Seasonal Fluctuation and Population Distribution of *Otocryptis wiegmanni,* Wagler, 1830 (Reptilia: Agamidae) Inhabiting a Tropical Lowland Rain Forest of Sri Lanka

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Abstract

The seasonal fluctuations of population density and distribution of *Otocryptis wiegmanni* inhabiting indifferent habitats of the Yagirala forest reserve of Sri Lanka was investigated during the north-east, first inter-monsoon, south-west and second inter-monsoon seasons of the year 2014. Three linear transacts, each measuring 200 m in length were marked along the natural forest, degraded forest and riverine forest habitats. All transects were surveyed by visual encounter survey (VES) method. Ambient temperature, relative humidity, canopy cover and leaf litter moisture content were measured in three points of each transect (50, 100 and 150 m) and the monthly total rainfall data was obtained from Meteorological Department. The highest mean adult population density and the highest number of juveniles were recorded during the relatively dry north-east monsoon season. *O. wiegmanni* preferred the degraded forest habitat (0.027±0.020 lizards/m^2) compared to the natural (0.007 ± 0.006 lizards/m^2) and riverine forest habitats during all four climate seasons. Fluctuations in the population density varied according to season and habitat conditions. This species fed mostly on insects of the Orders Orthoptera, Coleoptera and Hymenoptera, and the common breeding season was during the north-east monsoon (NEM) in January-February period.

Key words: Yagirala forest reserve, agamid, kangaroo lizard, habitat preference

1. Introduction

Currently the genus *Otocryptis* in Sri Lanka consists of two species, *O. wiegmanni* and *O. nigristigma* both endemic to the island. The former is mainly confined to the wet and intermediate climatic zones whilst *O. nigristigma* occurs mainly in the dray zone. *O. wiegmanni* inhabits in tropical, moist, lowland rain forests. They can be found on the forest floor, rocks, the roots of large trees, low vegetation and even on boulders along streams from sea level to 1,300 m (de Silva and Ukuwela, 2017). Additionally it is found in degraded forests, plantations, rural and urban home gardens (Pahathkumbura et al., 1996; Bahir and Surasinghe, 2005; Maduwage and Silva, 2012)

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where there is adequate leaf litter and shade. It is a small slender lizard which can be distinguished from other Sri Lankan agamids by its' distinct maroon patch present laterally on the dewlap of males body and long hind limbs (De Silva and Gunewardene, 2005; Somaweera and Somaweera, 2009).They are terrestrial lizards that quickly run when disturbed using bipedal gait (Manamendra-Arachchi and Liyanage, 1994). Adults usually sleep hanging from the forelimb on slender twigs (Somaweera and Somaweera, 2009). *O. wiegmanni* mainly feeds on ants, ground moths, grasshoppers, spiders, small geckos and beetles and occasionally on plant materials like tender shoots (De Silva et al., 2004). Males display territorialism and fight with invading males by flicking the dewlap in quick succession (Karunarathna and Amarasinghe, 2008).

Domestic cats, poultry and the common coucal (*Centropus sinensis*) are the known predators of agamids, geckos, skinks and snakes (de Silva, 1996). According to de Silva (1996) *O. weigmanni* has been recorded being killed by domestic cats. Although *O. wiegmanni* is widely distributed in the wet zone of Sri Lanka its seasonal fluctuation of population density and distribution in tropical forests is unknown. Thus the present study attempts to fill this knowledge gap with the objective of contributing to the effective conservation of the species.

2. Materials and Methods

2.1 Study site

The study was conducted at the Yagirala rain Forest Reserve, located in the Western province of Sri Lanka (6^0 21' to 6^0 26' N and 80^0 06' to 80^0 11' N) from January to December, 2014. It is a tropical lowland rain forest with an area of 2004 ha. The elevation ranges from 10 to 26 m above MSL. The dominant habitat types are the natural forests degraded forests and riverine forest habitats. Pine plantations (*Pinus caribaea)* were present adjacent to the main forest habitats.

