ON THE DISTRIBUTION AND BIOLOGY OF *VARANUS MABITANG*[1]

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ABSTRACT

During the past two years, our knowledge on the distribution, morphology, and biology of the Mabitang (*Varanus mabitang*) has enhanced significantly. Captured *Varanus mabitang* were examined and marked permanently by passive integrated transponders before being released. While the first recapture provided initial information on activity range, observations of live animals, the examination of feces, and isotope analyses revealed a dominant frugivorous diet, comprising a minimum of 16 different food plants. Invertebrates such as crabs, insects, and snails are an additional food source for *V. mabitang*.

Sightings and spoor of *V. mabitang* show that this animal is rare, but not as rare as originally feared. It is confined to primary forests and only rarely can be seen in secondary growth areas adjacent to primary forests. Results of distribution surveys on neighboring islands leave little hope that this animal exists outside of Panay.

Introduction

Gaulke *et al.* (2002) published the first information on the ecology of the Mabitang. At that time, only two specimens of this rare, arboreal, large monitor lizard were known to science, and very few observations were available. Distribution surveys have been conducted throughout Panay, as well as on different islands of the Semirara Island Group, and on Cebu Island. Results of the distribution surveys indicated that within Panay *V. mabitang* is restricted to the forested regions in the northwestern and western parts of this island. However, no indications of its existence on the other visited islands were found.

To gain further information on its biology and distribution, two projects were initiated: (1) the continuation of the distribution survey on Panay and on other neighboring islands, and (2) the resumption of the field research in different investigation areas in lowland evergreen rainforests of NW-Panay. These activities are necessary in order to estimate the population status and the ecological requirements of this unique lizard, indispensable prerequisites for well-aimed conservation measures.

At present, the distribution survey has been completed, and the field research has been progressing for more than 2.5 years. Using a non-invasive method to gain insight into food web structures, Struck *et al.* (2002) examined the stable isotopic composition of a Mabitang and their findings showed that the animal is herbivorous.

This paper endeavors to report many more data that have since become available.

Methods

Two factors influenced the choice of islands for the continuation of our distribution survey. First, these islands had to belong to the West-Visayan faunal region (Heaney, 1985; Heaney & Regalado, 1998; Kennedy *et al.*, 2000); second, information on the occurrence of a large, black monitor lizard had become available from residents or former residents of the respective islands. Following these considerations, the Romblon Island Group (Tablas, Romblon, Sibuyan), Negros, and Mindoro were surveyed. The islands of the Romblon Island Group were visited only once (February 2003), Mindoro was visited twice (March 2003, April 2004), and Negros four times (May 2002, April 2003, March 2004, and May 2004). The distribution survey on

Panay Island has been continuing for the past two years. In all visited areas, local inhabitants (especially hunters or former hunters and *kaingineros* living at the forest edge) were interviewed using standardized questionnaires and photos (for further details see Gaulke *et al.,* 2002).

Field research began in June 2002. After preliminary surveys, three promising research areas with a size between 20 and 25 km^2 were identified: one area is located in the forest of the NW-Panay-Peninsula (in the Municipalities of Libertad and Buruanga), and two areas are in the northern part of the West-Panay-Mountain-Range (one in the South-Pandan-Forest, Municipality of Pandan; one in the Alegre-Forest, Municipality of Sebaste). In June 2004 the research area of the NW-Panay-Peninsula was replaced by a third one in the West-Panay-Mountain-Range, in the North-Culasi-Forest at the foothills of Mt. Madja-as, Municipality of Culasi (Fig. 1, Appendix).

From June 2002 until April 2004, the field assistants worked 10 full days per month.[2] Since May 2004 their working days have increased to 12 per month. Their task included searching in their former hunting areas for the Mabitang (*Varanus mabitang*) or its spoor (tracks, scratch marks on trees, fecal pellets, food plants, and trees used as resting places). Scratch marks of the Mabitang are differentiated from the scratch marks of other similarly sized, tree-climbing animals (in this region mainly wild cats or civet cats) by their size. Because a Mabitang has extremely long fingers and claws, the single scratches of its scratch marks are longer and set wider apart from each other than those of other animals. Another task of the field assistants was to capture sighted Mabitangs by hand. Traps were not used in order to avoid the risk of harming other wildlife such as civet cats or macaques. The equipment used by field assistants in the field research included altimeters, binoculars, and a GPS.

Captured Mabitangs are carefully examined, and standard mensural and meristic data are collected (including body measurements, body mass, scale counts, description of scars and wounds, recording of ectoparasites, and clipping of claw tips for later isotope analyses). Excreted feces are kept for identification of food remains such as seeds. Animals are marked with a transponder (reading-device Minimax with integrated LD display and 9 V battery, injector IIID 100, and ID 162 transponders; from ANITECH, Friedrichsfehn), so that they can be identified in case of a recapture. Following the collection of organismal data, animals are released at capture sites.

A herbarium and a species list of botanical food items and tree species used by the Mabitang as refugia have been assembled; data on phenology and altitudinal ranges have been included. Plant identification followed Salvosa (1963), and Madulid (2001; 2002).

