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TAXONOMY AND BIOLOGY OF PHILIPPINE WATER MONITORS (VARANUS SALVATOR)

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INTRODUCTION

The water monitor *Varanus salvator* is one of the largest living lizards (family Varanidae). In various places it attains a maximum total length of approximately 3 m. Its distribution extends from Sri Lanka in the west to the Philippines and Sulawesi in the east and southeast. In the north it reaches South China, and includes most Southeast Asian islands. Three subspecies of the water monitor are found in the Philippines: *V. s. marmoratus* in the western and northern provinces (from Palawan to Luzon), *V. s. nuchalis* in the middle Visayan Islands, and *V. s. cumingi* in the western Visayan Islands and Mindanao. Because of their impressive size, water monitors, locally known as "bayawak" (Tagalog) or "halo" (Visayan), are well known throughout the Philippines. However, they are viewed in a negative light and are believed to be one of the main predators of domestic fowl. This bad reputation is only partly outweighed by their palatability: they are a favorite "pulutan" (finger-food) for many people. Despite this, the local population knows very little about these interesting reptiles, which play important roles in the ecosystem of the Philippines. As predators of crop pests they are even beneficial to man.

The aim of this article is to fill this gap in knowledge by introducing the reader to different aspects of the water monitors natural history, and its different subspecies in the Philippines. The article is divided in two parts, part one dealing with distribution and taxonomy, part two concerned with behavioural ecology.

MATERIALS AND METHODS

The primary investigations took place during several field trips to the Philippines in the years 1984 to 1991. The following islands were visited: Calauit, Basilan, Bohol, Bongao, Busuanga, Cebu, Leyte, Luzon, Masbate, Mindanao, Negros, Palawan, Panay, Samar, Sanga Sanga, Siasi, Sibutu, Siquijor, Tawi-Tawi, and Ticao.

Behavioural aspects were observed mainly during an eight months stay in the wildlife sanctuary Calauit. Here 173 water monitors were captured with snare traps.

Different morphometric data were taken, the sex was determined with a 3 mm probe, and the animals were marked individually, using the locally available boat paint. After the markings dried, the lizards were released. Sightings of marked animals provided data on their activity range, and from the recaptures the population number was estimated estimated.

Local V. salvator subspecies were determined in all the islands visited and a few animals were sacrificed for further investigations in the "Forschungsinstitut und Naturmuseum Senckenberg", Frankfurt, F.R.G.. In all, the taxonomy of 43 specimen were studied using cluster and factor analysis.

The stomach and intestine content of the preserved animals were analyzed to obtain data on their food preferences. Different methods were used to determine the composition of the diet of water monitors. These included examination of:

1. The gastrointestinal tracts of 42 water monitors (18 of which were empty). Food items were rinsed and kept for determination either by air drying or storage in 70% alcohol.
2. The disgorged stomach contents of ten water monitors.
3. Five fecal pellets (two of which did not contain identifyable items).
4. Thirteen observations on predation.
5. Observations on feeding aggregations around three carcasses found in the field.

Information concerning their population status were obtained through direct observation and discussions with officials of the Department of Environment and Natural Resources (DENR), hunters, skin dealers, and local people.

DISTRIBUTION AND TAXONOMY

In Welch (1990) seven subspecies of *Varanus salvator* (Laurenti 1768) are listed, however, there exists disagreement about the validity of some of the subspecies. The nominate subspecies has by far widest distribution, occuring in most of the places listed in the introduction, while all other subspecies are known from one small island only, or a small island group. The only country within the distribution of *V. salvator,* which is not reached by the nominate form, is the Philippines. This archipelago is inhabited by three endemic subspecies:

Varanus salvator marmoratus (Wiegmann 1834)

This form was first described in 1834 by Wiegmann as "*Hydrosaurus marmoratus*", giving Luzon as terra typica. In 1922 Taylor synonomised it with *V. salvator* (Laurenti 1768), recognizing no difference between this form and the typical form. Mertens (1942a,b,c) revised the genus and introduced the subspecies *V. s. marmoratus* for this form. This name is valid at the present time.

According to Taylor (1922) the distribution of *V. s. marmoratus* includes Luzon, Mindanao, Mindoro, and Palawan. According to Mertens (1942c) it occurs on the Calamian Islands, Luzon, and probably in Mindoro and Palawan.

Recent investigations (Gaulke 1991) confirmed the occurrence of *V. s. marmoratus* in Calamian Island, Luzon, Palawan and Balabac, and it could be found on different islands of the Sulu archipelago (Bongao, Sanga Sanga, Siasi, Sibutu, Tawi-Tawi) (Figure 1), but it is absent from Mindanao. Mindoro was not visited, but in view of the known distribution, the occurrence of *V. s. marmoratus* in this island is most likely.

The following description and morphometric data is based on the examination of 176 animals, most of which were released after the examination:

V. s. marmoratus can attain a maximum total length of about 2 m, making it the largest of the Philippine subspecies. It is a very darkl coloured water monitor (Figure 2). The ground colour of the head and the dorsum is dark grey, with a widely varying amount of irregular whitish markings on the head. The indistinctive whitish markings on the back are arranged in transverse rows of spots or ocelli. The neck scales often show whitish posterior margins. The dorsal side of the tail is dark, with whitish mottlings proximally, and a differing amount of whitish crossbands distally. The chin and throat are whitish, with numerous irregular dark spots, and sometimes dark bands across the throat.. The venter is whitish, with more or less distinctive dark crossbands. The underside of the tail is whitish proximally, and dark grey distally. The extremities are dark with numerous small whitish spots on the outer surface, and whitish with irregular dark markings on the inner side.

Different scale counts and size relations are presented in Table 1. Figure 3 shows the size distribution determined for *V. s. marmoratus* in Calauit. Animals between 110 and 160 cm total length are most abundant. Juveniles are not present in this figure, since they could not be caught in the snare traps used.

In *V. s. marmoratus* some inter-island specific variations was observed. The animals examined on Palawan have somewhat smaller nuchal and occipital scales compared to the animals from Calauit. The water monitors from southern Luzon (Sorsogon Province) differ slightly in their coloration. Their ventral ground colour is bright yellow instead of whitish. However, only few lizards from this province were examined, so this observation cannot be generalized.

Varanus salvator nuchalis (Guenther 1872)

This form was first described by Guenther (1872) as *Hydrosaurus nuchalis*. The terra typica was given only as the Philippines. In his compilation on Philippine lizards, Taylor (1922) still considered it as a valid species (V. nuchalis). However, later the subspecies *V. s. nuchalis* was introduced for this form by Mertens (1942a,b,c). The distribution for *V. s. nuchalis* is given by Taylor (1922) as Luzon, Mindoro, and Negros. Mertens (1942c) listed only Guimaras and Negros. Recent investigations (Gaulke 1991) show that the distribution is larger than previously reported, including most of the middle Visayan Islands: Cebu, Masbate, Negros, Panay, Ticao. (Fig. 4)

The description is based on the examination of 25 *V. s. nuchalis*: V. s. nuchalis attains a total length of approximately 1.4 m, being the smallest of the Philippine water monitors. Two varieties can be clearly distinguished. The typical one, on which all former descriptions are based, shows an extremely variable individual colour pattern. The head is mainly dark, sometimes with irregular whitish markings. The neck scales sometimes have whitish posterior margins, and a light medial stripe may be present. The dark back is patterned with indistinct to distinct transverse rows of spots or ocelli, and often has a light medial stripe (Figure 5). The upper surface of the tail isdark, with whitish mottlings proximally and whitish crossbands distally. The chin is whitish with dark crossbands, and the throat is whitish with dark, inverse V-shaped stripes. The ventral ground colour is whitish or bright yellow, with dark reticulated markings. The under side of the tail is whitish with dark reticulations proximally, and uniform dark distally. The extremities are dark with numerous yellow spots on the outer side, and whitish with irregular dark markings on the inner side.

The other variety, found on Masbate and Ticao Islands, is almost melanistic (Figure 6), only the back scales sometimes showing whitish posterior margins. The whitish medial stripe, typical for *V. s. nuchalis*, is sometimes faintly present, as are the crossbands on the tail. The chin and throat are dark grey, the skin between the scales being whitish. The belly is almost uniform dark, or whitish or yellow with a large amount of irregular dark markings. Refer to Table 2 for scale counts and size relations.

Beyond the two clearly distinguishable, allopatric varieties described above, no specific inter-island variability is recognizable. However, the members within one population, especially those from Cebu, are very heterogenous with regards to their colouration.

Varanus salvator cumingi (Martin 1838

Martin described *V. cumingi* in 1838, reporting Mindanao as the terra typica. Taylor (1922) considered this species as valid, but Mertens (1942a,b,c) reduced it to subspecies status, as *V. s. cumingi*.