2.2 Survey of Lizards

The three main habitats; natural, degraded and riverine forest within the Yagirala Forest Reserve were identified using digital maps. *O. wiegmanni* census was carried out by visual encounter survey method along three fixed length path transects of 200 m in each habitat. Transect length and width was determined using measuring tapes and were marked with tapes tied to the vegetation. Due to the complex vegetation structure and the possible bias caused by variation in visibility between species and transects, only those lizards observed within 3 m path of the habitat (1.5 m on each side of the transect) were recorded.

All transects were surveyed hourly from 06.00 h to 18.00 h for six days per season during the four monsoon seasons; northeast (NEM) (January-February), first inter-monsoon FIM) (March-April), southwest (SWM) (May-June) and second inter-monsoon season (SIM) (October-November). Transects were surveyed by two observers who walked slowly (3-4 m/min) carefully searching the dense vegetation and the forest floor on both sides of the transect line. Tree bases, trunks, branches and shrub plants were checked and rocks and logs were overturned and leaf litter on the ground was disturbed with snake hooks to expel hidinglizards. *O. wiegmanni* recorded along these transacts were identified using "Lizards of Sri Lanka: A color guide with field keys" (Somaweera and Somaweera, 2009) and hand captured to take measurements (Howells, 2013).

O. wiegmanni was categorised into three discrete classes as adult male, and female and juvenile based on the approximate snout to vent length (length from tip of snout to the anterior margin of cloaca), tail length (length from tip of tail to the anterior margin of cloaca) (Planka, 1971), weight, coloration and obvious secondary sexual characteristics such as presence or absence of gular sac. Snout to vent length and tail length were measured to nearest 0.1 mm by a vernier caliper (Sudasinghe and Kusuminda, 2013) and live wet weight to nearest 0.1 g was measured using a weighing scale (Planka, 1971).

2.3 Habitat variables

Six habitat variables were recorded along transect at 50, 100 and 150 m. Ambient temperature at breast height above ground in shade was measured to the nearest 0.10^0 C using a bulb thermometer (Planka, 1971). Relative humidity at breast height (DBH) above ground in each transect were recorded using weather meter (Kestrel 400, USA) (Blair, 2009). Canopy cover was measured using a 2.5 cm diameter tube on which a grid drawn on a polythene paper was fixed. All squares that cover more than 50% when vertically looking up at the canopy cover were counted and percentage values were calculated. The litter depth was measured by inserting a metal ruler vertically into the litter until the ground was felt. Leaf litter moist content was measured during each sampling day. Monthly total rainfall recorded at the Mathugama agronomy station during the research period was obtained from the Department of Meteorology, Colombo, Sri Lanka.

3. Results

Population densities of *O. wiegmanni* during the four climatic seasons are given in Table 1. There was a significant difference in population density of *O. wiegmanni* during the four climate seasons (ANOVA, $p<0.05$). The highest mean population density 0.04 ± 0.02 lizards/m^2 was recorded in NEM and the lowest population density 0.0 ± 0.01 lizards/m^2 was recorded during SIM. A gradual decrease in the population density was observed from NEM to SIM.

Table 1: Seasonal fluctuation of mean population density of *O. wiegmanni* in Yagirala Forest Reserve (n=6).

Climate Season	Mean population density (lizards/m^2)
North-East Monsoon season	0.04 ± 0.02^b
First Inter Monsoon season	0.03 ± 0.02^a
South West Monsoon season	0.02 ± 0.01^a
Second Inter Monsoon season	0.01 ± 0.01^a
Probability	P<0.05

Different superscripts in the same column indicate significant differences ($p< 0.05$) at 95% probability level according to the Tukey's test.

The seasonal population density fluctuation of *O. wiegmanni* in different habitat types is given in Table 2. Degraded forest habitat had the highest population density and the natural forest habitat had the lowest density. Population density in the degraded forest habitat during the four climatic seasons was significantly different (AVOVA, $p<0.05$). Highest mean population density

in the degraded forest was observed during the NEM (0.073±0.006 lizards/m^2) and the lowest population density (0.022 ± 0.006 lizards/m^2) was recorded during the SIM. *O. wiegmanni* population density during the four climate seasons in the Riverine forest habitat was significantly different (AVOVA, $p<0.05$). In Riverine forest habitat, the highest mean *O. wiegmanni* population density (0.04±0.02 lizards/m^2) was recorded during the NEM and the lowest mean population density (0.01±0.01 lizards/m^2) was recorded during the SIM. The highest mean population density in natural forest habitat was recorded during the NEM (0.02±0.01 lizards/m^2) and the lowest mean population density was recorded in SIM (0.004±0.01 lizards/m^2). Lizard population density fluctuation among four climate seasons in natural forest habitat was significantly different (AVOVA, $p<0.05$).

