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Effects of swidden agriculture on chameleon diversity and abundance in eastern tropical rainforest in Madagascar

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Abstract

We studied the impact of habitat change on the chameleon distribution and abundance in Madagascar's eastern tropical rainforest using distance sampling with line-transect and asses species' microhabitat preference. Three zones of interest around the Corridor Ankeniheny-Zahamena were visited over three periods February to April 2014, October to December 2014, and January to April 2015. Five habitat types were targeted: closed canopy forest, tree fallow, shrub fallow, degraded land, and reforestation plot. Following the previous study, habitat classification was based on the vegetation structure and plant community. In total, 44 localities were sampled composed of 10 closed canopies, eight tree fallows, 11 shrub fallows, 10 degraded lands, and five reforestation plots. Fifteen chameleon species belonging to three genera were recorded. Ten species were found inside of closed canopy forest, only four species were encountered from shrub fallow and three from the degraded land. Species abundance changed across sites. Canopy and underground cover were identified as the main parameters that can affect the species' presence. However, forest loss by swidden agriculture is the main threat across the studied area. Restoration of degraded forest is vital because species richness and abundance increase from reforestation plots and the old regeneration vegetation.

Keywords: Abundance, Chameleon, Corridor Ankeniheny-Zahamena, Distribution, Eastern Madagascar, Habitat types

Introduction

Madagascar is one of the 25 countries considered as global biodiversity hotspots, (Myers et al., 2000) and deforestation is the main threat to biodiversity in the country. From 1950 to 2000; the island lost 40% of its forest cover with 43% of loss to the humid forest. A previous study indicated that by 2025 rainforests will only exist in a few places if habitat destruction continues at the present rate (Vallan, 2000). Swidden agriculture, known locally as “Tavy”, and more widely as “slash-and-burn”, is the traditional and predominant land use practice of eastern Madagascar. Primary forest or secondary vegetation is cut and burned, and upland rice is cultivated for one season, followed by a root crop such as cassava or sweet potato. After the harvest, the land is left to fallow for 3-5 years before a new cycle of Tavy is initiated. It has been estimated that between 5-7 cycles of tavy can convert forest into exhausted land, depending on the soil characteristics, crops grown, and length of the fallows (Styger et al., 2007). During the last half-century, Tavy cycles have shortened, and fields are not abandoned for periods long enough to allow forest regeneration (Sussman et al., 1994). This situation causes people to extend the agricultural area into primary and secondary forests (Klanderud et al., 2010) Fire kills native, regenerating tree species and allows exotic, invasive shrubby and herbaceous species to colonize the open surfaces (Koechlin, 1972; Lowry et al., 1997). The transition from rainforest to grassland through stages of fallows, often referred to as Savoka, has been described by several authors. Their analysis largely concentrated on botanical descriptions of vegetation group succession (Lowry et al., 1997; FAO, 2000, Klanderud et al., 2010).

Herpetological communities are considered among the most threatened terrestrial vertebrates worldwide (Baillie et al., 2004; Böhm et al., 2013). This is largely related to their ectothermic nature, which makes amphibians and reptiles highly vulnerable to local environmental changes (Owen, 1989; Navas & Otani, 2007). Such changes are particularly remarkable in smaller forest patches and near forest edges (Kapos, 1989; Laurance et al., 2002). Edge effects and the loss of microhabitats and suitable reproductive sites can explain the local extirpation of many amphibians and reptiles in smaller forest patches (Vallan, 2000; Schlaepfer & Gavin, 2001; Pineda & Halffter, 2004; Bell & Donnelly, 2006; Whatlin & Donnelly 2006; Urbina-Cardona et al., 2006; Becker et al., 2007) and this is probably the reason for the extinction of most species in very open and degraded habitats In Madagascar, most research has focused on biodiversity within forest inside protected areas or has compared only disturbed and undisturbed forest, and other stages of vegetation such as tree and shrub fallows, and grasslands associated with widespread agriculture have been neglected (Jenkins et al., 2003, Rabearivony et al., 2007, Klanderud et al., 2010). This study provides the first quantitative assessment of the effect of land use change in Madagascar, through the various stages of the slash-and-burn process on chameleon species distributions and abundances. We also studied the main changes between each stage to determine the parameters that are most likely affecting species abundances at each stage habitat type. This study provides new information on habitat requirements and natural recovery capacities, which assists in understanding species vulnerabilities.