Taylor (1922) mentioned only Mindanao as the range for *V. s. cumingi*, while Mertens (1942c) listed Mindanao, Cebu, and Leyte, and suspected its occurrence on Samar. My investigations confirmed that V. s. cumingi inhabits Mindanao, Leyte, and Samar, but it is absent from Cebu (Gaulke 1991). Instead it could also be found on Basilan and Bohol (Figure 7).

The description is based on the examination of 15 individuals. With a total length of approximately 1.5 m *V. s. cumingi* is slightly larger than V. nuchalis.

V. s. cumingi is the most beautiful of the Philippine water monitors, with bright yellow colour patterns (Figure 8). The head is yellow with a differing amount of dark markings. The neck is dark with large distinct yellow patches, and the back is dark with distinct yellow crossbands, transverse rows of ocelli and spots. The chin and throat are mostly uniform yellow, seldom with dark markings. The belly is whitish with more or less

distinct dark crossbands. The under side of the tail is whitish or yellow with longitudinal dark ocelli. Scale characteristics and size relations are presented in Table 3.

The inter island variation in this form is distinct. While the animals found on Mindanao are the most strikingly coloured, the animals from Samar, Leyte, and Basilan are generally darker in appearance. The water monitors examined from Bohol differ from the other *V. s. cumingi* populations in having a whitish instead of a yellow throat. However, only few animals could be obtained on Bohol, so it is not known whether this feature is characteristic for the entire Bohol population.

NATURAL HISTORY

Habitat

As indicated by their names, water monitors are semiaquatic animals, and therefore prefer habitats such as mangrove swamps, river and creekbanks, or natural and artificial ponds and their surrounding (e.g. Vogel 1979, Auffenberg 1980, 1981, 1988; Luxmoore & Groombridge 1989, Gaulke 1989b). Accordingly, the highest population densities can be found at the coastal regions, while the mountainous inner parts of the Philippine islands shelter a much lower number of water monitors. While the swamps, rivers, and lakes and the surrounding areas are searched for food, the accompanying vegetation, such as nipa or mangrove forest, dipterocarp forest, bamboo groves, or secondary growth, are used for hiding. Savannah areas, which are quickly spreading all over the Philippines as consequence of kaingin (burning) and logging, offer neither adequate feeding grounds nor shelter, and so are the most unimportant water monitor habitat.

Different types of shelters (sleeping places) are used by *V. salvator*, depending on the habitat. In Calauit, where most of the observations took place in the mangrove areas, trees were found to be the most common sleeping places. The lizards prefer trees standing near the creeks, selecting horizontal branches 3 to 4 m in height. Semiadults sometimes use the large leaves of nipa palms (Nypa fruticans) for their night rest. For short rests during the day all kinds of trees might be used, such as coconut trees (Cocos nucifera), even when they do not stand in the vicinity of water.

In other less forested habitats, ground shelters are the most common night retreats. These may be rock crevices, holes in tree trunks, burrows in river banks, and even crevices under concrete or native buildings. Water monitors know the hiding places within their activity range, and if a lizard is disturbed near one of its shelters, it will run straight towards it to hide. Some of the lizards use their shelters regularly, while others change their sleeping places more frequently.

Demography

Sex dimorphism and sex determination:

As with most varanids, water monitors show no secondary sex characters, such as crests, dewlaps, etc., and so their sex is difficult to determine visually. Due to the inverted hemipenes, the tail base is slightly wider in males than in females, but this

feature is of use only for experienced observers. For many varanids it is reported that males are larger in size, and are of heavier build. Table 4 shows that such differences are hardly recognizable at least in *V. s. marmoratus*, and therefore are of no use for sex determination. The most common method used for determining the sex of alive varanids is by probing the hemipeneal lumen. However, the results obtained through this method are unreliable, since the lizard is able to hinder penetration of the probe by muscle contractions. Sometimes males can be forced to evert their hemipenes by suddenly lifting them up by their tail. In gravid females the eggs are palpable.

Sex ratio:

The sex ratio of monitor lizards remains a puzzling question. While in most reptiles the male to female ratio is approxi-mately 1:1, in several varanid species males seem to predominate, e.g. *V. eremius* (Pianka 1968), *V. gouldi flavirufus* (Pianka 1969), *V. gouldii rosenbergi* (King & Green 1979), *V. komodoensis* (Dunn 1927, Darevsky & Kadarsan 1964, Auffenberg 1981), and *V. tristis* (Pianka 1970). The following male : female ratios were determined for V. salvator: 2.46:1 in West Malaysia (Khan 1969), 2.24:1 in Java (Vogel 1979), and 2.41:1 in Calauit/Philippines (Gaulke 1989b). King & Rhodes (1982) and Stanner & Mendelssohn (1987) demonstrated for *V. acanthurus* and *V. griseus* respectively, that the male dominated sex ratio depends on sexual specific behavioural differences, not on the actual sex structure. This can also be demonstrated for water monitors (Gaulke 1989c). Male water monitors are more active and less cautious than females, and therefore are trapped more easily. Capture methods excluding the influence of behavioural differences (for example traps set on the entrance of inhabited burrows) even resulted in a predomination of female water monitors in the Philippines. Nonetheless, it would be interesting to investigate newly hatched water monitors to determine the actual sex ratio.

Growth:

Growth rates of free ranging water monitors are poorly known, since determination of the rates is extremely time-consuming. Table 5 summarizes the few data obtained from recaptured animals on Calauit. The growth rate is very probably erratic during the course of one year, being influenced by the seasonally varying food supply (Gaulke 1989b).

The allometric change of weight to length during growth is presented in Fig. 9.

Activity

Activity rhythm:

Water monitors are diurnal animals. Deraniyagala (1931) reported that they leave their night retreats at around 10 a.m. on Sri Lanka. In Calauit they normally start and end activity during sunrise and sunset respectively. However, animals sometimes remain in their shelter for 24 hours or more, probably after consuming a large meal.

The daily activity rhythm, as ascertained in Calauit, is shown in **Figure 10.** A first activity peak is reached between 9 and 10 a.m., a second between 3 and 4 p.m.. The underlying data were obtained from the number of sighted active animals in a given time (1 hour), as recorded throughout the entire observation period.

Nocturnal activity for *V. salvator* is reported by Hagen (1890), Volz (1903), Werner (1904), and Hendrickson (1958). They mention that water monitors sometimes enter poultry yards to feed on chicken, and dig up sea turtle nests at night. I observed two water monitors feeding on the carcass of a wild pig (Sus barbatus) during the night. Throughout the entire night they moved to and fro between the carcass at the forest edge, and the forest.

The daily activity rhythm during the rainy and dry seasons differs only slightly (**Figure 11**). The second activity peak is reached somewhat earlier during the rainy season due to the lower temperatures at midday. However, the time and distinctness of the rainy and dry seasons vary in the different regions of the Philippines, so this is difficult to generalize.

Rainfall itself only slightly influences the activity of water monitors. Even during heavy rains active lizards could be observed.

Activity range:

Capture-recapture experiments, as well as repeated sightings of marked animals on Calauit, demonstrated that most were residents, at least within the observation period. Most of the lizards were recaptured in the same trap, or in the nearest adjacent trap. Some of the marked animals were observed quite regularly throughout the entire observation period within a small area. The activity range, determined by the "convex-polygon-method" (Jennrich & Turner 1969), is suprisingly small, ranging from 0.087 to 0.04 km_2. In the Ujung Kulon Reserve on Java much wider activity ranges (approximately 1.5 km_2) were determined for water monitors (Vogel 1979). This remarkable difference surely depends on the food availability. In Calauit the activity range normally includes a high percentage of mangrove swamp, offering a high food supply, so the monitor lizards don't need extended foraging ranges to satisfy their food requirements. In some other parts of the Philippine islands, where the habitat and therefore the food supply is much less profitable, water monitors surely occupy wider activity ranges.

Despite being resident, water monitors are not territorial on Calauit. The same range is used by several adult and juvenile lizards of both sexes. Auffenberg (1980) reports from Flores that the core areas (meaning the most restricted activity range, including sleeping and sun bathing places, but not the foraging area) of water monitors are approximately 500 meters apart from each other. This was not observed in Calauit. Sometimes two or three adult water monitors were found sleeping on adjacent trees. This difference may also depend on the food supply of the habitat.

Water monitors sighted in the savannah areas of Calauit proved to be transients. They probably cross those areas while searching for a better habitat. The reasons for

leaving their prior range might be either overpopulation or continued disturbances caused by man.

Nutrition

Foraging and feeding:

Water monitors spend a large part of the day foraging. Olfactory and optic cues are both important for the tracking of prey animals. Rock crevices, rotten tree stumps, or holes in the ground, as well as crevices under water, which have a higher probability of sheltering prey than for example the open forest floor, are detected visually. Afterwards these places are carefully investigated olfactorial with the nares and the tongue. If prey is detected, the lizard starts digging with its forelegs or snout, until the prey can be captured.

