

Who are the important sea turtle nest predators at Wreck Rock beach? (#16428)

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Who are the important sea turtle nest predators at Wreck Rock beach?

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Excessive sea turtle nest predation is a problem for conservation management of sea turtle populations. This study assessed the predation of the endangered loggerhead sea turtle (*Caretta caretta*) nests at the Wreck Rock beach adjacent to Deepwater National Park in Southeast Queensland, Australia after a control program for feral foxes was instigated. The presence of predators on the nesting dune was evaluated by passive soil plots (2 x 1 m) every 100m along the dune front. There were 21 (2014-2015) and 41 (2015-2016) plots established along the dune and these were monitored for predator tracks daily over three consecutive months in both nesting seasons. Camera traps were also set to record the predator's activity around selected nests. The tracks of the fox (*Vulpes vulpes*) and goanna (lace monitor *Varanus varius* and/or yellow-spotted goanna *V. panoptes*; we could not distinguish these two species tracks from each other) were found on sand plots. Goannas were widely distributed along the beach and had an eight times higher Passive Activity Index (PAI) (0.31 in 2014-2015 and 0.16 in 2015-2016) compared to foxes (PAI 0.04 in 2014-2015 and 0.02 in 2015-2016). Camera trap data indicated that the appearance of yellow-spotted goannas at loggerhead turtle nests was more frequent than lace monitors and further that lace monitors only preyed on these nests after they had been previously opened by yellow-spotted goannas. No foxes were recorded at nests with camera traps. This study suggests that large male yellow-spotted goannas are the major predator of sea turtle nests at the Wreck Rock beach nesting aggregation.



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23

24 Abstract

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26 populations. This study assessed the predation of the endangered loggerhead sea turtle

27 (*Caretta caretta*) nests at the Wreck Rock beach adjacent to Deepwater National Park in

28 Southeast Queensland, Australia after a control program for feral foxes was instigated. The

29 presence of predators on the nesting dune was evaluated by passive soil plots (2 x 1 m) every

30 100m along the dune front. There were 21 (2014-2015) and 41 (2015-2016) plots established

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42 major predator of sea turtle nests at the Wreck Rock beach nesting aggregation.

43

44 Key words Camera trap, Passive sand plot, Sea turtle, Nest, Predator, Predation, Yellow-spotted
45 goanna, Lace monitor, Activity 

46 Introduction

47 Sea turtles are oviparous and construct their nests on dunes adjacent to the beach where
48 embryos take about two month to incubate without any further parental care. Sea turtle
49 hatchling nest emergence success is determined by nest temperature, salinity, humidity, water
50 inundation and predation (Fowler 1979; Miller 1985; Reid *et al.* 2009; Wang & Weathers 2009).
51 During incubation  a wide range of predators may attack sea turtle nests and have a significant
52 effect on  sea turtle hatchling recruitment and thus long-term population persistence (Stancyk
53 1995). At many beaches  nest predation is the main cause of hatch failure of sea turtles with
54 some regions reporting more than 50% of nests being destroyed by predators (e.g. Fowler 1979;
55 Blamires & Guinea 1998; Blamires *et al.* 2003; Maulany *et al.* 2012; McLachlan *et al.* 2015). A
56 large variety of non-human species have been reported as sea turtle nest predators  including
57 fire ants, crabs, turkey vultures, black vultures, coatis, raccoons, dogs, red foxes, golden jackals,
58  mongoose, snakes and goannas in different regions of the world (Stancyk *et al.* 1980; Stancyk
59 1982; Mora & Robinson 1984; Brown & Macdonald 1995; Frick 2003; Leighton *et al.* 2008). In
60 Australia, sea turtle nest predators include several species of native goanna (*Varanus spp*), the
61 native dingo (*Canis familiaris dingo*) and  the introduced fox (*Vulpes vulpes*), pig (*Sus serofo*) and
62 wild dog (*Canis familiaris*) (Limpus 1978; Limpus & Fleay 1983).

63

64 The loggerhead turtle (*Caretta caretta*) is an endangered species on the IUCN Red List (IUCN
65 2003) and nests in significant numbers (~400 nests per season) at Wreck Rock beach adjacent
66 to Deepwater National Park, Queensland, Australia, (Limpus 2008). Predators of sea turtle nests
67 at Wreck Rock beach include foxes, dingoes and goannas (Limpus 2008). From 1987 onwards,
68 1080 poison baits have been used to control fox predation but a recent nest survey (McLachlan
69 *et al.* 2015) indicated that while fox predation of nests was minimal, a large number of nests
70 were predated by goannas. Thus, predation by goannas has become the most significant threat
71 to the hatching success of the loggerhead turtle nests at Wreck Rock beach. The lace monitor
72 (*Varanus varius*) and yellow-spotted goanna (*Varanus panoptes*) are likely to be the main
73 goannas attacking loggerhead nests because of their distribution along the coastline and ability
74 to dig holes while foraging (Cogger 1993).
75
76 For some animal species, it is difficult to estimate population density by standard census
77 methods such a mark and recapture (Engeman & Allen 2000) because of large home ranges,
78 rough terrain habitats, relatively sparse populations and/or difficulty in capturing animals or
79 making direct observations (Pelton and Marcum 1977). To overcome these problems, Engeman
80 & Allen (2000) developed and refined a passive activity index (PAI) for monitoring wild
81 carnivorous species, which is simple and quickly applied in the field, and can also provide
82 accurate information reflecting population changes over time or space. Engeman & Allen (2000)
83 argued that it is unnecessary to know the precise population density of predators when
84 formulating predator control measures, all that is needed is a reliable index that tracks predator

activity and how this activity changes with instigation of management strategies. This method has been used previously to monitor predator activities, including the common water monitor (*Varanus salvator*) activity on an olive ridley turtle (*Lepidochelys olivacea*) nesting beach in Alas Purwo National Park, Banyuwangi (East Java), Indonesia over two nesting seasons (Maulany 2012).



