Urban avian population and possible heavy metal contamination at Parc Tsarasaotra, Alarobia, Antananarivo, Madagascar

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Abstract

Fifty species of birds have been recorded in the Parc Tsarasaotra (also known as Ile aux Oiseaux), a 27 ha property 4 km from the Antananarivo city center. The habitat within the park consists of three interconnected lakes and associated wetlands, and many of the locally occurring bird species spend a significant amount of time in the aquatic habitat. In order to determine the water quality of these lakes, testing was performed on three occasions. High levels of nitrate (> 5 mg/L) and low pH (< 6), were found in the inflow to the park, as well as possible heavy metal contamination by mercury, zinc, and nickel. Heavy metal testing was qualitative. Upstream sources of these contaminants, as well as more quantitative testing are necessary to confirm their presence and the source of the nitrate contamination.

Résumé détaillée

Le Parc Tsarasaotra appelé aussi Ile aux Oiseaux, est une propriété privée de 27 ha, à 4 km du centre d'Antananarivo. Le Parc contient des habitats terrestres et aquatiques. Ces derniers se composent de trois lacs ou étangs (ils sont désignés Lac 1, 2 et 3). L'eau coule du Lac 1 vers le Lac 2 et ensuite vers le Lac 3 et à partir de ce dernier, l'eau se déverse finalement dans le Fleuve Ikopa, qui est à environ 2 km au sud-ouest du Parc. Le Lac 1 est aussi utilisé par la population locale pour la production de riz et la pêche.

Cinquante espèces d'oiseaux ont été enregistrées dans le Parc, entre autres, le Héron garde-boeufs (*Bubulcus ibis*), le Héron crabier chevelu (*Ardeola ralloides*), le Héron Bihoreau à calotte noire (*Nycticorax nycticorax*), l'Aigrette dimorphe (*Egretta dimorpha*), le Canard à bec rouge (*Anas erythrorhyncha*), le Dendrocygne veuf (*Dendrocygna viduata*), le Canard à bosse (*Sarkidiornis melanotos*), le Martin-pêcheur malachite (*Corythornis vintsioides*) et la Rousserole de Newton (*Acrocephalus newtoni*).

Après l'observation d'un grand nombre d'oiseaux morts autour du Parc, la famille Ranarivelo, propriétaire du Parc Tsarasaotra, a demandé à l'école américaine d'Antananarivo de faire un test de la qualité d'eau. L'analyse a été exécutée trois fois : le 18 janvier, le 7 mars et le 8 juin 2008, pour déterminer la température, le pH, le nitrate, la turbidité, le chlore, l'oxygène dissout (DO), la turbidité (la clarté d'eau) et la présence de métaux lourds.

Un taux élevé de nitrate a été trouvé dans tous les afflux du Lac 1. Les concentrations exactes n'ont pas pu être déterminées car les concentrations ont excédé la gamme maximale du kit d'essai. Les plus hautes concentrations, >> 10 ppm, ont été trouvées dans les échantillons du côté sud du Parc. Une quantité plus faible, 2 ppm, a été trouvée dans l'échantillon du côté est du Parc. Ces résultats indiquent que l'afflux au système aquatique dans la partie du sud-est du Parc est lourdement contaminé avec le nitrate. Bien que l'azote soit un élément indispensable pour la vie, dans l'excès, il peut agir comme un polluant. Il est un élément limitant dans les endroits aux climats ressemblant à ceux d'Antananarivo, où il y a des saisons pluvieuses et sèches distinctes. Par conséquent, l'apport d'azote, dans la forme de nitrate, peut augmenter la croissance de certaines plantes. En outre, l'excès d'azote pourrait changer les types de plantes présentes dans un endroit donné. Les espèces comme la jacinthe d'eau se développent quand les concentrations d'azote sont élevées.

Du métal lourd a été aussi trouvé dans tous les afflux du Lac 1, pourtant le kit du test de métaux était qualitatif et aucune donnée quantitative sur les concentrations n'a été obtenue. Les analyses ont indiqué la présence de mercure, de nickel, de zinc et du cuivre. Des métaux lourds comme le cuivre, le zinc, le nickel et le mercure sont associés aux différents processus industriels tels que la réparation d'auto, l'entreposage et le traitement pétrolier, la fabrication de peinture et son utilisation, le tannage de cuir, la fabrication de textile, le traitement de bois, le traitement de caoutchouc, la réalisation de cuivre jaune, le fer et le travail d'acier.

