two rangers are required to visit all sites at least twice a year (i.e. every 6 months). A long-term environmental monitoring program to measure possible changes in sea-level, temperature and water table ought to be established to assess potential impacts of global climate change on the Gove Peninsula.

Control of exotic species

Grassy weeds. Perennial Mission Grass and Gamba Grass have the potential to invade and become serious weed problems on the Gove Peninsula. Control and eradication of known infestations and the need to maintain vigilance against new outbreaks are therefore high priorities. Small infestations or isolated plants can be removed by hand pulling or grubbing out with a mattock or hoe, preferably after rain when the soil is moist. Larger infestations can be slashed, followed by spraying with glyphosate (Anon. 2006a, 2006b). The latter form of eradication should be implemented during the build-up or wet season (November to March–April) before the plants set seed (April to June for Perennial Mission Grass; May to August for Gamba Grass). The area should be revisited four weeks after spraying to check that all plants have died and there are no newly established seedlings. The area should then be re-vegetated with native grasses before the end of December. A vehicle quarantine inspection service needs to be established on the Central Arnhem Road to disinfect incoming vehicles, especially mining trucks and rental cars, from the Katherine region to ensure they are not carrying seed of grassy weeds into the Gove Peninsula. This inspection service could take the form of a washdown station, and could be established at Bulman where there is already an existing cattle truck station (T. Marsh, pers. comm.)

Yellow Crazy Ant. Survey, monitoring and control of Yellow Crazy Ant is currently been undertaken on the Gove Peninsula by the Crazy Ant Management Group coordinated by CSIRO Tropical Ecosystems Research Centre, DLMAC, P&WS of the NT Government, the Australian Government Department of the Environment and Water Resources and Northern Land Council, with funding from the Australian Government. Due to the size and extent of the infestation the program has now shifted its focus from eradication to methods for control and containment. Funding for the current program expires in September 2007.

Feral animals. At present there is no survey and control program of water buffalo and feral pig on the Gove Peninsula. A feral animal control strategy is therefore recommended, which should be undertaken by DLMAC with support from P&WS.

Supporting Actions

Information gaps. Further work of the Gove Crow by staff of the Biodiversity Conservation Division of NRETA in conjunction with DLMAC and Yirralka Laynhapuy Rangers is required to fill critical information gaps, especially to determine the ecological requirements more precisely, and to identify the most critical populations.

Climate change. Sea-level rise and site disturbance from more intense cyclones through climate change posses a large-scale threat to the integrity and long-term survival of the habitat of the Gove Crow, and activities to reduce greenhouse gas emissions must be practiced.

Costs

The total estimated cost required to implement the recovery plan is $973,120. The recovery plan is to be carried our over a five year period, and a detailed breakdown of the cost in relation to the management actions identified above, plus a plan to fill critical information gaps, is given in Table 2. The costs are divided into three sections, those associated with the first year, those on-going costs for each of the five years, and those for the final year. The costs for year 1 ($501,670) include a ranger development and training program for the Gapuwiyak Aboriginal Community, equipment for monitoring and control of exotic species, and a scientific research plan to fill critical information gaps, specifically to determine ecological requirements and identify critical populations. The second set of costs ($461,450 or $92,290 per year over years 1–5) is associated with an education and community awareness program, monitoring and control of exotic species. The third set of costs ($10,000) is associated with evaluation and performance review of the plan.

Landholders, community groups, and other bodies may obtain support for management actions that benefit the Gove Crow on their lands or in areas of their interest, through competitive funding and grants from a range of sources, including the following:

Australian Government Envirofund
www.nht.gov.au/envirofund/index.html

Northern Territory Environment grant scheme
www.nt.gov.au/nreta/environment/grants/environment/index.html

Threatened Species Network, a community-based program of the Australian Government and WWF–Australia
www.wwf.org.au/ourwork/species/tsngrants/

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Table 1. Known resident populations of *E. a. enastri* on the Gove Peninsula in north-eastern Arnhem Land of the Top End, NT. All populations occur in discrete areas (numbered as sites 1-7). Population 2 comprises the largest area with observations from three sites (2a-c). Maximum number of individuals recorded at each site are also indicated. Populations are listed from west to east.