The aim of the current study was to quantify goanna activity on nesting dunes during the sea turtle nesting season at Wreck Rock beach and to see how this activity related to sea turtle nest predation. In addition, camera traps were used to monitor goanna activity at sea turtle nests in order to identify which goanna species is the main predator of these nests.

Methods

Study site and nest monitoring

This study was conducted along the beach for 2 km immediately to the north and south of Wreck Rock adjacent to Deepwater National Park, Southeast Queensland (24°18' 58 S, 151°57' 55" E) (Fig. 1). This section of the beach is marked by numbered stakes every 100 m for ease of marking and relocating nests. The beach was monitored nightly by personnel from Turtle Care Volunteers Queensland Inc. to record the presence of emerging female turtles and successful nesting activities. All work was approved by a University of Queensland Animal Ethics Committee (permit #SBS/352/EHP/URG) and conducted under Queensland Government National parks scientific permit # WITK15315614. When a nest was located, its position was

marked by a red ribbon attached to a small stake and recorded using a handheld GPS (Garmin eTrex 30, Kansas, USA).

Once a nest was located it was visited daily throughout the incubation period in order to identify predation events and the tracks of animals visiting nests. Nest visitation rate was quantified as a percentage by dividing the number of days fresh tracks were found at a nest by the total number of nest inspection days (nest inspection days = total number of times a nest was inspected during the season until hatchlings emerged from the nest or until it was totally predated) multiplied by 100.

Camera traps

Camera traps (Reconyx Hyperfire HC600, Holmen, Wisconsin, USA) were set up to capture images of predators visiting a sample of 12 loggerhead turtle nests between 6 December 2014 and 27 January 2015, and 30 nests between 1 December 2015 and 27 February 2016. Camera traps were at each nest for 25 days in the 2014-2015 and 30 days in the 2015-2016 nesting season. This enabled information on the frequency, time of day and species to be collected. To compare the relative activity of goannas visiting nests each year with PAI and nest predation rates between years, we calculated the number of camera trap days each season (= sum of total number of days each nest was monitored in a season for all nests monitored in a season). Nest visitation rate (%) for camera trap monitored nests was defined as the 100 times the number of independent photographs of goannas recorded at nests divided by the number of

127 camera trap days.

128 Passive soil plots

129 Passive soil plots were used to estimate a predator species' relative activity during the peak sea

130 turtle nesting time (December – March) across two consecutive years. In the 2015-2016 these

131 plots were also monitored for four days in April, a time when most sea turtle clutches had

132 finished incubating and hatched. Twenty-one sand plots (2 m x 1 m) in the first nesting season

133 (2014-2015) and 41 in the second nesting season (2015-2016) spaced 100 m apart were set up

134 on the primary dune (where most sea turtle nests were constructed). The plots covered the

135 dunes for 1 km (2014-2015) and 2 km (2015-2016) north and south of Wreck Rock camping area

136 and their locations were marked by sticks placed at each corner of the plot and the plot

137 location recorded with a handheld GPS. Each plot was inspected during the afternoon (weather

138 permitting) and the number of tracks and species of each track were recorded. After reading,

139 plots were resurfaced using a rake to obliterate tracks insuring the same tracks were not

140 recorded on subsequent days. The activity of predators was quantified as a passive activity

141 index (PAI) according to the method of (Engeman *et al.* 1998):

$$142 \quad PAI = \frac{1}{d} \sum_{j=1}^d \frac{1}{P_j} \sum_{i=1}^{P_j} X_{ij}$$

143 where the X_{ij} value represents the number of passive plot tracks by an observed species at the

144 i th plot on the j th day; d is the number of days of inspection, and P_j is the number of plots

145 contributing data on the j th day. PAI was calculated for weekly intervals throughout the study.

146

147 Results

148 Nest monitoring

149 During the first sea turtle nesting season (5/12/2014 until 4/3/2015), 52 loggerhead turtle nests
 150 were monitored and 57.7% of these nests were predated by goannas as indicated by burrows
 151 constructed into the nest egg chamber. During the second nesting season (7/12/2015 until
 152 28/2/2015), 46 nests were monitored and 17.4% of these nests were predated by goannas. No
 153 fox or other predators were observed to raid turtle nest in either season. During the 2014-2015
 154 nesting season, 520 goanna nest visits as evidenced by their tracks were recorded, with a daily
 155 visitation rate of 26.8%. Three hundred and forty-three nest visitation events were recorded in
 156 the 2014-2015 nesting season, with a daily visitation rate of 14.1%. No tracks of foxes or wild
 157 dogs were recorded on the nests in either nesting seasons.