En outre, le mercure est associé au traitement de l'or, des crèmes décolorantes pour la peau et des

Barratt, N., Lashaway, C., Rai, A., Molou, I., Kartchner, Z. & Holley, A. 2009. Urban avian population and possible heavy metal contamination at Parc Tsarasaotra, Alarobia, Antananarivo, Madagascar. *Malagasy Nature*, 2 : 167-172.

ampoules électriques. Les métaux peuvent provoquer des troubles neurologiques chez les humains et la vie sauvage, particulièrement le mercure et le zinc. Les métaux lourds sont des substances qui sont bioaccumulées, ce qui signifie qu'ils s'accumulent à l'intérieur d'un organisme qui n'a aucun moyen de se débarrasser de la toxine après son ingestion. Quelques métaux sont aussi des bioamplificateurs, c'est à dire que des organismes se plaçant en haut de la chaîne alimentaire contiennent un taux plus élevé de toxine par rapport à celui des autres qui se trouvent à un niveau inférieur. Les oiseaux de proie, comme les hérons et les rapaces, sont particulièrement susceptibles à ces bioaccumulation et biomagnification.

L'eau d'afflux avait aussi un pH faible. Au mois de janvier et peut-être en mars, cela pourrait être dû à de récentes pluies, qui sont habituellement acides, mais c'est improbable en juin. Le pH faible indique la présence d'acide dans l'afflux. L'acide est très utilisé en industrie incluant les travaux de fer et d'acier, le traitement de métal, la réalisation de caoutchouc, le tannage de cuir et la fabrication de textile. Les sources naturelles incluent la chute de pluie, qui est acide en raison des acides libérés dans l'atmosphère par les feux de cuisson et les gaz d'échappement. Un pH faible est extrêmement préjudiciable aux écosystèmes aquatiques, particulièrement pour les amphibiens. La perte d'organismes sensibles pourrait avoir des effets sur la chaîne trophique. D'autres variables de la qualité d'eau étaient dans la gamme normale. Des analyses du sol et d'échantillons d'eau supplémentaires sont nécessaires pour déterminer l'ampleur, les sources et une possible remède de la situation.

Introduction

Madagascar has 283 bird species, of which 209 nest on the island and of these 51% are endemic (Goodman & Hawkins, 2008). With 37 endemic genera, and 5 endemic families, Madagascar has more unique bird life than any other African country. Lake Tsarasaotra is a 27 ha, property in a neighborhood known as Alarobia, consisting of lakes and tree plantations, and about 4 km from the center of Antananarivo. Fifty species of birds have been recorded at the site (Malzy, 1967; Wilmé & Jacquet, 2002), which include a number of taxa associated with aquatic habitats:

- egrets: Cattle Egret (*Bubulcus ibis*), Squacco Heron (*Ardeola ralloides*), Black-crowned Night Heron (*Nycticorax nycticorax*), and Dimorphic Egret (*Egretta dimorpha*);
- ducks: Red-billed Teal (*Anas erythrorhyncha*), White-faced Whistling Duck (*Dendrocygna viduata*), Knob-billed Teal (*Sarkidiornis melanotos*);
- kingfisher: Malagasy Kingfisher (*Corythornis vintsioides*); and
- songbirds: Madagascar Swamp-warbler (*Acrocephalus newtoni*).

The park is owned by the Ranarivelo family, who enlisted the support of the Malagasy Government, the World Wildlife Fund, Birdlife International, and Peregrine Fund, to protect this urban freshwater habitat for breeding and visiting birds. To preserve the Tsarasaotra wildlife habitat, the Ranarivelo family created in March 2001 the "Association Parc de Tsarasaotra" (APT), an independent association. The main objective of the organization is to protect, conserve, value, manage, and maintain the park. The APT is also maintaining the historical buildings at the site. There is an "Information Center" on the estate where up-to-date information on the seasonal and migratory birdlife is available. The park is also classified as a RAMSAR site by the International Convention on Wetlands.