Small amounts of claw material from most captured Mabitangs, food remains in Mabitang feces, and some fresh food were collected for later isotope analyses as well as for comparison purposes with a *V. salvator* and *Hydrosaurus pustulatus*. The analyses will be conducted at the GeoBio Center, Ludwig-Maximilians-University Munich (LMU). For the analyses of the claw material of the holotype and its stomach contents, and some museum material of Philippine *Varanus salvator* and *Hydrosaurus pustulatus*, approximately 1mg of claw material or (due to much lower nitrogen concentrations) around 20mg of plant tissue has been used. Samples were dried at 40°C in a heating oven for more than 12h. Before stable isotope analyses, all dried samples were homogenized with a pestle and mortar. Stable isotope analyses of nitrogen and carbon were performed simultaneously using a Thermo/Finnigan MAT Delta plus isotope ratio mass spectrometer, coupled to a Thermo NA

2500CN elemental analyzer via a Thermo/Finnigan Conflo II interface. Stable isotope ratios are expressed in the conventional delta notation ($\delta^{13}C/\delta^{15}N$) relative to atmospheric nitrogen (Mariotti, 1984) and PDB (PeeDee Belemnite standard). The standard deviation for repeated measurements of laboratory standard material (peptone) is better than 0.15‰ for both nitrogen and carbon. Linear regressions and correlation coefficients of $\delta^{15}N$ and $\delta^{13}C$ from claw samples were calculated using the Xact software package version 7.1 (SciLab, Hamburg).

Abbreviations used include: AF = Alegre-Forest; asl = above sea level; NCF = North-Culasi-Forest; NWPP = NW-Panay-Peninsula; SPF = South-Pandan-Forest; SVL = snout-vent-length; TaL = tail-length.

Results

Distribution survey. The interviews conducted on Negros, Romblon, Sibuyan, and Tablas yielded no indication of the existence of the Mabitang on any of these islands. The monitor lizard known on these islands is the Rough-necked Water Monitor (*Varanus salvator nuchalis*), a typical member of the West-Visayan faunal region.

On Mindoro, some information on the occurrence of a large, black monitor lizard, besides the common water monitor (on Mindoro represented by the subspecies *V. s. marmoratus*), in two regions had been received. One of the regions is the well-known Siburan Forest, in the Municipality Sablayan, in Mindoro Occidental; the other is a small limestone forest relict between the Municipalities of Bulalacao and Mansalay in Mindoro Oriental. Information gathered from respondents in the distributional survey revealed their knowledge of the water monitor. Meanwhile, at least one resident from each area reported the presence of a large, completely black, monitor lizard living in the forest. However, inhabitants of this area had no distinctive local name for this lizard, unlike in West-Panay, where the *V. mabitang* is known as Mabitang, and the *V. s. nuchalis* as Halo. Moreover, apart from the color, respondents could not tell the difference between this black lizard and *V. s. marmoratus*. Consequently, it remains unclear whether the respondents were referring to a melanistic form of the water monitor, or possibly another species. For this reason, the black *Varanus* from Mindoro is at the moment tentatively considered as a dark form of *V. s. marmoratus*. This can only be clarified when a specimen of this blackish monitor lizard becomes available for identification.

The continuation of our survey throughout Panay confirms the restriction of the Mabitang to the forested areas of the western and northwestern part of the island, within the West-Panay-Mountain-Range and the NW-Panay Peninsula.

Field research. The research areas (Figure 1) consist mainly of lowland and lower montane evergreen rainforest, with some patches of secondary forest along their outer edges. While the forest remnants on the NW-Panay Peninsula are isolated from the forested areas of mainland Panay, the South-Pandan-, the Alegre-, and the North-Culasi-Forest belong to one continuous, larger forest area, which stretches up to the high elevation forest of the West-Panay-Mountain-Range.

Tables 1 and 2 (Appendix) give the number of sightings of Mabitangs or scratch marks, and the number of collected Mabitang fecal pellets in the four research areas. The tables show a significant difference in the percentage of records among the different areas. This difference mainly depends on one factor: elevation. As Table 3 shows, more than 80 % of all sightings were made below 500 m asl. All four areas are mountainous, with a maximum altitudinal range between 90 m and 930 m (in the AF area). However, the percentage of low, medium, and higher areas differs significantly between the four research areas. This is reflected by the number of fieldwork-days spent by the field assistants within the different altitudinal ranges of their respective research areas, as shown in Table 4. While the field assistants working in the NWPP and the SPF spent 87% of their time in regions below 501 m asl, the field assistant working in the AF spent only 54 % of his time below 501 m asl. Meanwhile, in the only area not reaching altitudes below 400 m asl, the assistants working in the NCF spent 9% of their time in the region.

Most direct sightings took place in primary forests during sunny, or at least dry weather conditions; only two sightings were made in secondary forests. Fourteen (14) out of the 20 observed Mabitangs were on the forest floor during sighting. Usually the animal would immediately climb up a nearby tree as soon as it detected human presence in its proximity. On one occasion, the Mabitang was observed taking refuge in a crevice of a large rock. One Mabitang was observed resting on the branch of a dead but still erect tree near a riverbank, in a height of more than 10 m. This was the largest of the sighted animals, with an estimated total length of more than two meters. Another Mabitang was observed resting on a bird's nest on a tree trunk. According to the observer (N. Paulino), it was clearly a pregnant female with a visibly swollen belly. An individual (total length 132 cm, measured after capture) was observed sunbathing on the trunk of a Bonglew tree (*Polyscias nodosa*); another (total length 136,5 cm, measured after capture) was resting on the top of a fig tree (*Ficus minahassae*); and one more was sighted high up on a branch of a huge Lauan tree (*Shorea* sp.). Still another individual (total length 105 cm, measured after capture) was seen climbing down a fig tree (*Ficus* sp.) during the observation. On separate occasions, 2 Mabitangs were observed feeding on the ground: one (estimated total length around one meter) was feeding on a small, red land crab (local name *Kwataw* or *Man-ok*, scientifically still unidentified); the other (total length 124,2 cm, measured after capture) was feeding on the ripe fruits of a fig tree (*Ficus* sp.) that had fallen on the ground.

Ten of the 20 sighted individuals were caught for further examination and injected with transponders. Two more *V. mabitang* were turned over to the project by hunters of adjacent areas, and after these were examined and permanently marked, were subsequently released at their capture sites. All 12 individuals were caught on trees, either because they already were on a tree during sighting, or because they climbed up a tree when spotting the field assistant. None of the animals tried to jump down from the tree when pursued by the field assistant. The exact capture positions were recorded with a GPS.