Population	Location	Latitude*	Longitude*	Reference	Maximum number of adults recorded
1	Near Gapuwiyak airstrip, Arnhem Bay	12°28'40"S	135°49'19"E	M.F. Braby and I. Morris	2 (13 Jun. 2006, M.F. Braby)
2a	Baralminar River, 11 km ESE of Gapuwiyak, Arnhem Bay	12°31'06"S	135°54'46"E	M.F. Braby and I. Morris	6 (14 Jun. 2006, M.F. Braby)
2b	Headwater of creek draining into Baralminar River, 13 km S of Gapuwiyak	12°37'13"S	135°48'37"E	M.F. Braby and I. Morris	4 (13 Jun. 2006, M.F. Braby)
2c	Baralminar River near Dhamiyaka Outstation, 17.5 km SSE of Gapuwiyak	12°39'19"S	135°51'31"E	M.F. Braby and I. Morris	15 (16 Jun. 2006, M.F. Braby)
3	upper Goromuru River, Arnhem Bay			Fenner (1992)	
	c. 1 km NE of Gurrumuru outstation, c. 2.5 km E of Goromuru River	12°35'14"S	136°14'11"E	P&WS and DLMAC	10 (28 Jun. 2006, M.F. Braby)
4	6 km NW of Mt Bonner, 40 km WNW of Rocky Bay			Fenner (1991)	
	5.6 km NW of Mt Bonner	12°04'50"S	136°31'36"E	DLMAC and P&WS	12 (22 Oct. 2004, P. Wise)
	"	12°04'57"S	136°31'41"E	DLMAC and P&WS	
5	Yanungbi, Melville Bay	12°18'11"S	136°40'03"E	DLMAC	<5 (late dry 1994, B. Marika)
	"	12°18'03"S	136°40'05"E	DLMAC	
6	Near Port Bradshaw, 20 km SW of Rocky Bay			Fenner (1991)	
	Mosquito Creek, Port Bradshaw	12°25'39"S	136°50'08"E	P&WS and DLMAC	2 (8 Apr. 2003, C. Wilson)
7	Rocky Bay			Fenner (1991)	
7a	c. 5 km S of Yirrkala, Rocky Bay	12°17'45"S	136°54'11"E	L. Wilson	15 (24 Mar. 2006, M.F. Braby)
7b	Shady Creek, Rocky Bay	12°16'52"S	136°53'42"E	L. Wilson	4 (Aug. 2005, L. Wilson)

DLMAC = Dhimurru Land Management Aboriginal Corporation; P&WS = Parks and Wildlife Service.
* Coordinate system = DMS, Datum = WGS84.

Table 2. Estimated budget to implement a recovery plan for *E. a. enastri*.