Table 2: Seasonal fluctuation of *O. wiegmanni* population density among three habitat types (Lizards/m^2).

Habitat	NEM	FIM	SWM	SIM
Natural forest habitat	0.0217 ± 0.0084	0.0150 ± 0.0024	0.0083 ± 0.0024	0.0042 ± 0.0062
Degraded forest habitat	0.0733 ± 0.0064	0.0517 ± 0.0047	0.0250 ± 0.0024	0.0218 ± 0.0064
Riverine forest habitat	0.0358 ± 0.0012	0.0275 ± 0.0035	0.0125 ± 0.0012	0.0117 ± 0.0074

Mean snout to vent length of juvenile *O. wiegmanni* was 2.21±0.62 cm, adult female was 4.79 ± 0.46 cm and adult male was 6.42±0.82 cm. Tail length of juvenile *O. wiegmanni* was 4.24±1.05 cm and adult female was 12.67±1.60 cm and adult male was 15.39±2.08 cm. Mean body weight of juvenile *O. wiegmanni* was 4.13±0.82 g, adult female was 7.71±0.68 g and adult male was 12.56±0.76 g (Table 3).

Table 3: Morphometric measurements of *O. wiegmanni* in discrete age classes (Mean ± SD).

Age class	n	Snout to vent length (cm)	Tail length (cm)	Weight (g)
Juvenile	317	2.21 ± .62	4.24 ± 1.05	4.13 ± 0.82
Adult female	197	4.79 ± 0.46	12.67 ± 1.60	7.71 ± 0.68
Adult male	202	6.42 ± 0.82	15.39 ± 2.08	12.56 ± 0.76

The percentage number of individuals in three discrete age classes fluctuated seasonally. The highest percentage of juveniles (59.57%) was recorded in NEM. During this period the percentage of adult females was less than the percentage of adult males. Lowest juvenile count was recorded in SIM (6.14%). During this period the percentage of adult females was high compared to the adult male percentage (Table 4).

Table 4: Seasonal variation of percentage number of individuals in discrete age classes of *O. weigmanni.*

Habitat	NEM	FIM	SWM	SIM
Juvenile	59.57	36.10	12.64	6.14
Adult Female	16.25	23.47	15.88	14.44
Adult Male	24.19	23.47	16.61	9.75

NEM=Northeast monsoon; FIM=First inter monsoon, SWM=Southwest monsoon, SIM=Second inter monsoon.

Among the four climate seasons, the minimum mean rainfall of 67.00 mm was received in NEM and the maximum mean rainfall of 510.5 mm was received in SWM. The entire forest was comparatively a dry during the first four months which included NEM and FIM due to the low rainfall. The forest was comparatively wet during the rest of the year due to the higher rainfall received during SWM and SIM (Fig. 1).