Examinations of the 12 *V. mabitang* confirm the species diagnosis (Table 5) and their distinctive characteristics distinguish them from the Philippine Monitor (*V. olivaceus*), its closest relative (Ziegler, Gaulke, & Böhme, unpublished data). All examined Mabitangs are entirely or almost entirely dark grey to black. In some individuals a few scales of the neck and the extremities have yellow edges identical to the holotype; other individuals show no traces of yellow. Ventral and dorsal scale counts are significantly higher (ventrals average 127; dorsals average 139; n = 13) than in the Philippine Monitor (ventrals average 109, n = 106; dorsals average 112.2; n = 5); the ventrals are always strongly keeled, and the tail has a distinctive, triangular shape.

The average SVL of the measured individuals is 51.6 cm (n = 13). They are significantly larger than the other monitor lizard species occurring in the area, the Rough-necked Water Monitor (*V. salvator nuchalis*), with an average SVL of 40.4 cm for 26 adults (Gaulke & Reiter, 2001). The SVL is almost identical to that of *V. olivaceus* (51.2 cm, n = 99; Auffenberg, 1988), but the average weight of *V. mabitang* (2,200 g, n = 13) is lower than in *V. olivaceus* (3,130 g, n = 97; Auffenberg 1988). The allometric curves of body weight versus total body length for *V. mabitang* and *V. olivaceus* (Figure 2) indicate the higher weight of *V. olivaceus*, most significant for large individuals. One Mabitang (no. X, see Table 5) had a SVL of 68 cm (total length 163 cm), the largest SVL measured for a Mabitang so far (Rough-necked Water Monitors of this size are unknown). The first Mabitang ever measured had a total length of 175 cm, but its SVL was only 64 cm (Gaulke & Curio, 2001), suggesting that no. X might be missing a bigger portion of its tail. Several of the measured individuals were missing a small portion of the tail tip; however, it is impossible to estimate the percentage. With the TaL/SVL ratio ranging from 1.36 to 1.62 (average 1.5; n = 13), the relation between size and TaL/SVL ratio is not evident.

With an estimated total length of more than two meters, the largest Mabitang sighted during this study was visibly larger than any of the measured individuals (see above). As given by control measures during different opportunities, the field assistants tended to underestimate rather than overestimate sizes. However, it is necessary to wait for larger individuals to turn up for measurement before it can be safely stated that the Mabitang can attain a total length of more than two meters. A length of two meters or more is only reached by very few *Varanus* species (Pianka & King, 2004).

Sex determination of most varanid species in the field is very difficult, and often impossible with 100% reliability (Gaulke, 1997). This is the case with the Mabitang. While the sex of the holotype was determined by dissection, and four males everted their hemipenes during handling, in other individuals sex could only be estimated using the controversial "hemipeneal pocket probing method" (see Gaulke, 1997). In three individuals even a sex estimate with this method was impossible, due to the intermediate length of their pockets. However, we observed behavioral differences during handling, which might be of help in sexing: three of the four obvious males were very aggressive, while the obvious female (holotype) and the presumed females (F?) were completely calm during handling (see also Gaulke & Curio, 2001). All the animals with questionable sexing were calm during handling; considering this characteristic, Table 5 would presumably present 7 females and 6 males.

Other data gathered from the examined Mabitangs are number and location of ectoparasites. Although they had an average of 18.4 ticks each, tick infestation varied highly among the individuals. While two were free of ectoparasites (and the recaptured one during recapture, but not during initial capture), the others were infested with 2 to 62 ticks. Most ticks were found at the insertion of the front- and hindlimbs, in the gular region, and around the cloaca. Samples of the ticks were collected, but not yet identified. Most probably, they belong to the species *Amblyomma helvolum* and/or *Aponomma fimbriatum*, very common and widespread ticks of Southeast Asian varanids (e.g. Auffenberg, 1988). Other ectoparasites, such as mites, were not found. Fresh feces of some *V. mabitang* contained nematodes; no internal parasites have yet been detected.

Compared to Water Monitors, Mabitangs have few and usually very small scars, and none showed signs of serious new or old injuries. The typical scratch marks in the middle of the back of larger Water Monitors, being a result of their bipedal combat fights (e.g. Gaulke, 1989), have not yet been observed in *V. mabitang*, indicating that these ritualistic fights are not part of their behavioral inventory.

Before the examined animals were returned to the capture site, a transponder was injected below the skin of their left shoulder region. So far, one Mabitang (no. VIII [698475]) was recaptured, after a period of around 10 weeks (Table 6). A recheck of the transponder showed no changes in the Mabitang's original condition during time of capture; no signs of an infection were discernible at the puncture. There was no increase in SVL or weight. The direct distance between both capture sites, as measured with a 50 m rope, is 1100 m, with the trail leading across the ridge of a hill. Both capture sites were close to Sarawag trees (*Pinanga insignis*) bearing ripe fruits.

More than 60 different tree species were recorded, on which *V. mabitang* or its scratch marks were sighted. Due to taxonomic problems, many tree species can not yet be safely determined. According to Madulid (2002), NW Panay is a species-rich and ecologically-diverse area. Tree density and total tree basal area are remarkably higher than in many other regions of the Philippines. On the Peninsula, Madulid (2002) differentiated three forest types: the lowland evergreen rainforest (dominated by dipterocarps), with high endemism, tree density, and species diversity; the forest over limestone (dominated by deciduous or semi-deciduous species), with high endemism, but low tree density and diversity; and the forest over ultrabasic soils, also with high endemism. Several species were recorded for the first time for Panay, 24% of the trees from the lowland evergreen rainforest, and 10% of the trees from forest over limestone (no data given for the forest over ultrabasic soils) could not be identified. In several instances even genus and family could not be identified and only the local names are known. The comparison of the local names as reported by our field assistants with the local names mentioned in Madulid (2002) suggests that the same local name might mean several different species. This implies that the actual number of trees being used by *V. mabitang* might be higher than reflected by our data.

