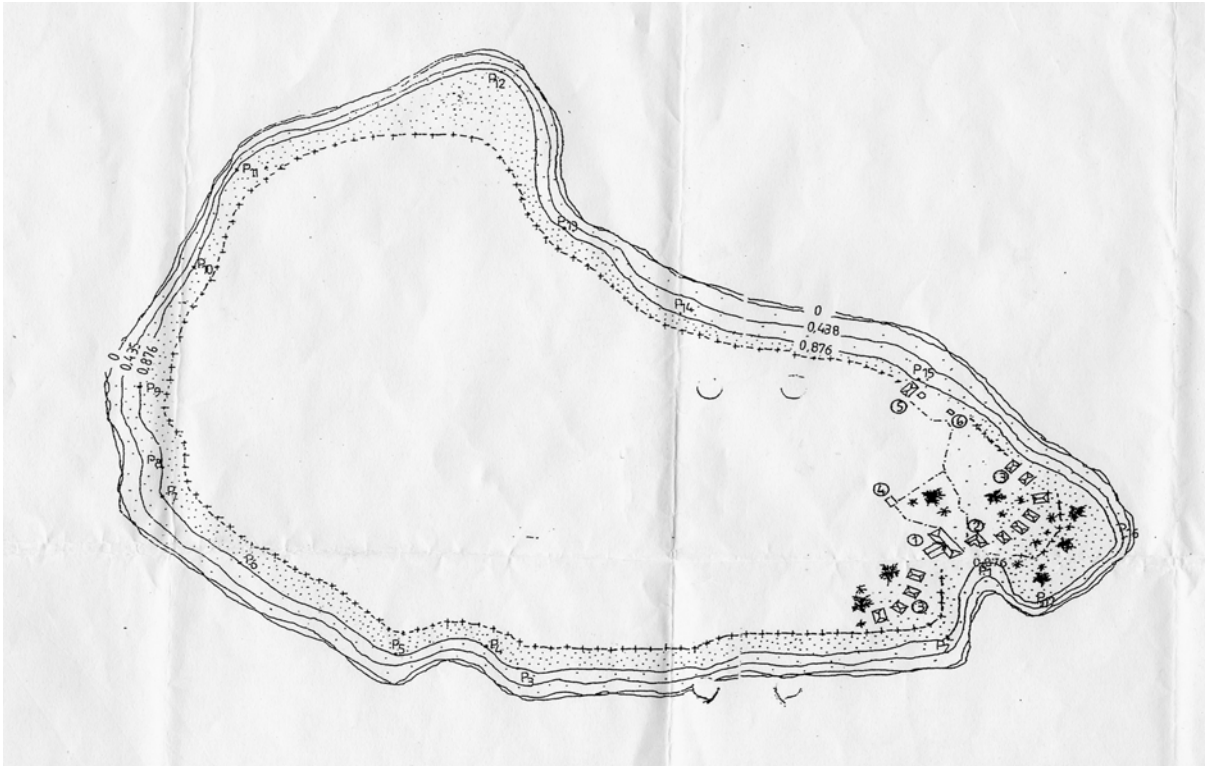
Eradication of invasive rats on Sangalaki-Island, East-Kalimantan – part of a project for marine turtle conservation

Islands Location

Sangalkai-Island is one of the smaller islands located within the Derawan-Island group, belonging to the province of East-Kalimantan, Indonesia. It is situated nearly 100 km east of the town Tanjung Redep and has a total land size of around 13,25 ha (map 1 and 2). The island has no permanent settlement except the personnel of the "Sangalaki-Dive-Lodge" based on the island, and the staff of Sangalaki's marine turtle monitoring station which is staying in personal shifts there. The island is oval shaped, of sandy structure and volcanic origin. Two thirds of it are covered by partially secondary forest with single large old trees spread in between. They are remains of former primary forest logged over in previous decades. Sangalaki is encircled by coral reefs and has sandy beaches of different sizes and estimations (fig.1).

Map 1 – Location of Derawan-Islands.

Fig.1 – Sangalaki, remote located in the Celebes Sea.



Map 2 – GPS based map-sketch of Sangalaki-Island (no equal proportions or fixed scale are applied).

Status of the island

Sangalakis environmental importance arises from the island being a general refuge for various threatened species. However its main weight for conservation lays in the islands function of being a nesting site for populations of Green Turtles (*Chelonia mydas*) which, for centuries now have been coming every night on the beach to dig their nests. Although numbers have decreased from a few hundred animals in the past to only a few dozen at the moment, it is still the most important nesting site in the whole Derawan-Island group. In addition Sangalaki is famous as a diving spot with a rich variety of marine fauna and flora.
A combination of all these factors has led to the Sangalaki's official declaration as a strict conservation site by the local governmental environment authority KSDA. The new sanctuary included the whole island as well as a 3 km marine zone around and granted all marine turtles in this area a basic protection status. Through further conservation lobby work of different NGO's like German based "Turtle Foundation", Indonesian's "KEHATI" and "WWF-Indonesia" and with support of the German Embassy in Jakarta a 100 % protection status to all species in the sanctuary was granted in January 2002 and a monitoring station was constructed on the island. To enforce this protection status the Indonesian National Police and the country's Military had send personnel support to the island for control work of different extend. Other local NGO's are meanwhile flanking this conservation initiative through their engagement in community organising and awareness creation within the regions people and settlements.

Threats by Invasive Alien Species

Since the islands declaration as a marine turtle sanctuary, all collecting and trade in marine turtle eggs from Sangalaki has been banned. Soon afterwards it came clear that the island had a significant population of Black (or Roof) Rats (*Rattus rattus*) probably subspecies *diardii* (the Malayan House-rat), which are not native to Indonesia although widely distributed. Although these animals were known to be present (probably unintentionally introduced years earlier, perhaps in times as egg collectors brought over construction materials for the building of a former permanent settlement on the island) their real pest-status to the island and especially its marine turtle's nests and hatchlings has only now been recognized as before the majority of these nests were collected by poachers. The severe impact of the exotic rat population on the turtles and their hatchlings was clearly witnessed by everybody on the island. Rats have eaten turtle eggs as well as hatchlings on their way to the sea. Often whole nests (containing around 80 eggs/hatchlings) were terminated completely in a matter of minutes. Also juvenile turtles were hunted by the rats (fig. 2 and 3) and killed instantly or wounded deadly by pulling out their intestines. The soft shell of the turtles didn't offer any protection (fig. 4 and 5). Survival rate of the attacked nests or hatchlings were at best 10 % but mostly tended to be zero, allowing no hatchling to reach the comparable safety of the sea.

