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Research Article

Comparison of the Ant Assemblages in Three Phytophysionomies: Rocky Field, Secondary Forest, and Riparian Forest—A Case Study in the State Park of Ibitipoca, Brazil

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Ant assemblages are almost all related with the vegetation composition and so can provide us important information for conservation strategies, which are especially relevant to an environmentally protected area. We sampled the ant fauna in three different phytophysionomies in order to verify if the composition of ant species is different among the areas, especially because one of the areas is a Rocky Field and there is little information about the ant fauna in this habitat. A total of 8730 individuals were registered and an NMDS analysis showed that the ant assemblies are different at the three phytophysionomies (Rocky Field, Riparian Forest, and Secondary Forest). This study shows that the species that compose the ant assemblies in different phytophysionomies are a reflex of the environment, supporting the hypothesis that the vegetational composition results in different compositions in the ant assembly. Vegetal composition is determinant in the formation of the litter and consequently in the occurrence of ant species that depend on this layer of organic matter for nesting and foraging.

1. Introduction

Ants exert important effects in most ecosystems due to their abundance, population stability, and foraging activity [1, 2]. Some of their main activities are the nutrient cycling and control of other invertebrate populations [3]. They also participate actively in the composition of vegetation through seeds dissipation [4, 5], which gives them great importance in recovering degraded areas [6].

Besides their ecological importance, the Neotropical ants fauna are still little studied, especially if we consider the region of "Mata Atlântica" (Atlantic Forest) which occupies only 7% of its original area, according to the Ministry of Environment data [7]. Studies made in this biome indicate a high diversity of endemic species, which may comprise 50% of total species and 95% in certain groups [8, 9].

Actually in recent years, myrmecologists attention has been concerned essentially with ant communities, ant-plant relations, mutualisms, biomonitoring, biogeography, morphology and anatomy, genetics and cytogenetics, and taxonomy [10]. Ant species inventories made in Brazil are used to evaluate the conservation state of the environments, especially in fragmented areas, as the Atlantic Forest [11]. Also, according to Delabie et al. [10] perusal of recent papers indicates there are still new ant species to be described in Neotropical.

Inserted in the Atlantic Forest Biome, the State Park of Ibitipoca (PEIb) is classified in the category of "Extreme Biological Importance" because of endemism of some species, the relevance, the speleological singularity, and the diversity of habitats [12]. This park occupies an isolated hilly area from other areas of Rocky Field, presenting a distinctive flora of "Cadeia do Espinhaço" itself, being considered a disjunction concerning this Range [13].

PEIb presents significant diversity not only of vegetation, but also of fauna, landforms, soils, and microclimates [14] and covers two areas of regional vegetation, originally composed by semideciduous seasonal forests and "cerrados" [15]. It may be distinguished by five basic types of phytophysiognomies—altitude "cerrado", Rocky Fields, Riparian Forest, capon of forest, and an area of dense ombrophilous secondary forest.

The Rocky Fields are distinguished mainly by the grassland vegetation consisting of grass, herbs, and shrubs on outcrops of quartzitic rocks associated to shallow soils and high solar incidence [16]. The PEIb floristic studies indicate predominance of "candeia" specimens (*Vanillosmopsis erythropappa*).

The Semideciduous Secondary Forest covers an area of 90 hectares at the south of the PEIb and it is totally surrounded by woodlands, being named "Mata Grande." Due to the presence of anticlinal crests, this environment is greatly influenced by clouds, winds, and lightning [17]. There is marked abundance of epiphytic plants and lichens, with predominance of high trees (up to 25 m) [18].

The Riparian Forest in its extension mostly consists of shrubs patches that accompany the distribution of thicker soils, in slope conditions or concave lands. This subtype of vegetation is humid, with reduced wind action and remarkable presence of bromeliads and mosses and, in the edges or less shaded areas, many kinds of lichens [19].

Considering that the vegetation is a good predictor of the structure of community of ants [20–23], one could suppose that in different phytophysionomies the composition of ant species is equally distinct. In this context, a comparison of ant assemblies in three distinct phytophysionomies was accomplished—Rocky Field, Semideciduous Secondary Forest, and Riparian Forest—in the PEIb. The knowledge of how the ant species composition varies according to different characteristics of habitat provides important information for conservation strategies, which are especially relevant to an environmentally protected area.