158

159 Camera traps

160 Images from camera traps showed that goannas were the only predators to visit monitored
 161 nests during the study period, no images of foxes or wild dogs were recorded. All of the
 162 monitored nests had at least one image of a goanna visit during the deployment period, with 55
 163 nest visitation events being recorded in the 2014-2015 nesting season, and an overall daily
 164 camera trap visitation rate of 18.3%. Forty-seven (85.5%) of these visitation events were made
 165 by yellow-spotted goannas (*Varanus panoptes*) and only 8 (14.5%) were made by lace monitors
 166 (*Varanus varius*). Despite all camera traps being deployed by 20 December 2014, only two
 167 goannas appeared at nests in December 2014, but activity at nests increased sharply from the
 168 beginning of January 2015 (Fig. 2a). Eggs were seen to be consumed on 17 occasions (14

169 yellow-spotted goannas, 3 lace monitors). Yellow-spotted goannas were seen to open a nest for
 170 the first time on 17 occasions, but lace monitors were only ever seen to visit nests that had
 171 already been opened. In the 2015-2016 nesting season, no images of foxes or wild dogs were
 172 recorded. One hundred and seven goanna nest visiting events were captured, with a daily
 173 camera trap visitation rate of 11.9%. Camera traps captured 87 yellow-spotted goanna (81.3%)
 174 and 20 lace monitor (18.7%) events (Fig. 2b). Eggs were seen to be predated by yellow-spotted
 175 goanna on 6 occasions. No lace monitor was seen to consume eggs during this season. In both
 176 seasons, large adult yellow-spotted goannas were seen to open turtle nests, but no images of
 177 yellow-spotted goanna hatchling or sub-adults visiting turtle nests were recorded. Hence, adult
 178 yellow-spotted goannas were the most common visitors to sea turtle nests in both seasons. The
 179 visitation events of each monitored nest are listed in Table 1.

180

181 Goannas visited nests at any time of the day between 8:00 and 18:00 (Fig. 2). An entire nest
 182 opening sequence was recorded on 23-01-2015. A large yellow-spotted goanna first began
 183 digging at 2:12 pm (Fig 3a). It reached the egg chamber and consumed the first egg at 2:28 pm
 184 after 16 minutes of continuous digging activity (Fig 3b). Turtle eggs were swallowed intact one
 185 at a time by the goanna rather than being opened and having their contents licked out (Fig 3c).
 186 This goanna stopped feeding and left the nest at 4:56 pm after almost 2.5 hours of feeding and
 187 consuming approximately eight eggs.

188

189 Passive soil plots

Monitored soil plots revealed tracks of two potential egg predators, goannas (lace monitors and yellow-spotted goannas combined as it was not possible to distinguish between the two species on the basis of their tracks alone) and red fox (*Vulpes vulpes*). Only a few dog tracks were identified in soil plots during the course of the study. However, these dog tracks were most likely made by pet dogs accompanying tourists visiting the beach, and so have been excluded from analysis.

In both the 2014 - 2015 and 2015 - 2016 nesting seasons goanna activity was approximately eight times greater than fox activity (2014-2015 goanna PAI 0.31 ± 0.03 (mean $\pm$ SE), fox PAI 0.04 ± 0.01 ; 2015-2016 goanna PAI 0.16 ± 0.01 , fox 0.02 ± 0.01). During the 2014-2015 season, goanna activity on the dune front remained relatively constant throughout the season (Fig. 4). Fox activity was generally much lower than goanna activity from December through January, but there was a conspicuous increase in fox activity in February (Fig. 4). In the 2015-2016 nesting season, goanna activity was relatively low in December, increased during January and February and decreased again at the end of February and was lowest in April at a time when most sea turtle nests had hatched. Fox activity remained low and relatively constant throughout the entire season (Fig. 4). Goanna activity was twice as great during the 2014-2015 sea turtle nesting season compared to the 2015-2016 season (Fig.4).

Discussion

Nest predation potentially decreases the recruitment of hatchlings and has become an

important challenge for the conservation of egg-laying reptiles (Leighton *et al.* 2010). Hence, understanding the activity of predators adjacent to endangered reptilian species breeding aggregations is important for designing conservation strategies. The deployment of passive sand plot and camera traps allowed us to continuously monitor nest predators activities adjacent to a loggerhead turtle nesting beach. There were two significant results from the study that provide new insights into goanna predation of sea turtle nests. First, camera trap data indicated that yellow-spotted goannas are the most frequent visitors and predators of sea turtle nests at Wreck Rock beach suggesting they are the main cause of nest predation. Second, the nest predation rate and activity of goannas on the nesting dune varied by a factor of two between the two seasons that we studied.

Predator activities at nests

In the current study, camera traps allowed us to explore the loggerhead turtle nest predator species, predation time and behavior of predators while at nests. Yellow-spotted goannas were the most frequent visitors and predators of sea turtle nests in this study. Large adult yellow-spotted goannas have the ability to dig up sea turtle nests and swallow turtle eggs intact, suggesting future management strategies should be targeted at these individuals. Indeed, no lace monitors were observed to open sea turtle nests directly, they were only observed predating nests that had already been opened by yellow-spotted goannas. Hence, lace monitors appear to be opportunistic nest predators on this beach. Lace monitors are frequently arboreal and are equipped with long, recurved claws that facilitate climbing (Cogger 1993).



232 Such claws are not particularly useful for digging, therefore this species may not have the ability
 233 to dig up sea turtle nests. Anecdotal observations made while regularly walking the beach also
 234 suggest that lace monitors use the beach area less frequently than yellow-spotted goannas,
 235 because yellow-spotted goannas were regularly seen on or adjacent to beach dunes, but lace
 236 monitors were rarely seen. Using GPS tracking methodology, Lei & Booth (2015) reported
 237 yellow-spotted goannas use the beach more than lace monitors and are therefore more likely
 238 to predate sea turtle nests than lace monitors. Hence, it appears that yellow-spotted goannas,
 239 in particular the large male individuals that open up nests, make the nest available for
 240 predation by opportunistic lace monitors. Moreover, camera traps did not record foxes at nests,
 241 and no fox tracks were observed over nests during this study indicating that the fox baiting
 242 program deployed by park managers is currently effective at inhibiting fox predation of sea
 243 turtle nests at Wreck Rock beach.