Fig.2 – Invasive rat targets Green Turtle-hatchling.

Fig.3 – Green Turtle-hatchling caught by rat.

Fig.4 – Attacked turtle-hatchling with open body.

Fig.5 – Green Turtle-hatchlings killed by rats..

Management options:

After the full extent of the problem was recognized the Turtle Foundation sought international assistance for the problem. One source approached was InGrip-Consulting & Animal Control whose employees were able to offer first comments and advise. After personal meetings, the supply of specific requested details on the situation, and under observation of other recommendations coming in (for example to introduce cats !) InGrip-Consulting recommended a rat-eradication attempt as the solution of the problem and the islands further protection. Approached for this by Turtle Foundation our company offered to execute such undertaking if all operational cost would be carried by the Foundation. Under the presupposition that no salary can be paid it was then decided in February 2003 to give the task of attempting an eradication of the introduced rats to InGrip. The work was scheduled in great detail to become implemented in the best available time within the next six months of the same year.
Decision to try a complete eradication was made because of the situation as reported to InGrip by staff on the island. This especially took into account the island's small size, the absence of any endemic, native or threatened rodent species and even any terrestrial mammal at all, the specific extent of the problem the rats pose to this conservation site, the approximate population size the invasive rats had established, the significance of Sangalaki as a unique marine turtle nesting site in the region, the availability of funds, time and motivated personnel to undertake such an operation, including its necessary follow up work, the potential to use such a project as an example project for other places with the same problem in the area, and the existing support and willingness to act by all potential partners or stakeholders involved.
No permanent control work would have the chance of the same results, could be kept in place with the same effort and efficiency, or would have an equal cost-benefit ratio for the limited resources of Turtle Foundation. All costs for a fully poisoning operation were carefully calculated with a safety margin to avoid problems of running out of funds or materials during the control work.
Because of different reasons no sort of biological control was discussed as an appropriate method to the solution of the rat problem on Sangalaki. After careful assessment of all management options available Turtle Foundation accepted the suggestions by InGrip, which were explained ahead in a full proposal to the Foundations board.

Control Method:

With the given situation a one-move poisoning with toxic bait was chosen as the most appropriate technique for the full elimination of Sangalakis invasive rats under accordance of local and national law and all aspects of animal-welfare. Such a method has proven effective in numerous projects and eradications around the world and is economically feasible for even small budget projects.
It was learned that for the control of single populations on Sangalaki (especially in the area of the dive lodges' restaurant and its immediate tourist facilities) a Malaysian pest controller was employed over the last years to control, very temporarily, certain individuals or at best small populations. It was not apparent what sort of poison this person used but upon hearing that he applied just about any toxin which killed the rats immediately it was taken into consideration that certain individuals might have developed bait shyness, or even worse, resistance to different substances over this period of unplanned control. Hence a very powerful and specific rodenticide, many times successfully applied by eradication projects around the globe, was chosen for the elimination of the rat population on Sangalaki. Within the decision process it was presumed, that rats on Sangalaki were also feeding on birds, bird eggs, lizards and lizard eggs, invertebrates of all kind, fruits, leaves, plants, garbage and human food or even excrements.
A decision was made to set a grid over the whole island, consisting of points every 25 meter on compass-marked lines which were themselves 25 meters apart. With this a grid of 25 m² could be established on which points poison was be put out to be monitored. Each point and line was marked with a specific combination of letter and number, written on marking tape sign. Absolute accuracy was necessary to apply in this process already.
In regard to the poison it was decided to take a commercially available rodenticide, from the group of so called 'second generation anticoagulants' – poison which interrupts the animals Vitamin K production thus hindering the process of natural blood clotting. It is produced in poisoned grain, for better weather protection mantled by a wax layer and pressed in form of a cube. The toxin is 'brodifacoum' in concentration of 0,005 mg, which allows a rat to ingest a lethal dose within a single feeding. Trade name of the poison chosen was "Klerat" and is worldwide available from the production company "Syngenta". In Indonesia it comes in bags of 5 kg, each containing 1.000 pieces of five gram blocks weight (fig. 6 and 7). "Klerat" is usually coloured blue and it has the bitter-substance "Bitrex" added to avoid accidental feeding and poisoning by non-target species. However that is not reducing chance of bait-take by rats or other rodents, as they are physically not able to detect such bitter substances.

Fig.6 – "Klerat" anticoagulant poison.

Fig.7 – 5 g "Klerat" wax blocks with brodifacoum poisoned rice.

At each of the grid-points eight blocks of "Klerat" were estimated to be the right amount of bait, a total of 40 grams. The poison was kept in place for around three weeks. As the type of "Klerat" (which differentiates from country to country) offered for sale in Indonesia is in shape and size smaller then the wax blocks available in other regions it was decided to build at each point a provisional bait station that the bait would be placed in to keep non-target species away from these toxins. For economic reasons it was decided to use locally available material as opposed to buying commercially available bait stations. So bait stations were built from emptied 1,5 litre plastic-water- bottles. They were cut at the top and the end and resulting in a plastic tube of 22 cm length and around 10 cm in diameter. It was further enhanced by inserting two pieces of wire through the middle of each bottle, a few centimetres apart (fig. 8 and 9). The space in between the two wires was designed to be the storing place for the "Klerat" wax blocks. This measure was taken to keep the bait better in place and make control and monitoring more accurate and easier. Due to the bait blocks rather fragile structure, their small size and no existing holes in the middle (as other types of "Klerat" have), it was not possible to fix the blocks with some wire on a object. Any attempt to drill such hole into the bait blocks failed. The bottles also had the further advantage of protecting the bait against rain, which fortunately did not arrive during the poisoning-phase.
As the same type of bottles were laying around on the island in slightly larger numbers their appearance on Sangalaki was at least known to a part of the rat population and, since they were often together with any sort of food washed ashore the beach, they were perhaps even associated by the rats (at least those controlling this area) with food in general. It was hoped that the use of 'familiar' objects would be beneficial in reducing the rats neo-phobia, i.e. their mistrust of new objects. The bottles transparency offered advantages for the later control work, as the content of each bottle could be clearly seen and any handling and disturbance at the stations therefore minimised. The concentration of poison with a higher toxic level as compared with other projects around the world was justified as – carefully managed and supervised – this is widely proved to lead to a shorter period in which the toxins are out in the environment and thus the target-population is fully controlled faster.

