

Distribution, use and selection of nest type by Komodo Dragons

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Abstract

We report the abundance, patterns of distribution and physical characteristics of Komodo dragon (*Varanus komodoensis*) nests on Komodo Island in Indonesia. A total of 46 Komodo dragon nesting sites were identified, of these 26 nests were considered active for the 2002/2003 season. The distribution of nests coincided with large coastal valleys in northern Komodo Island. There was a significant preference by breeding females to utilize the mound nests (61%) over both open hillside (19.5%) and ground nests (19.5%). Further, within these mound nests, females discriminated for nests based on habitat characteristics, especially sunlight exposure. The main implications for management and conservation drawn from this study is that there is a small number of females nesting annually on the largest island within Komodo National Park. Further, continuation of nesting surveys could provide a cost effective accurate way to gather important long term demographic information on this species.

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1. Introduction

The Komodo dragon (*Varanus komodoensis*), the largest monitor lizard, is currently restricted to five insular and fragmented populations inhabiting islands in the Lesser Sundas region of Eastern Indonesia. Four island populations are located within Komodo National Park. Clearing of coastal tropical deciduous forest, anthropic fire regimes and competition with humans for prey species, such as Timor deer (*Cervus timorensis florensis*), are thought to be threatening processes influencing the viability of historically small dragon populations. Populations that are particularly at threat are those restricted to habitats on western Flores Island, outside the boundaries of Komodo National Park.

Despite being the focus of a great deal of scientific curiosity and subject to an array of studies by western and Indonesian scientists, a paucity of basic information on this species' life-history, demography and much of the general ecology persists (Ouwens, 1912; Auffenberg, 1981; Ciofi, 1999). Such life-history and

ecological information combined with existing management information are crucial for promoting integrated strategies and applied conservation measures for this CITES listed (Appendix 1) species, both inside and outside of Komodo National Park (Ciofi et al., 1999, 2002).

Understanding the basic attributes of female reproductive ecology, such as the size of the annual female nesting population, and the habitat and physical characteristics that influence both distribution and selection of nest sites, are core aspects which are necessary to facilitate informed decisions regarding management and conservation of this species. There have been no systematic, absolute counts or direct estimates of population abundance of Komodo dragons other than the annual census carried out within Komodo National Park since 1993 (Department of Nature Protection and Conservation unpublished reports). These censuses are conducted by park staff at multiple baiting stations and provide only a crude index of trends in population abundance as they can be confounded by methodological inconsistencies and visual sampling biases. (In 2002, 23 adults were observed at 44 baiting sites on Komodo Island and when extrapolated using a simplistic formula produced an estimate of 649 adult Komodo dragons.) From this information, while large scale or catastrophic

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fluctuations would be detected, it would be difficult to assess reliably smaller natural fluctuations in population abundance of Komodo dragons within the National Park, or more importantly, to determine definitively whether there has been a significant gradual change in overall abundance over time.

To find a simple, cost effective way of providing accurate demographic information on this species for the managers of Komodo National Park, we initiated a monitoring program to determine the number of active Komodo dragon nests on the island. This program covered the majority ($\approx 90\%$) of suitable nesting habitat on Komodo Island. Annual female nesting effort, as indicated by active nests, could be an extremely useful indicator to assess both the number of breeding females and, indirectly, the potential for hatchling recruitment into the population. Alternative field measures such as hormone analysis, laparoscopy or ultrasonography (Tucker and Limpus, 1997), while effective for estimating annual female reproductive rate, represent costly options that demand skilled and experienced researchers and additional resources that are not currently available at Komodo National Park.

In this study, we examined four elements of female nesting ecology that had specific application to the conservation and management of this species. First, we undertook extensive surveys of 12 major coastal valleys and adjacent habitats on Komodo Island to ascertain the number of Komodo dragon nesting sites. At present, apart from a small number of nests commonly known to park rangers on Komodo Island, there is no single estimate of the number of breeding sites utilized by female Komodo dragons. According to park rangers, nests are fixed sites that can be used in successive years, so the location of nesting sites, coupled with observations of marked breeding females, could provide an important index for gauging population persistence, interbreeding intervals and female survivorship.