Smaller, very agile prey species (e.g. fish, small rodents, frogs) are never released from the mouth from capture to swallowing. Larger and bulkier food items, such as mangrove crabs, might be released several times before they are completely swallowed. The lizard then presses the prey animal to the ground with one foot, while trying to get a better mouth hold. Usually bigger crustaceens are dismembered, and the extremities, pinchers, and body are swallowed separately. From larger carcasses, water monitors try to tear off pieces with their mouth and forearms, sometimes throwing their whole body forcefully backwards and sideways. In few cases, water monitors could even be observed fastening their jaws on a carcass and then rotating around their long axis until a piece of meat is torn loose. This behaviour is also known for several crocodilians (e.g. Steel 1989), but displayed in the water. Food is swallowed without chewing. Due to the kinetic skull joints, and therefore a high flexibility, large food items can be swallowed.

Food resources:

In Table 6 the results of the examination of the gastrointestinal tracts are summarized. The lack of correlation between water monitor size and food preference is somewhat surprising. However, a similar result was obtained by Losos & Greene (1988) for different varanid species. Locusts are by far the most common insects found in the stomach contents, while anurans are the predominate vertebrate prey. Even the introduced *Bufo marinus* is taken, in spite of its highly toxic gland secretions. Small rodents are also in the diet. In the stomachs of two *V. salvator,* small lumps of hair were found, together with some mouse bones (Figure 12). It is likely that they would have been disgorged later on, as they look exactly like the gastric pellets of *V. salvator* pictured and described by Petzold (1967).

Observations on predation and the disgorged stomach contents obtained on Calauit (Tables 7 and 8), crustaceans dominated.

Observations on a juvenile water monitor for two consecutive days revealed that it fed on ground dwelling and burrowing spiders and insects. Only once within this time did it try to capture a young skink (*Mabuya multifasciata*), however, without success.

The three carcasses (listed in Table 8) were found in Calauit within seven months period. While the dolphin was left in situ on the beach, both dead wild pigs were transferred to localities better suited for observation. However, since they were left in the same type of habitat, this should have had no effect on the number of monitor lizards attracted.

Various factors influences the diet of water monitors:

1. To some extent seasonal variation influences the diet. All observations of water monitors preying successfully on fresh or brackish water fish were made during the dry season peak (February to March in Calauit). During this time, fish are concentrated in residual pools and puddles, representing an easy prey for monitor lizards. An indirect seasonal influence can be seen in the differing nutritional value of some of the prey animals. Some crustaceans especially (e.g. *Scylla serrata* and *Thalassina anomala)* are fatter during the rainy season than during dry season. As a consequence, water monitors weighed during the rainy season were slightly heavier than animals of the same size weighed during the dry season (Figure 13).
2. An ontogenetic shift in diet occurs, as the growing lizard include a wider range of food (such as larger prey animals and especially carcass) in their diet. However, even adults also rely, to a high extent on arthropods.
3. The reason for the intrapopulational variation in diet probably results from differences in microhabitat utilization. Water monitors are active hunters, spending a main part of the day searching for food. While some of their raids are prey specific (for instance on sea turtle eggs, Deraniyagala 1931; crocodile eggs, Whitaker & Whitaker 1980; or ghost crabs, Gaulke 1989b), most food searches take place in areas sheltering a diverse fauna. In their preferred habitats, larger crustaceans such as *S. serrata* are common, and so preyed upon quite frequently. However, those habitats, which still remain intact in the wildlife sanctuary of Calauit, are destroyed in most parts of the Philippines. As a consequence, water monitors have had to adapt to other habitats with a much lower crab density, but where other arthropods, such as insects and spiders, are still abundant.

It can be assumed that the feeding habits of water monitors in the Philippines have undergone a change during the last decades, due to the ever increasing influence of man.

The importance of carrion as food resource was probably overestimated in the past (e.g. Taylor 1922, Auffenberg 1988). Bigger game, such as wild pigs and deer, are widely exploited in many Philippine Islands, so the chance for a water monitor to detect a large carcass is quite low. Nevertheless, they may have an occasional importance as an additional food resource,offering a high nutritional value in respect to the low energy expenses, compared with hunting. When water monitors detect carrion, they remain in the near vicinity, until it is completely consumed.

Contrary to local belief, domestic fowl are only rarely catch by *V. salvator*. Probably feral cats are much more efficient predators of at least small chicks.

Cannibalism does occur in *V. salvator* (Table 6). However, it cannot be decided whether the water monitor remnants found in a conspecifics' stomach result from carcass feeding, or predation. Juveniles and semiadults do not approach water monitor feeding aggregations around carcass, probably to avoid being injured or even killed by adults.

Breeding biology

Courtship:

Observations on courtship and mating in varanid lizards are rare. In contrary to several other lizard families, which demonstrate stereotyped behaviour with typical displays, the few observations made on water monitors do not indicate the occurrence of any stereotyped behaviour patterns.

In Calauit premating and mating of *V. salvator* was observed three times (by one pair, taking place within one afternoon). The following behavioural elements were documented:

1. Male and female licking each others bodies, especially the sides of the head, neck, and insertion of the hind limbs.
2. Lateral head bobbing by the male.
3. Head rubbing on back and shoulders of female by the male.
4. Scratching of female's back by the male.
5. Slow flight of female, followed by male.
6. Female lying down.
7. Male mounting female.

There is no regularity in the sequence of the elements 1 to 4. They might be displayed in changing sequence and frequency, and differing distinctness.

Most astonishing was the fact that in the cases observed in Calauit, mating was initiated by the female, while normally males take the active part (in varanids as well as in other lizards). In these observations, the female approached the feeding male, started licking his head and neck, and after obtaining his attention slowly walked away a few yards to wait for the male to follow. The actual mounting period was very short in all three instances (approximately 1.5 minutes), and probably no copulation took place. After the male dismounted her the first time, the female retained her mating position for another 3.5 minutes, looking backwards to the male at the feeding site, before she followed him.

Subsequent to the three premating-mating instances, both animals fed together. The observation indicated quite clearly that the couple knew each other before. All

behavioural interactions took place at a lower level of cautiousness and aggressiveness, than would be expected between two strange lizards. Auffenberg (1981) reports for *V. komodoensis* that a mating couple knew each other before, and Falk (1921) even assumed for *exanthematicus albigularis* (now *V. albigularis*) that they live together in pairs.

All the above behavioural elements also occur in other intra-specific coactions, including mounting, which is also a dominant behaviour.

Nesting:

Different places, e.g. sandy soil, hollow tree trunks, or termite mounds, are used by water monitors for nesting (Laidlaw 1901, Taylor 1922, Loveridge 1946, Rotter 1963, Biswas & Kar 1981).

Table 9 summarizes observations on egg laying localities made on the Philippines. Termite mounds are used by many varanids as egg laying places, e.g. *V. niloticus* (Cowles 1930, Branch & Erasmus 1982), and *V. varius* (Gow & Swanson 1977). While some species (e.g. *V. niloticus*) use occupied termite mounds, others like the water monitor use abandoned ones. In Calauit the first record of a varanid using a bird's nest mound for egg laying was made. The advantages are surely the same as those offered by termite mounds: an ensured high incubation temperature and a good protection. It is also the first record of a communal oviposition site for a varanid (a single clutch never contains significantly more than 20 eggs, as shown in Table 10). However, communal oviposition sites are recorded from other squamates, e.g. the colubrid snake *Natrix natrix* (Kabisch 1978).

Clutch and egg sizes, incubation, seasonality:

Data on clutch sizes of V. salvator are presented in Table **10.** The high variability in clutch sizes may, in part, depend on female size (as is reported for many lizards, with larger females laying larger clutches). However, data confirming this for *V. salvator* are rare. Egg sizes are given in Table **11**, whilst some data on the size and weight changes during incubation are shown in Table **12.** Weight and size of the *V. s. nuchalis* eggs is significantly lower than those of the nominate form. This may be correlated with total size, since *V. s. nuchalis* is smaller than the typical form, but more data is needed for confirmation.

The incubation time of most varanid eggs is long, varying from 7 to 10 months even under artificial incubation. Incubation times recorded for V. salvator are: 207-209 days (Honegger 1971), 260 days (Anonym. 1978), 291 days (Anonym. 1980), and 218 days (Groves 1984). Even in clutches incubated under the same conditions, the time between first and last hatching may vary from 241 to 327 days (Kratzer 1973). Biswas & Kar (1981) determined daily incubation temperature of 28 to 29.5°C for a *V. s. salvator* egg clutch in a termite mound; external temperature fluctuations were much higher. According to observations made in the Madras Snake Park in India (Anonym. 1978) the gestation period between mating and egg laying is approximately one month. V. salvator might lay two clutches in one year, with an interval of about four months (Andrews & Gaulke 1990). It is not yet known, if they lay eggs every year.

The breeding season differs widely between the different regions of distribution. Table 13 gives an overview of the times of breeding activities as observed, or determined from gravid females, in the Philippines.