Fig.8 – Empty water bottles used as bait stations.

Fig.9 – Wire construction keeps bait in the station.

Implementation

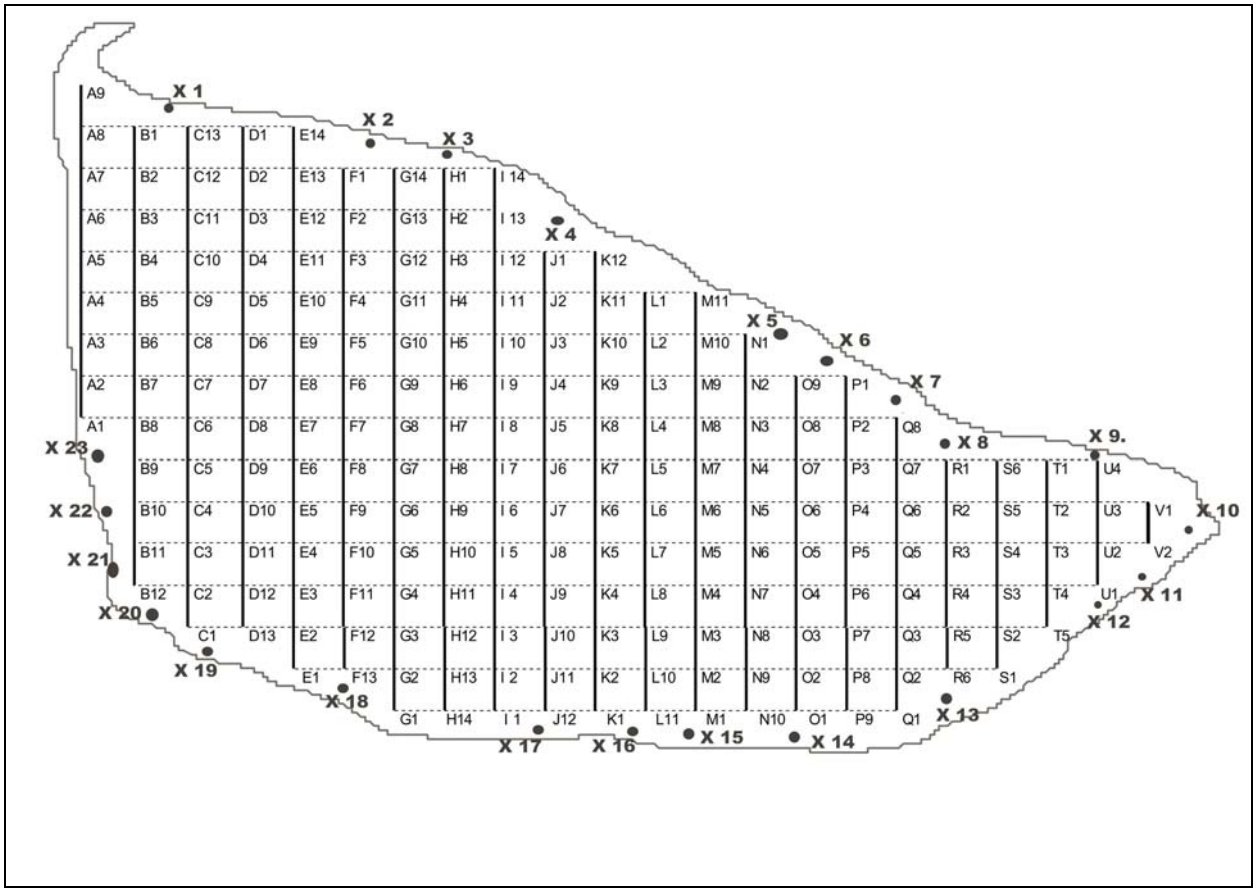
After advise by the experts, the local Turtle Foundation staff bought the appropriate rodenticide in the estimated quantity and brought it in advance of the arrival of the controllers to Sangalaki, where it was stored safe and dry. Meanwhile all necessary permissions to undertake a pest control operation against the invasive rats on Sangalaki were made available from Turtle Foundation to the personnel from InGrip-Consulting. Also all necessary local contacts were arranged prior to the arrival of the controllers. "Sangalaki-Dive-Lodge" generously offered both free accommodation and food for the whole stay, on the island (i.e. G. G. Meier five weeks and K. Varnham two weeks). Part time assistance of, in total, six persons from different organisations, all of which were temporarily based on the islands' monitoring station was offered or provided by their responsible administrations. Implementation of the control project was executed under the responsibility of InGrip-Consulting and started after the arrival of the two control experts on June 18th, 2003 following the prepared time schedule.

First phase was reserved for cutting the grid of lines and marking the points which led finally to having Sangalaki completely divided into squares of 25 metres by 25 metres. This was done manually and implemented by two two-person teams equipped with compass, tape measure and machete (fig.10). The goal of setting the grid was achieved within ten days and created 22 lines (lettered A to V) each having between a minimum of 2 and a maximum of 14 points, all of which were marked with rubber marking tape (fig.11).

Fig.10 – Lines have to be measured by compass and tape measure to be exact.