Second, we examined broad scale distribution and density patterns of nests to identify the location of key nesting habitat on Komodo Island. Spatial patterns of nest distribution, ranging from high density focal aggregations to low density or random distributions, could provide important information on resource requirements influencing female choice of nest site and offspring fitness. Further, such patterns are important for management in the advent of anthropic and natural processes which could reduce specific habitats that influence the abundance and distribution of nests.

Third, we wished to ascertain if there is a preference for females to use a particular nest type. Environmental factors within a nest can have a profound effect on phenotypically plastic traits of hatchling reptiles including monitor lizards (Shine and Harlow, 1993; Phillips and Packard, 1994; Elphick and Shine, 1998; Madsen and Shine, 1999). The thermal regimes characteristic of

natural nests have also been found to induce major modifications to the phenotypes of hatchling skinks and to impart a lasting effect on size, shape, locomotor performance and anti-predator tactics (Elphick and Shine, 1998). Significant size variation in hatchling varanid lizards has been recorded as a result of incubation parameters (Phillips and Packard, 1994). While all female Komodo dragons will excavate large conspicuous holes or chambers in the soil into which they oviposit (Auffenberg, 1980), female dragons use three discreet types of site into which they dig their nest: hill-side nests, ground nests, and mound nests initially built by the orange-footed scrub fowl (*Megapodius reinwardt*). This variation in nest site selection may, therefore, have a dramatic influence on offspring fitness in an oviparous reptile such as the Komodo dragon, and the choice of nest site made by female Komodo dragons may have a considerable effect on offspring survivorship (Madsen and Shine, 1999; Shine and Harlow, 1993).

As megapode nests represent pre-existing potential nesting sites for female dragons, we wanted to determine whether there is evidence that a selective process, based on physical characters that could influence the incubation environment, might be occurring when females are selecting a particular nesting site. So our final aim was to determine if nest preferences exist for female Komodo dragons and, if so, to what extent, and how, such preferences could be altered by threats such as habitat alteration.

2. Material and methods

Field work was conducted on Komodo Island ($8^{\circ}35'40''\text{S}$; $119^{\circ}25'51''\text{W}$), the largest island (336 km^2) in Komodo National Park, in Eastern Indonesia, from April through to November 2002. Upon Komodo Island, circum island surveys were conducted in habitats that were considered suitable for nest site location. In particular 12 large valleys, adjacent slopes and coastal flats comprised mostly of open deciduous forest (dry monsoon forest), closed forest or savannah woodland was surveyed (Fig. 1). Apart from one medium sized coastal valley in the south west that was not surveyed for logistic reasons, more than 90% of coastal habitat on Komodo Island was surveyed. We did not survey at higher elevations as good anecdotal evidence from park rangers and a small number of initial montane surveys of 4 days in which no nests were located, suggested that nesting surveys should be restricted to low lying coastal valleys dominated by open deciduous woodland and savannah woodland. Further, the driest habitats that consisted entirely of savanna grassland (the majority of the island surface area) and that were greater than 400 m from the open deciduous forest/grassland ecotone were also excluded from survey