244

245 Doody *et al.* (2014, 2015) reported that yellow-spotted goannas can dig warren complexes that
 246 required removal of sand from up to 3 m deep, and that both males and females contribute to
 247 warren excavation. Hence, the job of digging into a sea turtle nest which is combatively shallow
 248 (40 - 80 cm), should be relatively easy as evidenced by it requiring only 16 minutes of digging to
 249 gain access to eggs in one of our monitored nests. Our camera trap photos indicated yellow-
 250 spotted goannas normally dug into the nest at an angle from one side of the nest to reach the
 251 nest chamber rather than digging a hole vertically downwards from directly above the nest.
 252 This is probably an instinctive way to dig, because burrow construction by this species in the

area well behind the dunes are always at an oblique angle to the surface and never vertical

(pres. obs.). This digging behaviour may save on the amount of sand needed to be removed in

order to access eggs in newly constructed nests because the relatively loose sand covering a

newly constructed nest tends to collapse inward during vertical shaft construction. Hence,

when covering a nest with mesh as a management strategy used to deter nest predation, the

mesh must be relatively large in area (at least 1 x 1 m) to prevent yellow-spotted goanna

burrowing into the nest (Lei & Booth 2017 Unpublished data). Turtle nest predation rate is

highly dependent on cues left by the female turtle (e.g. visual, tactile, and olfactory) and many

predators have the ability to detect these cues (Vander Wall 1998, 2000; Geluso 2005; Leighton

et al. 2009). Goannas use their forked tongue to transfer olfactory cues to the specialised

chemosensory Jacobson's organ and so are adept at using olfactory cues to find prey (Blair

& Guinea 1998; King & Green 1999; Vincent & Wilson 1999). In addition, goannas are skilled at

memorizing prey cues and searching images of prey which enhance their foraging strategies

(King & Green 1999). We found that once a turtle nest was opened, this nest was continually

predated over subsequent days by multiple yellow-spotted goannas.

Predator activity

Based on the PAI analysis of passive soil plot data, the activity of goannas was higher than foxes,

suggesting goannas are the main predator of sea turtle nests at Wreck Rock beach, a conclusion

also supported by nest track and camera trap data. We found that all of our monitored nests

were visited by goannas, and that between 17% (2015-2016) and 58 % (2014-2015) of nests

274 were opened by yellow-spotted goannas, and goanna predation of nests had previously been
 275 reported as greater than 50% at this beach (McLachlan *et al.* 2015). The question remains if
 276 goanna predation of sea turtle nests was this high at Wreck Rock beach during pre-European
 277 settlement times, or if perturbations have occurred leading to unnaturally high nest predation
 278 in relatively recent times. During the 1970's, 1980's and 1990's goanna predation of sea turtle
 279 nests at this location was not detected, but fox predation of nests was high, 90% of nests being
 280 predated in the 1970's and up until 1987 (Limpus 2008). From 1987 onwards, a fox baiting
 281 program reduced fox predation on sea turtle nests to negligible levels (Limpus 2008). Goanna
 282 predation of sea turtle nests was first reported in the 2003-2004 nesting season when two
 283 nests were predated (Limpus 2008), and since then goanna predation of sea turtle nests has
 284 increased so that over 50% of sea turtle nests are being attacked by goannas (McLachlan *et al.*
 285 2015). Hence, the reduction in red fox numbers may have also resulted in an increased
 286 recruitment of yellow-spotted goannas (because red foxes probably also predated yellow-
 287 spotted goanna nests) to historically high levels. However, before European settlement and the
 288 introduction of foxes, hunting of goannas by native people may have kept the density of
 289 goannas on the frontal dunes at a low level.

290

291 Goanna activity in 2014-2015 was twice as high compared to the 2015-2016 nesting season, as
 292 was the nest predation rate. This suggests that nest predation is positively correlated with
 293 goanna activity. The fact that Maulany (2012) reported olive ridley turtle nests suffered a 100%
 294 predation rate in a high goanna activity beach (PAI of 1.27 in 2009 and 1.41 in 2010) adjacent to

295 Alas Purwo National Park, Banyuwangi (East Java), Indonesia suggests that goanna activity on
 296 dunes is a good predictor of intensity of goanna predation on sea turtle nests
 297 activity increased at the end of the 2014-2015 nesting season. Typically the park managers
 298 fox bait twice during the sea turtle nesting season, once in early December and again in early
 299 February. In 2014-2015 the February baiting was missed so any new foxes that might have
 300 moved into the beach area may not have been removed by baits, and thus fox activity
 301 increased. However, in the 2015-2016 season, the early February fox baiting proceeded and this
 302 might have kept fox activity to low levels.

303
 304 The predation rate in 2014-2015 was three times higher than in 2015-2016 and it correlated
 305 with an increase in goanna activity on the dune. The nest visitation rate by recording tracks in
 306 2014-2015 was nearly twice that in 2015-2016. In addition, nest visitation rate from camera
 307 traps in 2014-2015 (18.3%) was higher than 2015-2016 (11.8%) nesting season. These results
 308 suggested goanna activity on the dune in 2014-2015 was higher than in 2015-2016. However,
 309 he observed no obvious reason why goanna dune activity and sea turtle nest predation rate
 310 varied remarkably between the two monitored sea turtle nesting seasons.

