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Biawak, 3(1), pp. 9-17

Garbage Appeal: Relative Abundance of Water Monitor Lizards (*Varanus salvator*) Correlates with Presence of Human Food Leftovers on Tinjil Island, Indonesia

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Abstract - Though considered common throughout the majority of its range in Southeast Asia, the water monitor lizard, *Varanus salvator* has been subjected to hunting pressures in response to global demand for leather products made from lizard skin. Previous research has indicated that *V. salvator* has an extremely broad diet and will scavenge food leftovers from residents and tourists in addition to seeking out live prey. Such indiscriminate eating habits and potential tolerance of close human inhabitation may be one key to the maintenance of population levels as *V. salvator* are increasingly forced to adapt to living in close proximity to humans.

On Tinjil Island off the southern coast of West Java, Indonesia, a study was designed to investigate the effects of human presence on *V. salvator* behavior by comparing relative abundance of monitor lizards in areas of human habitation to areas in which humans do not reside or prepare food. In the absence of hunting pressure by humans it was hypothesized that *V. salvator* would be attracted by the possibility of scavenging food leftovers, thus increasing the relative abundance of monitors in inhabited areas where human food preparation was common. The results of the study showed a statistically significant difference ($p<0.0001$, Poisson test) in relative monitor lizard abundance of the two areas, with an average approximate abundance of 4 specimens/km^2 in uninhabited areas (where human food leftovers were not available) as compared to 1400 specimens/km^2 in areas inhabited by people.

Introduction

Indonesia is home to several varanid species (Böhme, 2003) and of these, water monitor lizards (*Varanus salvator* spp.) inhabit numerous islands (Koch et al., 2007). Historically, large lizards such as *Varanus salvator* have been heavily utilized by indigenous people, who have traditionally used lizard meat as a source of food and lizard skins for domestic and ceremonial purposes. For thousands of years such patterns of use have been sustained, due to low human density and little degradation of suitable monitor habitat (Green and King, 1993). In the recent past, however, international demand for lizard skins has increased, reaching a high in 1994 with an estimated 2-3 million varanid lizards killed worldwide (Jenkins and Broad, 1994). Large lizards are caught, killed, and skinned in their country of origin, with the skins exported to other parts of the world as the base material for high-quality leather goods. Due to its relative abundance, large size, and suitable skin, *V. salvator* has been the most heavily exploited lizard species in the international leather trade, with an estimated 600,000 to 1.5 million specimens taken from Indonesia for the leather industry in 1990 alone

(Luxemoore and Groombridge, 1990). With Indonesia's establishment of annual export quotas beginning in 1995, lizard skin exports have appeared to decrease, though records ranged widely with 356,000 to 700,000 skins exported annually from 1993-2001 (TRAFFIC and the IUCN/SSC Wildlife Trade Programme, 2004). Though clearly of less impact with a reported 2,300-6,600 live specimens exported annually during the same time period (TRAFFIC and the IUCN/SSC Wildlife Trade Programme, 2004), live capture of *V. salvator* for food and pet trade is also considered a factor when reviewing overall species activity.

Though shown to have a preference for live prey, *V. salvator* will also opportunistically scavenge human leftovers (Traeholt, 1993; Traeholt, 1994a, b; Auliya, 2003). Such an adaptive shift in eating habits may aid in the maintenance of populations in areas in which traditional *V. salvator* habitat has begun to overlap with human development. However, the allure of garbage combined with a potential lack of concern regarding humans may also subject such *V. salvator* individuals to an easy capture, leading to heavy harvesting of local populations.

Tinjil Island, located off the southern coast of West Java, Indonesia (Fig. 1), has a *V. salvator* population that has been casually observed for many years, though no scientific work has been done on the island's population (R. Kyes, pers. comm.). Since 1987, Tinjil Island has been designated as a natural habitat breeding facility for long-tailed macaques (*Macaca fascicularis*) (Kyes, 1993), and has had limited accessibility to humans. *Varanus salvator* appears to be the only varanid species living on Tinjil Island. In addition, the island's *V. salvator* population has no known natural predators as in most areas of its range, and has not been subjected to human hunting pressures. As such, Tinjil Island lends itself well to the study of relatively undisturbed *V. salvator* populations that have had potentially regular yet limited contact with humans.