ITEM	COST	TOTAL
ADDITIONAL COSTS FOR YEAR 1		
Development and involvement of local indigenous rangers		$445,070
Ranger development and training program for Gapuwiyak Aboriginal Community (18 months)		
ranger salary (x 4 indigenous rangers @ $29,250 per ranger per year)	$175,550	
mentor/instructor salary ($50,000 per year)	$75,000	
mentor/instructor accommodation ($90 per week)	$7,020	
training costs ($30,000 per year)	$45,000	
capital costs (vehicles, quadbikes, slashers, GPS, equipment @ $60,000 per yr)	$90,000	
consumables ($35,000 per year)	$52,500	
Monitoring to assess threats		$2,075
Field equipment (Yirralka Laynhapuy Rangers)		
GPS, Garmin GPS60 (x 2 @ $359)	$718.00	
digital camera, Kodak V570 5MB x5 optical zoom compact	$499.00	
butterfy net plus spare bag (x 2 @ $68.05)	$136.10	
notebooks, all weather waterproof (x 2 @ $22.55)	$45.10	
postage	$21.80	
Map of IPA (DLMAC)		
1:50000 topographic maps hard copy (x 6 maps @ $9.25)	$55.50	
preparation of wall map (cutting, mounting, acryllic surface, framing)	$550.00	
packaging	$50.00	
Control of exotic species		$24,525
Control of grassy weeds		
slasher equipment (DLMAC)	$300	
slasher equipment (Yirralka Laynhapuy Rangers)	$300	
quadbike, 4WD Honda 350 TRX-FM (x 2 @ $11,170) (Yirralka Laynhapuy Rangers)	$22,640	
Control of feral animals		
firearms (308) (x 2 @ $500) (Yirralka Laynhapuy Rangers)	$1,000	
safe for firearms (holds 4 guns) (Yirralka Laynhapuy Rangers)	$285	
Plan to fill information gaps		$30,000
3 x 12-day field trips to survey new sites and map breeding habitat of two key sites (P&WS)		
DLMAC rangers, vehicles and meetings	$16,800	
4WD vehicle and quadbikes (rent and fuel)	$6,000	
helicopter flights (@ $1400 per hr for 2.5 hrs)	$3,500	
food	$1,100	
flights between Darwin and Nhulunbuy	$1,500	
other (aerial photos, maps, equipment etc)	$1,100	
Subtotal		**$501,670**
ON-GOING COSTS (YEARS 1-5)		
Education and community awareness		$40,000
4 workshops @ $10,000 each (DLMAC)	$40,000	
Monitoring to assess threats		$3,900
4 sites twice per year (DLMAC)		

ranger salary (x 2 @ $180 per day)	$2,900	
vehicles (x 1 @ $75 per day plus @ $50 fuel and maintenance per day)	$1,000	
Control of exotic species		$45,890
Part-time P&WS ranger (10%): salary plus consumables	$20,000	
Quadbike maintenance, service and use (x 2 @ 200L fuel plus $350 lease per bike)	$2,640	
Control of grassy weeds		
ranger salary plus vehicles (DMLAC & P&WS)	$3,300	
slasher equipment maintenance	$300	
chemicals (4 drums)	$500	
consumables (Yirralka Laynhapuy Rangers)	$3,440	
consumables (Gapuwiyak Aboriginal Community)	$3,440	
Control of feral animals		
ranger salary plus vehicles (DLMAC & P&WS)	$4,500	
maintenance of firearms (cleaning, agents etc)	$300	
ammunition (x 10 boxes @ $25 per box of 20 shells)	$250	
licensing (x 2 staff @ $20 per ranger)	$40	
training	$1,500	
replacement of 308 guns	$500	
consumables (Yirralka Laynhapuy Rangers)	$2,590	
consumables (Gapuwiyak Aboriginal Community)	$2,590	
Administration and evaluation		$2,500
Consumables: printers, photographics, other media, GIS Software update (5% of total operating costs, DLMAC)	$830	
Administration (10% of total operating costs, DLMAC)	$1,670	
Subtotal (per year)		**$92,290**
Subtotal (5 years)		**$461,450**
ADDITIONAL COSTS FOR YEAR 5		
Consultant to evaluate plan		$10,000
Total		**$973,120**

List of figures

Figs 1–11. Life history of *E. a. enastri*: (1) adult male; (2) mixed tall paperbark swampland at Rocky Bay, showing larval food plant *Parsonsia alboflavescens* in left of foreground; (3) egg; (4–8) final instar larva, showing (4) dorsal, (5) dorsolateral and (6) lateral views, (7) anterior end showing head and thoracic segments, lateral view (8) posterior end showing abdominal segments 5–10, dorsolateral view; (9–11) pupa, showing (9) lateral, (10) dorsal and (11) ventral views. Photos © M.F. Braby.

Fig. 12. Spatial distribution of *E. a. enastri*, showing locations of the known populations (•) on the Gove Peninsula, north-eastern Arnhem Land, NT. Populations are numbered 1–7 as per Table 1. Inset map shows the Top End of the Northern Territory.