Fig.11 – Points were marked every 25 m.

All points were identified in specific letter and number combinations to avoid misleading doubling effects. The total number of the regular lines points finally came to 221 over the entire island (map 3).



Map 3 – Sangalaki-island map based on grid for poisoning-phase. Every square is 25 x 25 meters. Points are always in the upper left corner of the letter. X-points of the perimeter line are marked in addition. X 9 is identical to U4. All lines are strictly measured and set from south to north and east to west. Only for reasons of simplification is south given as bottom of the figure here.

As expected, rat activity was observed to be remarkably high along the shoreline of the island (fig.12 and 13). The decision was therefore made to establish an additional 'periphery-line' in a circle along the beach to target certain individuals with specialised feeding behaviour in only or mainly this area. This circular line was named X and had 23 points in total, covering space along the shoreline and between the regular lines going from south to north and reverse. However, as one point of the X-line was nearly identical with one end-point of the regular lines, the X-points in the end were effectively only 22 in number.

Fig.12 – Rat and men patrolling along the shoreline.

Fig.13 – Tracks are good signs for rat presence.

Between July 5th, 2003 (control day 1 of the poisoning-phase) and July 26th, 2003 (control day 22, last day of having poison out in the grid system type) a further 18 stations were established, each one close to a building of the dive-lodge's area. This proved necessary as rat concentration was clearly the highest in these places (fig.14) and additional bait had to be offered here to outbalance this large concentrations and thus harmonize the time schedule of the total control.
It was considered possible that some rats might live exclusively in the houses and so would not come across bait placed in a station further away.

Fig.14 – Black rat (*Rattus rattus*) caught with Tomahawk Live-trap on Sangalaki-Island, June 2003.

Two of these stations (which were all named after the house they were attached to) were withdrawn on control day 17 as it was seen that they were regularly emptied by a large land crab which carried the bait into its shelter under one of the houses.
For additional specific treatment of small-territory ranging rats two more stations were placed into the dive lodge's bar/restaurant and another one in the kitchen of the turtle monitoring station. These were kept in place from control day 8 until control day 22. So the maximum number of bait stations out on one single day came to 264. As each contained eight blocks of "Klerat", a total amount of 10,56 kg of rodenticide were out daily on the island at the peak time of the operation. This was equivalent to 0,8 kg/ha. Furthermore loose bait was manually placed into hollow walls and on dividing ceilings in buildings, as well as the toilets or openings in the dive-lodge's sewer system. As this is in itself a closesd pipe-system no threat of contamination to environment or people could take. A few more loose bait blocks were placed in other existing former settlement structures on the island. These are structures like the former turtle hatchery and nearby old toilets (which are recommended to be removed over short anyway). The number of these extra bait blocks spread were in total 513, or the equivalent of 2,56 Kg.
The last modifications in the number of stations was undertaken on control days 13 and 20.
On control day 13 three stations with reduced bait (four blocks each) were placed in two empty store rooms near the dive lodge restaurant and one fully stocked station (eight blocks) in a hitherto unknown food store room belonging to the dive-lodge's kitchen. On control day 20 a single full stocked station was added in the first floor of the dive stations staff and equipment building to target an unknown movement there. This was not based on a confirmed rat sighting or tracks but more on rumours. The placing of this station was accompanied by setting live-capture traps and distribution of bait in the hollow walls of the building. This station was removed without any bait-take three days later because of the island-wide end of the poisoning-phase.
All stations were built prior to the start of the poisoning-phase and brought out on their place of destination two days before the poisoning started.
Before the whole systems implementation a test-baiting was undertaken by the control experts. For this two sets of four unwired and four wired plastic-bottle bait stations were placed on comparable locations near to each other. Within 48 hours a clearly growing acceptance to both models of bait stations and - especially important - the poisoned bait offered in could be recorded. This finally resulted in the complete emptying of all eight stations by rats within four days.

In the first two days of July 2003 all persons present on at Sangalaki were informed about the beginning poisoning-phase. Additional necessary precaution measures were also taken (fig.15). Garbage and alternative food sources were as best as possible removed or burned.
After these final preparation measures poisoning was started on the 4th of July 2003.

Fig.15 – Signboards in Indonesian and English were placed all over the island while poisoning lasted.

On this day "Klerat"-rodenticide was placed in the planned quantity (eight blocks for each station) into all bait stations across the whole island (fig. 16). As scheduled this was completed in one single day. Bait stations themselves were at this day placed by the controllers in a final, optimal position. Depending on the locality some stations were camouflaged to increase the acceptance by rats through giving them specific shelter-character and at the same time minimising the stations visual attractiveness to non-target species (fig. 17). Partially stations were fixed with wire, string or twigs to avoid animals carrying them away. This proved to work even though a few were moved around a bit.

Fig.16 – Filled bait station in the time of the poisoning-phase.

Fig.17 – Camouflaged bait station.

To cover all 243 stations existing so far 1.944 blocks of "Klerat" rodenticide with a total amount of 9,72 kg (equivalent to 0,75 kg/ha) were brought out onto the island in a single day. No pre-baiting was done but following the results of the test-baiting a normal activity of bait-take and -acceptance was expected to take place.
As of the next morning daily controls were started by having a person patrolling all lines and recording all changes on stations or number of bait in the stations. This person noted all information and was responsible for replenishing any missing bait blocks.

The time needed for a control of all lines was ten hours in the beginning and seven hours by the later stages of the project (because re-baiting came less necessary). The first control day was on the 5th of July 2003 and the last on the 26th of July 2003, with only four days of planned breaks in between.

The first days after poisoning began showed a significant and expected pattern. Bait-take increased from control day 1 (47 % taken from 100 % offered) to control day 2 (77 % taken, figure includes the content of 18 stations added on the 5th of July) and remained for control day 3 (76 % taken) and control day 4 (67 %) on nearly the same level. By then as expected the first sharp drop down occurred, reasoned in having the first part of the population dying during these days. This resulted in a decreased bait-take on control day 5 (37 %) over control day 6 (15 %) to control day 7 (11%) which so fare marked the first minimum (fig.18).