The purpose of this study was to compare relative abundances of monitors in two types of areas. Monitor abundance in areas of human habitation where food leftovers were often available was compared to monitor abundance in areas where human activity was not associated with food to evaluate the effect of human presence on lizard location and behavior. As it has been shown that monitors will scavenge food if available in the form of human leftovers (Auliya, 2003) it was predicted that the concentration of monitors would be higher in areas of human settlements, due to the presence of food

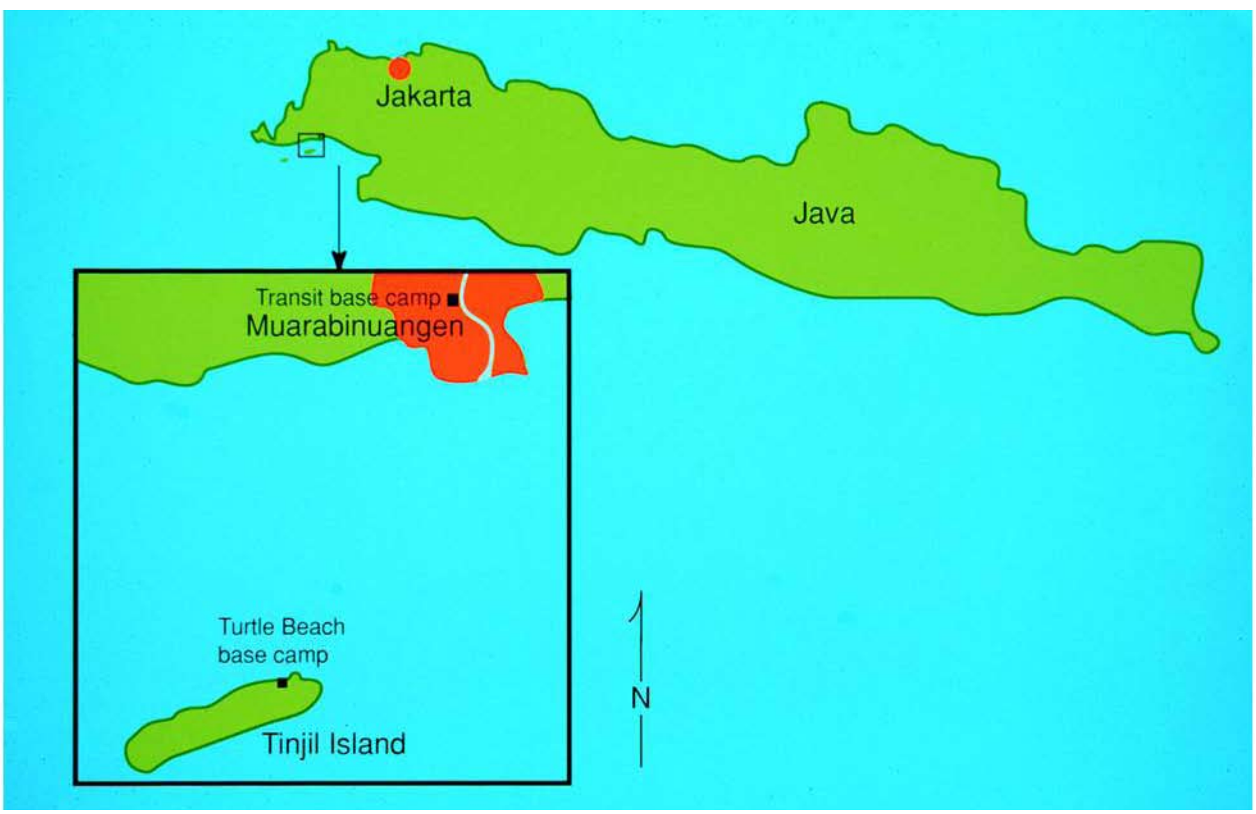

Fig. 1. Location of Tinjil Island off the southern coast of West Java, Indonesia.

or possible association between humans and food in the form of leftovers or garbage.