Martial and methods

Corridor Ankeniheny-Zahamena (CAZ) is one of the largest remaining contiguous rainforests in the mid-eastern region of Madagascar (Styger et al., 2007). The entire corridor comprises an area of 505,734 ha spanning an elevational range of about 400-1,500 m. Most of the corridor is composed of mid-elevation humid forests between 550-1500m. A few remaining remnants of low-elevation humid forest (<550 m) can be found on the eastern side of the corridor. Annual rainfall is between 2550 mm (at 550 m a.s.l.) and 3450 mm (at 750 m a.s.l.) with annual mean temperatures of 21.5 and 20.4 C, respectively. The soils are Inceptisols and Ultisols (US Soil Taxonomy) with moderate to high acidity (pH 3.5–5.0) and aluminum saturation between 60% and 90%. Nutrient contents, especially phosphorus, are extremely low in surface and subsoils (Johnson, 1992; Brand & Rakotondranaly, 1997). The study area, typical of the eastern region, is characterized by the traditional slash-and-burn agriculture (tavy) of the Betsimisaraka people and by forest cover loss and soil degradation. Three zones of interest were selected to study, representing low and mid-altitude zones (Figure 1). Within these three zones; four core habitat types that Styger et al. (2007) describe as characterizing the slash-and-burn farming practices in the rainforest region of Madagascar were sampled; namely closed canopy forest, tree fallow, shrub fallow and degraded land. In addition, reforestation plots were also visited during this study to indicate the potential of restoration initiatives in the area to influence the suitability of the landscape for chameleons. A total of 44 localities were surveyed across the three zones of interest and composed of five habitat types.