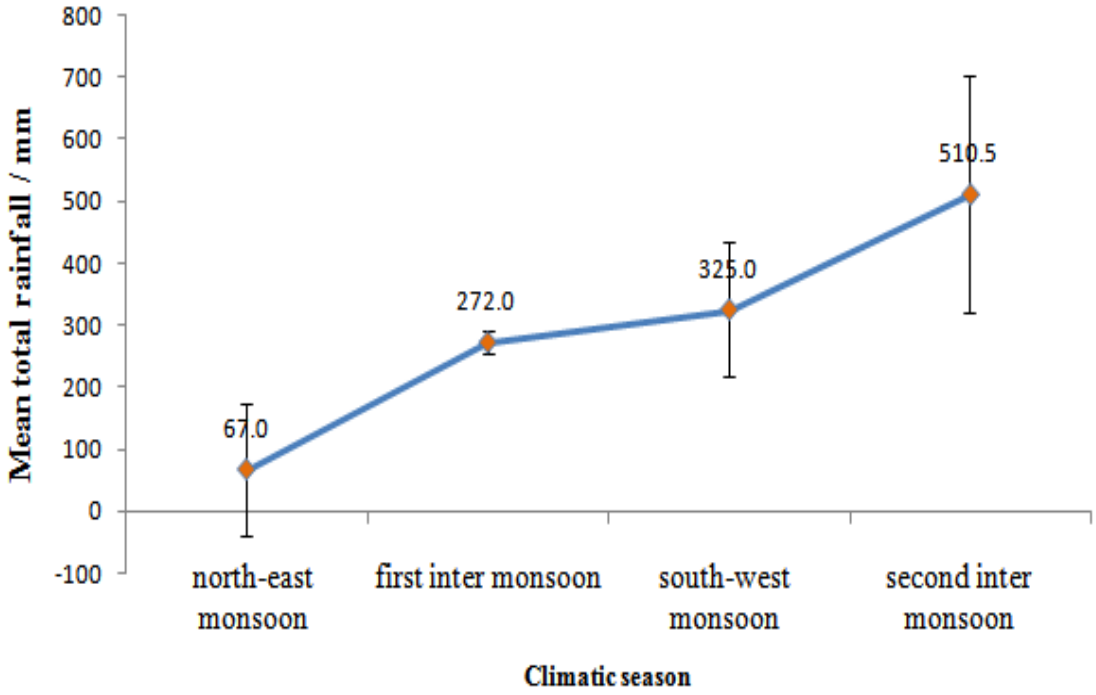

Figure 1: Seasonal variation of mean rainfall during the study period.

The ambient temperature differed significantly during the four climate seasons in each habitat (ANOVA, $p<0.05$). However, the mean ambient temperature did not differ significantly among habitats. In all four climate seasons degraded forest habitat had the highest mean ambient temperature. The highest mean ambient temperature was recorded in NEM and the lowest mean ambient temperature was recorded in SIM in all the habitats studied. During FIM and SWM moderate mean ambient temperatures were recorded in each habitat (Table 5). In all four seasons degraded forest habitat had the lowest mean relative humidity. The lowest mean relative humidity in each habitat was recorded in NEM and the highest mean relative humidity was recorded in SIM (Table 6).

Table 5: Seasonal variation of mean ambient temperature in Yagirala forest reserve from Jan -Dec 2014 (n=18).

Climate season	Degraded forest habitat	Riverine forest habitat	Natural forest habitat
North-east monsoon season	31.16±0.95[a]	30.84±1.14[a]	30.61±1.21[a]
First inter-monsoon season	30.11±0.84[b]	30.06±0.88[a]	30.00±0.81[b]
South-west monsoon season	29.52±0.84[c]	29.35±0.79[b]	29.21±0.75[c]
Second inter-monsoon season	28.27±0.95[d]	27.76±1.65[c]	28.80±1.34[d]
Probability	P<0.05	P<0.05	P<0.05

Different superscripts in the same column indicate significant differences (p<0.05) at 95% probability level (Tukey's test).

Table 6: Seasonal variation of% mean relative humidity during the study period (n=18)

Climate season	Degraded forest habitat	Riverine forest habitat	Natural forest habitat
North-east monsoon season	65.65±7.12[a]	65.94±3.97[a]	67.03±2.99[a]
First inter-monsoon	77.80±14.96[b]	78.46±2.11[b]	78.35±15.94[b]
South-east monsoon season	90.21±0.88[c]	94.53±2.11[c]	95.72±1.78[c]
Second inter-monsoon season	92.071±2.26[c]	94.32±3.97[c]	96.52±1.24[c]
Probability	P<0.05	P<0.05	P<0.05

Different superscripts in the same column indicate significant differences (p<0.05) at 95% probability level Tukey's test

The leaf litter moisture content in each habitat differed significantly according to the season (ANOVA, p<0.05). However, the leaf litter moisture content did not differ significantly among habitats. The leaf litter moisture content was minimum during the NEM and it was maximum during the SIM in each habitat. Degraded forest habitat had the minimum mean leaf litter moisture content while natural forest habitat had the maximum leaf litter moisture content (Table 7).