Methods

The study was conducted on Tinjil Island, located approximately 16 km off the south coast of West Java, Indonesia (Fig. 1). The island consists primarily of lowland, secondary tropical rain forest and coastal vegetation. Tinjil is approximately 1 km wide (north-south), and 6 km long (east-west), with a total area of approximately 600 hectares.

Multiple transects have been cleared on the island to facilitate regular surveys of the island's *M. fascicularis* population; three east-west, and nine north-south (Fig. 2). Turtle Beach base camp, located on the northeast edge of the island, is the largest camp on the island and is the only area where there are permanent facilities. There are no permanent residents on Tinjil Island, though the island is staffed year-round by a few caretakers of who rotate off and on from the mainland of Java. In addition to Base Camp, there are three additional areas that are typically inhabited by local fishermen, spaced along the northern edge of the Island. These three camps are referred to as fisherman camps #1, #2, and #3. The fisherman camps are smaller scale camps with primitive huts and no modern facilities. Fishermen who utilize the camps are typically based on the main land of Java, but use the camps for days at a time when fishing off the coast of Tinjil Island. Cooking and food handling by humans were common occurrences in both Base Camp and the fisherman camp areas throughout the course of the study.

Varanus salvator abundance in areas of human habitation (where food leftovers were present) and uninhabited areas (where there were no human food leftovers) of Tinjil Island were estimated by sampling along both the preexisting line transects and around the base camp and fisherman camps. Sampling took place from 28 August 2008 to 10 September 2008, with observations and data collection done primarily between the morning and early afternoon (ca. 0645-1200 h) every day, rotating between the CD and SA transects, and counts of the fisherman and base camp populations. Transects CD (running the full length of the island east to west) and SA (running the full width of the island north-south) represent locations that were not commonly frequented by people, while base camp (bc) and fisherman camps (fc) #1, #2, and #3 are representative of areas often inhabited by people. Line transect sampling was conducted by walking along the transects at a rate of approximately 2-2.5 km per hour. The distance from transect to monitor lizard was measured for each animal sighted. Fisherman camp counts were taken by conducting a modified point