On most tree species, scratch marks were discovered only once or twice during the observation period. Others, especially the different dipterocarp species, were climbed often. Several of the climbed trees had bigger holes in their trunks. From direct observations we know that the Mabitang uses tree holes as shelter (see also Gaulke *et al.*, 2002).

Table 7 lists plants whose fruits are eaten by *V. mabitang*. Several of the identified food plants, like the small Sarawag (*Pinanga insignis*), a palm tree with a small diameter (12 – 20 cm), are only determined from fecal pellets. In others, such as *Combretodendron quadrialatus,* and particularly *Pandanus* spp., which are often climbed by *V. mabitang*, many scratches have been recorded. During the fruiting season of these trees, their seeds comprise the most frequent components found in fecal pellets of the Mabitang. Many fecal pellets contain exclusively *Pandanus* seeds, oftentimes reaching a high percentage. Next frequently discovered are the seeds of palm trees, especially *Pinanga insignis* (year round), while the small seeds of fig trees (fruiting season depending on species) are found less frequently. The other food plants are known from significantly less, a few of them from unique, records. We refrain from giving percentages here. As many of the collected fecal pellets were old during time of discovery, it is likely that the remains of smaller food items (e.g. the small seeds of fig trees) were either washed away by rain or carried away by insects, while the large, resistant seeds of screw palms remain in place for a much longer time. It is remarkable that the Mabitang feeds not only on fruits. Remains found in feces also show that the Mabitang eat the leaves and flowers of a plant belonging to the family Begoniaceae (with the local name *Topsi*). From all other known food plants, the ripe fruits are eaten.

Direct observation and examined fecal pellets of *V. mabitang* show that contrary to first observations, these animals are not strictly frugivorous. While most feces contain exclusively plant materials, others also contain shells of freshwater- and/or landcrabs, insects (beetles, grasshoppers), and in two cases, of land snails.

Stable isotope analyses. The nitrogen and carbon isotope composition of claw material from *V. mabitang*, *V.*

salvator, *Hydrosaurus pustulatus*, and for some food items of *V. mabitang* is given in Table 8. A relatively high interspecific variability in $\delta^{15}N$ was determined for *V. salvator* (6 - 10.2‰). The variability of the carbon isotopic record is less pronounced. The low nitrogen values for *V. mabitang* and the two specimens of *H. pustulatus* (1.8 - 3.5‰ $\delta^{15}N$) indicate a congruent trophic level similar for both species. In contrast, completely different feeding habits on a much higher trophic level are given for *V. salvator* (6 - 10.2‰ $\delta^{15}N$). Plant material collected from the stomach of *V. mabitang* appears strongly depleted in $\delta^{15}N$ (-3.1‰ for *Pandanus* sp.).

Discussion

With indications of the existence of a blackish monitor lizard in the forests of Mindoro remaining vague, results of our distribution survey point to the assumption that *V. mabitang* is an endemic species of Panay, restricted to the forested areas in the northwest and west of this region. This restricted range is somewhat puzzling. Many Philippine island endemics are inhabitants of isolated mountain regions, but the Mabitang is more common in lowland areas. It is very likely that in earlier times, when the forest cover of the Philippines was much larger than it is at present, it had a wider distribution at least within the West-Visayan-Subprovince.

A very important issue to determine is altitudinal distribution of *V. mabitang* within the West-Panay-Mountain-Range. Besides the NW-Panay Peninsula, with a forest cover of 5000 ha (50 km^2), this mountain range holds the last remaining primary forests on Panay (approximately 40,000 ha, or 400 km^2). The majority is montane forest (the range reaches elevations of more than 2000 m asl; the highest mountains are Mt. Madja-as with 2090 m, and Mt. Nangtud with 2050 m), while most of the lowland forest is either cleared or degraded.

The results of our field research show clearly that the preferred habitat of *V. mabitang* is the lowland forest below 500 m asl. Much fewer sightings were made in higher altitudes. However, two observations confirm the presence of *V. mabitang* up to elevations of approximately 1000 m asl: G. Operiano found scratch marks and feces on Mt. Banderahan, NW-Panay Peninsula, at around 950 m asl, while a hunter living at the lower Mt. Madja-as region (around 1000 m asl) informed us that he had once caught a Mabitang at this location. Nevertheless, we assume that the survival of *V. mabitang* depends on the existence of lowland forests. It is highly improbable that the few animals occurring in higher altitudes might stabilize a vital population; they have to be presumed as occasional migrants.

The closest relative to *V. mabitang*, the Philippine Monitor (*V. olivaceus*), a member of the Luzon-Faunal subprovince, is also a frugivore varanid. The known maximum vertical distribution of *V. olivaceus* is significantly lower, occurring from sea level to a maximum elevation of about 400 m (Auffenberg, 1988). In full agreement with Auffenberg (1988), we consider the distribution of the main food plants as an important limiting factor for the vertical distribution. The main food plants of *V. mabitang* and *V. olivaceus* are not identical (see below), and this might be one of the reasons for the difference in vertical distribution. However, some of the known food species occur in higher areas than are occupied by either *V. mabitang* or *V. olivaceus*, thus additional factors related to food sources should be responsible for the distributional patterns observed, as also noted by Auffenberg (1988).