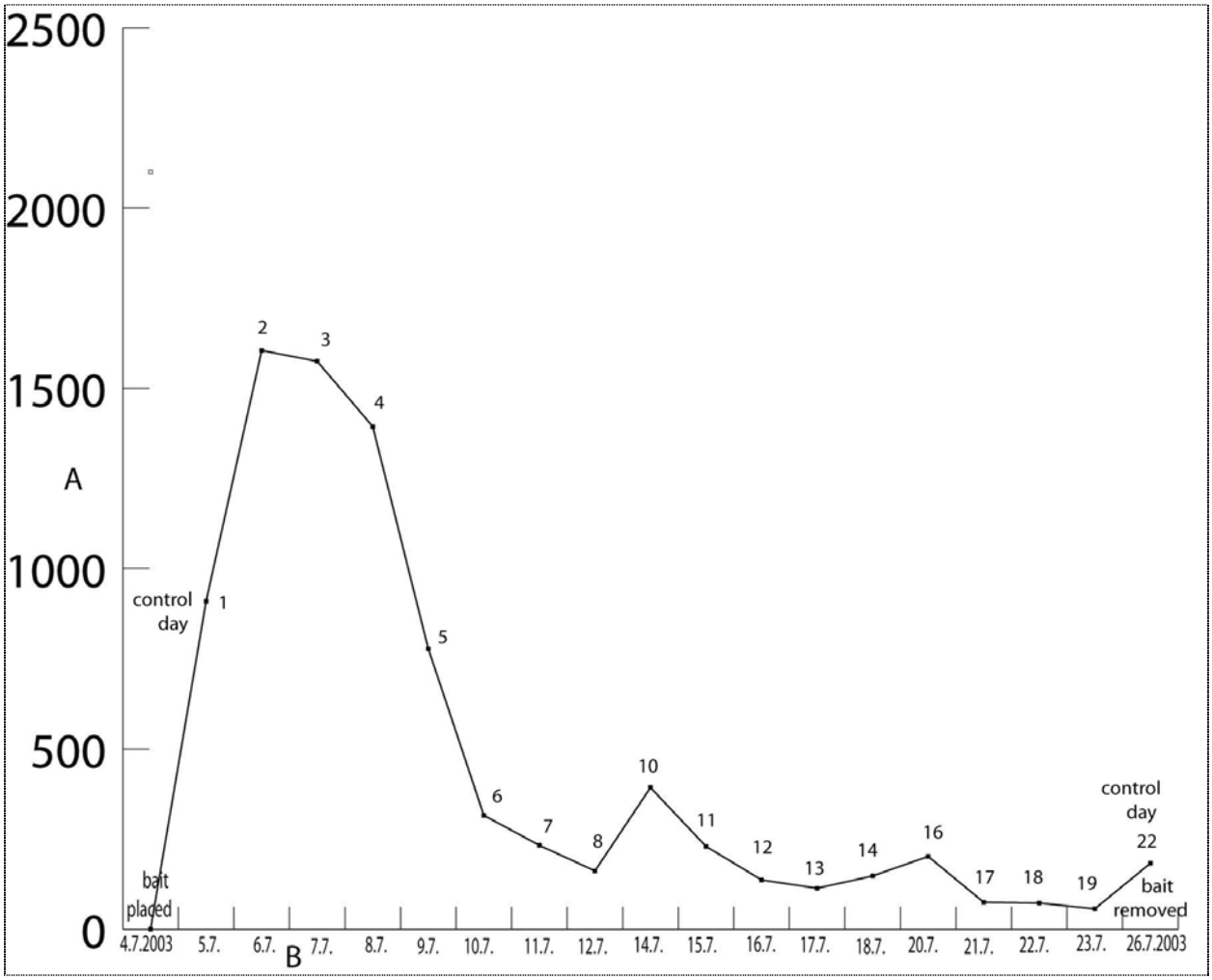


Fig.18 – Amount of daily replaced blocks of rodenticide "Klerat" (i.e. bait take) in the poisoning-phase of the eradication. A= amount of wax blocks replaced (bait taken); B= date of control days; numbers of control days are marked in graph.

At this stage all rat droppings found were blue, showing the lethal contamination of these particular individuals. However, not too many droppings were found but all of them were blue by these days. Every day the particular place was carefully cleaned so that new droppings could be identified. A similar picture as for the bait-take was also observed in regard to the number of active (used) and passive (not used) bait stations, which increased and dropped comparable. The percent of active stations (out of 100% as being the total number of all stations out on this day) was 67 % on control day 1, increased to 90 % on control day 2 (figure includes the 18 stations added on the 5th of July), remained roughly on this level for the control days 3 (95 %) and 4 (90 %), followed by a drop down on control days 5 (63 %) and 6 (40 %) reaching a first minimum figure on control day 7 with only 36 % of stations active (fig.19).

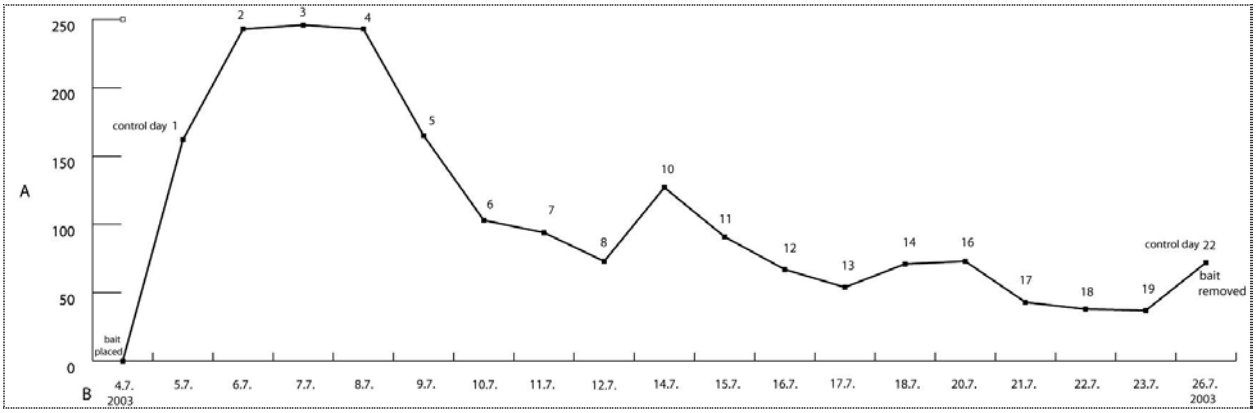


Fig.19 – Number of active bait stations (stations with bait take by any source) in the poisoning-phase of the project. A= total number of all stations; B= dates of control days; numbers of control days are marked in the graph.