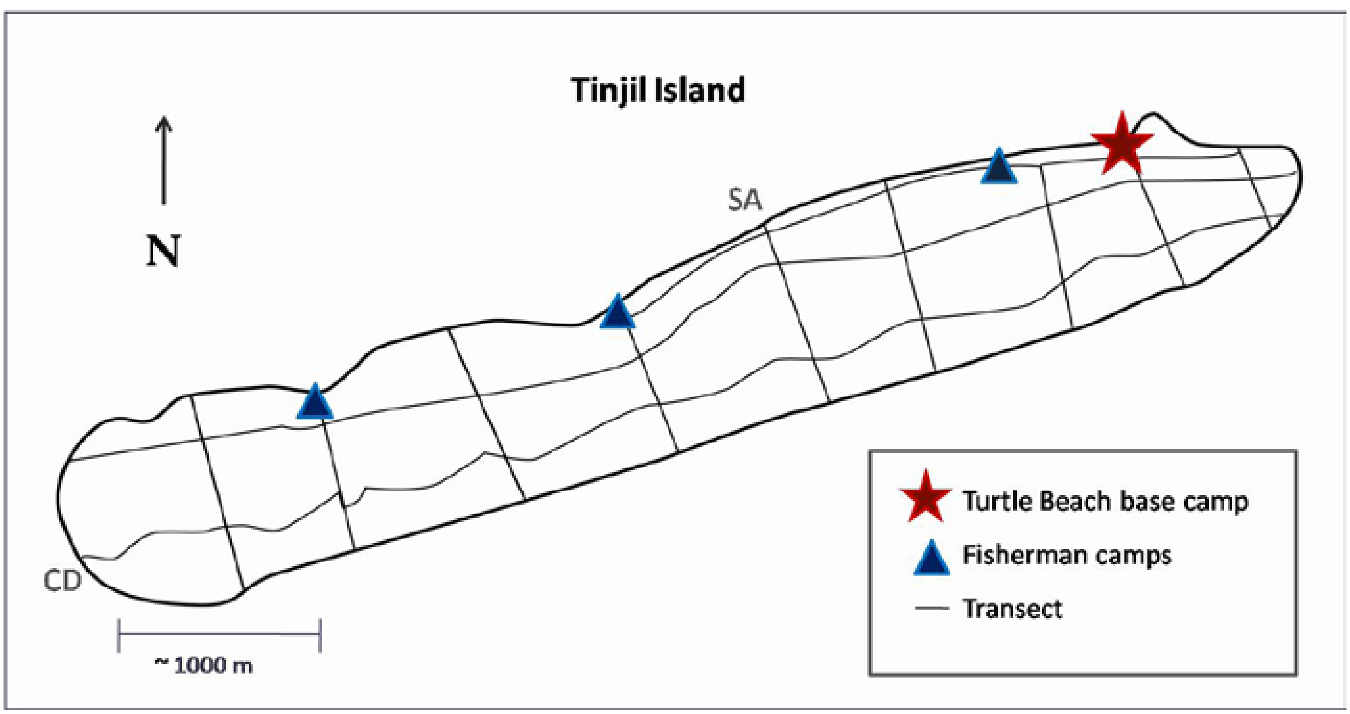

Fig. 2. Tinjil Island transects and location of fisherman camps.

count from the center of each camp. Sampling was accomplished by walking a radius of 5 m from the center of camp (Fig. 3) at a rate of approximately 2-2.5 km per hour. Fisherman camps consisted of 3-5 small huts, were bordered by forest on one side and the ocean on the other, and were clearly delineated sandy areas in which monitor lizards were readily visible.

Time of contact, location on transect (utilizing location markers which are placed every 25 m along the transect), compass direction from the transect and basic behavior of the animal (i.e. moving, basking,) were recorded.

Basic sampling schedule:

Day 1: transect CD
Day 2: point count base camp and fisherman areas #1- #3
Day 3: transect SA
Day 4: observation / rest

Monitor abundance was determined based on a calculation of number of animals seen, divided by the area covered by transect and fisherman camp area counts. Transect sample areas were calculated based on a strip width of 5 m, since sampling was carried out 2.5 m on each side of the transect line. A strip width of 5 m was selected due to the trail itself being 2-3 m in width with the immediate areas on either side of the trail being relatively clear. Total transect area sampled was equal to 5 m multiplied by the length of the transect which in the case of CD was 7 km, and in the case of SA was 1 km. The sampled base camp (bc) area was based on a radius (r) of 20 m, with the sampled area = πr^2. Likewise, the areas of the fisherman camp (fc) counts were based on a radius of 15 m.

Estimated abundance of monitors in uninhabited areas was calculated by combining raw data from all counts of CD and SA transects, while monitor abundance in inhabited areas was estimated by combining counts of base camp and fisherman camps. Poisson distributions were used to compare the two estimates for statistical significance ($p<0.05$).