311

312 Implications for management

313 Lei & Booth (2017 Unpublished data) compared different methods of directly protecting sea
 314 turtle nests against goanna predation, and found deploying the plastic mesh on the top of turtle
 315 nest was the most effective and economic way. Combined with our observations of digging



behaviour of yellow-spotted goanna captured on camera traps, we suggested the size of plastic mesh needs to be at least 1 x 1m to prevent yellow-spotted goannas digging into the nest chamber. In addition, camera trap data indicated turtle nest predation activities happen any time between 6:00 and 17:00, suggesting turtle nest management should be deployed in the early morning following the night that nests are constructed. More management strategies such as temporary removal of large male yellow-spotted goannas or egg relocation should be investigated in the future to counter act the loss of sea turtle nests to yellow-spotted goanna predation.



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Table 1(on next page)

Table of sea turtle nest visitation events

Table 1. The nest visitation events of each monitored nest during 2014-2015 and 2015-2016 nesting seasons.

Table 1. The nest visitation events of each monitored nest during 2014-2015 and

2015-2016 nesting seasons

Nest no.	Monitored days	Visitation events by yellow-spotted goanna	Visitation events by lace monitor
<u>2014-2015</u>			
K77290	25	1	0
QA45120	25	23	4
QA45007	25	4	2
K90312	25	3	0
K77224	25	1	1
QA2361	25	1	1
K34755	25	4	0
T22728	25	1	0
QA45046	25	1	0
K67674	25	2	0
QA45041	25	5	0
K97736	25	1	0
<u>2015-2016</u>			
K17005	30	1	0
K19816	30	14	3
K22153	30	0	1
K22233	30	2	0
K22264	30	1	0
K67576	30	3	2
K71417	30	14	2
K77273	30	1	1
K91832	30	2	0
QA10173	30	3	0
QA2303	30	1	0
QA2308	30	5	0
QA2310	30	4	0
QA2349	30	3	1
QA2356	30	1	0
QA27794	30	1	0
QA30893	30	0	1
QA4159	30	2	0
QA45138	30	1	1
QA45152	30	1	0
QA45154	30	2	0
QA45166	30	2	0
QA45172	30	1	1
QA45178	30	6	0

QA45191	30	1	1
QA45197	30	5	0
QA50213	30	1	0
QA50215	30	1	2
QA50248	30	6	2
QA50257	30	4	0

Figure 1(on next page)

Image of study area

Figure 1. Location of study site, Wreck Rock beach adjacent to Deepwater National Park, Queensland, Australia. Shaded grey area indicates the section of beach monitored in this study. The locations of the loggerhead turtle nests monitored in the study are indicated by diamonds (2014-2015) and triangles (2015-2016).