No statistic calculations are presented here but all relevant data was carefully recorded and detailed lists and figures are available from InGrip-Consulting upon request. In regard to interpretation of the graphs shown in figures 18 and 19 a few additional information have to be given here. For the figures of bait used to replace missing bait it has to be observed that from control day 7 onwards controller Meier started to reduce numbers of "Klerat"-wax blocks in certain stations depending on the general as well as specific situation. This was done with great care and concerned only the lines A to N and some of the X points close by to these lines. Daily control at this stage had shown that none of the points concerned were having bait-take of more then two or three blocks per day, meaning that a minimum of five blocks remained in every of these stations. Also no clearly rat-caused feeding signs were detected. If this was the situation in the whole line for three days in a row, and in addition to this also on all adjacent points further west and east of the point concerned, it was decided by controller Meier to reduce the number of bait blocks on these lines by 50 %, i.e. to now only four blocks (20 g) of "Klerat"-rodenticide. It was assumed that this situation wasn't going to change as in fact it not did. The reason for this step was at first that these lines were the ones lying in the most forested part of the island, believed to have the lowest density of rats; an assumption which the picture of comparable fast reduction in bait-take at these stations matched. Furthermore this area is – being the most remote and less disturbed by humans on the island – the part of Sangalaki which harbours the major populations of the relevant non-target species Monitor Lizard and Megapode. With the reduction of the poison in this part of the island to a new necessary limit already a general reduction of 50 % of toxins in this environment was achieved. Furthermore the risk of non-target poisoning of especially smaller animals of any kind would be limited. Finally because of this decision the bait stations did become more secure – this due to the limited number of wax blocks the bait remained more stable and hence safer in the bottles as compared to the double number of blocks in the same space. It might be needed to repeat here again that such reduction was only undertaken on certain lines under specific circumstances. Never a situation existed where no bait was available in one of these stations and special attention was always given to these lines. Bait-take went down to zero on most of these stations soon afterwards anyway.

In regard to any interpretation of the graphs in figures 18 and 19 it has to be observed that some bait stations were added to the earlier total number and two others were withdrawn before the poisoning-phase ended. A further 'graph-manipulation' occurs through the days of no control. These were the otherwise normally control days 9 (13th of July), 15 (19th of July) and 20 - 21 (24th - 25th of July 2003). Control activity on these days was set out by plan to maintain material, give personnel time to recover from work, arrange notes, prepare permanent bait stations, search intensively for rat signs or potential wildlife damages on the island etc. Due to the fact of loosing some bait to the climate conditions (melting in single cases) and non-susceptible feeders as hermit crabs and other invertebrates the control days immediate following these breaks were always ended with a larger amount of replaced bait and an increase of active stations (which was not automatically related to rat presence).

Therefore the illustrated graphs are rising following such days of no control work. The first increase in these both figures (at control day 10) further correlates to the observed and documented fact that after an initial crash of a large part of the rat population now feeding came possible for smaller and juvenile animals. They were probably before kept away from the new food sources by dominant animals or were now forced to look for food themselves after rearing females died or didn't returned to the nest.

This expected picture was underpinned by the finding of mostly juvenile dead rats at this time and observations of nearly exclusively smaller animals feeding on the bait.

Also if – any way whether at day or night – rats were encountered alive these were also smaller animals, and their always abnormally behaviour showed that they stood already under the rodenticide's influence.
The second rise in the graphs (at control days 14 to 16) again includes one no-control day which has to be calculated in. Furthermore it is reasoned that at this stage a very large reduction in rat numbers and their density had taken place, which was nearly immediately followed by intensive feeding of hermit crabs on the, now, easier available bait (no real rat competition existed anymore). Although the majority of the encountered hermit crabs were of smaller size then the one seen on other islands and projects, they had the same ability to learn quickly about the locations of the bait and in the following hours rapidly massed up at these stations. Some larger hermit crabs found were able to empty off a whole station's content within a few hours. This crab infestation on the bait stations was observed also on days of no-control, but nevertheless no station was checked or cleared of crabs on these days, leaving conditions equal across whole Sangalaki. However, it was always guaranteed that some bait would remain in every station for any rat to feed on. Hermit crabs as well as other invertebrates are not harmed by consumption of this type of rodenticide, but their negative impact in regard to the increasing bait loss and less bait availability for rats has to be observed and calculated ahead in any comparable project.
The effect of the crab activity was countered in the following days by modifications on the bait stations locations toward more crab safe (but not rat excluding) places. This resulted in a renewed decline of bait-take and number of stations active over the following days. In addition candles on wire were placed near to certain stations to detect what animals are feeding there at night. By so it was at some points possible to identify that crabs were carrying away or eating poison. In such cases crab-claw signs could be seen on candle pieces (fig. 20). Toward the end of the poisoning-phase (on control day 22) this downward trend in bait-take and stations active was reversed by an exclusive two day break in control activity. This break was followed by a new increase in both figures, especially in the area along the coast which had the highest crab presence. No rodent signs were detected by this time anymore. It was also observed that bait was destroyed and carried away by ants.
However, some other factors might in addition play a role, and not all are fully understood (e.g. the influence of small skinks observed to shelter in the stations). All data were carefully recorded and are available from InGrip-Consulting upon request.