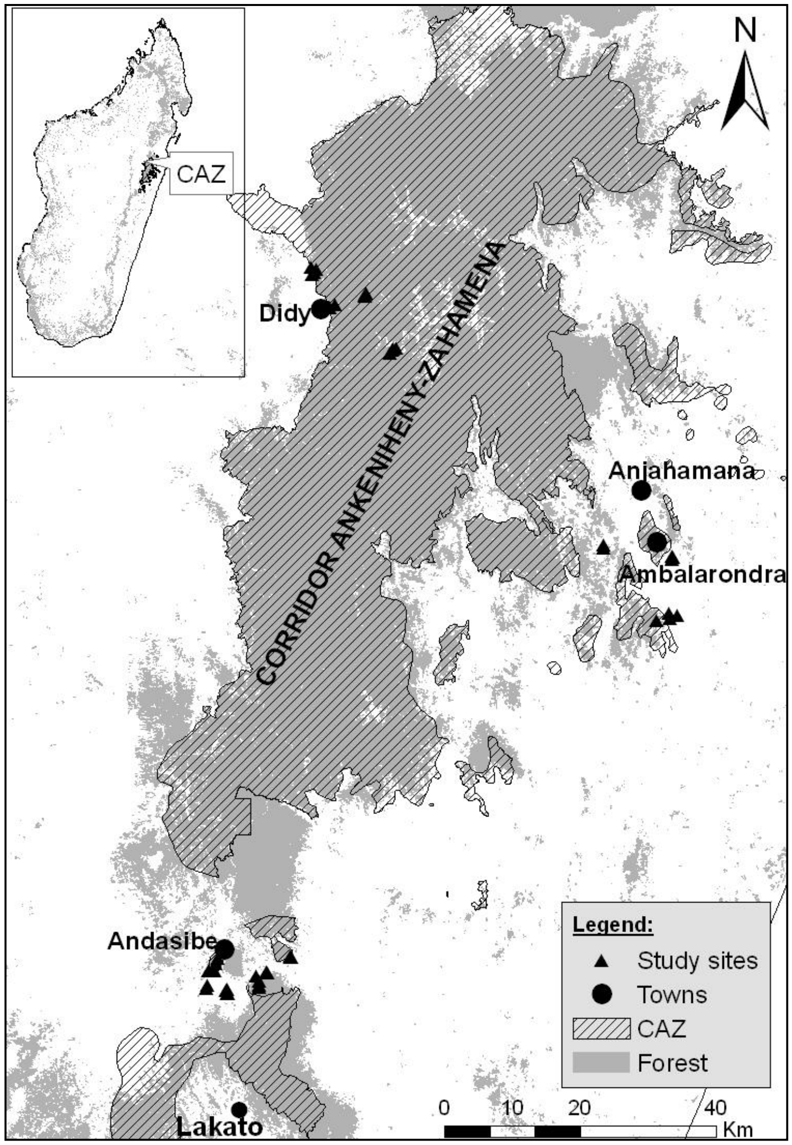

Figure 1. Map of the study sites showing the three zones of interest

The fieldwork was conducted during the rainy season where the maximum chameleon activity (Raxworthy, 1998), over three periods from February to April 2014, October to December 2014, and January to April 2015. The closed canopy forest habitat is composed of the evergreen humid forest at low altitudes (0–800 m) and mid-altitude (800–1800 m) described in Humbert (1955); Faramalala (1988, 1995); Du Puy and Moat (1996). Some of the forest that we visited was logged many years ago but enrichment by planting forest species was done and the structure of the forest is still the same as the unlogged area. The dominant tree in the mid-land forest is composed of *Tambourissa*, *Weinmannia*, *Symphonia*, *Dalbergia*, and *Vernonia*. This forest type is rich in understorey species and epiphytes (Koechlin, 1972). In lowland forests, vegetation is characterized by a high canopy and the dominant species is composed of the series of *Myrtaceae* and *Anthostema* (Cornet & Guillaumet, 1976). The tree fallow habitat combined Vadikatana and Savoka matoy (mature fallow) described in Styger and al. (2007). Vadikatana is the first fallow after the first deforestation following the first rice crop. The vegetation is dominated by *Trema* and *Harungana*. They are sometimes associated with the shrub *Solanum mauritianum* which has a rapid initial growth, forms quickly a low canopy, but dies back after 6–12 months giving way to *Trema*. In the absence of *Trema* and *Harungana*, the endemic shrub *Psiadia altissima*, dominates the first cycle as seen in the Ambavaniasy area. The shrub fallow combines three stages of regeneration after tavy; "Ramarasana", "Dedeka" and "Savoka" as described in Styger et al. (2007). They are the three first stages of vegetation recovery after swidden agriculture practice. Ramarasana is the initial fallow stage after the rice panicles are manually harvested and this can take between 6 months and 2 years depending on location and soil quality. A Dedeka is a shrubby fallow that is small in height (1– 1.5 m) and the dominant species are *Psiadia*, *Rubus,* and *Lantana*. A Savoka is also a shrubby fallow but taller (2– 4 m).

The degraded land stage occurs after the third or fourth tavy cycle when the two fern species, *Pteridium aquilinum* and *Sticherus flagellaris*, and the pantropical grass *Imperata cylindrica* start to appear in low density. They thrive on fire and are favored over more susceptible species with each burning cycle a fact widely acknowledged for *Imperata*, for instance, reported from West Africa (Chikoye et al., 2000) and Indonesia (Hartemink, 2001). These species become dominant beyond the fifth cycle of slash-and-burn practice. Beyond the 6th cycle and after repeated burning *Imperata* is replaced by a few grass species composed of *Aristida similes*, *Aristida* sp., *Hyparrhenia rufa*, Paspalum *conjugatum*, Paniicum *brevifolium*, and *Pennisetum* sp., among others (Pfund, 2000). One other additional habitat was the reforestation plot where tree planting was done to help the natural regeneration from degraded habitat to primary forest. Vegetation in these areas is composed of tree fallow species with some planted autochthon trees such as *Rhodoleana leroyana* and "Lalona" with some secondary vegetation species such as *Trema*, *Harungana*, and *Psiadia*. The reforestation was done in the first stage of shrub fallow after crops and to restore forest from degradation by tavy. During this study, we focused on the reforestation plot during the TAMS project around the Andasibe area.