Results

Raw data on transect and camp sampling are presented in Table 1. Transect CD was sampled 6 times, and SA sampled 5 times to gather information on presence of *V. salvator* in areas of Tinjil Island with low human activity (and no human food leftovers). During the course of these samples, only one individual was observed. The individual was an adult *V. salvator* which was directly on the trail and flushed upon human approach. The base camp was sampled 15 times for a total of 45 sightings, and fisherman camps #1, #2, and #3 were sampled

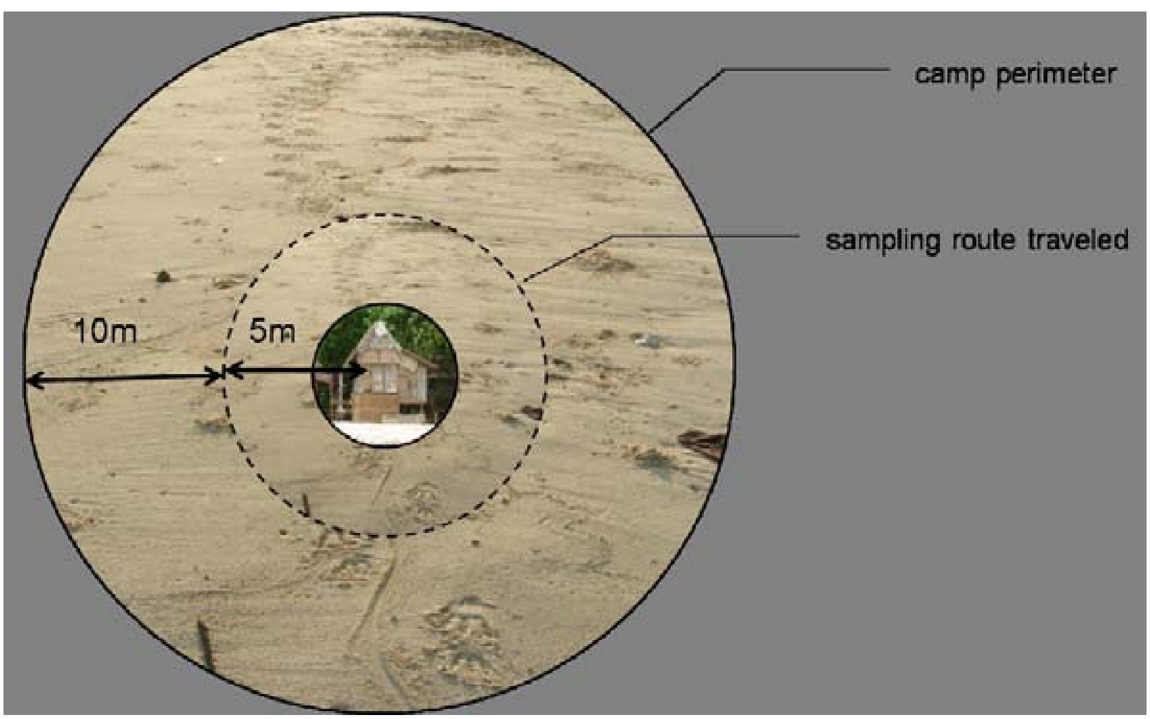

Fig. 3. Sampling area of fisherman camps.

Table 1. Transect and camp sampling.
A=adult, sA=subadult, J=juvenile, tl=total number of sightings
*approximate abundance in specimens/km^2

Sampling Location	Area (km^2)	# of Samples	Total Area Sampled (km^2)	# of Sightings	Abundance
CD	0.0350	6	0.2100	0	0
SA	0.0050	5	0.0250	1A	40
CD+SA			**0.0235**	**1A**	**4**
bc	0.0013	15	0.0190	32A, 8sA, 5J = 45 tl	2400
fc1	0.0007	12	0.0084	1A, 1J = 2 tl	200
fc2	0.0007	10	0.0070	1A, 2sA, 2J = 5tl	700
fc3	0.0007	8	0.0056	1A, 3sA. 1J = 5 tl	900
fc1 + fc2 + fc3			**0.0210**	**12**	**600**
bc + fc1,fc2, fc3			**0.0400**	**57**	**1400**

12, 10, and 8 times respectively for a combined total of 12 sightings. Total length of individuals observed throughout the course of the study ranged from 80 cm to approximately 2 m.