The first known owner of the park was Rainimaharavo, who sold the property in 1835 to Rainiliarivony. The park served as a stopover for Queen Ranavalona III on her trip between the palace of Ambohimanga and Manjakamiadana. Tsarasaotra was the last residence of Rainiliarivony before his exile to Algeria. It has been almost 100 years since Emle Ranarivelo bought Tsarasaotra from the descendents of the first Prime Minister, Ratlifera (Boogie Pilgrim, 2007).

The park contains both terrestrial and aquatic habitats. The wetland habitats consist of three small lakes or ponds that we designate as Lake 1, 2, and 3 (Figure 1). Lake 1 in the easternmost part of the park and contains all the inflows to the local aquatic system. Water from Lake 1 then flows into Lake 2, and then into Lake 3 that is the outflow of the system and that eventually finds its way to the Ikopa River, approximately 2 km southwest of the park. Lake 1 is also used by local people for fishing and rice production.

Methods and Materials

The American School of Antananarivo brought students to the Parc Tsarasaotra to conduct water quality testing on three dates: 18 January, 7 March,

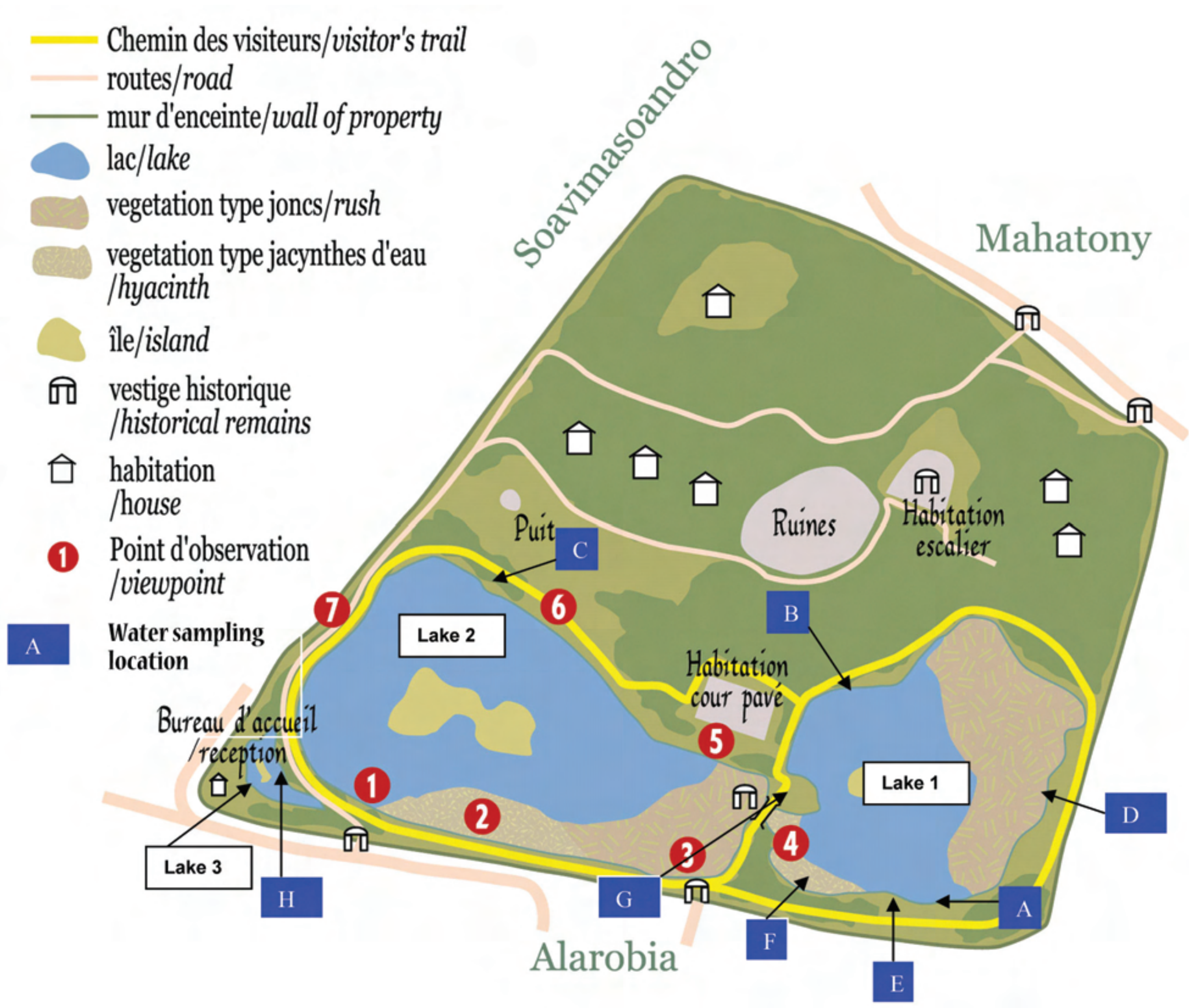

Figure 1 – Parc Tsaratsoatra modified from (CD-ROM de Parc Tsaratsoatra, Boogie Pilgrim, 2007).

and 8 June 2008. Testing was performed upon the request of the Ranarivelo family after they observed a considerable number of dead birds around the park. During each visit, water quality testing was performed at multiple locations (Figure 1). Locations A, D, E, F, and G are small inflows (< 0.5 m^3/s) to the aquatic system. Samples from site A were obtained from a concrete lined culvert running into the Lake 1. Sample B was from the north side of Lake 1. Sample C was from the northern edge of Lake 2 and sample H from Lake 3. Tests were performed to determine temperature, pH, nitrate, turbidity, chlorine, dissolved oxygen (DO), secchi depth (water clarity), and presence of heavy metals. Only a single test of each type was performed at each location on a particular day.

Water sampling was done using pre-washed 500 ml Nalgene bottles. Each sample was obtained by triple rinsing the sample bottle and then submerging the bottle completely under the water surface. Testing was performed using "Chemetrics" (CHEMetrics, Inc., Calverton, Virginia, USA) test kits for nitrate (0 – 10 ppm range), chlorine (0 – 3 ppm range), and dissolved oxygen (0 – 10 ppm range), standard laboratory pH test strips, an alcohol thermometer (-10--50°C range), and using the "LaMotte Qualitative Chemical Metal Test Kit", code 313 (colorimetric) (LaMotte Company, Chestertown, Maryland, USA). Water depth was estimated using a standard wooden meter stick with 1 cm gradations.