Intraspecific agonistic behaviour

As reported above, water monitors are non territorial, therefore aggressive confrontations are rare. Under normal conditions two meeting lizards just pass by each other, without taking much notice. If there is a significant size difference, the smaller one will step aside and wait, until the larger one disappears. The only places where aggressive interactions arise frequently are at larger carcasses or other feeding sites, such as waste sites, where normally several *V. salvator* meet.

The intraspecific behavioural inventory observed in such communities can be differentiated into various categories: explorative behaviour, threat behaviour, fighting behaviour, appeasement and avoidance behaviour, and dominance behaviour. However, most of the different displays listed below also occur in other situations.

1. Explorative behaviour
   a) Alert behaviour: The lizard adopts a position by means of which it is better able to view its environment. The anterior body is held up, with highly erected neck, and head held horizontally.
   b) Encircling: The lizard slowly encircles the bait site and feeding aggregation, while tongue flicking.
   c) Tongue-touch: The lizard briefly touches a conspecific with its tongue.
2. Threat behaviour
   a) Lateral orientation: The lizard tries to impress a conspecific by presenting itself laterally, feigning a larger size. Normally lateral orientation is accompanied by sagittal expansion and neck- arching.
   b) Lateral head-bobbing
   c) Tail-threatening: The lizard waves its tail slowly back and forth, as if attempting to lash.
   d) Hissing
   e) Side-nudge: The lizard pushes its snout against body of a conspecific.
3. Fighting behaviour
   a) Attack-feigning: The lizard suddenly runs toward a conspecific, but stops or changes direction before reaching it.

b) Tail-lashing

c) Biting

d) Ritualized combat fight: During the combat a bipedal position is assumed, while the combatants grip each other with their forearms, and lay their heads over each others shoulder. In this position they wrestle, trying to push down the opponent.
Varanids are the only group of lizards displaying this interesting behaviour. Aside from *V. salvator* it is reported in *V. bengalensis* (e.g. Ali 1944, Deraniyagala 1958), V. varius (Worrell 1963, Breeden & Breeden 1972), V. spenceri (Horn 1981), V. t. timorensis and V. t. similis (Horn 1985), V. dumerilii (Davis et. al. 1986), and V. gilleni (Murphy & Mitchell 1974, Carpenter et. al. 1976).

Normally these fights are reported to occur in connection with courtship behaviour. However, in Calauit, fights also occur over food competition.

4. Avoidance and appeasement behaviour
   a) Flight: The lizard runs or walks away from a conspecific displaying threat behaviour, either after any kind of a fight, or to avoid a fight.

   b) Attaining female mating position: The lizard demonstrates its submission (e.g. after a combat fight) by lying motionless on the ground.

5. Dominance behaviour
   a) Persecution: The dominant lizard pursues a fleeing conspecific.

   b) Attaining male mating position: The dominant lizard mounts for a short moment the subdominant lizard.

Hierarchies in feeding aggregations are mainly established by size. That means that the largest lizard clearly dominates the community with only few displays for demonstrating its position, such as occasional head-bobbing. However, hierarchies between almost same sized animals are constituted by means of the behavioural elements listed above. These hierarchies change frequently even within one day, probably depending on the nutritional condition of the animals.

Population status

In connection with a survey on the population status of Asian monitor lizards, guided by the IUCN, the situation of water monitors in the Philippines was investigated (Gaulke 1989a). Because Calauit Island (3760 ha) is a wildlife sanctuary since 1976, the situation in this place might be considered as most natural, compared to the other places visited. The *V. salvator* number in this place, determined by capture/recapture, was 913 (+/- 131) in 1984/85. Sightings of water monitors during this time were abundant, with many different *V. salvator* sighted and observed daily. A relatively similar situation was

found in the visited islands of the Sulu-Archipelago, with several water monitor sightings every day. Most of the inhabitants here are Moslems who do not hunt for water monitors. In contrast, field trips to other islands mostly ended without even one *V. salvator*. These observations, as well as statements from farmers and other rural people, indicate clearly that population densities in most parts of the Philippines are decreasing rapidly. As it functions in controlling crop pests, as well as serving as a protein resource for the rapidly increasing Philippine population (which might become more important in the future), more attention should be paid to the protection of the water monitor.

SUMMARY

Three subspecies of water monitors are distributed throughout the Philippines. These are: *V. s. marmoratus* in Luzon, Palawan, and Sulu-Archipelago; *V. s. nuchalis* in the middle Visayas (Masbate, Negros, Cebu, Panay); and *V. s. cumingi* in the eastern Visayas (Bohol, Samar, Leyte), Mindanao, and Basilan. Water monitors prefer the coastal lowland regions, such as mangrove swamps, but also occur in bamboo forests and along rivers and lakes in mountainous regions. They feed on all kinds of protein food, animals either caught alive or carrion. Their preferred food items are crustaceans and other larger sized arthropods, frogs, and small rodents. They occupy a steady home range, but are non territorial. Normally they are diurnal, and only in connection with special food resources do they become active at night.

They lay about 10 to 12 eggs/clutch. Regional differences in the breeding season occur within the Philippines. Eggs are deposited in the ground, in termite mounds, or in nest mounds of megapode birds. A wide variety of mostly visual and tactile displays is demonstrated in intraspecific coactions. The most remarkable being highly ritualized bipedal wrestling matches, which establish temporary dominance hierarchies among animals of equal size.

The water monitor populations are rapidly decreasing throughout the Philippines, due to habitat destruction and hunting for food and skin.

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VARANUS SALVATOR MARMORATUS				
	min.	max.	x	n
Vsr	80	98	88.2	176
Msr	131	147	140	9
Osr	48	60	55.1	9
So	2	9	-	176
Svl (cm)	-	78.8	54.8	176
Tl (cm)	-	200	-	176
Nu : Oc Nu + / - = Oc Nu : Do Nu > Do Oc : Do Oc > Do				

Legend:

Vsr: Ventral scale rows, from groin to gular folding
Msr: Midbody scale rows
Osr: Scale rows across occipital region, from corner of the mouth to corner of the mouth
So: Supraoculars
Svl: Snout-vent-length
Tl: Total-length
Nu: Nuchal scales
Oc: Occipital scales
Do: Dorsal scales

Table 1. Scale characteristics and size relations of *varanus salvator marmoratus.*

VARANUS SALVATOR NUCHALIS				
	min.	max.	x	n
VSR	82	92	87.3	25
MSR	131	169	150.5	24
OSR	50	62	54.2	26
SO	4	8		26
SVL (CM)		55	38.3	24
TL (CM)		140		25
Nu:Oc N > or > > Oc	Nu: Do Nu > or > > Do	Oc: Do Oc = or > Do		

Table 2. Scale characteristics and size relations of *varanus salvator nuchalis*.

VARANUS SALVATOR CUMINGI				
	min.	max.	x	n
Vsr	77	87	82.3	12
Msr	128	147	138.9	10
Osr	45	59	50.6	10
So	5	7	-	10
Svl (cm)	-	60	42.2	10
Tl (cm)	-	150	-	12
Nu: Oc Nu < or = Oc	Nu: Do Nu > Do	Oc: Do Oc > Do		

Table 3. Scale characteristics and size relations of *varanus salvator cumingi*.

	Male	Female
Average weight (g)	3191 (n = 75)	2932 (n = 50)
Maximum weight (g)	7200	6500
Average svl (cm)	56.74 (N = 75)	53.66 (n = 50)
Maximum Svl (cm)	76.5	76
Average ratio tl : svl	1.57 (n = 34)	1.53 (n = 31)

Legend:
tl: tail-length hl: hindlimb-length

Table 4. Comparison of morphological characteristics between male and female *varanus salvator marmoratus* (Calauit).

	1	2	3	4	5
Date of capture	8/22/84	8/25/84	8/27/84	9/11/84	9/14/84
Total-length (cm)	147.5	150.5	143	168	163
Date of recapture	2/17/85	11/19/84	11/21/84	2/20/85	11/20/84
Total-length (cm)	148.5	154	148	171.3	164
Average growth rate	0.17	1.17	1.67	0.63	0.45

Table 5. Growth-rates of *varanus salvator marmoratus* determined from recaptures.

SVL [cm]	26.8	30.9	32.0	33.0	34.0	34.1	35.0	35.5	36.2	37.3	37.8	38.0	39.0	39.2	39.5	40.2	40.5	42.0	43.0	43.7	47.0	48.5	48.5	51.0
Prey \ Sex	♀	♀	♀	♂	♀	♀	♀	♀	♀	♂	♀	♂	♂	♀	♀	♂	♀	♀	♂	♀	♂	♀	♂	♂
Crustacea				X			X														X	X		
Insecta		X	X		X	X	X					X	X		X	X	X				X		X	X
Arachnida							X																	
Millipeda																								X
Pisces																		X						
Anura				X						X	X			X		X								
Reptilia			X																X					
Aves		X							X											X				
Mammalia								X				X												
Vert. [indet.]	X				X																			
Gastropoda																X								
Plants	X																					X		
Stones																X								

Table 6: Sex and snout-vent-length of dissected *Varanus salvator*, and food items determined from their gastrointestinal tract (n = 24).