In total, we surveyed 44 localities from three Zones of Interest (ZOI) and the number of visited localities per ZOI changes according to the habitat type availability. For all zones of interest, we visited 10 closed canopies, 8 tree fallows, 11 shrub fallows, 10 degraded lands, and 5 reforestation areas. Ideally, one campsite should have one of each habitat type but in reality, this criterion was not kept in the field each campsite had at least two types of habitats except one in ZOI3 where there was one campsite with only a closed canopy forest. Twenty localities were visited in ZOI2, which was the only ZOI where we could survey reforestation. Because of the accessibility and habitat availability constraints, only 9 sites were studied in ZOI3 situated at low altitudes. Fifteen sites were visited in ZOI4, situated on the western boundary of the Corridor Ankeniheny-Zahamena new protected area.

Distance Sampling

Within each locality sampled we searched for chameleons at night along transects that were placed systematically perpendicular to the slope (i.e. across the slope) in the target land uses categories. Each of the transects consisted of 200 m (4 parallel lines of 50 m) for the main plot and 150 m (3 parallel lines of 50 m) for the extra plot to increase research effort but this extra plot wasn’t done for all of the sites but only few them in the zone of interest number two. The starting point was located 5m from the pitfall trap line for the herpetofauna inventory conducted during the same period of this study. Each transect in the main plot was visited twice but only once for the extra transect. Transect lines were set up at least 24 hours before the nocturnal survey to minimize disturbance to the chameleons. Survey teams were composed of two experienced observers who moved slowly along each line at night, searching opposite flanks for roosting chameleons with the aid of PetzlMyo XP LED head torches (Jenkins et al., 2003). All field personnel were trained in chameleon surveys by experts before the fieldwork. Chameleon identifications were based on the key descriptions in Glaw & Vences (2007). For each encountered animal, we measured the perpendicular distance from the animal's original position to the transect line, the roosting (perch) height, and the maximum height of the plant. Each chameleon was placed in a cloth bag and measured the following morning. Body mass (Pesola balance), snout-vent length (calipers) age, and sex were recorded. Chameleons were released at the exact point of capture the afternoon after the nocturnal transect.

All chameleons observed during the nocturnal survey were brought to the campsite for biometrics measurements. A sample of the chameleon roost perches was marked each night with a colored tag and we returned to the site the following morning where a quadrat of 5 × 5 m was placed on the ground with the perch at the center. Within these quadrats, we recorded 14 microhabitat variables such as the abundance of trees in two categories (canopy tree and small tree), the number of trees cut by humans or felled by natural causes (e.g., cyclones), and leaf litter depth (cm). Using a 1 m stick marked with centimeter gradations, we recorded whether there was contact with low vegetation in four height categories (0-0.24 m, 0.25- 0.49 m, 0.50-0.74 m, and 0.75-1.0 m) every 25 cm along two 5 m lines with the perch at the center in the plot. The percentage canopy, understory, and leaf litter cover was estimated by eye in, or above, each quadrat by four people and the mean value was used in subsequent analyses. A liana index was used to assess the abundance of this plant and ranged from 0 to 3 (Randrianantoandro et al., 2008, 2010).

Density estimation

Based on the measured perpendicular distances between detected individuals and the transect lines, the population density of chameleons was estimated by the software Distance 8.3, which fits a detection function to the observed distances (Thomas et al., 2002). Population densities were calculated using the computer program *Distance* version beta 8.3 (Thomas et al., 2004). The program fits a series of functions to the distance data and the model best fitting the data was selected by the Akaike Information Criterion (Buckland et al., 2001). We used four of the models provided by Distance 8.3 (uniform key with cosine adjustments, a half-normal key with cosine adjustments, a half-normal key with Hermite polynomial adjustments, a hazard-rate key with simple polynomial adjustments) which perform best in many studies (Thomas et al., 2010).

There are several important assumptions regarding the use of *Distance* sampling and the key one is that all animals on the line (i.e., at 0 m) are detected and we made every effort to locate chameleons through careful searching of all vegetation on the transect line. The analysis started with excluding the non-accurate data from the field survey. As noted in other studies (Jenkins et al., 1999; 2003), nocturnal surveys of chameleons are limited by reduced detectability of animals roosting high in the canopy. In this study, we used a vertical ceiling of 6 m, similar to the vertical truncation in other studies made in the rainforest (Jenkins et al., 1999, 2003; Andreone et al., 2005). Due to the vegetation density in some of the land uses especially the shrub fallow and the forest; visual and acoustical detections are very unlikely at distances more than 6 m and resulting distance measurements are too inaccurate (Randrianantoandro et al., 2010). Hatchling chameleons were excluded from the analysis because they are in general found in grouped individuals near the area where they hatched.