Results

The details of the various chemical and physical aspects of the different water samples are presented in Table 1. Numerous water quality variables are within the normal range and are not discussed in any further detail. During the January 2008 sampling, the poorest water quality was found in the south inflow to Lake 1 and subsequent sampling focused on inflows to this lake. High levels of nitrate were found in all the inflows to Lake 1. Exact concentrations could not be determined because the levels exceeded the maximum range of the test kit. Highest concentrations, >> 10 ppm, were found in samples from A, E, F, and G, that flow in from the south side of the park. A lower amount, 2 ppm, was found in sample D, which flows in from the east side of the park. These results indicate that the southeastern inflow to this aquatic system is heavily contaminated with nitrate.

Heavy metals were also found in all the inflows to Lake 1. However, the metals test kit was qualitative and no quantitative data for concentrations were obtained. Using the LaMotte kit, presence of metals is determined by a color change, which indicated the presence of mercury, nickel, zinc, and copper.

The inflow water also had a low pH. In January and possibly March, this could have been due to recent rains, which are usually acidic, but this is unlikely in June, which is during the dry season. Hence, during this latter period the low pH is presumed to indicate the presence of acid in the inflow.

Nitrogen

Nitrogen is a nutrient essential for life, but in excess, it can act as a pollutant. Nitrogen is the limiting nutrient for the growth of plants in places with climates like Antananarivo, where there are distinct rainy and dry seasons. Hence, the addition of nitrogen, in the form of nitrate, can increase plant growth. The more nitrogen added, the more plant growth occurs. In addition, the extra nitrogen can change the types of plants present. For example, introduced species like water hyacinth (*Eichornia crassipes*, Family Pontederiaceae) thrive when nitrogen concentrations are high (Horne & Goldman, 1994; Henry-Silva *et al*., 2008). These plants can be harvested as a method of nitrogen removal. Currently, aquatic plants clogging the open water of Parc Tsarasaotra are harvested almost continuously by the staff. However, the removed plants are stockpiled on the edge of the lake, where they decompose, and release nitrogen back into the lake. In several tropical and developing countries, the harvested plants are stockpiled, moved off-site, and used as compost or burned as a biogas fuel (Jayaheera *et al.*, 2007).