Estimated monitor abundance in uninhabited areas CD and SA combined was calculated at approximately 4 specimens per square kilometer, while an abundance estimate of the fisherman camp areas combined with base camp yielded a statistically significant difference of approximately 1400 animals per square kilometer (Poisson test, $p<0.0001$). Due to the comparatively high concentration of individuals in base camp (2400 specimens/km^2), combined fisherman camp density (nearing 600 specimens/km^2) not including base camp figures was compared to that of uninhabited areas (4 specimens/km^2) and was also shown to be statistically significant. Estimated monitor abundances in each area sampled are shown in Fig. 4.

Discussion

Tinjil Island

It became clear through the course of observation that *V. salvator* individuals were attracted by the potential for leftover food, particularly at the base camp area. At the base camp area a specific garbage dumping area existed in the form of an uncovered large dirt depression. This "garbage hole" was often occupied by individuals during sampling sessions, and many *V. salvator* were casually observed searching the hole for food on different occasions and at other times of the

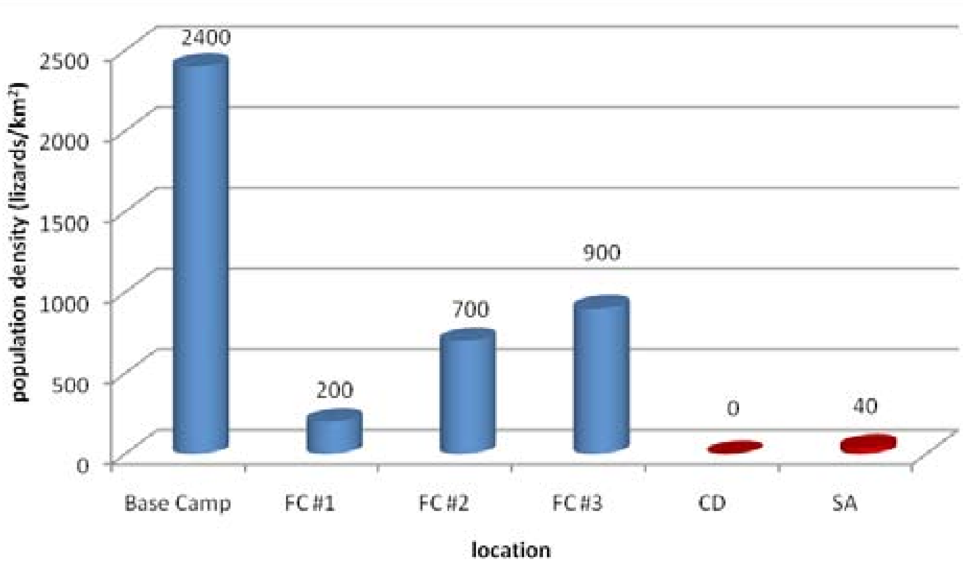

Fig. 4. Estimated relative monitor abundance in camps (blue) and transects (red).

Fig. 5. Subadult *Varanus salvator* at the “garbage hole”.

day. Each morning as soon as the sun rose (ca. 0545 h) up to 5 adult *V. salvator* were observed vying for the chance to search or eat at the center of the garbage hole (Fig. 5). Early morning temperatures on Tinjil Island in August and September were relatively warm, averaging around 25°-28° C, and *V. salvator* have been reported to be active at lower average temperatures relative to other monitor species such as *V. komodoensis* (Traeholt, 1995; De Lisle, 2007).