2. Material and Methods

2.1. Area of Study. This study was conducted in the State Park of Ibitipoca—PEIb (21°40′44″ S and 43°52′55″ W) in the city of Lima Duarte, Minas Gerais, Brazil (Figure 1). The PEIb has approximately 1.488 ha with a mesothermic humid climate (Köppen classification), with dry winters, pleasant summers, and average annual temperature around 18.9°C. The influence of the relief over the climate is very important, because the altitude and topography are differentiated and the anticlinal crests in the PEIb stand out locally concerning the neighboring areas, leading to a differentiated climate in the area [17]. In the PEIb three phytophysionomies were sampled: Rocky Fields (RKF), Semideciduous Secondary Forest (SSF), and Riparian Forest (RPF).

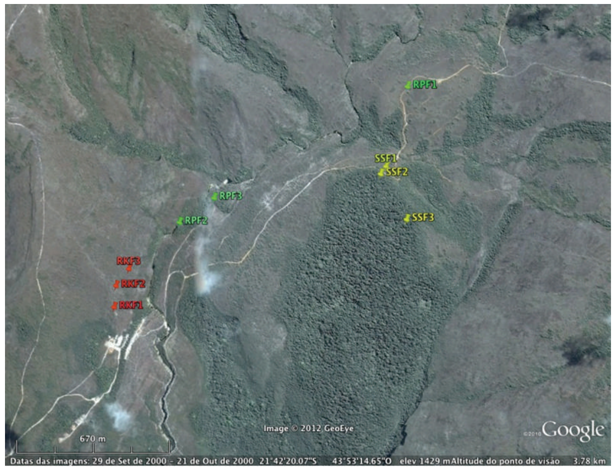

Figure 1: Parque Estadual do Ibitipoca (PEIb) in Minas Gerais State, Brazil. Red pins: Rocky Fields (RKF); Green pins: Riparian Forest (RPF); Yellow pins: Semidecidous Secondary Forest (SSF). Font: Google Earth, 2010.

2.2. Ants Sampling. In each of the three phytophysionomies, three quadrants of 800 m^2 each were established. The minimum distance between the quadrants within the same phytophysionomy was 50 m. The sampling of ants was accomplished monthly between July and December 2008.

In each quadrant three parallel transects were established, spaced from each other by 10 m. Along each transect the sampling points were determined apart from each other also by 10 m, in a total of 15 samples/quadrant. In each transect a different method was employed, as follows: honey and sardine attractive baits, pit-fall traps, and extraction in Berlese funnel of litter samples.

The baits contained 5 g of a mixed paste of honey and sardine (1 : 1 vol), distributed over paper tissues. The baits remained in the field for 60 min [24], after been collected for screening. Pitfall traps consisted of 500 mL plastic cups filled with 200 mL of water and liquid neutral detergent (10%). Pitfall traps remained in field for 24 h. Litter samples were standardized with a plastic grid of 0.25 m^2 on soil. The litter was put in Berlese funnel for 48 h for screening material.

In the quadrants of Rocky Fields, the pitfall traps and the litter samples were replaced by the attractive bait, considering the impossibility of using these methods, because litter is absent in the Rocky Fields and the installation of pitfalls under the rock is infeasible.

Collected ants were sorted, counted, and stored in alcohol 90%, recording phytophysionomy, method, and date of collect. After, a taxonomic identification was made under stereoscopic microscope (Leica), from dichotomous keys

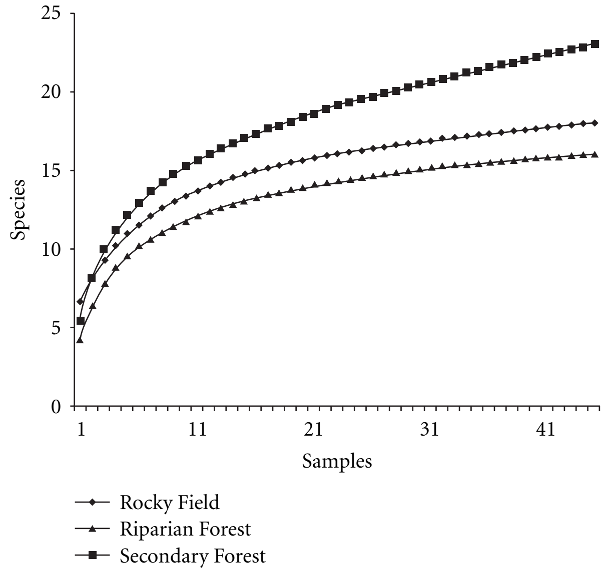

Figure 2: Sample-based rarefaction curves for the ant species at three phytophysionomies at Parque Estadual do Ibitipoca—Brazil. July–December, 2008.

[25, 26]. Ants were coded at genera level and separated in morph-species. Dr. Rodrigo Feitosa from the Museum of Zoology of São Paulo confirmed the species identification. The specimens were mounted and deposited in the thematic collection of MirmecoLab, ICB-UFJF (Campus Universitário, Cidade Universitária-s/n, Juiz de Fora-MG, CEP: 36036900).