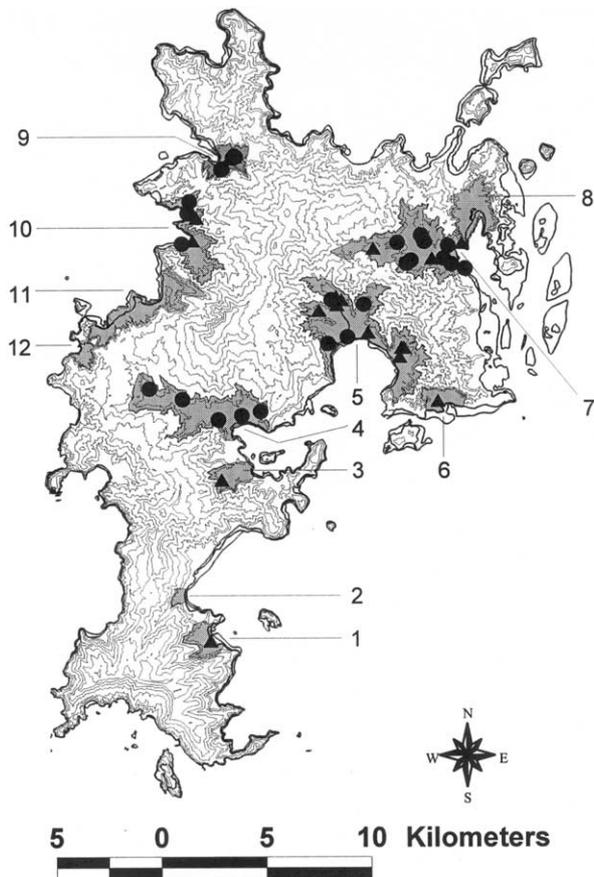


Fig. 1. Topographical map indicating the distribution of Komodo dragon nesting sites on Komodo Island, Komodo National Park, Indonesia. Shaded areas indicate valley area covered in surveys for Komodo dragon nests. Circles indicate active nest sites, triangles indicate inactive nests. Valleys are numbered 1–12 and represent the following locations—(1) Loh Wau, (2) Loh Gong, (3) Loh Pinda, (4) Loh Lawi, (5) Loh Liang/Loh Kubu, (6) Loh B'oh, (7) Loh Sebita, (8) Loh Baes, (9) Loh Boko, (10) Loh Wenci, (11) Loh Srikaya/Sok Pure, (12) Laju Pemali/Seloka. The scale of elevation of contour lines is units of 100 m.

(after conducting several surveys in these areas to determine their suitability for nesting), as such habitats are too exposed and hot for long-term habitat utilization by Komodo dragons.

Field methods used to inventory Komodo dragon nesting sites consisted of intensive focal sampling across consecutive transect grids. This method involved multiple observers (5–8) walking at intervals of approximately 25 m apart along a series of parallel transects marked with projected GPS way points. The length and number of transects in each valley was defined by the prevailing topography of the valley. The purpose of these comprehensive transects was to try and identify all potential Komodo nesting sites and all megapode nests within each valley up to an elevation of ≈ 100 m above sea level. In addition, we frequently climbed to high vantage points in the savanna above the valley woodland, to access and identify hillside nests. Search effort

was comprised of a primary sampling period of between 2 and 9 days per location depending on valley size. Following these primary events, each valley was checked monthly until November to confirm the nest status. Over the course of this study, a total of 67 days were allocated to nest surveys.

Komodo dragons nest were identified by the presence of large chambers up to 2 m long sloping into a nest. These nesting chambers are distinguished from resting chambers (Auffenberg, 1981) by the presence of multiple decoy chambers. Komodo dragon nests were confirmed active by the presence of recent digging activity by females (beginning in August) or by repeated observations of the female in association with the nest (August through November). Inactive Komodo dragon nests were confirmed by the absence of recent digging activity or female guarding the nest throughout the nesting season. These inactive nests were known to be used by Komodo dragons due to observations by park rangers (prior to the current season) of female digging and nest attendance activities or due to changes in structural characteristics, particularly the size and number of chambers in the nest.

The density of active and inactive Komodo dragon nests was analyzed by dividing total nest number for each category by the area searched as calculated by shape polygons using Arcview 3.1. As an index of nest dispersion, the mean nearest neighbor measurement was calculated between valleys as the average distance to the closest neighbor from each active nest in a survey location.