Table 7: Seasonal variation of leaf litter moisture content during the study period (n=18)

Climate Season	Degraded forest habitat	Riverine forest habitat	Natural forest habitat
North-east monsoon season	7.96±0.51[a]	9.64±0.38[a]	11.26±0.67[a]
First inter-monsoon season	10.23±2.01[b]	12.13±1.78[b]	13.938±1.13[b]
South-west monsoon season	14.74±1.11[c]	15.57±1.05[c]	16.39±0.70[c]
Second inter-monsoon season	17.16±0.64[d]	18.03±0.93[c]	18.79±0.85[d]
Probability	P<0.05	P<0.05	P<0.05

Different superscripts in the same column indicate significant differences (p<0.05) at 95% probability level Tukey's test.

The percentage canopy cover did not vary significantly seasonally in each habitat (ANOVA, $p>0.05$). However, the canopy cover differed significantly among the three habitat types (ANOVA, $p<0.05$). Degraded forest habitat had the minimum canopy cover while the natural forest habitat had the maximum canopy cover in all four seasons. There was a negative relationship between the canopy cover and mean *O. wiegmanni* population density (Pearson correlation, r=-0.474, $p>0.05$) (Fig. 2).

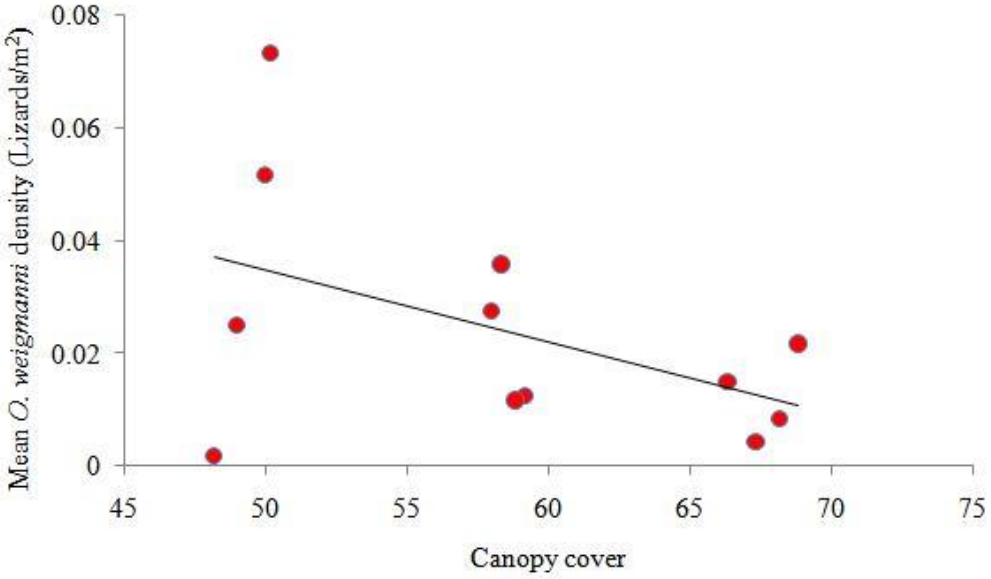

Figure 2: Relationship between canopy cover and mean *O. wiegmanni* population density.

Total number of 55 feeding behaviors was observed during the study period. Insects of three orders were recorded as pray species of *O. weigmanni*. They belonged to the orders Orthoptera, Coleoptera and Hymenoptera. Degraded forest habitat had the highest mean number of prey species and the natural forest habitat had the lowest mean number of prey species (Table 8).

Table 8: Variation of % canopy in Yagirala forest reserve during the study period (n=18).

Habitat	NEM	FIM	SWM	SIM
Degraded forest	50.17 ± 3.76^{a}	50.00 ± 3.74^{a}	49.00 ± 3.10^{a}	48.17 ± 3.19^{a}
Riverine forest	58.33 ± 4.13^{b}	58.00 ± 4.20^{b}	59.17 ± 2.93^{b}	58.83 ± 3.56^{b}
Natural forest	68.83 ± 2.14^{c}	66.33 ± 3.27^{c}	68.17 ± 2.32^{c}	67.33 ± 3.13^{c}
Probability	P<0.05	P<0.05	P<0.05	P<0.05

Different superscripts in the same column indicate significant differences ($p<0.05$) at 95% probability level Tukey's test.