We assume that the presence of dipterocarp trees is one of these additional factors. By far the highest percentage of Philippine dipterocarps is restricted to elevations below, most of them significantly below, 1000 m (De Guzman *et al.*, 1986), and none of the few species growing at higher altitudes is recorded from our research areas on Panay. As our surveys show, dipterocarps are the preferred resting trees for *V. mabitang*, and it seems quite possible that tree holes in the trunk of dipterocarps are used as egg-laying sites. Many larger animals are not able to climb the smooth and high trunks of dipterocarps, which offer a good protection against a number of potential predators from the ground. This also would explain that up to now no egg-laying sites have been discovered during the field surveys, neither for the Mabitang nor for the Philippine Monitor. The presence of suitable shelter trees was discussed as a limiting factor for the distribution of *V. olivaceus* on Polillo Island (Bennett, 2001).

With only one successful recapture so far, information on the activity range of the Mabitang is still lacking. Auffenberg (1988) calculated the annual activity range areas from 0.22 to 2.71 ha for adult *V. olivaceus* (using radiotelemetry), which is very small for a large varanid. Long-term radiotelemetry data for two carnivore varanids can be given for comparison: *V. griseus* 13.7 – 116 ha (Stanner & Mendelssohn, 1987), *V. albigularis* 5,400 – 9,200 ha (Phillips, 1995). The reason for this difference in annual activity range size is most probably due to the frugivory of *V. olivaceus* and the carnivory of the other varanids (Auffenberg, 1988). Under this assumption, we would expect a small home range for *V. mabitang*. But the distance of more than 1 km traveled within 10 weeks by our recapture is rather long, and makes larger activity areas more likely. This would imply that food availability in our research areas on Panay is small in comparison to the food availability in Auffenberg's *V. olivaceus* research area on Luzon. Within less favorable feeding grounds, the Mabitang would need to explore wider areas and even search for food trees at higher altitudes, despite the decreasing density of these areas.

Citing Parmentier (1976), Auffenberg (1988) emphasized that even the most refined methods for estimating population densities of natural populations are often grossly inaccurate. Only extremely high sampling intensities might be able to reduce the biases to reasonable levels. This certainly is not the case in our study. However, the data are sufficient to compare them with information available for *V. olivaceus*. Auffenberg (1988) and Bennett (2001) base their population density estimations on search hours per team, related to captures/sightings of *V. olivaceus*. In Auffenberg´s research area (15 km^2) in the province of Camarines Sur in southern Luzon, a team searching for five hours a day caught an animal every one or two days (based on this he gives an estimate of 0.61 animals per hectare). In Bennett´s research area (2.6 km^2) on Polillo, 119 search hours resulted in six captures and two sightings.

Converted to "Auffenberg units", with five search hours a day, this would mean a catching/sighting success of one animal every third day (he made a rough estimate of 0.03 individuals per hectare). If we transfer this to our investigation, it means that the field assistants must spend five hours each field day intensively searching for *V. mabitang* (this is a conservative assessment as the actual time spent in the field during working days might be longer). Since the three teams (a "team" may be composed of one or two people; part of the time the field assistants work alone and sometimes accompanied by a friend or relative) had 906 field days, and only 20 sightings/captures, this translates to only one sighting/capture every 45 days!

How can this enormous difference between the research results on *V. olivaceus* and *V. mabitang* be explained? One factor certainly is methodology. Both, Auffenberg´s (1988) and Bennett´s (2001) field teams were working with hunting dogs, making the search much more effective. But the disadvantage of this method is overwhelming. Of the 126 *V. olivaceus* caught during Auffenberg (1988) study, 61were injured by the dogs and all of them died as a result of infections, even though the initial bite appeared minor. For this reason, the use of hunting dogs is banned in our research. However, we can fall back upon the previous experiences of our field assistants. Before they started to work on the project, most of these field assistants used dogs to hunt in the current research areas, although in an irregular basis. Yet, even during those times, they only rarely caught a Mabitang (the preferred game were wild boars.) Moreover, the dogs were untrained and pursued whatever prey they could track down. As a consequence, we are fairly certain that the population density of *V. mabitang* is indeed significantly lower than that of *V. olivaceus*. Low food sources are the most plausible explanation for this difference.

So far, 16 different food plant species belonging to at least six families have been determined for *V. mabitang*. Unfortunately several of them are still unidentified (for reasons see under Results). Auffenberg (1988) determined 16 different food plant species from 8 families (some of them were only eaten in captivity) for *V. olivaceus* within his 22 month-investigation period in southern Luzon, while Bennett (2001) identified the fruits of 9 different plant species from 5 families within a 3 months study on Polillo.

During fruiting season, the fruits of *Pandanus* are the most important food for the Mabitang. Most fecal pellets found during this time contain high numbers of *Pandanus* seeds, and most screw palms bearing ripe fruits show scratch marks of *V. mabitang*. Another very important fruit tree, which is available throughout the year, is the palm tree *Pinanga insignis*. Up to 53 *P. insignis* seeds were found in one Mabitang dropping! The importance of fig trees is impossible to assess because their small seeds are difficult to identify. However, we assume that they are more important than the actual proof from sightings would suggest, with regards to the high number of different fig tree species in the area (most of them still unidentified), and the perennial availability of ripe fruits of some species.

Fruits of screw palms, palm trees, and fig trees (mostly different species from those on Panay) are eaten by *V. olivaceus* too (Auffenberg, 1988; Bennett, 2001), but they are of less importance as source of nutrition. Among the most important fruits for *V. olivaceus* in both research areas are those of *Canarium* spp. (Fam. Burseraceae). On Luzon, another very important food plant is *Grewia stylocarpa* (Tiliaceae), and on Polillo *Gnetum gnemon* (a gymnosperm; Fam. Gnetaceae). At least one *Canarium* species occurs in our areas, but so far we have no proof that it is eaten by *V. mabitang*. Even when we assume it is eaten, *Canarium* sp. is obviously not an important food plant; otherwise we would have discovered its seeds in fecal pellets long ago, and besides, *Canarium* trees are rare in the area. Neither *Gentum gnemon* nor *Grewia stylocarpa* are reported for NW-Panay. Possibly, the diet of *V. mabitang* (e.g. screw palm and palmfruits) has a lower nutritional value in comparison to the staple food of *V. olivaceus*. This would explain both findings: the much lower population density of *V. mabitang* as compared to *V. olivaceus*, and its significantly lower body mass (see Figure 2). It also suggests that carnivorous food, even though it is taken, is of little importance for the nutrition of the Mabitang. A wide range of insects, crustaceans, and gastropods is available in the area, and we doubt that their density is lower at NW-Panay than in the distribution range of *V. olivaceus*.