Komodo dragons were observed to use three types of nest and these were categorized as follows:

1. Ground nests—consisting of deep sloping horizontal burrows constructed in the ground.
2. Hill nests—typically consisting of large excavations resulting in one or more tiered platforms across the face of the hill. Into these excavations females would dig an egg chamber alongside a number of decoy chambers. These nests were situated in open savanna grassland which covers most low hillsides.
3. Mound nests—Komodo dragons utilized mound nests constructed by orange-footed scrub fowl. Active scrub fowl mound nests were distinguished from active Komodo dragon mound nests chiefly by the amount of debris and recent diggings that had occurred, particularly during August and September. This was fairly easy to determine as orange-footed scrub fowl nest earlier in the year, with eggs recorded from January until April (Lincoln, 1974), plus megapode nests tend to incorporate vegetative debris into the mound and the chambers into which the birds oviposit (Frith, 1956; Jones et al., 1995).

Once a megapode or Komodo dragon nest was found, data were recorded for a number of

characteristics including location, elevation, adjacent vegetation type, activity status (active or non-active), which species was active (megapode or dragon), direct overhead shade from vegetation (categories of 0–25, 26–50, 51–75, 76–100% shade). In addition, structural characters of each nest were also recorded including length, width, height, and the number and size of chambers built for each nest. *t*-Tests (or rank sum tests in the case of non-normally distributed data) were used to assess whether structural differences between megapode and Komodo dragon nests were significantly different. A combination of statistical tests were used to assess significant differences in categorical and continuous data. For categorical data, chi square tests were used to assess if there were significant differences in the proportion of variables against expected values. Parametric tests, including *t*-tests and ANOVA were used for assessing significant differences between means using continuous data that met the assumptions of normality and homogeneity of variance. Continuous data that did not meet these assumptions were log transformed. Linear and polynomial regressions were also performed to assess significant trends in continuous data. For all statistical tests, significance was inferred at $\alpha < 0.05$.

3. Results

3.1. Abundance and spatial distribution patterns

Across the valleys and coastal flats of Komodo Island, 46 potential Komodo dragon nesting sites were

identified, of these 26 (56%) were active for the 2002/2003 nesting season (Table 1). Komodo dragon nests, including both active and unused nest sites, occurred from 6 to 80 m above sea level, with an average nest elevation of 29.64 ± 2.39 m. The mean elevation of active nests only in each valley ranged from 19.25 to 40.06 m above sea level, with an average elevation of 30.42 ± 2.56 m (Table 1). Active nests were not randomly located with respect to direct overhead shade, rather, there was a significant pattern ($\chi^2 = 9.29$, $P \leq 0.05$) for active nests (62%) to be located in areas of $\leq 25\%$ overhead shade. While nests were typically constructed in areas that contained little direct overhead shade from vegetation, almost all nests were constructed within the mosaic of open deciduous forest with only two (7.6%) being located in savanna grassland, and again these nests were typically not far (< 100 m) from the ecotonal divide between savanna grassland and more complex forest.

Nests were not distributed uniformly across all the valleys and coastal areas surveyed across Komodo Island. Inactive and active nesting sites were located in nine and five of the twelve valleys surveyed, respectively. Active nests were located in the largest valleys within central and northern regions of Komodo Island (Fig. 1). There were significant positive relationships between the valley size and both the total number of nests located (Polynomial regression: $F_{3, 8} = 6.42$, $P = 0.016$; $r^2 = 0.71$) and the number of active nests located (Linear regression: $F_{3, 8} = 11.675$, $P = 0.007$; $r^2 = 0.54$; valley areas ranged from 0.42–13.41 km²; Fig. 2). Moreover, for active nests there appeared to be a lower limit of 3.5 km² of suitable valley area and habitat required, below which females did not utilise valleys in the 2002/2003 nesting season. Even if valleys were above this minimum required area, the presence of unsuitable vegetation