Dead Black Rats were found only in small quantities but in larger numbers than originally expected. The total number of found animals was around 60 individuals of all sizes, ages and both genders. This was probably roughly 10 % of the islands total population. Except three individuals all dead rats were found in the area of the dive lodge and its buildings, which was reasoned in the comparable high population of rodents in particular this part of the island. Due to normal preferences and likely competition rats had placed their nests in the upper parts of the buildings (fig.21). Very likely the dead or dying animals encountered in the dive lodge area (here mostly found below trees or in front of the houses) were animals to weak for climbing up into their higher located nests.

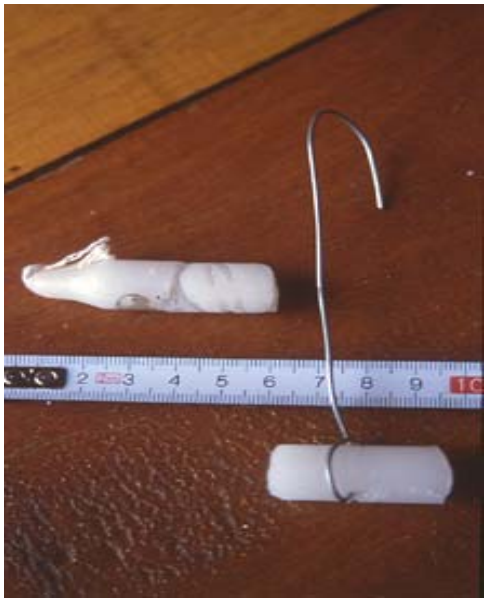


Fig.20 – Detection candle marked by crab.

Fig:21 – Black rat living in the roof of a building.

The first dead animal was first found on control day 4. In the following days the number of cadavers increased until after control day 8 only very occasionally a dead rat was found. Parallel to the decrease of dead animals found a decline in their sizes was recorded as well.

All carcasses were centrally collected and every evening all dead rats, any exchanged bait blocks and the rubber gloves used for collecting and handling of rats were burned. Smell of decaying rats, three dead animals found and the stop of bait-take on stations near to this allowed also to record success of the poisoning work in the forested area of the island.
Along the beach no tracks of rats were seen anymore since control day 8.
The last living rats were observed on the 12th of July near the monitoring station (two small and weak animals), on the 14th of July at the cleared, former garbage site (unverified employee-report about one animal) and on the forest edge near the staff's living house one animal encountered by G. Meier ob in a bait station. This was the last personally observed living rat - a small animal with clearly toxin-influenced behaviour.
A report on a surviving animal in the kitchens food store showed the importance to place bait stations literally within the range of every animal. It seemed that a small rat survived in the locked store until control day 13. It was then targeted with a bait station placed in this room. Small bait take was detected at the next day and obviously resulted in a dying animal, as observed by the kitchen personal a few days later. Since then no bait was taken anymore from this station. Another bait station, placed in the kitchen of the monitoring station, was emptied for two days in a row before bait take stopped and a dying animal was observed by the staff there.
All bait and bait station were withdrawn at control day 22 (26th of July 2003). The total amount of bait used had reached around 55 kg, (equivalent to 4,15 kg/ha). Live trapping with Tomahawk collapsible live-traps (Type TLT no. 202 - squirrel size), was undertaken for several days to detect any potentially surviving rat. Highly attractive bait (fish, shrimps, chicken, fruits, peanut butter, toasted bread and cookies) was used and traps set on carefully chosen localities, spread over the whole island, but in totally 444 trapping hours between the 19th of July and 26th of July 2003 no rat was caught.
The same live-trapping procedure was undertaken on the 2nd and 3rd July 2003 and resulted in the catch of 8 animals (including one female with juvenile) in only 7 trapping hours. Until proven different Sangalaki was therefore declared temporarily rat free at Guntram Meier's departure on the 28th of July 2003.

Costs

Detailed accounting was already presented to Turtle Foundation and all costs are settled.
General project costs resulted in the amount of € 3.150, -- which totally was shouldered by Turtle Foundation. The majority of the money was needed to cover the travel costs of the two consultants (two tickets from Germany via Singapore and Balikpapan to Tanjung Redep and return). Other costs resulted from buying the rodenticide (€ 360,--), paying for different project materials and additional transport costs of K. Varnham (together € 500,--), costs for four hotel nights in Balikpapan (€ 100,--), material and preparation costs in Germany (€ 290,--) and additionally arising return-travel costs (as air port taxes, excess luggage etc. - € 100,--).Based on this the costs of the rat eradication project came to an equivalent of around € 240,-- per hectare. This figure would have been clearly higher in case consultant fees or any other salaries would have been charged by InGrip-Consulting or freelancing Invasive Species Biologist MSc. K. Varnham. To the well of the turtle project no such payments were requested, billed, or received by the control experts.

Risk and effects to non-target species

On Sangalaki lives no terrestrial mammal except one species of Flying Fox (probably *Pteropus spp.)* which roosts at least sometimes in small number (less then a dozen) at the islands forest. Thus no other mammal was placed at risk by the rat eradication effort with this type of poison. Such would have been by way of secondary poisoning (through eating dying or dead rats) or through direct bait take. Especially the on the island living omnivore Monitor Lizards (*Varanus salvator*) were the species most likely to become effected by a secondary poisoning, as these animals would eat dying rats or their carcasses. In deed such consumption was later recorded while the project proceeded.
In regard to direct bait-take poisoning the species of most concern was the Megapodes (*Megapodius spp.* probably *cumingii*; publication on their status is currently in preparation for the IUCN-Megapode Newsletter) living on the island. It was especially likely that this species becomes attracted by the poisoned rice-grains in the wax blocks. As some of the wax blocks were of poorer quality rice corns were sometimes clearly seen and could be directly approached. Juvenile Megapodes were especially vulnerable as they from their hatching on are completely self-depending. Therefore it was considered that new food sources might becoming directly approached and tested, hence also the poison-bait in the stations. Therefore the already mentioned precautionary measures were taken (the selection of the specific rodenticide "Klerat", the preparation of bait stations), but in addition wire-sheets were made, which were later added in front of certain bait stations. This was designed to further increase the protection against entrance of non-target species.