2.3. Data Analysis. To evaluate the sampling effort, we constructed a rarefaction curve [27], using the program EstimateS [28]. Sample-based rarefaction curves indicate that sampling effort was significant for three phytophysionomies (Figure 2).

The content of five samples per method of collect was grouped to obtain a single sample for each transect in each quadrant. To compare the ant species composition from different phytophysionomies, we used multivariate analysis with the program PAST [29]. Data were organized in a binary matrix, considering the taxonomic level of genera (presence and absence) and submitted to nonmetric multidimensional ordination (NMDS). The dissimilarity between the phytophysiognomies was calculated through the Bray-Curtis index, which is less affected by the occurrence of rare species in the samples [30]. The stress index calculated by NMDS is a measure of goodness-of-fit [31].

Also a one-way analysis of similarity was applied (one-way ANOSIM), with 10 thousand permutations. This analysis compares the differences between the averages of the ranked similarities among the samples within and between the phytophysiognomies, verifying if there are significant differences in the composition of genera. ANOSIM generates a statistic R, which is a measure of dissimilarity between the areas. R values near zero indicate high similarity while R values near 1 indicate low similarity [32]. To calculate ANOSIM, the Bray-Curtis index was also used and each R value has its corresponding probability.

A similarity percentage test (SIMPER) was applied, which permits to determine which genera more contributed to discriminate among assemblies. SIMPER analysis provides a percentage of dissimilarity among the phytophysiognomies, presenting a percentage of contribution of each genera for such dissimilarity [31].

3. Results

A total of 8.730 individuals were collected, belonging to 46 species, 20 genera, and eight subfamilies: Ecitoninae, Ectatomminae, Heteroponerinae, Ponerinae, Formicinae, Dolichoderinae, Pseudomyrmecinae, and Myrmicinae, providing a list of ant species that occur in the PEIb (Table 1).

The greatest number of species was recorded for Riparian Forest, followed by Rocky Field and Secondary Forest, listing as exclusive species of Riparian Forest: *Pheidole* sp6, *Strumigenys louisianae*, *Brachymyrmex* sp2, *Paratrechina* sp1, and *Labidus* sp1. As unique species of Rocky Field are listed up: *Cephalotes pusillus*, *Brachymyrmex* sp3, *Camponotus genatus*, *Myrmelachista* sp2, *Myrmelachista* sp3, and *Pseudomyrmex* sp1; and in the Secondary Forest: *Brachymyrmex* sp1, *Myrmelachista* sp1, and *Hypoponera foreli* (Table 1).

Among the 19 ant species shared within the three studied areas, the most representative genera were *Pheidole* (7 species), *Camponotus* (4 species), and *Hypoponera* (3 species). We highlight the *Camponotus* absence in the Secondary Forest and the exclusive occurrence of each one of the three *Brachymyrmex* species in each phytophysionomy (Table 1).

Ant species composition in the three phytophysionomies differed significantly. (ANOSIM, $R = 0.48$, $P = 0.0001$), being more similar to the samples belonging to the same phytophysionomies (Figure 3, Table 2). The ordination NMDS indicates a stress value of 0.16, with the coordinates 1 and 2 explaining 48% and 26% of data variation, respectively. Actually, the greatest values of dissimilarity were verified between the Secondary Forest and the Rocky Fields (Table 3), being their samples, respectively, separated by coordinate 1.

According to the SIMPER test, the genera that most contributed for the dissimilarity among the phytophysionomies were *Crematogaster* and *Myrmelachista* which are responsible for 66.58% of the variation of species composition among the phytophysionomies (Table 4).

4. Discussion

The phytophysionomies showed differences in the composition of ant species, especially between SSF and RKF (Figure 3), evidencing the relationship between the vegetation and the ant fauna.

The SSF presents larger diversity of vegetal species, with genera of the families Rubiaceae, Lauraceae, Myrtaceae, Euphorbiaceae, Nyctaginaceae, Melastomataceae, Annonaceae, Palmae, Apocynaceae, and Monimiaceae [19]. This

Table 1: Relative frequency of occurrence of ant species in the three phytophysionomies in the Parque Estadual do Ibitipoca, Brazil. July–December, 2008.