Food Items	Observations
Crustacea	
Scylla serrata	5
Thalassina anomala	2
Ocypoda sp.	4
Insecta and Arachnida	2
Mammalia	
Axis calamianensis (1 horn of 12 cm)	1
unidentified bones	1

Table 7. Food items determined from disgorged stomach contents (n = 10) and fecal fellets (n = 3) of *varanus salvator* (Calauit). All data from adult lizards. One sample may consist of different items.

Prey	Observations	Habitat	involved V. salvator
Crustacea			
Scylla serrata	3	mangroveswamp	3 (adult)
Thalassina anomala	2	mangroveswamp	2 (adult)
Ocypoda sp	5	sandy coast	2 (adult)
Insecta and Arachnida	41	high savannah	1 (juvenile)
Mammalia			
Rattus sp	1	sec. forest	1 adult
Macaca fasciularis	1	high savannah	1 (adult)
Pisces			
Periophthalmus sp.	5	brackish water	2 (adult)
Megalops cyprinoides	1	brackish water	1 (adult)
unidentified	1	brackish water	1 (semiadult)
Carcass			
Sus barbatus	2	high savannah	29 (adult, in 4 days)
Dolphin	1	sandy coast	2 (adult, in 1 day)

Table 8. Prey of 13 *Varanus salvator*, as observed in Calauit Island; and number of *V. salvator* observed in feeding aggregations around three carcasses in Calauit. In four cases one *V. salvator* caught more than one animal during the observation.

Island	Date	Locality
Calauit	1983	60 to 70 water monitor eggs found in a megapode bird nest (Megapodius freycinet cumingi)
Negros	11 July 1984	Water monitor depositing eggs in a hole in sandy creek bank
Calauit	19 August 1984	Water monitor digging a hole in an abandoned termite mound
Calauit	22 February 1985	Water monitor digging several holes in a sandy area near a lagoon

Table 9. Observations on egg-laying localities in the Philippines.

Country	Clutch Size	Remarks
Hainan	10	Eggs deposited after capture (Schmidt 1927)
India (Orissa)	20, 9, 6	Clutches found in field (Biswas & Kar 1981)
India	14	Zoo breeding (Anonymous 1978)
Java	14	Clutches found in field (Vorstmann 1928)
West Java (Ujung Kulon)	24	Egg deposition observed (Vogel 1979)
Philippines (Calauit)	14	Egg deposition observed (Tormo, pers. com.)
Philippines (Negros)	9	Egg deposition observed, female size: Tl = 110cm, Svl = 45 cm (Gaulke 1989b)
Philippines (Negros)	12	Eggs obtained from oviducts, female size: Tl = 116.9cm Svl = 48.5cm, weight = 2450g
Philippines (Mindanao)	10	Eggs obtained from oviducts, female size: Tl = 127.9cm Svl = 52cm, weigth = 2100g
Sumatra	7	Zoo breeding (Meer Mohr 1930)
Thailand	14	Eggs deposited after capture (Kratzer 1973)
U.S.A.	13	Zoo breeding (Groves 1984)
U.S.A	15	Zoo breeding (Anonymous 1980)

Table 10. Clutch sizes of *Varanus salvator*.

Country	Length (mm)	Width (mm)	Weight (g)	in:
Hainan	75-80	38-41	-	Schmidt 1927
India	68-79	38-41	52.4-65.9	Biswas & Kar 1981
India	68-76	44-47	77.5-87.2	Biswas & Kar 1981
India	64-77	35-38	55.0-60.5	Biswas & Kar 1981
India	70	40	30	Anonymous 1978
Java	65-72	42-45		Vogel 1979
Philippines (Negros)	68.5-73.2	30.5-35.0		Gaulke
Philippines Negros)	64-69	29-33	30-42	Gaulke 1989b
Sri Lanka	92-100	35-38		Deraniyagala 1931
Sumatra	70.5-74.5	37-38.5	30	Anonymous 1978
Thailand	65-74	37-45	56-77	Kratzer 1973

Table 11. Egg sizes of *Varanus salvator*.

		1	2	3	4	5	6	7	8	Average
Width (mm)	1.	30	31	31	31	31	31	29	30	30.5
	2.	33	32	32	32	30	33	32	31	31.9
Lenght (mm)	1.	65	69	69	68	66	65	64	66	66.5
	2.	66	65	68	67	65	67	69	66	66.6
3Weight (g)	1.	37	30	29	37	36	35	32	34	33.8
	2.	42	36	38	33	33	42	40	39	37.9
1. Day of egg deposition; **2.** Ten days later										

Tab. 12. Developmental changes of egg size in a clutch of *Varanus salvator nuchalis* (Negros).

Island	Date	Observation
Calauit	8/19/84	Digging of nest hole (Gaulke 1989b)
Calauit	11/8/84	Courtship and mating (Gaulke 1989b)
Calauit	2/22/85	Digging of nest hole (Gaulke 1989b)
Calauit	11/22/85	Egg deposition (Tormo, pers. com.)
Negros	11/7/84	Egg deposition (Gaulke 1989b)
Negros	5/21/88	Fully developed eggs in oviducts (Gaulke)
Negros	July-Dec.	Fully developed eggs in oviducts (Negritos, pers. com., in Gaulke 1986)
Mindanao	6/11/88	Large but not yet fully developed eggs in oviducts (Gaulke)

Table 13. Breeding activities of *Varanus salvator* as observe in the different islands of the Philippines.

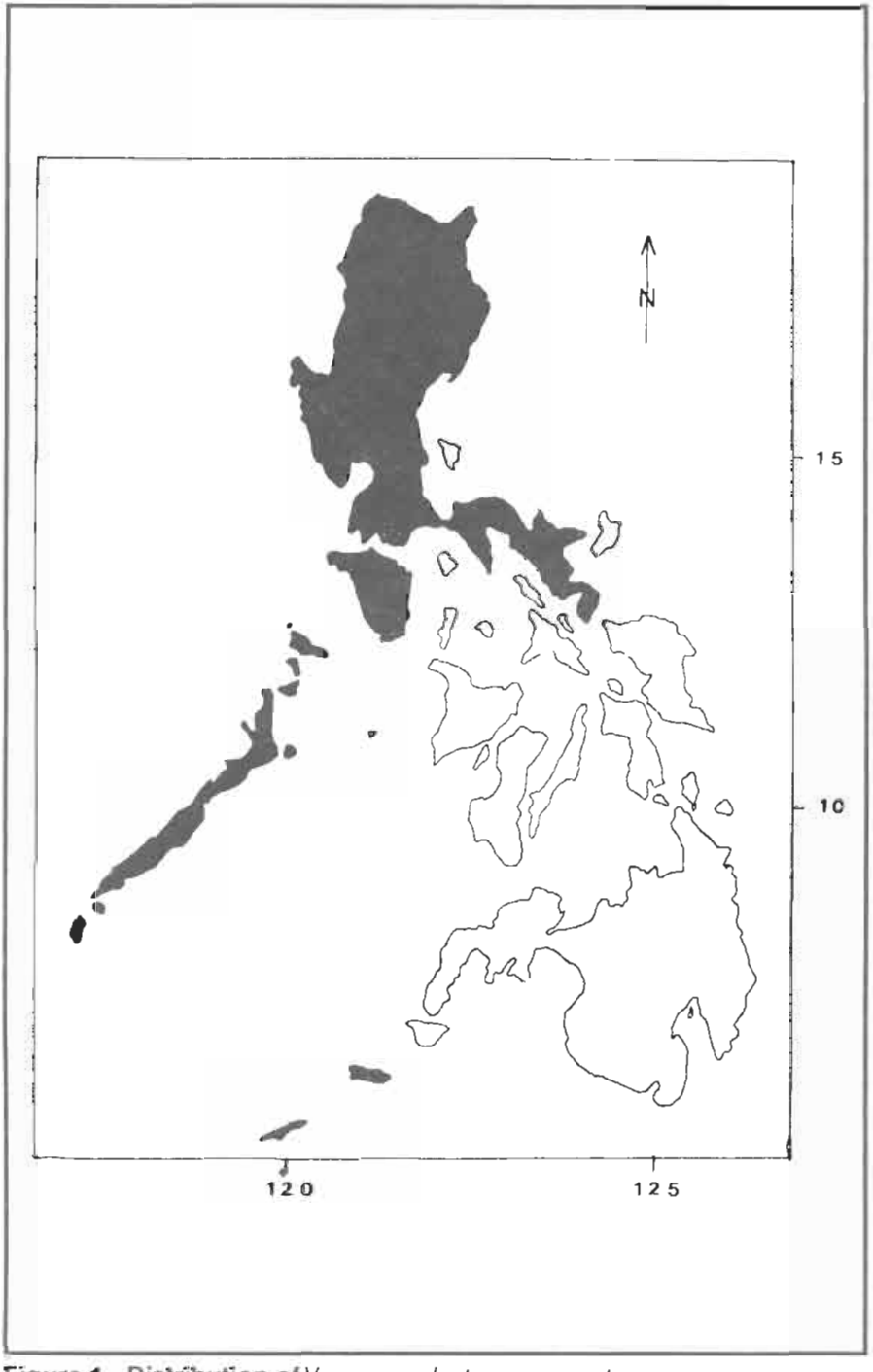

Figure 1. Distribution of *Varanus salvator marmoratus*.