Auffenberg (1988) demonstrated a seasonal shift in the dominance of the different food types (he differentiated three food types: sugar-rich fruits, oil-rich fruits, and animals rich in proteins and calcium), and an ontogenetic shift in food preferences. As in several omnivore reptiles, juvenile *V. olivaceus* consume a higher percentage of animals than adults. His very detailed analyses of food and feeding habits were possible because of the examination of gut contents of more than 100 dissected specimens. So far, our data show no correlation between size and feeding habits. However, all caught Mabitangs, whether considered small or large in table 7, are mature. We have to wait for juveniles before we can address the question about an ontogenetic shift in diet.

A typical $\delta^{15}N$- enrichment of consumers with respect to their ingested food of generally 3 ‰ can be considered, generated during digestion processes causing $\delta^{15}N$ enrichment in body tissues while feces stay depleted in $\delta^{15}N$ (Peterson & Fry, 1987; Kelly, 2000). It is not possible to exactly date the time span recovered by the isotopic analyses of a claw tip. However, it can be assumed that the measured claw tips provide an integrated record for the feeding habits when this particular part of the claw was growing, perhaps within weeks or month. Therefore, the claw material of *V. mabitang* documents only a short and discrete time span of its feeding habits. If changing feeding habits throughout the year is assumed, on account of seasonal and local availability of specific food sources, variability in isotopic compositions can be expected.

The comparison of the nitrogen and carbon isotope composition between that of *V. mabitang* and that of *H. pustulatus*, a well-known herbivore lizard (Werning, 2002), and *V. salvator*, a well-known carnivore lizard (Gaulke, 1991) shows very clearly that *V. mabitang* and *H. pustulatus* occupy a similar low trophic level (Struck *et al.*, 2002), while *V. salvator* occupies the much higher trophic level of carnivores (Peterson & Fry, 1987). Summarizing all observations and isotopic measures, it can be stated that a sporadic carnivorous feeding behavior is given for *V. mabitang*, but with minor nutritional impact. Its trophic level is identical to herbivorous lizards such as *H. pustulatus*, but by no means comparable to carnivorous varanids such as *V. salvator*.

Conclusions and Prospects

Varanus mabitang is highly specialized in diet and habitat requirements. This monitor lizard depends for food and shelter on specific rainforest trees whose altitudinal distributions are primarily below 500 m asl. The density of these trees decreases rapidly with increasing elevation, and none of the important trees grow above 1000 m asl. The extremely low population density of the Mabitang, as compared to its closest relative *V. olivaceus*, indicates that even its preferred habitat, the lowland evergreen rainforest, supplies food only for a very small number of individuals. Due to habitat destruction, it can be assumed that the Mabitang population has already reached a critical stage.

Unlike the forest on the NW-Panay Peninsula, which has been declared a Protected Area, the forests of the West-Panay-Mountain-Range, the most important habitat of *V. mabitang*, are not yet protected. If this situation does not change drastically in the shortest possible time, the continuing habitat loss will threaten the existence of this large varanid, its extinction possibly within the next decades.

Acknowledgments

The work of the Philippine Endemic Species Conservation Project of the Frankfurt Zoological Society has been formalized under the aegis of a Memorandum of Agreement with the Department of Environment and Natural Resources (Quezon City, Philippines). For this, the help of the Protected Areas and Wildlife Bureau under Director M. Lim, and former Director W.S. Pollisco, is gratefully acknowledged. Much appreciation for their close cooperation in this project goes to Aklan State University, through its President, Dr. B. Palma, as well as to Dr. G. Canoy.

The distribution survey was sponsored by the Frankfurt Zoological Society (FZS) while the field research is sponsored by the Patrons for Biodiversity (BIOPAT e.V.), and supported by the German Society for Herpetology and Herpetoculture (DGHT). Their support is highly appreciated. We are very grateful to H.-G. Horn, whose strong recommendation of our project to the DGHT resulted in the above mentioned financial support.

The field research could not have materialized without the committed participation of the field assistants: F. Geronimo, J. Mangga, R. Mangga, G. Operiano, and N. Paulino. Their experience and knowledge are very much valued. PESCP veterinarian E. Sanchez was responsible for the transponder injection, while PESCP forester J. Espiritu as well as Dr. M.M.J. van Balgooy from the Nationaal Herbarium Nederland patiently helped with plant identification; sincere thanks are due to the three of them. Several other staff members of the Philippine Endemic Species Conservation Project (PESCP) supported our work with practical help and relevant information. Special mention go to B. Tacud and R. Ebon, but deepest gratitude goes to all those who supported our work.

Dr. Rafe Brown and Dr. Kai Philipp reviewed the draft of the manuscript and made many helpful comments.

Notes

[1]This paper is publication No. 58 of the Philippine Endemic Species Conservation Project of the Frankfurt Zoological Society; in close cooperation with Aklan State University President, Dr. B. Palma.

[2] Because of their extensive experience, former hunters, namely, F. Geronimo (replaced in June 2004 by J. Mangga and R. Mangga), N. Paulino, and G. Operiano were hired as field assistants.