By the time this study was conducted, a daily 0600 h dumping of food scraps at the garbage hole had been established by the base camp cooks. Due to their highly developed sense of olfaction the monitors were attracted to the smell of food once it had been dumped. Interestingly, however, animals were observed searching for food at the garbage hole in the early morning even when the regular schedule of dumping food was halted. This occurred when observation of the religious holiday Ramadan began approximately mid-way through the course of the study. Due to the month-long fasting associated with Ramadan, cooks departed from the usual schedule of food preparation and as a result did not dump food scraps in the early morning as was typical in other times of the year. Despite the change in schedule, monitors continued to arrive at the garbage hole at daybreak. Though on a smaller scale and less regular schedule, fisherman camps also provided potential leftovers for scavenging, as fisherman often gutted or cleaned their fish around camp, as well as frequently cooking over an open fire. Monitors sighted at fisherman camps were sometimes observed in the “investigative search” behavior described by Traeholt (1993), which was characterized by regular tongue flicks combined with lateral head movements and slow forward speed.

Tinjil Island’s monitors have likely been conditioned to associate people with food in areas where human leftovers are commonly encountered, and to expect food scraps to be available at certain places and times. Such conditioning could have led to regular visits to the garbage hole in the early morning due to the base camp cooks’ daily schedule of food scrap dumping. If such conditioning had in fact occurred, it was also irregularly reinforced by the unscheduled dumping of additional food scraps throughout the day, as well as by the potential for discovering incidental bits of food and garbage left around in other areas of the base camp.

Though scheduled sampling attempts on CD and SA transects yielded only a single sighting, additional monitors were encountered incidentally in other areas of the island and throughout the course of the study, suggesting that an estimate of 4 specimens/ km^2 in uninhabited areas may have been excessively low. While it is possible and even likely that monitor abundance along CD and SA transects is significantly lower than other areas of the island, several factors may have led to counts that are not fully representative of the study population. Juveniles for example, due to intraspecific competition and possible cannibalism around the garbage hole, where the largest adult present aggressively defended the food source, are more likely to be difficult to spot and may be found predominantly in trees, potentially leading to inaccurate counts. Monitors sighted incidentally while walking or while sampling transects were typically spotted when flushed from what were most likely basking or resting positions, and were never observed in the “investigative search” behavior. While monitors in the base camp or fisherman camp areas were often moving and highly visible in open areas, specimens resting or lying inactive in areas not immediate to the transects may have been more likely to remain inactive, and potentially unseen. A 5 m transect strip width used for calculating population density was conservative, as typical behavior of monitors spotted within and beyond this range was a characteristically noisy and obvious flushing. However, a tendency to lie beneath the leaf litter when resting should also be noted as a behavior which could potentially make less easily frightened monitors difficult to spot when sampling on the transects. It is also possible that in response to human approach, animals on the transects were simply flushing or moving away from the sampling area before researchers were able to detect their presence. It is also important to consider the possibility that multiple factors may have led to excessively high estimations of monitor lizard density in areas of human activity such as the garbage hole. Monitors were not marked or identified individually, and were likely counted numerous times over multiple samplings of these areas as a result. Scaling the original, small effective sample areas to kilometers squared, along with using a total estimate of sightings rather than a mean estimate of sightings at each site also potentially contributed to a likely overestimation of monitor abundance in the base camp and fisherman camp areas. Due to limitations of the study methods, emphasis should be placed on results regarding the relative abundances of animals observed rather than interpreting the estimated values of abundance as an absolute population estimate of Tinjil Island's total monitor lizard numbers.

Tinjil Island's *V. salvator* population has no known predators and is not subjected to harvesting by humans. At 16 kilometers away from the main island of Java, Tinjil's population is essentially isolated. When observed in areas of human habitation, monitors did not appear threatened by humans, did not aggressively approach them, and seemed relatively unconcerned by regular human activity, infrequently fleeing and more often slowly avoiding direct contact. However, when observed in areas uninhabited by humans, monitors seemed more likely to flush abruptly and to frantically flee greater distances.