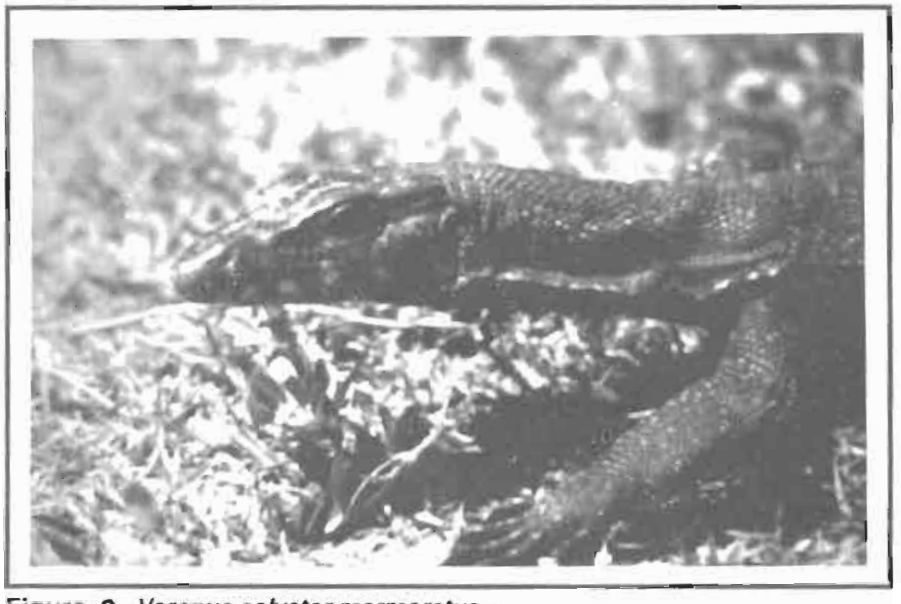

Figure 2. *Varanus salvator marmoratus*.

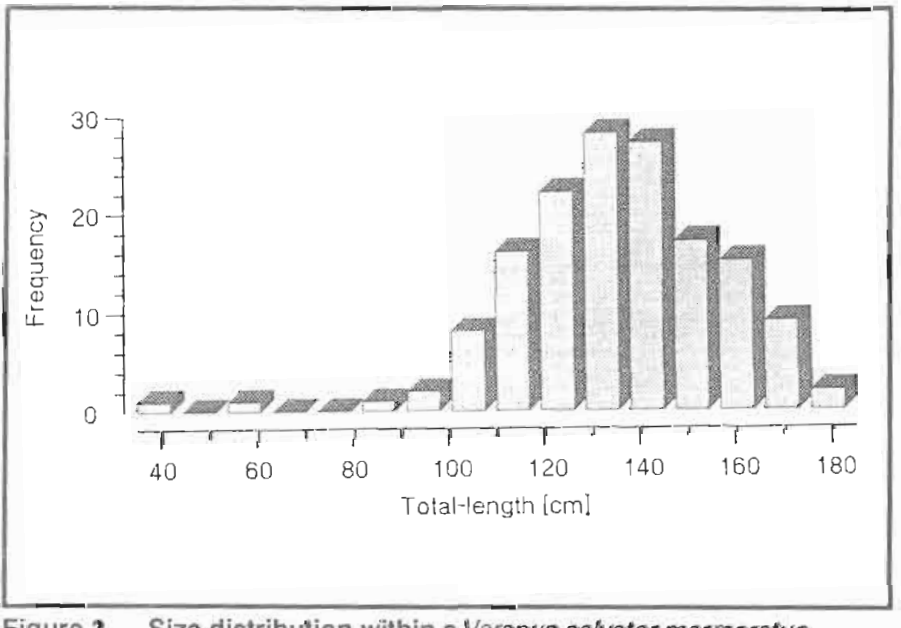

Figure 3. Size distribution within a *Varanus salvator marmoratus* population (Calauit, n = 150)

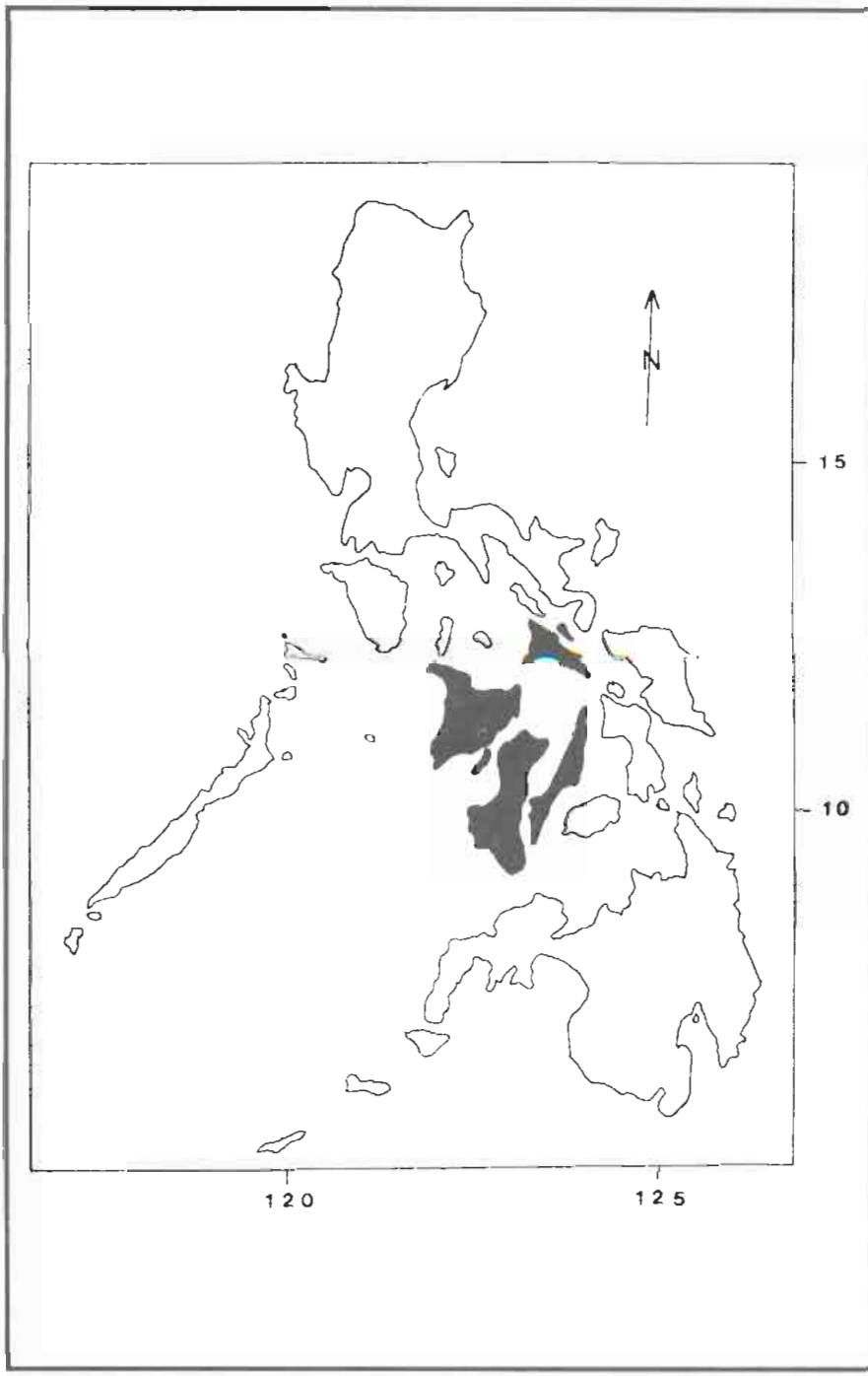

Figure 4. Distribution of *Varanus salvator nuchalis*.

Figure 5. *Varanus salvator nuchalis*, typical form (Negros).

Figure 6. *Varanus salvator nuchalis*, dark variety (Masbate).