4. Discussion

Population density of *O. wiegmanni* in the Yagirala forest reserve decreased from January to November in 2014 due to their differing activity levels during different seasons. The higher activity level and the population density recorded in NEM were due to the influx of juveniles during this period.

Present study revealed that *O. Wiegmanni* preferred the degraded forest habitat than the natural and riverine forest habitats. This is a surprising finding given the fact that most organisms prefer unaltered habitats. Degraded forest habitat had less canopy cover and more exposed areas where the lizards could expose themselves to the direct sunlight for thermoragulation. Therefore, being ectotherms, they may have preferred the degraded forest habit over the other habitat types where they could get optimal body temperatures to keep them more active. Population density was lowest in natural forest habitat as it maintained the lowest ambient temperature, highest relative humidity and highest leaf litter moisture content due to maximum canopy cover. Population density in riverine forest habitat was ranked second position compared to degraded forest habitat and natural forest habitat as it maintained values for habitat variables less favorable than degraded forest habitat but slightly greater than natural forest habitat due to moderate canopy cover.

The morphometric measurements of *O. wiegmanni* showed three discrete age class categories; the mean snout to vent length of juvenile *O. wiegmanni* was 2.21±0.62 cm, adult female was 4.79±0.46 cm and adult male was 6.42±0.82 cm respectively without much color variation.

Digging the ground for egg laying was observed only during NEM which also recorded the highest number of juveniles. Therefore, it can be concluded that NEM (January-February) to be the main breeding season of *O. wiegmanni in* Yagirala Forest Reserve. Relatively drier weather conditions, higher temperatures, low leaf litter moisture and low mean relative humidity values that prevail in this season could be triggering the onset of breeding providing suitable conditions for incubation and egg hatching. According to de Silva et al. (2004) reproduction of *O. wiegmanni* takes place between July and January, with a peak between October and January. Results, of the present study was similar to that up to some extent since juveniles were observed in lesser numbers in other months as well. However, February was identified as a prominent breeding month along with January according to the results. As the breeding reached to a climax in North-East monsoon season adult females were less active than males. This trend is similar to previous studies done by Stamps (1983) and Cooper (1990) which suggest that during breeding season males risk more exposure to predators in order to find a mate and females may be less likely to risk exposure to predators during mating season because of reduced locomotory ability due to carrying eggs.

The negative correlation between canopy cover and mean *O. wiegmanni* density implied that, with decreasing canopy cover the lizard density was increased. Decreased canopy covers allow the habitats to be more exposed to sunlight. The significantly low canopy cover observed in the degraded forests compared to other habitats allowed sunlight to reach forest floor offering additional basking places for the lizards which may have indirectly contributed for the increase in their numbers in the degraded forests. This is further evident since a larger percentage of lizards preferred the direct sunlight when compared to shaded or dappled sunlight. The degraded forest habitat recorded the highest number of prey species of *O. wiegmanni,* mostly the insects of order

Orthoptera, Coleoptera and Hymenoptera. Significantly lower canopy cover in degraded forest habitat should be the reason for higher insect abundance in concordance to the findings of Binckley and Resetarits (2009) on insect population in an open canopy. Barreto-Lima et al., (2013) has recorded a similar observation in a similar forest habitat. De Silva (2006) also suggests that *O. wiegmanni* has adapted to live in home gardens, plantations and degraded habitats. Present study further confirms this observation. Riverine forest habitat and natural forest habitat recorded lower densities of *O. wiegmanni* probably due to the lower ambient temperature, high relative humidity and high leaf litter moist content. These factors has increased generally in all the three habitats during rainy period of second inter-monsoon season (SIM) creating comparatively a wetter environment in the forest which supported the lowest population densities.

The findings of the present study help not only the conservation of this endemic species, but also effective conservation and management of Yagirala forest reserve as a whole.

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