Table 1

Summary data of nest occurrence on Komodo Island with valley location (the bracketed number refers to location in Fig. 1), total number of active and inactive nests (no. nests), number of active nests (no. active nests) mean elevation of active nests, mean distance to the nearest neighbouring nest and the density of nests in each valley

Location	Survey area (km ²)	No. nests	No. active nests	Mean elev. (m) active nests	Mean nearest neighbor distance between nests (km)	Active nest density (nest/km ²)
(1) Loh Wau	2.39	1	0	–	–	–
(2) Loh Gong	0.42	0	0	–	–	–
(3) Loh Pinda	2.52	1	0	–	–	–
(4) Loh Lawi	11.36	5	5	37.42	1.24 ± 0.17	0.44
(5) Loh Liang-Kubu	13.41	13	4	40.06	1.26 ± 0.16	0.29
(6) Loh B'oh	2.04	1	0	–	–	–
(7) Loh Sebita	10.84	12	9	30.69	0.49 ± 0.09	0.83
(8) Loh Baes	3.83	0	0	–	–	–
(9) Loh Boko	3.37	7	5	19.25	0.06 ± 0.01	1.48
(10) Loh Wenci	5.09	5	3	20.00	0.86 ± 0.30	0.59
(11) Loh Srikaya-Sok Pure	5.75	1	0	–	–	–
(12) Laju Pemali-Seloka	1.15	0	0	–	–	–
Total/mean Komodo Island	62.17	46	26	30.42	–	–

habitat types (open savanna woodland/savanna grassland) could preclude use of these areas by females as indicated by valley and coastal areas such as Loh Baes and Loh Srikaya (Fig. 1).

Loh Sebita had the greatest number of active nests ($n=9$), with three to five nests found in each of Loh Liang, Loh Lawi, Loh Boko and Loh Wenci (Table 1). Four additional valleys showed evidence of previous nesting activity by Komodo dragons due to the presence of inactive nests in each valley, including two small valleys located in the south of Komodo Island. Between valleys, the mean nearest neighbor measurement (an index of nest dispersion) differed significantly (one-way ANOVA: $F_{4, 21} = 13.64$, $P < 0.001$) and ranged from 0.06 ± 0.01 to 1.26 ± 0.16 km. Nests in Loh Boko exhibited the least amount of dispersion. Moreover, they were comparatively clustered with respect to nearest neighbor distance (0.06 ± 0.01 km), as nests in this region appeared to be concentrated around a dry river bed. At the other extreme, nests were disparately scattered in two large valleys, Loh Lawi and Loh Liang, where the average nearest nest measurements were 1.24 ± 0.17 and 1.26 ± 0.16 km, respectively. As expected, given the low abundance of nests, densities were also low for each valley and ranged from 0.29 to 1.48 nests/km².

3.2. Preference of nest type

Komodo dragons were found to nest in all three possible nest types on Komodo Island; however there was a significant trend towards females nesting in mound nests ($\chi^2 = 9.29$, $P \leq 0.05$; Fig. 3). Sixteen (62%) of the total 26 nests were mound nests as opposed to only five (19%) each of active hill nests and active ground nests. While Komodo dragons showed a marked

preference for orange-footed scrub fowl nesting mounds as their own nesting site, not all megapode mounds were occupied by Komodo dragons. There was a tendency for female Komodo dragons to use mound nests that had relatively little direct overhead shade ($\chi^2 = 12.00$, $P \leq 0.05$); 62.5% of mound nest were located in the lowest shade category ($\leq 25\%$ direct overhead shade) typically coinciding with open deciduous forest. In contrast, mound nests utilized by scrub fowl were typically more shaded ($\chi^2 = 10.80$, $P \leq 0.05$), with 55% of nests having $> 50\%$ direct overhead shade, and were more often associated with more closed forest.