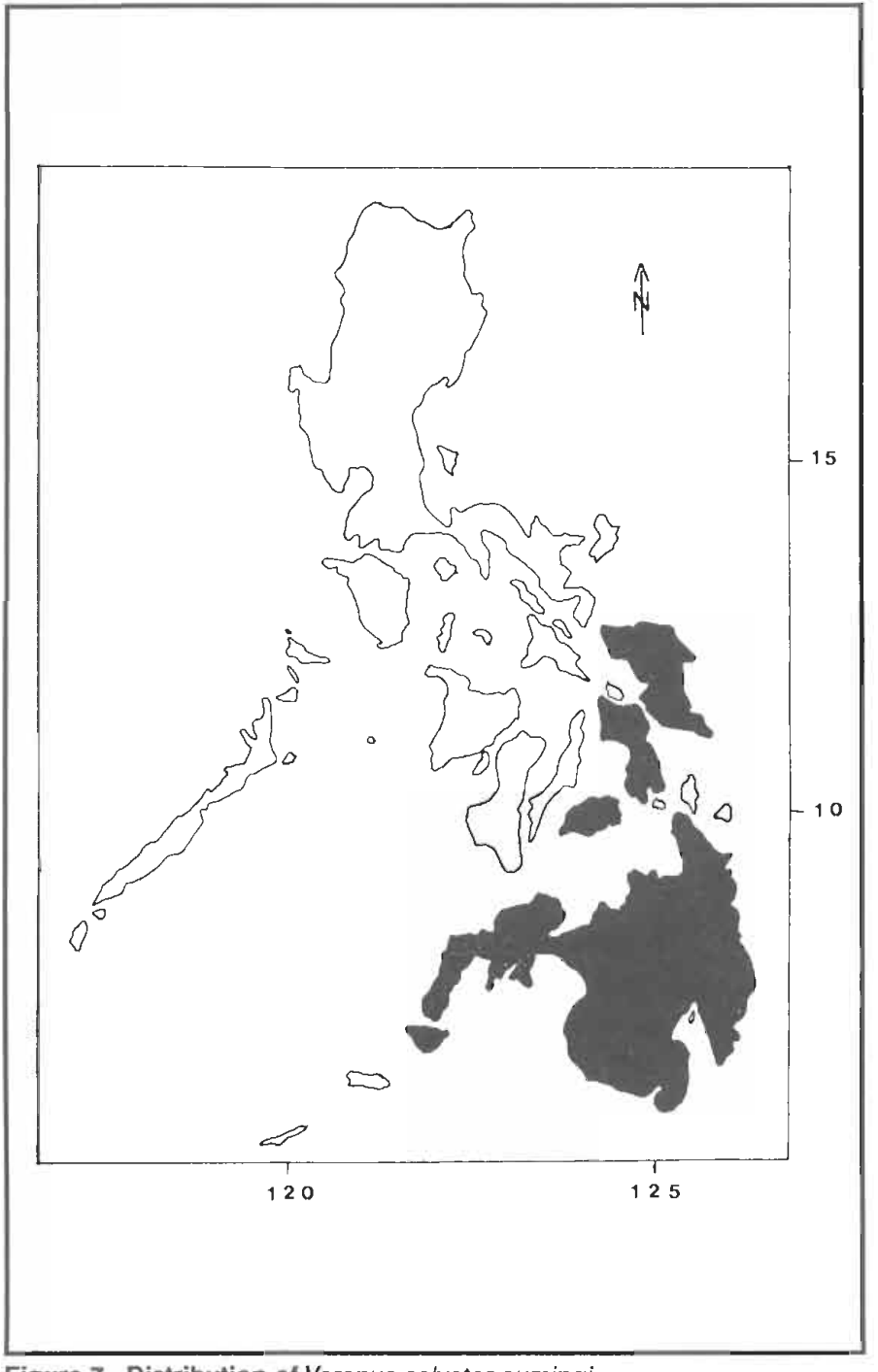

Figure 7. Distribution of *Varanus salvator cumingi*.

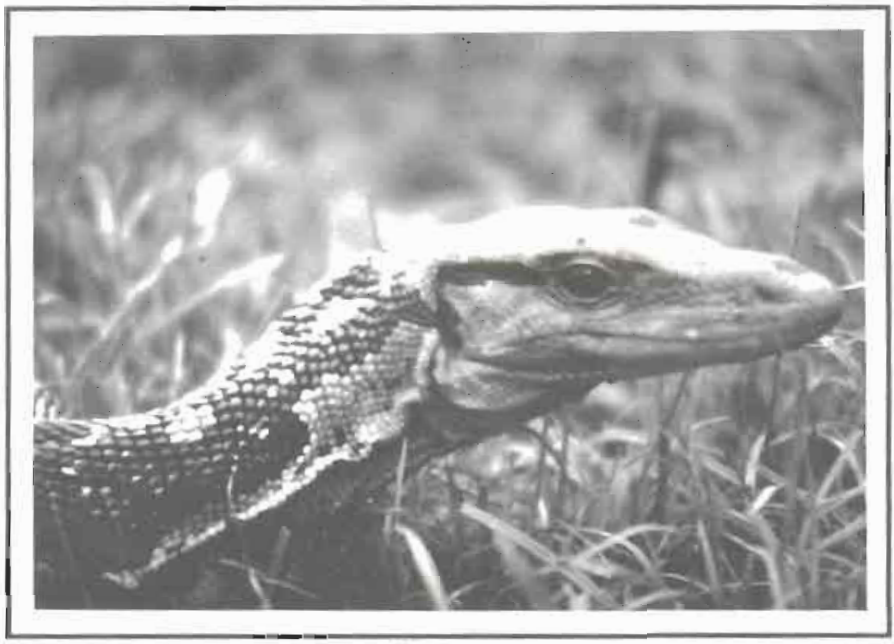

Figure 8: Varanus salvator cumingi.

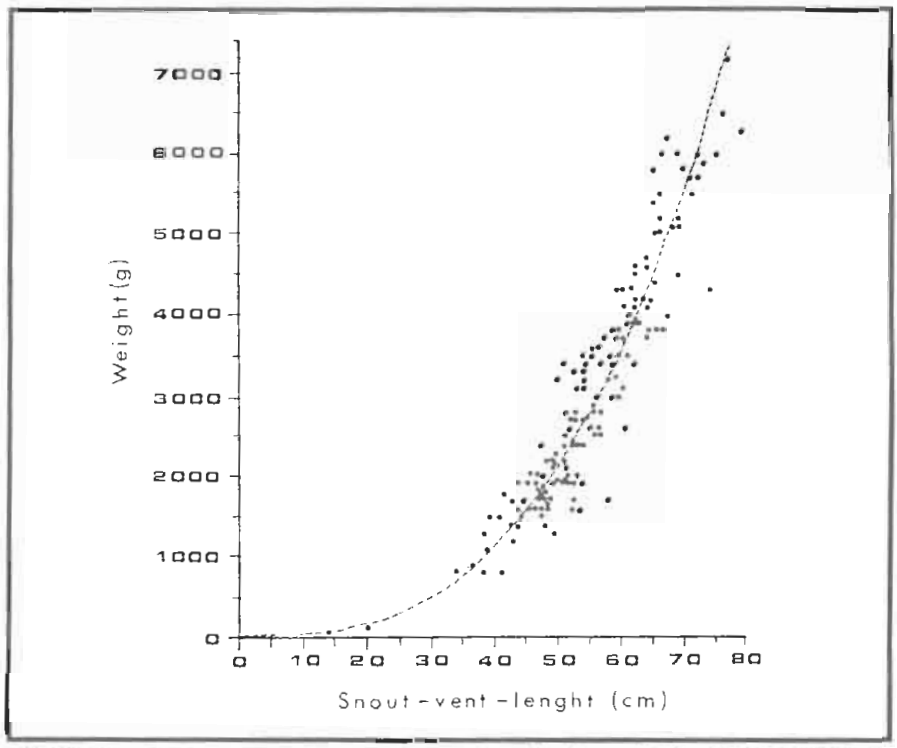

Figure 9. Weight to snout-vent-length ratio (n = 166) within a *Varanus salvator marmoratus* population (Calauit).

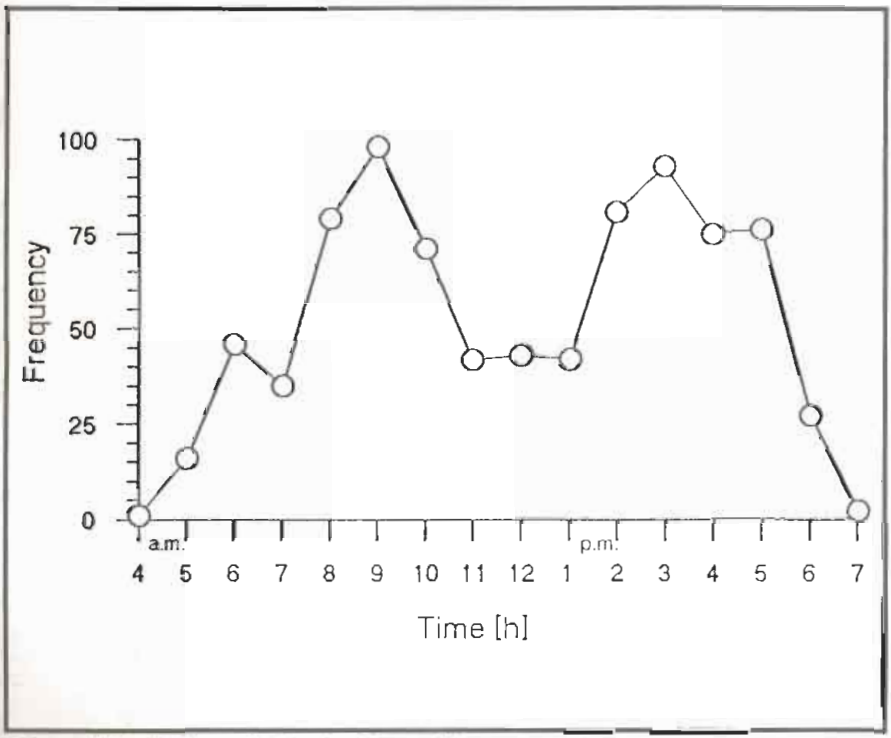

Figure 10. Daily activity rhythm of *Varanus salvator marmoratus* during the entire observation period (Calauit).