Heavy Metals

Heavy metals such as copper, zinc, nickel, and mercury are associated with light and heavy industrial processes such as automobile repair, petroleum storage and processing, paint manufacturing and use, leather tanning, textile manufacturing, wood processing, rubber processing, brass making, and iron and steel working (USEPA, 2008). In addition, mercury is associated with gold processing, skin bleaching creams, and light bulbs (TemaNord, 2002). Metals can cause neurological disorders in humans and wildlife, particularly mercury and zinc (Layla Resources, 1999). Heavy metals are substances that bioaccumulate in the tissues of animals, which means that they are built up at a level higher than the surrounding ecosystem, as the organism has no way to rid itself of the toxin after being ingested through water or food. Some metals also biomagnify, which means organisms higher up on the food chain contain higher levels of the toxin (Horne & Goldman, 1994). Predatory birds, such as herons and raptors, are particularly susceptible to this bioaccumulation and biomagnification (Hollamby *et al.*, 2004). Once metals enter the Tsarasaotra aquatic ecosystem via the culvert system, a substantial proportion fall out of the water column and enter the soil. From the soil

Table 1. Listing of different sample analyzed, collection dates, and various measured parameters.

Sample	Date sampled	Water depth (cm)	Temperature (°C)	pH	Chlorine (ppm)	Dissolved oxygen (ppm)	Possible metals present	Nitrate (ppm)
A	18 January 2008	20	25.0	5	0 .0	8.0	mercury	>> 10
B	18 January 2008	25	24.0	6	0.2	9.0	none	0.4
C	18 January 2008	20	25.0	7	0.0	8.0	none	0.0
A	7 March 2008	4	nd	6	nd	nd	nickel	>>10
B	7 March 2008	5	nd	nd	nd	nd	nickel	0.3
C	7 March 2008	26	nd	nd	nd	nd	none	0.0
D	7 March 2008	10	nd	7	nd	7.5	nickel	2
E	7 March 2008	5	nd	6	nd	7.0	zinc or Copper	>>10
F	7 March 2008	6	nd	6	nd	8.0	nickel	>>10
G	7 March 2008	6	nd	6	nd	7.0	nickel	>>10
H	7 March 2008	25	27	7	nd	7.0	none	0
A	8 June 2008	5	24	6	0	nd	zinc or copper	>>10
E	8 June 2008	4	24	6	0	nd	zinc or copper	>>10

nd = test not performed

plants can take up these metals. The plants are then eaten by insects or other small organisms, which are then consumed by fish, and subsequently fed upon by piscivorous birds, leading to bioaccumulation and, in some cases, biomagnification (Horne & Goldman, 1994).

Although it is difficult to detect how metal toxicity might be manifested in wild birds, the toxic effects of copper in birds include reduced growth rates, lowered egg production, and developmental abnormalities (Hollamby *et al*., 2004). Mercury is a mutagen (mutation-causing), teratogen (developmental abnormality-causing), and carcinogen (cancer-causing). Effects of mercury poisoning in birds can include altered breeding behavior, impaired vision, hearing, and motor skills, embryo death and deformities, reduced egg hatchability, reduced chick survival, poor coordination, and inability to fly (USEPA, 2008). Elevated zinc levels can cause mortality, pancreatic degradation, reduced growth, and decreased weight gain in birds (USEPA, 2008). Nickel is also a carcinogen and mutagen (Layla Resources, 1996).

Many nations have banned the used of these metals in items such as paints, pesticides, and industrial processes. Run off from agriculture, paint waste, and industrial waste water from gold processing, skin bleaching cream, jewelry making and PVC pipe cutting could all possibly be contributing factors to the high concentrations in the Parc Tsarasaotra. Heavy metals may accumulate in the water hyacinths and can be used as a remediation method for heavy metal contamination (Jayaheera *et al*., 2007; Henry-Silva *et al.*, 2008).