Reported *V. salvator* home ranges have varied from 15-150 ha depending on population location and source (Gaulke et al., 1999; Auliya, 2003). With a total area of 600 hectares, it is possible that Tinjil Island supports several *V. salvator* populations with different home ranges. If so, monitors with home ranges encompassing areas lacking regular human presence may not be habituated to human activity. As a result, such individuals may react differently upon encountering humans than those who have become accustomed to functioning around human activity. It is also possible that monitors do in fact have large home ranges that overlap inhabited as well as uninhabited areas, but that expectations regarding presence or absence of human activity result in a variety of reactions depending on the location of the monitor-human encounter.

Fig. 6. Adult specimen of *V. salvator* on Tinjil Island..

Implications for future study

This study has shown that monitor lizards will eat human leftovers and are not necessarily deterred by human presence. As human populations continue to grow, the trend will likely continue. It has already been suggested that such a tendency for monitors to be drawn closer to humans may leave financially prized *V. salvator* individuals vulnerable to capture, which could further result in extinction of local populations. In some instances monitors have appeared on average to be larger and more robust in some areas of incidental human supplementation (Auliya, 2003), demonstrating that an adaptation to coexistence with humans could be beneficial to monitor populations. Conversely, on many of the Philippine islands for example, human presence has resulted in water monitor populations retreating to areas with less profitable but natural food resources (Gaulke, 1991).

Sustainability of V. salvator populations

Habitat loss and harvesting due to global demand are both factors which affect monitor lizard population trends. However, accurately assessing the effects of factors such as hunting or deforestation on *V. salvator* populations is an understandably difficult undertaking. Though long term sustainability of *V. salvator* is certainly an issue of concern, current populations are difficult to estimate, and lack of adequate data has led to international agencies' differing interpretations of the severity of the situation. While *V. salvator* has been listed under CITES Appendix II since 1975, it is not correspondingly listed on the current 2008 version of the IUCN Red List. Admittedly, there have not been clear signs of population decline despite periods of intense harvesting of wild populations, leading many to believe that strict regulation may not be necessary. Additionally, many Indonesian communities have an economic reliance on *V. salvator* as a renewable natural resource, which may lead to a reluctance of government agencies to limit the harvesting of a species which is not visibly threatened or decreasing in numbers (Saputra, 1998; Soehartono and Mardiastuti, 2002).

Indonesia has come under international scrutiny due to concerns regarding the sustainability of such a high volume of skin trade, and has responded by reducing domestic export quotas in 1994, and conducting workshops such as the 1996 'Conservation, Trade and Sustainable Use of Lizards and Snakes in Indonesia' (Engler et al., 2007). Despite such measures, Indonesia has suffered from a lack of adequate resources, including insufficient numbers of enforcement officers to monitor the country's 17,000+ islands and vast geographic area. Not only does financial gain serve as a great incentive to illegally harvest high-value monitor lizards such as *V. salvator*, but complex trade routes combined with intricate re-import and re-export schemes of skins during various stages of processing also make any estimation of actual trade numbers extremely difficult. Despite notable CITES pressure from 1994 onward and implementation of further reduced export quotas in 1996, Indonesia has consistently shown an inability to properly regulate its reptile trade, including the trade of both live *V. salvator* specimens and *V. salv*ator skins (Soehartono and Mardiastuti, 2002).

In recent years, efforts to study all aspects of monitor lizard biology and behavior have increased. However, further research is necessary to assess both the immediate and long-term effects of human presence on the *V. salvator* populations, as well as to complete more accurate surveys in providing population baseline data for sustainability assessments. Finally, issues of adequate resources and funding must be addressed if the international expectation for a single threshold country such as Indonesia to successfully regulate the majority of the world's varanid skin exports is to be met.

Acknowledgements - I thank Randy Kyes for his guidance, assistance in the field, and encouragement. I would also like to thank Doug Sprugel, Diane Uyeda, Aaron Wirsing, Helen Buttemer, and Jeff Johnson for their time, thoughtful editorial comments, and insightful discussion throughout the preparation of my initial research paper. I am grateful to the editors of *Biawak* for patient review of this manuscript.

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Received 17 December 2008; Accepted 3 March 2009

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