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APPENDIX

Figure 1: Arrows indicate the position of the four research areas; from North to South: NW-Panay-Peninsula (NWPP), South-Pandan-Forest (SPF), Alegre-Forest (AF), North-Culasi-Forest (NCF). Hatched areas show Panay's remaining forest cover. Map modified from report Green Forum – Western Visayas (2000).

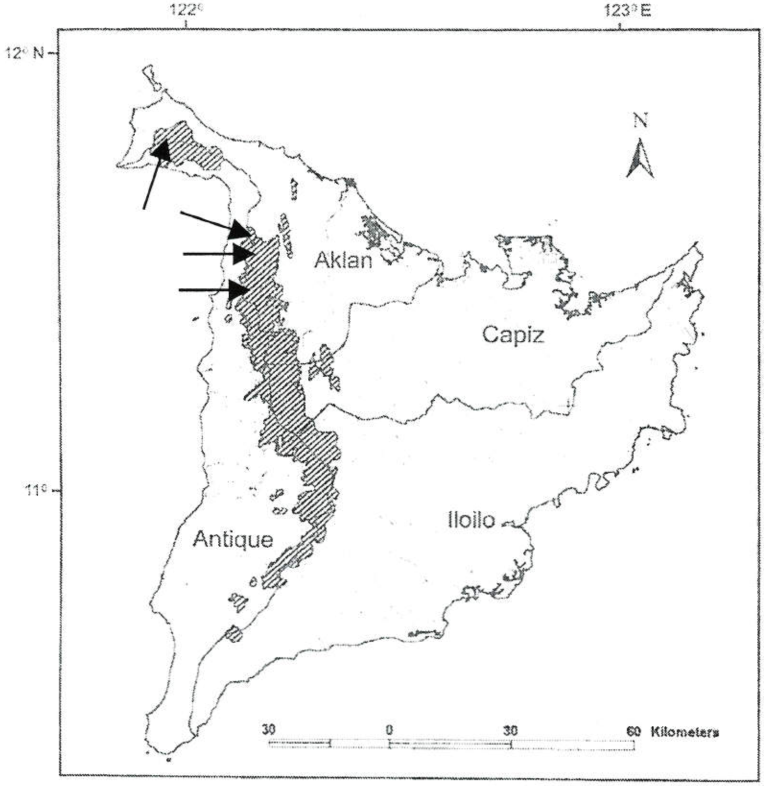

Figure 2: Weight-total length curvilinear relationship in *V. mabitang* (N = 14) and *V. olivaceus* (N = 106). Data for *V. olivaceus* from Auffenberg (1988, page 18, Fig. 2-2).

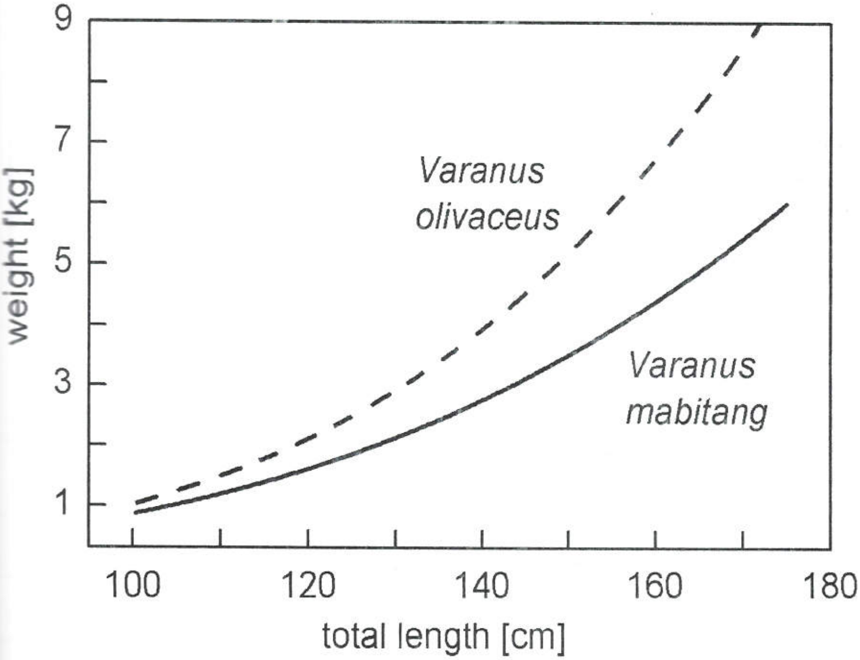

Table 1: Number of Mabitang sightings, identified Mabitang scratch marks on trees, and collected Mabitang feces in the three original research areas (beginning of June 2002 to end of May 2004). The number in brackets gives the number of Mabitang individuals that were caught during the sighting. % is the percentage of all sightings (n = 164) made during this time span.

RESEARCH AREA	SIGHTINGS	SCRATCH MARKS	FECES	%
NW-Panay Peninsula	3	43	7	32.3%
South-Pandan-Forest	5 (2)	55	20	48.8%
Alegre-Forest	4 (2)	18	9	18.9%

Table 2: Number of Mabitang sightings, identified Mabitang scratch marks on trees, and collected Mabitang feces in the two original areas and the new research areas (begin of June 2004 to end of November 2004). The number in brackets gives the number of Mabitangs, which were caught during the sighting. % gives the percentage of all sightings (n = 29) made during this time span.

RESEARCH AREA	SIGHTINGS	SCRATCH MARKS	FECES	%
South-Pandan-Forest	5(4)	7	7	65.5
Alegre-Forest	2(2)	2	2	20.7
North-Culasi-Forest	1(1)	3		13.8

Table 3: Number of sightings related to altitudes (direct sightings, scratch marks, and feces) in all four research areas, from the beginning of June 2002 to end of November 2004; n = 161 (during the first four months of the project no altimeters were available to the field assistants, therefore n in this table is lower than the total sightings from tables 1 and 2). Column 3 gives the number of sightings in percent, column 4 the accumulated percentage.