Due to the low number of observations for each species from each habitat type, we combined observations of the 15 species that we found into eight groups according to the classification made by Glaw & Vences (1994). These were as follows; the *Brookesia superciliaris*-group with two species (*B. superciliaris* and *B. therezieni*), *B thieli*-group with one species (*B. thieli*), *Calumma cucullata*-group with two species (*C. brevicorne, C. malthe*), , *C. nasuta*-group with three species(*C. nasutum, C. gallus* and *C. fallax*), *C. furcifer*-group with three species (*C. furcifer, C. gastrotaenia* and *C.* cf *vencesi*), *C. parsonii*-group with one species (*C. parsonii*), *Furcifer lateralis*-group with one species (*F. lateralis*) and *F. bifidus*-group with two species (*F. bifidus* and *F. willsii*). To maximize sample sizes for distance analysis we reclassified the five land uses described above, into 3 land use classes based on the level of habitat degradation. We kept the closed canopy forest alone and we considered it as the non-degraded habitat. The second group is composed of the tree fallow and the reforestation plot and we considered this group as a less degraded habitat because of the presence of their structural similarities. The last group is composed of the shrub fallow and the degraded land; where there are fewer trees and the vegetation is dominated by very low vegetation and we called this group a more degraded habitat. This combination of the land uses helps to increase the number of observations of the group of the species and allows density estimation plausible and the strength of some groups.

Statistical analysis

To compare habitat type characteristics; we used the nonparametric test because our data does not show a normal distribution. Kruskal Wallis test (Hollander & Douglas, 1973) was used to compare the parameters that we collected in each quadrat while studying chameleons' microhabitat in each transect line. To test for the effects of microhabitat parameters on the presence or absence of chameleons, we compared microhabitat data from quadrats with and without animals for each land use separately. To identify the main parameter of the presence or absence of the animal; we used a mixed model and separated the percentage parameter from the unit parameter. The two best parameters from both were analyzed together to identify the main two important. We used two packages (glmmADMB and MuMIn) on R-studio and the dredge function for all the analysis. We used the Wilcoxon test for paired samples (Bauer, 1972; Hollander & Douglas, 1973) to confirm if the difference between these two types of categories is significant or not.

Results

Number of the species found in each habitat

In total, fifteen species belonging to three genera (*Brookesia, Calumma,* and *Furcifer*) were found in all study sites and we classify each land use according to the number of species found to identify their land use preference. Figure 2 shows that the number of species found from each land use decreases from forest to degraded land but this number increases after habitat restoration by reforestation. Chameleon prefers closed canopy forests where we found 10 species and the degraded land is less preferred by chameleons with only tree species from 10 visited sites. All *Furcifer* species were found in open areas outside of the closed canopy forest but only one of them was found from degraded land. However, all *Brookesia* species were found inside of the forest and none of them can survive in degraded land. This result indicates that chameleon distribution is related to habitat quality.

Table 1. Species recorded across the habitat types.

Species	**CC**	**TF**	**SF**	**DL**	**RF**
Brookesia superciliaris	■				■
Brookesia therezieni	■	■			
Brookesia thieli	■	■	■		■
Calumma brevicorne	■				■
Calumma furcifer					■
Calumma gallus	■	■			■
Calumma gastrotaenia	■	■			
Calumma malthe	■				
Calumma nasutum	■	■	■	■	■
Calumma parsonii	■				
Calumma aff. *fallax*		■	■	■	
Calumma aff. *vencesi*	■				
Furcifer bifidus		■			
Furcifer lateralis				■	
Furcifer willsii		■	■		■
Number of species	**10**	**08**	**04**	**03**	**07**

CC: Closed Canopy, TF: Tree Fallow, SF: Shrub Fallow, RF: Reforestation, DL: Degraded land

All species are found inside of the forest and other land uses except three of them which were only found outside of the forest such as two *Furcifer* species and one *Calumma*. *Furcifer bifidus* was only found in tree fallow which is outside of the forest but with a remarkably high tree of more than 8m. Two species were classified as non-selective species in terms of habitat because they can be found in all land uses such as with or without trees. They are belonging one group of *Calumma* genus. Only one species is grassland-dependent and it belongs to *Furcifer* genus. From shows that all *Furcifer* species were found outside of the forest, most of *Calumma* and *Brookesia* need forest even though they can be found in other land use types. This result can explain that species distribution across habitats might be related to their external or internal characteristics.