Female Komodo dragons did not select mound nests based on elevational preferences, as there was no significant elevation difference between dragon mound nests (27.95 ± 3.75 m above sea level) and active scrub fowl nests (32.95 ± 3.10 m above sea level; t -test: $t_{1,34} = 0.31$; $P = 0.32$; Table 2). Mound nest size differed between Komodo dragons and scrub fowl, with Komodo nests significantly longer and wider, with more holes than scrub fowl (Table 2). There was no significant difference in nest height (Table 2).

4. Discussion

4.1. Number of nesting sites

One of the most conspicuous findings of this study was the relatively small number of active nests found across the 12 survey sites that incorporates the majority of suitable nesting habitat on Komodo Island. In total, 26 active nest were located through systematic survey, suggesting that the annual female breeding population is small (or at least it was small in 2002/2003), and in turn, it follows that juvenile recruitment for this nesting

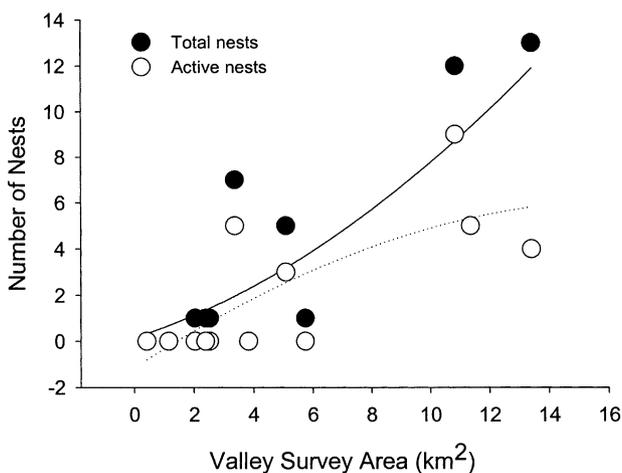


Fig. 2. The relationships between valley survey area and the total number of nests (black circles; solid regression line) and the number of active nests (open circles; broken regression line).

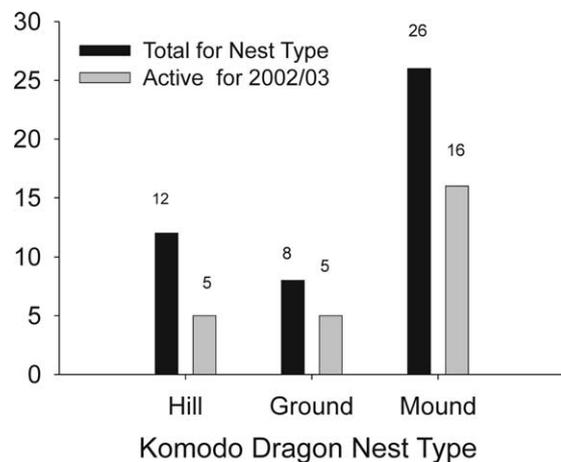


Fig. 3. Histogram of the number of active Komodo dragon nests (grey) and the total number of both active and inactive nests (black) found for each nest type (hill nest, ground nest or mound nest).

Table 2

A comparison of physical and structural properties of active mound nests used by Komodo dragons and orange-footed scrub fowl

Nest characters	Komodo ($X \pm \text{S.E.M.}$)	Megapode ($X \pm \text{S.E.M.}$)	t (T)	p	df	N (K; M)
Length (m)	10.4 \pm 2.0 ^a	7.0 \pm 2.1	4.8	<0.001	34	16; 20
Width (m)	9.6 \pm 1.8 ^a	6.5 \pm 2.1	4.2	<0.001	34	16; 20
Height (m)	0.9 \pm 0.3	0.8 \pm 0.4	1.0	0.32	34	16; 20
No. holes	6.0 \pm 2.2 ^a	2.7 \pm 2.0	4.6	<0.001	34	16; 20
Elevation (m)	27.9 \pm 2.4	32.9 \pm 3.6	1.0	0.32	34	16; 20

^a Mean \pm standard error (S.E.M.) is recorded, with an asterisk denoting significant difference between Komodo dragon (K) and megapode (M) nests.

season would only be comprised of several hundreds of hatchlings at the time of nest emergence (based on 15–36 hatchlings per nest, Horn and Visser, 1997; personal observation). It appears that an index of active nests is a good indicator of assessing annual rates of female reproductive effort, as nests are almost entirely used by solitary females, with only one nest recorded as being used by two females.