Poison bait was distributed over the whole island exclusively in bait stations and the stations were monitored carefully. Most attention was given to the stations in the island's forest, as here the majority of non-target species lived. As it came visible that the rats are carrying bait out of the station on a regular base, decision was made to cut down poison quantities in specially 'vulnerable area' by 50 % (as described earlier). Additionally certain bait stations in the area were extended by a tunnel-like wire construction put in front of the stations entrance. They were made out of 30 x 30 cm pieces of cut mesh wire. This was bended and added to stations which were frequently used by any hitherto 'unknown bait spreading organism' (fig. 22 and 23).

Fig.22 – Bait station protected with wire.

Fig.23 – Protected bait station with candle.

The whole construction was than covered with natural materials to reduce any potential neo-phobic effect. These installations were only introduced from control day 7 onwards and only at selected stations. By this date the poisoning had first success already, and so it is unlikely that the modifications had any significant repelling effect on the targeted rats. In most of the cases the station next to a wire-protected one was unprotected, and so this bait was open accessible for any more mistrusting rodent. The new constructions proved successful, as in many cases – assumingly by small reptiles, as personally observed – bait was moved out of the station but remained untouched under the new wire extensions.

Protecting the Monitor Lizards from eating poisoned rats could not be achieved completely. However, the majority of rats died in their nests underground or the vicinity of the dive lodge. They were immediately collected and completely burned every day. Given the size and weight of most of the Monitor Lizards on Sangalaki only a larger number of rats, eaten by the same individual reptile, could have created any harm. It is also believed that reptiles are less vulnerable to the poisons effects then birds or mammals are. Especially smaller Monitor Lizards were able to follow the smell of a dead or dying rats into their burrows. This risk however was naturally minimized by the occurrence of different species of ants and many crabs on Sangalaki. It was observed, that within shortest time the feeding by these invertebrates removed a single dead rat nearly completely. Nevertheless a certain risk to the named species remained throughout all of the project and should not be played down or ruled out. However this was accepted by all parties involved. Prior to the decision on the projects execution it was made clear that a secondary poisoning of a few Monitor Lizards could happen under worst circumstances, but as their population was probably suffering as well from rat predation (eating of eggs or juveniles), these reptiles were not endemic or threatened species, had established a good population with acceptable density on the island, and even the worst case would not lead to their full extermination, the decision was taken by all parties to bear such remaining risk.

However, no loss of a non-target individual was recorded at the end. All species, whether permanently or temporarily present on Sangalaki, were carefully observed and monitored throughout the project. This also includes birds like Brahminy Kite (*Haliastus indicus*), Osprey (*Pandion haliaetus*), White-bellied Seaeagle (*Haliaetus* leucogaster), Pacific-Reef Egret (*Egretta sacra*) or Collared Kingfisher (*Halcyon chloris*), which are as well potentially susceptible to secondary-poisoning.
A full list on observed avifauna is prepared separately by InGrip-Consulting.
Future investigations are needed to show all effects of the achieved rat eradication. So fare different people noted already an increase in small birds, butterflies, some invertebrates (as cockroaches and caterpillars), as well as fruits and flowers on the forest ground. However, these reports are only anecdotal and too subjective to conclude anything here already.

Follow up work:

Toward the end of the poisoning-phase forty permanent bait stations were established across Sangalaki-Island to prevent a rat re-infestation through new arriving animals.
The stations best positions were defined after a specific investigation of the area had identified the places of highest risk for successful re-colonisation. These are particular the supply boats landing-zones and the adjacent area of the dive-lodge and its facilities. Twenty-seven bait stations were established in this area alone and another nine along the islands shoreline. Further four stations were placed in a 50 m distance to create a type of north-south dividing-line between the dive lodge's area and the forested part of Sangalaki. All bait stations were numbered and mapped and these data, together with all remaining material and 65 kg remaining "Klerat"-rodenticide, handed over to the persons designated by Turtle Foundation to execute the follow-up work (fig. 23 and 24). The same poison as taken for the eradication will be used to stock the permanent stations with bait. The appropriate doses is currently set to be ten blocks (i.e. 50 g) of poison for each station. At the moment these stations are of the same types as used in the eradication, but they will become exchanged for commercially rodent-control bait stations within the next weeks.
It was scheduled that all stations get monitored on every 1st day of a new month and a monitor protocol has to be send to Turtle Foundation or/and InGrip-Consulting for remote counter-check of this patrols.

An emergency plan for the case of a rat-re-infestation will be provided to Turtle Foundation by InGrip-Consulting. Furthermore all supply-boats stopping on the islands are planned to become bait stations established on board. This will control rats or mice prior to their arrival on the island already, and further reduce chances of a successful new rodent arriving on the island.
Such operation should best be done in the context of an awareness-creating campaign, which specifically should tackle problems invasive animals are causing and the dangers rodent transmitted diseases are posing. The development of such campaign is still outstanding but could be designed together with other organisations or agencies working in nature protection or development cooperation.

Fig.24 – Marking of permanent bait station.

Fig.25 – Material for the follow up control.

InGrip-Consulting offers to act as a permanent advisor for all invasive animal aspects of the marine turtle conservation project at Sangalaki. However all guarantee for having the island continuously rat-free is strictly limited to the extend of properly executed follow up work, designed to be performed by the permanent staff on Sangalaki it self.

This is InGrip-Report No.1, prepared for Turtle Foundation - Hauptstr. 1 - 82541 Ammerland, Germany

Prepared in Berlin on the 20.11.2003, by:

Guntram Georg Meier
Senior Consultant
Member of IUCN/SSC Rodent Specialist Group

InGrip-Consulting & Animal Control
Strassmannstr. 46
D – 10249 Berlin
Germany

Phone: + 49 – 30 / 420 21 423
Fax: + 49 – 30 / 420 21 424
Email: contact@ingrip.com