Species	Rocky Field	Riparian Forest	Secondary Forest
Myrmicinae			
Acromyrmex aspersus F. Smith, 1858	0.00	92.29	7.71
Acromyrmex hispidus Santschi, 1925	20.08	78.74	1.18
Apterostigma (gr. *pilosum)* sp1 Mayr	20.00	40.00	40.00
Apterostigma sp2 Mayr	94.12	0.00	5.88
Cephalotes pavonii Latreille, 1809	93.52	6.48	0.00
Cephalotes pusillus Klung, 1824	100.00	0.00	0.00
Crematogaster sericea Forel, 1912	98.46	1.50	0.05
Octostruma balzani Emery, 1894	0.00	37.50	62.50
Octostruma rugifera Mayr, 1887	0.00	50.00	50.00
Pheidole obscurithorax Forel, 1985	77.78	15.56	6.67
Pheidole radoskowskii Mayr, 1884	44.32	5.68	50.00
Pheidole sp1 Westwood	21.90	59.65	18.45
Pheidole sp2 Westwood	39.20	14.20	46.60
Pheidole sp3 Westwood	48.88	26.85	24.27
Pheidole sp4 Westwood	33.33	18.52	48.15
Pheidole sp5 Westwood	60.14	17.39	22.46
Pheidole sp6 Westwood	0.00	100.00	0.00
Solenopsis sp1 Westwood	1.03	97.94	1.03
Solenopsis sp2 Westwood	38.96	57.14	3.90
Strumigenys louisianae Roger, 1863	0.00	100.00	0.00
Wasmannia affinis Santschi, 1929	27.78	50.00	22.22
Wasmannia auropunctata Roger, 1863	19.28	57.83	22.89
Formicinae			
Brachymyrmex sp1 Mayr	0.00	0.00	100.00
Brachymyrmex sp2 Mayr	0.00	100.00	0.00
Brachymyrmex sp3 Mayr	100.00	0.00	0.00
Camponotus crassus Mayr, 1862	92.14	7.86	0.00
Camponotus genatus Santschi, 1922	100.00	0.00	0.00
Camponotus melanoticus Emery, 1894	59.46	40.54	0.00
Camponotus pr *bonariensis* Mayr, 1868	60.00	40.00	0.00
Camponotus renggeri Emery, 1894	78.02	21.98	0.00
Myrmelachista sp1 Roger	0.00	0.00	100.00
Myrmelachista sp2 Roger	100.00	0.00	0.00
Myrmelachista sp3 Roger	100.00	0.00	0.00
Paratrechina sp1 Motschoulsky	0.00	100.00	0.00
Ectatominae			
Ectatomma edentatum Roger, 1863	58.23	40.51	1.27
Heteroponerinae			
Heteroponera dentinodis Mayr, 1887	0.00	18.75	81.25
Heteroponera inemis Emery, 1894	0.00	5.56	94.44
Ponerinae			
Hypoponera foreli Mayr, 1887	0.00	0.00	100.00
Hypoponera sp1 Santschi	1.75	8.77	89.47
Hypoponera sp2 Santschi	25.00	25.00	50.00
Hypoponera sp3 Santschi	0.00	7.32	92.68
Pachycondyla striata Smith, 1858	22.22	50.00	27.78
Ecitoninae			
Labidus sp1 Jurine	0.00	100.00	0.00

Table 1: Continued.

Species	Rocky Field	Riparian Forest	Secondary Forest
Dolichoderinae			
Linepithema cerradense Wild, 2007	89.61	7.79	2.60
Linepithema pulex Wild, 2007	9.35	90.65	0.00
Pseudomyrmicinae			
Pseudomyrmex sp1 Lund	100.00	0.00	0.00

Table 2: Comparisons ANOSIM paired of the composition of ant species in the three phytophysiognomies sampled in the Parque Estadual do Ibitipoca, Brazil. July–December, 2008.

	Riparian Forest	Secondary Forest	Rocky Field
Riparian Forest	—	0.257 ($P = 0.0003$)	0.435 ($P = 0.0003$)
Secondary Forest		—	0.747 ($P = 0.0003$)
Rocky Field			—

Table 3: Dissimilarity values (SIMPER) between the three phytophysiognomies sampled in the Parque Estadual do Ibitipoca, Brazil. July–December, 2008.