At present we do not know if the annual breeding rate is relatively constant or influenced by stochastic environmental factors such as rainfall patterns that could regulate energetic and nutrient flux through this wet-dry tropical ecosystem. Other reptile populations inhabiting climatically and biogeographically analogous wet-dry tropical habitats in northern Australia, undergo marked fluctuations in annual female reproductive rate ranging from 40 to 90% in water pythons (*Liasis fuscus*) and 5–60% in Arafura file snakes (*Acrochordus arafurae*) due to rainfall driven prey dynamics (Shine and Madsen, 1997; Madsen and Shine, 2000). Changes in breeding rate appear to be related to prey abundance in many cases. In water pythons, females respond to years of particularly low food abundance by lowering the body-condition threshold necessary to initiate reproduction, however this may have severe costs for their future survival (Madsen and Shine, 1999). If there is stochastic annual variations in recruitment, the population may never attain a stable age distribution (Houston and Shine, 1994; Madsen and Shine, 2000). Annual rainfall patterns in the Lesser Sundas region, particularly the brief torrential monsoonal rainfall period from December until March during which the vast majority of rainfall occurs, could drive diverse trophic processes influencing food productivity and availability. This, in turn, could mediate demographic processes of prey species, regulating their abundance. Consequently, prey abundance and condition could ultimately drive annual variation in the breeding rate of female Komodo dragons. The additional inactive nesting sites ($N=20$), that consist of previously known and newly identified Komodo dragon nests, supports the notion that there is annual variation in breeding rate of female dragons. Long term longitudinal studies,

coupled with an understanding of climatically regulated prey dynamics, are necessary to determine the amount of variation in annual female breeding rate in this species.

4.2. Spatial distribution

The spatial distribution of nests, especially active nests, appears to be restricted to the central and northern valleys of Komodo Island. This reflects the location of the largest valleys and, presumably, the greatest proportion of the population is concentrated in these areas. Moreover, for active nests there appears to be a threshold valley area of 3.5 km². From our data, the valley area has to be greater than 3.5 km², with appropriate habitat types present, before females use such areas for nesting purposes. In some valleys that were above this minimum required area, the presence of unsuitable xeric tolerant vegetation habitat types (open savanna woodland) precluded the use of these areas by females. This information is important in the design of management plans for this species both inside and outside of the national park, as it suggests that anthropic changes from forest clearing, which lead to decreased habitat, or formation of habitat fragments, could render the habitat matrix unsuitable for nesting by female Komodo dragons. In addition, altered fire regimes, for example deliberate arson for flushing game species, would increase the encroachment of more xeric habitat types at the margin of the ecotone, again reducing the availability of nesting habitat.

Whilst two nesting sites were recorded in southern valleys, they were inactive in the 2002/2003 nesting season. These inactive nests suggest that the number of adult females inhabiting these southern coastal areas is small. Moreover, if females breed less than annually, due to the suspected high energetic costs of reproduction, or because of variation in prey availability, inducing delays in accruing sufficient resources to induce annual reproduction, then these nests may be used only periodically. From a broad perspective there was no spatial evidence to suggest that use of nesting locations by females was structured or determined by focal

habitat requirements given the disparate positioning of nests relative to one another in the largest valleys in the north. Presuming that there were specific habitat regions on Komodo Island that promoted offspring fitness, through the availability of clumped resources including forage or better developmental habitat, we could expect that, like other reptiles, we would see high density areas of nesting activity, even if this required females to undertake a relatively small migration (tens of kilometers) to cross the island to access such resources. The only exceptions to the generally disparate and scattered distributions of nesting sites, was the observation that a small number of nests clustered along a dry river bed in Loh Boko, a small valley in the north and a single mound nest that was used by two females.