Low pH

Low pH is generally caused by addition of acid to the aquatic ecosystem. Acid has many industrial uses including iron and steel working, metal processing, rubber making, leather tanning, and textile manufacturing (USEPA, 2008). Natural sources of acid include rainfall, which is acidic due to acids in the atmosphere released by cooking fires and automobile exhaust (Horne & Goldman, 1994). Low pH is highly detrimental to aquatic ecosystems, particularly amphibians. Loss of sensitive organisms can have food chain effects. As pH decreases, metals also become more available. They are released from soil and other particulate matter and become dissolved in the water column. They then become concentrated in plant and animal tissue in the areas where pH is < 7 (Gosavi *et al*., 2004; van Gestel, 2008).

Conclusion

With the ever-increasing industrialization of the areas surrounding Antananarivo, the risk of environmental pollution increases. However, little has been published on this topic, which is critical for locally occurring and downriver human and animal populations. Herein, we have presented evidence from the Parc Tsarasaotra, that forms a portion of the Ikopa River drainage, that there is a notable problem of water pollution at the site, which is an important refuge for some local aquatic species.

It is very difficult and expensive to remove nitrogen and heavy metals from the water and soil at Parc Tsarasaotra. In order to more clearly understand the magnitude of the problem and potential mitigation steps needed, the next suggested research should focus on:

1. Collecting more water and soil samples over a larger geographic area of Antananarivo or more broadly across the Central Highlands. A broader period of sampling is needed to determine the extent of metals and/or nitrogen pollution and cyclic aspects.
2. If one or more inflows to the system are found to be high in levels of metals or nitrogen this must be monitored, the source located, and then curtailed.
3. Fishing in areas close to the inflow, with low pH levels, should be avoided to decrease the possibility of ingestion of heavy metals.
4. The harvesting of water hyacinth should continue within the local park ecosystem, but the harvested plants should be removed from the site, so that as the plants decompose, the nitrogen is not returned to the water. The removed plants could be composted, or used as a biogas fuel.

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New distributional records of Appert's Tetraka (*Xanthomixis apperti*) from Salary Bay, Mikea Forest, Madagascar

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Résumé

Le 19 octobre 2008 deux Tétraka d'Appert (*Xanthomixis apperti*) ont été observés à deux reprises à Baie de Salary, localité située à mi-chemin entre Toliara et Morombe, le long de la côte, dans un milieu appartenant au bush épineux sub-aride. Cette observation constitue une extension significative de la distribution de cette espèce endémique préalablement connue que de la forêt sèche caducifoliée de Zombitse-Vohibasia appartenant au domaine biogéographique de l'Ouest et de la forêt d'Analavelona, forêt humide de l'ouest.

Introduction

On 19 October 2008, we were bird watching 4 km north of the Hotel Salary Bay (coordinates of the hotel: 22˚33'19''S, 43˚17'08''E) located along the southwestern coast of Madagascar about half way between Toliara and Morombe. The dominant habitat at the site is south-western dry spiny forest thicket dominated by Didiereaceae and arborescent vegetation such as *Euphorbia enterophora* (Euphorbiaceae) (Moat & Smith, 2007) growing on sandy soil. The weather conditions were excellent, with a slight breeze, very good light, and still cool (18˚C at 6:30 am). This region of Madagascar receives little rainfall, around 450 mm per year (Donque, 1972), mostly between December and February.

On the morning of observation we were in the forest between 5:30 am and 8:30 am, very few birds were heard singing, and even fewer moving around despite the fact that mid-October is considered the beginning of the breeding season in this region. We observed several Lafresnaye's Vanga (*Xenopirostris xenopirostris*), Sicklebill Vanga (*Falculea palliata*), Archbold's Newtonia (*Newtonia archboldi*), Sub-desert Brush Warbler (*Nesillas lantzii*), Green-capped Coua (*Coua olivaceiceps*), Running Coua (*C. cursor*), and Sub-desert Mesite (*Monias benschi*). At 8:30 am, when we were about to leave the forest, a small mix-species flock was encountered, which was the first such flock that morning. As we were observing the different members of the congregation, which included two Archbold's Newtonia, two Souimanga Sunbirds

Langrand, O. & von Bechtolsheim, M. 2009. New distributional records of Appert's Tetraka (*Xanthomixis apperti*) from Salary Bay, Mikea Forest, Madagascar. *Malagasy Nature*, 2 : 172-174.