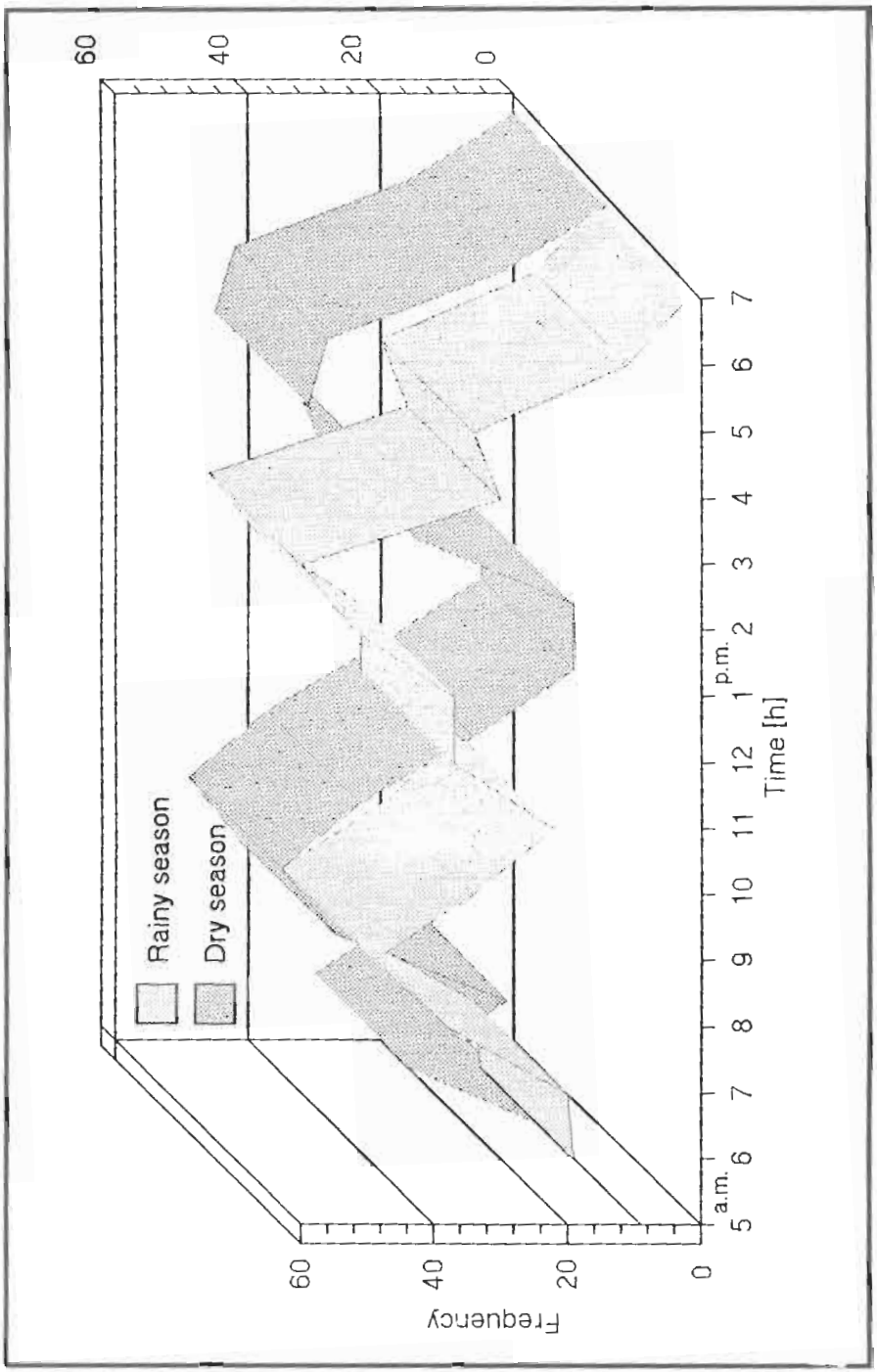

Figure 11. Daily activity rhythm of *Varanus salvator marmoratus* during rainy and dry season (Calauit).

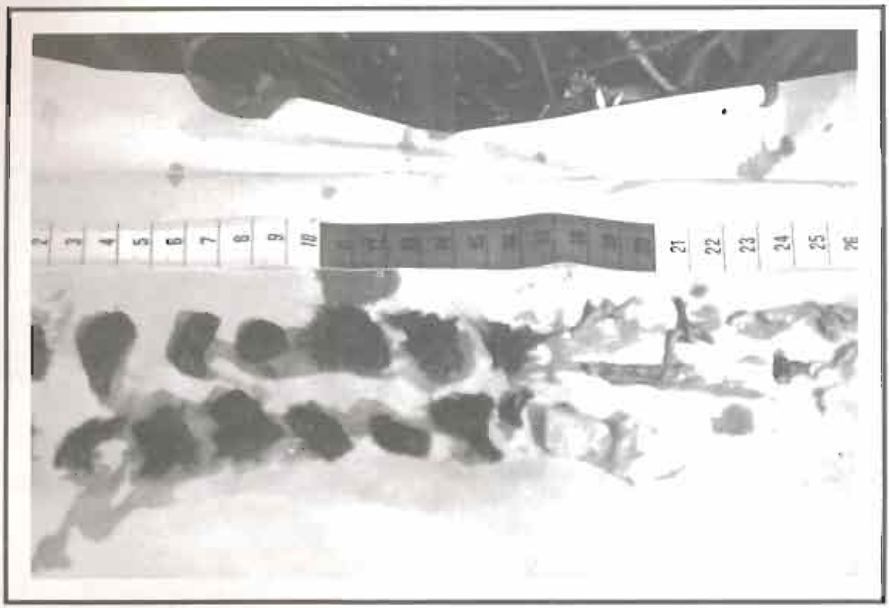

Figure 12. Lumps of hair and mouse bones, found in the stomach of *Varanus salvator nuchalis* (Negros).

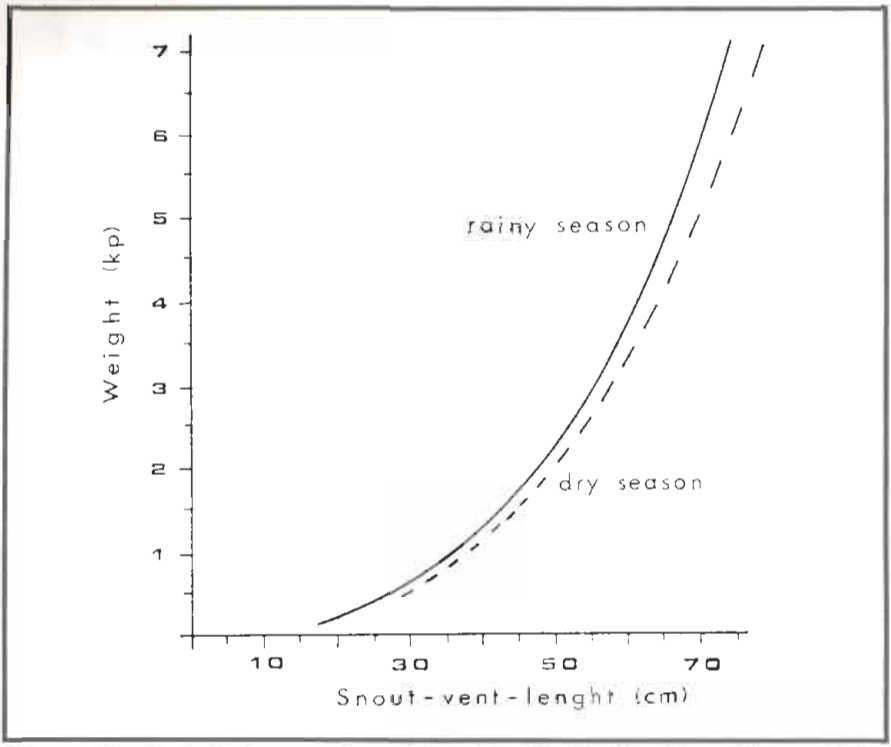

Figure 13. Weight to snout-vent-length ratio during the rainy and dry seasons (Calauit).