Most nests were located in open coastal deciduous forest, typically dominated by trees including tamarind (*Tamarindus indicus*) and kesambi (*Schleicera oleosa*). In comparison with the other three main vegetational communities on this island (closed evergreen forest that occurs mainly in montane areas and alongside major ephemeral creeks; savanna grassland and savanna woodland), open deciduous forest appears to provide the greatest mosaic of habitat requirements necessary for nesting activities of female Komodo dragons.

4.3. Nesting site preference and potential consequences

There was an obvious preference for female dragons to use pre-existing megapode nest sites over both ground nests and hill nests. We suspect that use of this particular nest structure represents a deliberate selection process by females, given that the use of alternative ground or hillside nest sites is not limited by either competition or lack of available habitat. Further, female dragons typically selected megapode nests that on average were significantly more exposed to sunlight. We presume that this selection process provides a more favorable incubation environment for the eggs that require up to 180 days incubation prior to hatching (King and Green, 1999). Studies of other oviparous reptiles have demonstrated the importance of maternal nest site selection in phenotypically plastic life-history traits in offspring (Elphick and Shine, 1998; Madsen and Shine, 1999). The choice of less shaded and presumably hotter nest sites by females may indicate a preference for fast incubation time, perhaps to ensure hatchling emergence coincides with the end of the wet season when insect prey abundance is at its greatest (Madsen and Shine, 1999). As a result of minor divergences in nest-site characteristics in water pythons, Madsen and Shine (1999) found striking differences in survivorship of adults, embryos and hatchlings from nests in hotter, more thermodynamically stable goanna mounds compared to nests found in cooler, more thermally variable hollows within tree root systems. Further

work on offspring survivorship and morphology will allow us to elucidate further the effect of nest site choice on Komodo dragon offspring.

4.4. Implications for conservation and management

In conclusion, it is evident that the size of the annual breeding population of Komodo dragons is relatively small, indicating that annual recruitment of juveniles will consist of perhaps hundreds of individuals. While monitoring the number of nesting females represents an important component of assessing trends in this small island population, it will be particularly important to assess the number of hatchlings produced from nests, as survival in these early life stages may vary considerably as seen in other reptiles, and will thus have a profound effect on the population as a whole (Bjorndal et al., 1999). Instigating a large scale mark recapture program would do much to provide solid demographic data for this species. However, even in the absence of such labor intensive monitoring programs, the capacity to assess annual variation in nesting populations reliably provides the managers of Komodo National Park with one simple strategy for improving their capacity to assess trends in the Komodo dragon population.

These preliminary results are extremely important in directing our future research to determine whether this figure is within the bounds of “normal” for this population and whether it is sufficient to maintain this population. Human encroachment on potential nesting habitat on Komodo Island so far appears to be limited, with a single village on the main island that gains most of its income from fishing, with additional income from selling trinkets to tourists. Wild populations of Komodo dragons may not be subject to threats that plague wild populations of monitors such as collection of *Varanus salvator* for the skin trade (Shine et al., 1996), however other threats such as habitat modification are shared by the majority of monitors in Southeast Asia (King and Green, 1999). Anthropogenic effects have been recorded in the past as causing the extirpation of Komodo dragons from Padar Island. This appears to be as a result of changed fire regimes modifying the habit, as well as poaching of deer, which deprived the larger dragons of an essential food source.

Finally, now that the locations of Komodo dragon nests are identified, annual monitoring of these sites will require relatively little time each year, is fairly inexpensive, and does not require sophisticated equipment or expertise. Hence, this type of monitoring project is well-suited to the funding and technical resources available in Komodo National Park which are typical of developing countries. Continued monitoring of this kind could provide valuable data from which to plan the long-term management of Komodo dragon populations both inside and out of Komodo National Park.

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