Density of chameleon between habitat quality

Table 2. The density of chameleon groups was calculated using *Distance* software.

Habitat quality	*superciliaris* group	*thieli* group	*nasutum* group	*gastrotaenia* group	*parsonii* group	*cucullatum* group	*lateralis* group	*bifidus* group
non degraded	24.04 (44)	NE (00)	11.25*(18)	8.40*(23)	NE (03)	NE (01)	NE (00)	NE (00)
less degraded	NE (01)	NE (02)	9.95*(22)	2.46*(10)	NE (00)	NE (02)	NE (00)	NE (06)
more degraded	NE (00)	NE (00)	5.04*(17)	NE (00)	NE (00)	NE (00)	NE(05)	NE (00)

NE: not estimated, *: Coefficient of variation more than 30%

As described in methods; we combined species into a few groups. We have *Brookesia superciliaris*-group with two species (*B.superciliaris* and *B. therezieni*), *B thieli*-group with one species (*B. thieli*), *Calumma cucullata*-group with two species (*C. brevicorne, C. malthe*), , *C. nasuta*-group with three species(*C. nasutum, C. gallus* and *C. fallax*), *C. furcifer*-group with three species (*C. furcifer, C. gastrotaenia* and *C.* cf *vencesi*), *C. parsonii*-group with one species (*C. parsonii*), *Furcifer lateralis*-group with one species (*F. lateralis*) and *F. bifidus*-group with two species (*F. bifidus* and *F. willsii*). This table shows the estimated density of each group of species. As we observed in the distribution, each group of species responds differently to habitat change. Most of the group of species found during this study didn't reach the condition for the strong population density estimation. Again, only the densities of some groups were estimated because of the low number of individuals. *Brookesia superciliaris*-group is more abundant in the non-degraded habitat than the closed canopy forest with only one individual in less degraded habitat and not observed in more degraded habitat. In contrast to this, *B thieli*-group was found outside of the forest but only existed in open areas with trees. All *Calumma* groups were abundant inside the forest except *C. cucullata*-group. All *furcifer*-group was found outside of the forest but one of them prefers the habitat without the emerging tree and one group was abundant in the area where the emerging tree is numerous.

Habitat characteristics between land uses

In general, all parameters were significantly different from all land uses analyzed together using the Man-Whitney nonparametric test. We compared all parameters between two land uses using a t-test unpaired after log-transform the data. This analysis indicates that closed-canopy forest characteristics are different from other land uses. Vegetation structure decreases from a closed canopy which is considered a complex structure with three stratum and high canopy. Tree fallows and reforestation plots have two stratums. Shrub fallows and degraded land have a very simple structure with only one stratum and a very low canopy (table 3). Only closed canopy forest shows a significant difference in tree number which is very high with about 20 young trees and five canopy trees inside of one plot (table 3). The percentage of letter cover shows a significant difference and it decreases from closed canopy to degraded land but increases in reforestation plots. However, the percentage of ground cover by herbaceous is very low inside of the forest but high in degraded land but this difference is not significant (table 3).

Table 3. Mean value of microhabitat parameters from different land uses.

Parameters	CC	TF	SF	DL	RF	P-*value*
Canopy cover (%)	64.78±2.94	25.71±3.20	13.38±2.25	1.04±0.83	18.05±3.14	4.649e-15
Ground cover (%)	57.60±2.95	75.30±2.76	76.33±3.05	77.80±3.34	61.33±4.89	< 2.2e-16
Litter cover (%)	85.85±1.85	67.14±2.65	46.95±2.88	36.56±4.20	69.08±2.73	< 2.2e-16
Canopy tree number	4.26±0.40	1.12±0.44	0.29±1.50	0.30±0.10	0.43±0.10	< 2.2e-16
Small tree number	20.88±1.11	8.89±1.13	9.07±1.23	3.79±0.66	6.61±0.85	< 2.2e-16
Canopy height (m)	16.42±0.42	4.69±0.25	3.35±0.19	1.37±0.14	4.44±0.31	1.423e-13

The main parameters involve species distribution from each land use.