ALTITUDE (M)	SIGHTINGS	%	ACCUM. %
0 – 100	1	0.6	0.6
101 – 200	2	1.2	1.8
201 – 300	37	23.0	24.8
301 – 400	54	33.5	58.3
401 – 500	37	23.0	81.3
501 – 600	13	8.1	89.4
601 – 700	10	6.2	95.6
701 – 800	4	2.5	98.1
801 – 1000	3	1.9	100

Table 4 (next page): Percentage of fieldwork-days (n) spent by the respective field assistant within the different altitudinal ranges of his research area.

ELEVATION (M)	NWPP (N = 201)	SPF (N = 279)	AF (N = 267)	NCF (N = 74)
0 – 100	4 %	1 %	--	--
101 – 200	12 %	7 %	5 %	--
201 – 300	23 %	27 %	9 %	--
301 – 400	25 %	31 %	17 %	--
401 – 500	23 %	21 %	23 %	9 %
501 – 600	11 %	8 %	19 %	22 %
601 – 700	1 %	4 %	18 %	50 %
701 – 800	--	1 %	6 %	19 %
801 – 1000	1 %	--	3 %	--

Table 5: Length, body mass, and scale counts of *Varanus mabitang*. **ID** (identification) gives the transponder numbers of the individuals caught during our project activities, arranged according to date of capture; **SVL** = snout-vent-length, measured from tip of snout to cloaca; **Tal** = tail-length, measured from cloaca to tip of tail; **sex**: **F** = female and **M** = male, identified either by dissection (only in the holotype) or by everted hemipenes; **M?** = hemipeneal pocket longer than 4 cm, **F?** = shorter than 3 cm, **?** = length in between 3 and 4 cm; **Ventrals** = transverse rows of ventral scales from gular fold to a virtual line connecting the insertion of hindlegs ventrally; **Dorsals** = transverse rows of dorsal scales from gular fold to a virtual line connecting the insertion of hindlegs dorsally.

ID	SVL (CM)	TAL (CM)	MASS (G)	SEX	VENTRALS	DORSALS
Holotype	52.7	74.1	1,850	F	124	138
I(16831)	46	70	1,300	M?	114	130
II(868775)	53.9	74.6	2,030	?	123	133
III(869159)	56	76	2,900	F?	125	153
IV(863513)	51	80	1,980	M?	116	124
V(867645)	47.7	76.5	1,600	F?	111	132
VI(763144)	54.5	82	2,430	M	134	136
VII(763607)	42	68	1,100	M	138	148
VIII(698475)	42	68	1,000	?	128	133
IX(714575)	42	63	1,000	?	125	132
X(867205)	68	95	5,000	M	143	175
XI(870222)	62	93	4,000	M	136	135
XII(722895)	53	80	2,400	F?	135	136

Table 6: Recapture data; SPF = South-Pandan-Forest

ID	DATE OF CAPTURE	CAPTURE SITE	DATE OF RECAPTURE	RECAPTURE SITE	DISTANCE BETWEEN CAPTURE SITES
VIII (698475)	Aug. 24, 2004	SPF, "Ligotan"-area, 439 m asl	Nov. 7, 2004	SPF, "Empogadan"-area, 384 m asl	appr. 1100 m

Table 7: Food plants of *V. mabitang* (several only known with their local name), as determined from seeds found in fecal pellets and direct observations. Relative Abundance refers to frequency of seeds found in fecal pellets.

LOCAL NAME	FAMILY/SPECIES	PART OF PLANT USED AS FOOD	FRUITING SEASON	RELATIVE ABUNDANCE
Small Sarawag	Palmae/*Pinanga insignis*	fruits	year round	common
Big Sarawag	Palmae	fruits	year round	common
Apoy	Palmae	fruits	year round	rel. common
Bariw	Pandanaceae	fruits	May to June, some trees up to August	very common
Karagumay	Pandanaceae	fruits	May to June, some trees up to August	very common
Biribid	Pandanaceae	fruits	May to June, some trees up to August	rare
Lunok/Balite	Moraceae	fruits	April	rare
Hagimit	Moraceae/*Ficus minahassae*	fruits	year round	rel. common
Nabukado/ Lanipaw	Combretaceae/ **Terminalia copelandii**	fruits	August to September	rare
Tapsi	Begoniaceae	leaves, flowers	year round	rare
Toog	Lecythidaceae/ *Combretodendron quadrialatus*	fruits	August to September	rare
Mamali	Leeaceae	fruits	Year round	rare
Kukud	?	fruits	September to October	rare
Malig-Ang	?	fruits	July to August	rare
Mangkilon	?	fruits	year round	rare
Polon	?	fruits	June to July	rare

Table 8: Nitrogen and carbon isotope composition of claw material collected from the holotype of *V. mabitang* (three claws measured), *V. salvator*, *H. pustulatus*, and stomach content of *V. mabitang*.

SPECIES	TYPE OF SAMPLE	LOCALITY	$\delta^{15}N$	$\delta^{13}C$
VARANUS MABITANG, HOLOTYPE	claw material	NW-Panay	2.5	-24.6
Varanus mabitang, Holotype	claw material	NW-Panay	2.1	-23.6
Varanus mabitang, Holotype	claw material	NW-Panay	2.5	-25.2
Varanus salvator	claw material	Philippines	8.8	-24.0
Varanus salvator	claw material	Philippines	8.8	-21.9
Varanus salvator	claw material	Philippines	6.0	-22.1
Varanus salvator	claw material	NW-Panay	10.2	-21.1
Hydrosaurus pustulatus	claw material	NW-Panay	3.5	-24.0
Hydrosaurus pustulatus	claw material	NW-Panay	1.8	-26.2
Pandanus sp.	stomach content of V. mabitang	NW-Panay	-3.1	-30.9