Figs 13-14. Habitats of *E. a. enastri*: (13) edge of monsoon forest (evergreen vine-forest), Baralminar River near Gapuwiyak; (14) mixed paperbark open swampland with rainforest elements in the understorey, Baralminar River near Gapuwiyak. Photos © M.F. Braby.

Fig. 15. Habitat of *E. a. enastri*, showing mixed tall paperbark swampland with rainforest elements in the understorey, Rocky Bay. Photos © M.F. Braby.

FIGURES 1-11

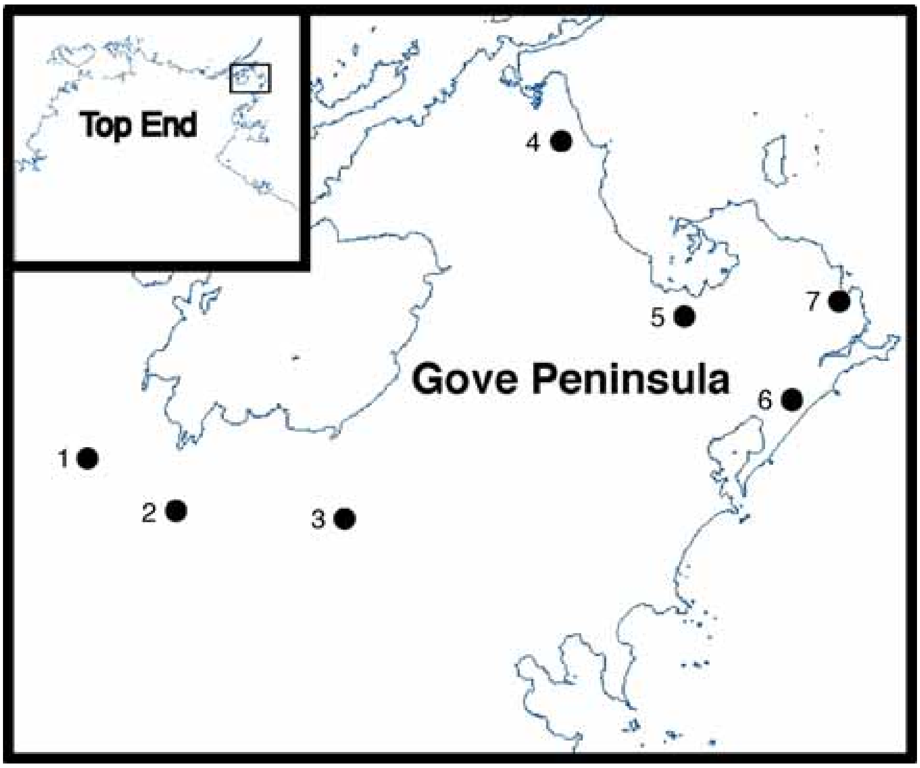

FIGURE 12

FIGURE 13

FIGURE 14

FIGURE 15

Appendix I

Locations of monsoon forest patches surveyed on Gove Peninsula in which *E. a. enastri* was not detected.

Latitude	**Longitude**	**Locality**	**Date surveyed**
12°29’49”S	135°55’53”E	Baralminar River E of Gapuwiyak	14 JUN. 2006
12°31’15”S	135°54’05”E	Baralminar River E of Gapuwiyak	14 JUN. 2006
12°44’14”S	136°22’48”E	Central Arnhem Rd near Gurrumuru turnoff	28 JUN. 2006
12°19’32”S	136°55’57”E	Macassan Beach	01 JUL. 2006
12°10’41”S	136°47’01”E	Town Lagoon (Gayngaru wetlands), Nhulunbuy	01 JUL. 2006
12°16’60”S	136°53’50”E	Rocky Bay	03 JUL. 2006
12°16’28”S	136°53’59”E	Rocky Bay	03 JUL. 2006
12°16’23”S	136°52’43”E	Shady Creek, Rocky Bay	04 JUL. 2006