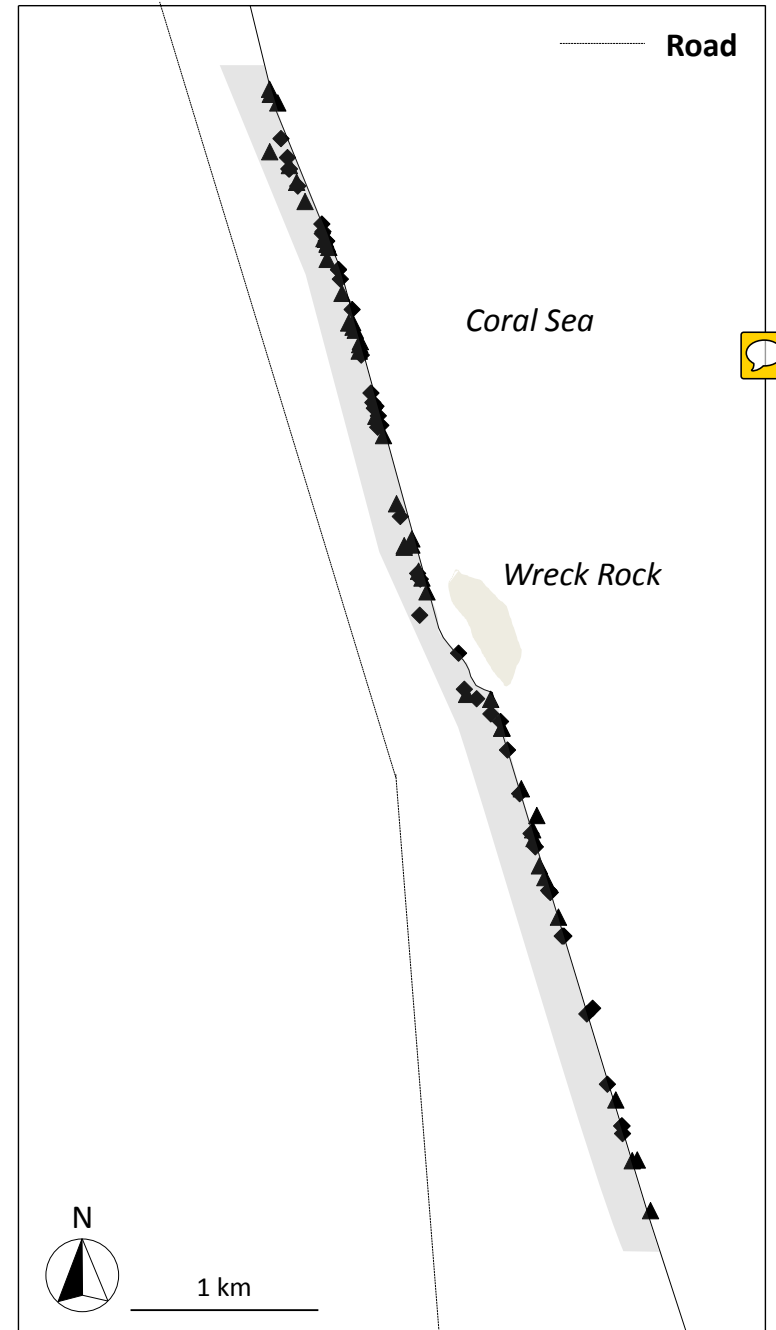
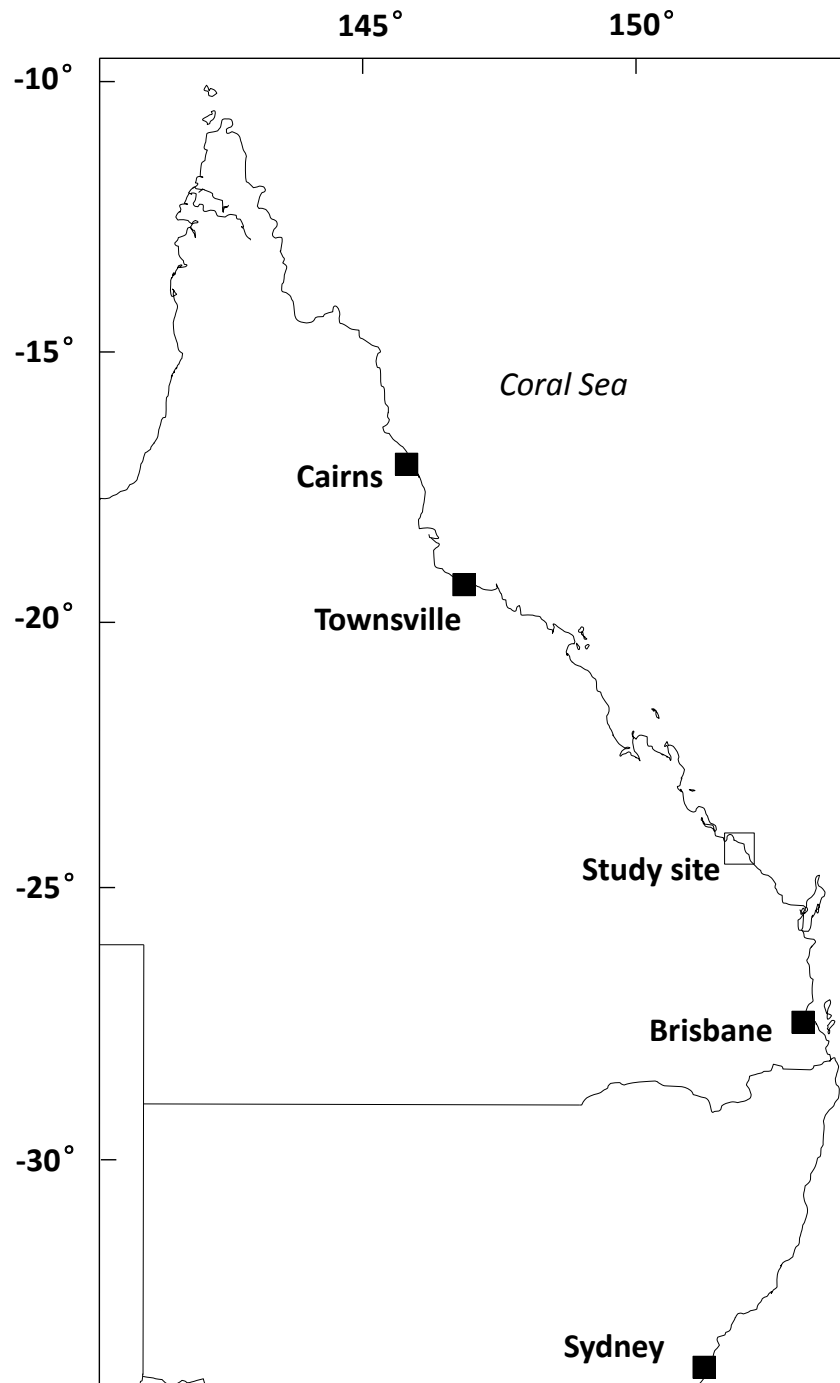


Figure 2 (on next page)

Figure of time and date of goanna appearances at loggerhead turtle nests as determined from camera trap records

Figure 2. Time and date of goanna appearances at loggerhead turtle nests as determined from camera trap records. Triangle symbols = yellow-spotted goannas, Diamond symbols = lace monitors. A. Three hundred camera days (12 cameras set for 25 days each) during the 2014-2015 season. B. Nine hundred camera days (30 cameras set for 30 days each) during the 2015-2016 season.