The percentage of canopy cover is the first main important parameter influencing chameleon presence or absence. This case was observed well for chameleons in general as well for each group of species except two of them (nasutum and lateralis group) where they were found in a more open area. Chameleon prefers places where the canopy is more closed (39.08±3.80) than the open area (23.36±1.91) and this difference is significant (less than 0.01). We analysed this relationship between parameters and each group of species and all results show the same situation. The second parameter identified as important in chameleon presence is the canopy height and animal prefer area with high canopy. This preference in terms of canopy height presents a send trend and the canopy cover.

Species vulnerability to land use change

We found six specialist species and three of them are forest-dependent. These forest specialist species are very vulnerable to land use change because forest restoration and regeneration needs many years, and until now no reforestation or regeneration vegetation plots have returned to the forest in his stage before tavy. This means the forest-dependent species lost their habitat probably forever and can't afford to survive within other land use types. The most vulnerable species inside of the study area was probably *Calumma* cf. *vencesi* only one individual inside the small fragment of forest in the buffer zone of CAZ protected area where many kinds of disturbance was observed such as logging. The three other forest specialist are not more vulnerable because of their large distribution range but the fragmentation effect can be a serious problem for these species in the future. All other species with tree dependence also are vulnerable to land use change because people cut also trees fallow and after many cycles of tavy, land is transforming to degraded land without trees where just a few species can survive.

Discussion

The result shows that chameleons respond negatively to land use change, especially forest degradation from swidden agriculture. This explains in detail results from previous research, which said that herpetological diversity decreases in highly disturbed areas, and is also applicable to disturbance from swidden agriculture. Many chameleon species are true forest dwellers and habitat disturbance has negative effects on diversity and abundance (e.g., *Brookesia* in Brady & Griffiths, 1999; Jenkins et al., 2003), and it was confirmed with a low number of species found in the degraded land against the high species richness inside of the closed canopy forest. Chameleons rely on vegetation cover to protect against predators and solar radiation (Hódar et al., 2000). Loss of vegetation through burning may therefore increase predation rates from raptors, hinder thermoregulation, and reduce food supplies. The small trees and shrubs present in the high-disturbance forest probably only provide marginal habitat for species (Jenkins et al., 2003). Results of other studies show similar responses of amphibians and reptiles to disturbance in tropical forests in Indonesia (Wagner et al., 2000). These patterns are often explained by changes in leaf-litter thickness that affect microhabitats (humidity and food-source abundance; Whitfield et al., 2007).

From the five land uses, the proportion of representation of the three genera observed during this study was very different. Two of three the *Brookesia* were forest specialist. All *Furcifer* species were found outside of the closed canopy habitat. Most species from this genus occur in general in the central, western, and southern part of Madagascar where they can be found in many habitat types such as the deciduous forest, edge of the forest, savannah, or agricultural land (Glaw & Vences, 2007). Our study confirms that *Furcifer* prefers the open and disturbed areas but each species has its requirement according to vegetation structure. *Calumma* species have previously been thought to occur only in humid forests (Glaw & Vences, 2007), however, species from this genus were found in all five habitats during the study but each species was found in different proportions between land uses depending on themselves. This case of different responses on land use change between genera and families was already observed by Vallan in 2002 for amphibians' taxonomic composition around Andasibe.