Time of a Day (h)

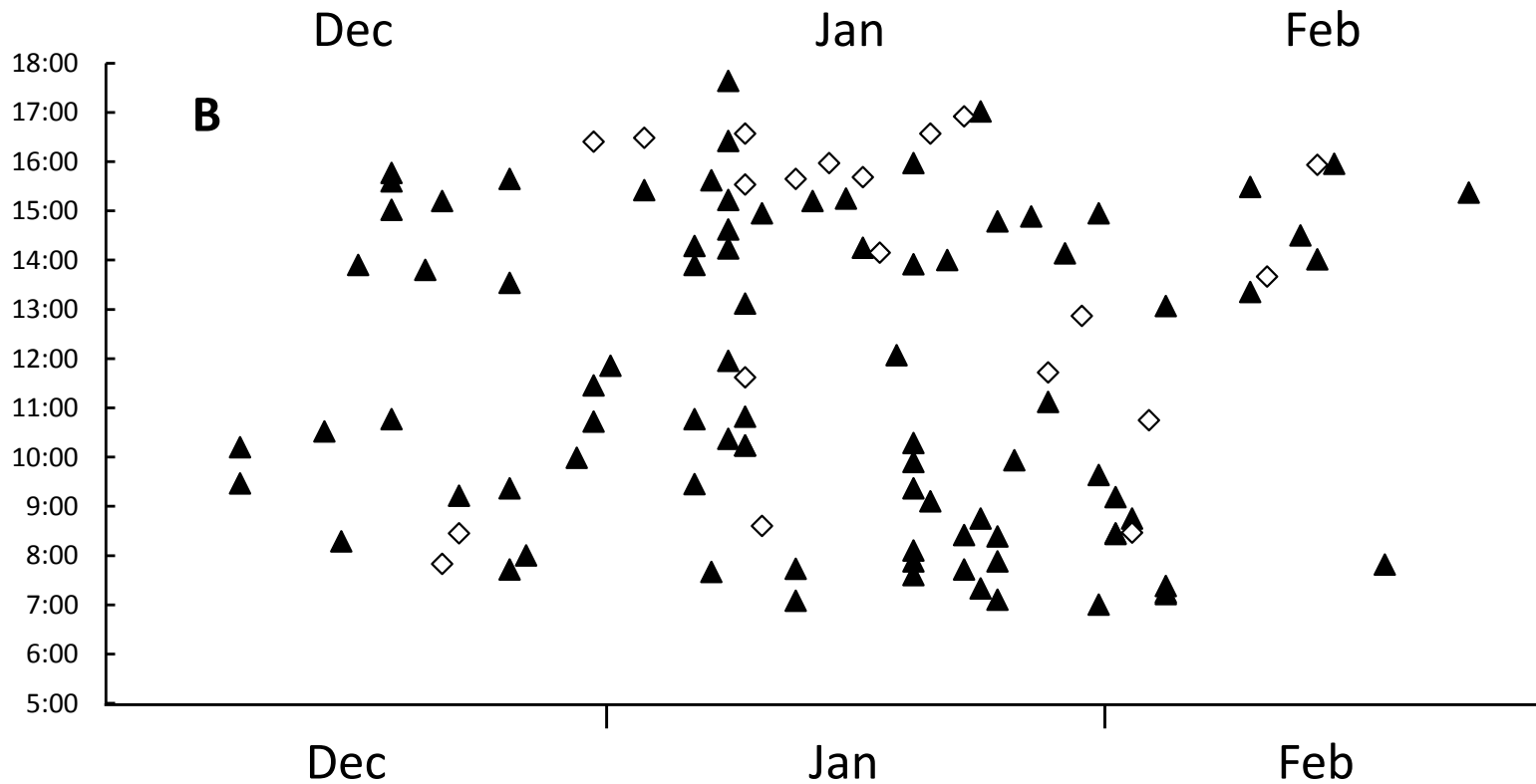
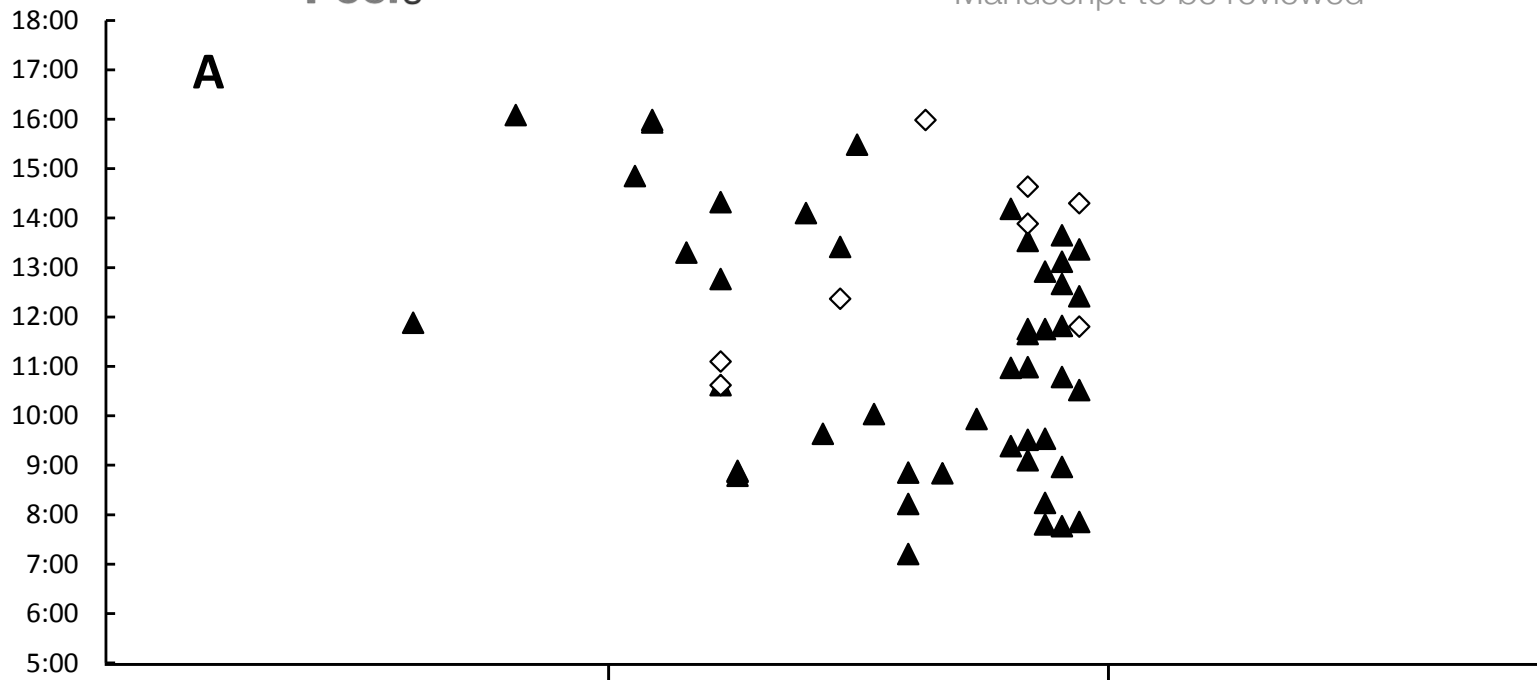


Figure 3

Image of a yellow-spotted goanna predating on a nest

Figure 3. A Yellow-spotted goanna opening and consuming egg from a loggerhead turtle nest on 23-01-2015. Photos were captured by a camera trap. A. Start of digging, B & C, removal and consumption of the first egg. For full sequence, see video in the supplementary information section on line.

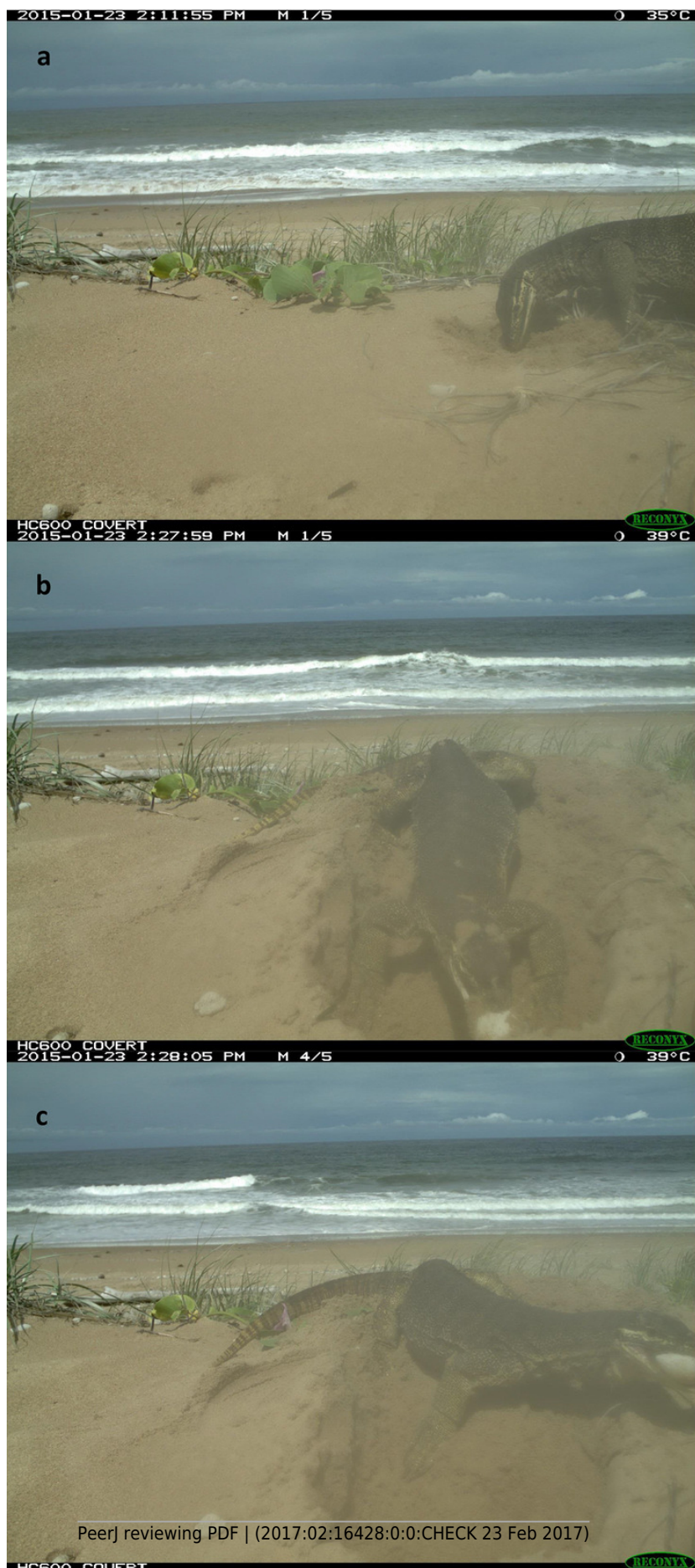


Figure 4(on next page)

A figure of predators' activity on the turtle nesting beach

Figure 4. Nest predator track activity on front dune at Wreck Rock Beach during the 2014-2015 and 2015-2016 nesting season. Solid line= Goanna tracks; Dotted line= Fox tracks.

Passive Activity Index (PAI)