In general, chameleon density decreases with the habitat degradation from non-degraded habitat (closed canopy forest), less degraded (tree fallow and reforestation) to more degraded habitat (shrub fallow and degraded land) but species or group of species groups respond differently to disturbance (Table 2). Most of the *Brookesia therezieni*-group was found inside of the forest and just a few individuals in less degraded habitats represented tree fallow and reforestation sites. Previous studies considered species in this group as forest-dependent such as Rabearivony et al., in 2007 in his study indicated that *B. superciliaris* was most abundant in the relatively intact forest and occasionally detected in the regenerating agricultural land and this result confirms this situation. *Calumma* species were more abundant in the non-degraded habitat than the other except species in *C. nasutum*-group which are more abundant in open areas. This case was already observed in the study by Rabearivony et al., (2007) which found *C. parsonii* to be more abundant inside the forest than in regenerating vegetation but in the opposite case of *C. nasutum* because they found this species more abundant inside of the forest that the regeneration vegetation. All species of *Furcifer* were found outside of the forest although some species, such as *F. bifidus* and *F. willsii*, were more abundant in regenerating habitats than in the degraded land. In contrast, *F. lateralis* is more abundant in degraded land. This case was already reported during some previous studies such as in Andreone et al., 2005 indicate that *Furcifer* chameleons are often considered to prefer open or degraded habitats and are therefore probably of lower conservation concern than species that rely on relatively intact forest vegetation. During the study, the low number of observations for each species in each land use is the real barrier to the density estimation. We suggest that the same study should be done in the same or other areas to increase the transect sample size and focus on the small biogeographic range to increase the number of observations from a few species to allow an accurate density estimation using *Distance* software which is the best issue to assess impact of the land use change on population. Vegetation structure is significantly different between land uses and it could be considered as the reason of species preference between the five visited land uses. During the field study, we observed that vegetation structure and species composition were very different from forest to other land uses. Some similarities were observed between tree fallow and reforestation sites because both their last cut for agriculture was dated a long time ago and tree species are grown such as described in Styger et al., 2007. Sometimes it was difficult to separate shrub fallow from tree fallow because of the different stages of regeneration vegetation after tavy practice, field team was a little bit confused. Degraded land is easily identified by the absence of trees and the dominance of *Imperata*. Previous studies indicate that slash-and-burn agriculture results in changes in the vegetation composition and structure and it also depends on the history of land uses, the bioclimatic zone of the area, and the soil fertility.

This study shows that canopy cover is the most important parameter for chameleons and most of them prefer the more closed area. This preference might be linked to predation because chameleons use vegetation cover against predators. Other studies indicate that canopy cover is one of the main predictors of amphibians' distribution but not for the reptiles which depend mainly on canopy heterogeneity (Wagner et al., 2000). Some studies reported that Reptiles respond to changes in the availability of suitable microhabitats when forest structure is changed and can undergo local increases or decreases in abundance accordingly (e.g., Lima et al., 2001; Shine et al., 2002; Todd & Andrews, 2008).

Conservation implication

Several studies done in different regions in Madagascar reported a negative impact of forest degradation on chameleons in Madagascar without details (eg: Brady & Griffiths, 1999; Akani et al., 2001; Jenkins et al., 2003, Randrianantoandro et al., 2010) but we were focused on how species respond to different stage vegetation cover change after tavy practice and our result shows the importance of secondary vegetation for some species which not occurs inside of the forest. In their study, Randrianantoandro et al., 2010 indicated that conservation efforts should focus on maintaining patches of relatively intact forest as well as restoring adjacent degraded forests and this study confirms that restoration is needed. Madagascar's eastern forest is under protection but forest destruction by the practice of tavy is still the main threat to the biodiversity in this region. This study also shows that regeneration vegetation is important because species can recolonize this area if the disturbance is stopped; the same case was found by Santos et al., in 2016 during their study in Africa who reported that reptile species exhibited a negative short-term response to habitat degradation but the number of species increased with more complex habitats such as shrub or tree fallows. Habitat restoration by tree planting is very important also because it can accelerate the regeneration of vegetation to rich its original stage but plant. Also, plant species used for the forest restoration should be selected because some invasive and pioneer species hurt biodiversity around; in the case of the pine plantation described by Santos, the number of species decreased with pine-plantation abundance in the 1000-m buffer.

Previous studies indicated that microclimate change from closed canopy forest to degraded habitat and abiotic factors are important for chameleons, and precipitation and humidity, are likely to influence species composition and abundance (Glos & Volahy, 2004). Research relationship between abiotic variable changes for each species could be studied to explain the difference response from each species to disturbance. A number study indicated that Reptiles respond to changes in the availability of suitable microhabitats when forest structure is changed and can undergo local increases or decreases in abundance accordingly (e.g., Lima et al., 2001; Shine et al., 2002; Todd & Andrews, 2008). Several studies have reported differences in chameleon density and abundance between relatively intact and degraded forests (Brady & Griffiths, 1999; Akani et al., 2001; Jenkins et al., 2003). These differences are presumably because of interspecific habitat requirements for roosting, foraging, and breeding and changes to vegetation structure and abiotic characters when closed canopy.

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