	Riparian Forest	Secondary Forest	Rocky Field
Riparian Forest	—	83.45	86.31
Secondary Forest		—	88.61
Rocky Field			—

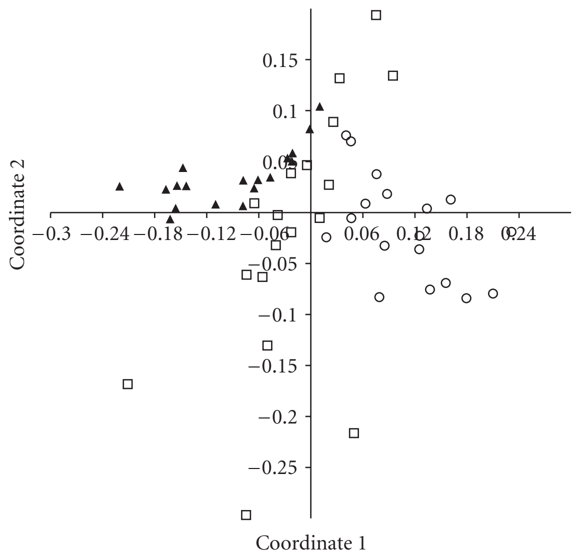

Figure 3: Nonmetric multidimensional ordination (NMDS) of ant species composition in three phytophysionomies sampled in the Parque Estadual do Ibitipoca, Brazil. July–December, 2008. Secondary Forest (triangles), Riparian Forest (squares), and Rocky Field (circles). Stress value = 0.16.

vegetation composition promotes the litter formation and, consequently the occurrence of cryptic ant species that depend on this layer to their nesting and foraging [33].

Actually we sampled seven and six cryptic ant species at SSF and RPF, respectively, while there are just four cryptic ant species at RKF. We pointed out that among these four cryptic species at RKF, two of them are arboricolous (*Myrmelachista*) [34], so they are not litter-dependent for nesting or foraging.

The Rocky Field presents characteristics completely different from the other areas. With a rocky soil, this open environment has a predominance of small trees with extra floral nectaries, especially of the genera *Vanillosmopsis* ("candeia"). Also the lack of nearby water bodies makes this phytophysionomy a hostile environment. According to Campos [16], rocky and sand exposed at the top of these fields are among the most extreme combinations of an environment. Mountainous areas, on which are found the rocky fields, are comparable to islands separated by very different ecological conditions [35]. The occurrence of arboreal ant species that present association with plants (*Crematogaster, Cephalotes, Pheidole, Camponotus, Myrmelachista, Linepithema,* and *Pseudomyrmex*) is a reflex of Rocky Field characteristics.

We emphasize the high frequency of *Camponotus* in the Rocky Field in contrast to its absence in the Secondary Forest. *Camponotus* is cited as the most frequent in open habitats such as sandbanks [36], "cerrado" [37–39], and "caatinga" [40]. This study includes Rocky Field as a habitat that allows to its occurrence. The absence of *Camponotus* in the Secondary Forest could be related to the achievement of collects exclusively in soil, combined with the high scale of the vegetation in this area.

Besides *Camponotus, Brachymyrmex* is also noteworthy, given the observed spatial segregation in which each of the three species was exclusively sampled in one of the areas. This spatial segregation can be explained given the high level of aggression recorded for the genera, even in intraspecific interactions [41].

For Riparian Forests the values of dissimilarity are near 50% and can be considered as a transition range between the two other phytophysiognomies, agreeing with the spatial location of this habitat in the PEIb (Figure 1) and with the presence of specialist (e.g., *Acromyrmex, Labidus*), invasive (e.g., *Solenopsis, Paratrechina*), and cryptic ant species (*Strumigenys*).

This study shows that the species that compose the ant assemblies in different phytophysiognomies are a reflex of the environment, especially of the plant species, supporting the hypothesis that differences in the vegetational composition result in different compositions in the ant assembly.

Also the vegetational composition is determinant in the formation of the litter and consequently in the occurrence of ant species that depend on this layer of organic matter for

Table 4: Cumulative contribution of ant genera for the dissimilarities among the phytophysionomies (SIMPER) sampled at Parque Estadual do Ibitipoca, Brazil. July–December, 2008.

Genus	Cumulative contribution %	Average abundance		
		Rocky Field	Riparian Forest	Secondary Forest
Crematogaster	42.64	1.78	0.05	0
Myrmelachista	66.58	0	1.78	0.05
Pheidole	80.35	0.05	0.27	2.78
Acromyrmex	93.13	3.83	0.33	0.11
Camponotus	96.92	0	0.22	2.83
Linepithema	98.83	0.22	0.5	0.27
Solenopsis	99.41	0.88	0	0.05
Wasmannia	99.68	0.11	0.11	0.27
Heteroponera	99.85	0	0.05	0
Strumigenys	100	0.11	0	0

nesting and foraging as the cryptic ant species [42]. Obtained data suggest that determination of ant fauna in the Secondary Forest and Riparian Forest is dependent of the conditions and resources provided by these phytophysiognomies, for instance, the presence of litter, shaded areas, and high trees. Unlike, in the Rocky Field, it is expected that the competition is the most important factor in determining the species that compose the assembly, considering the absence of litter, high insolation, and scarcity of resources.

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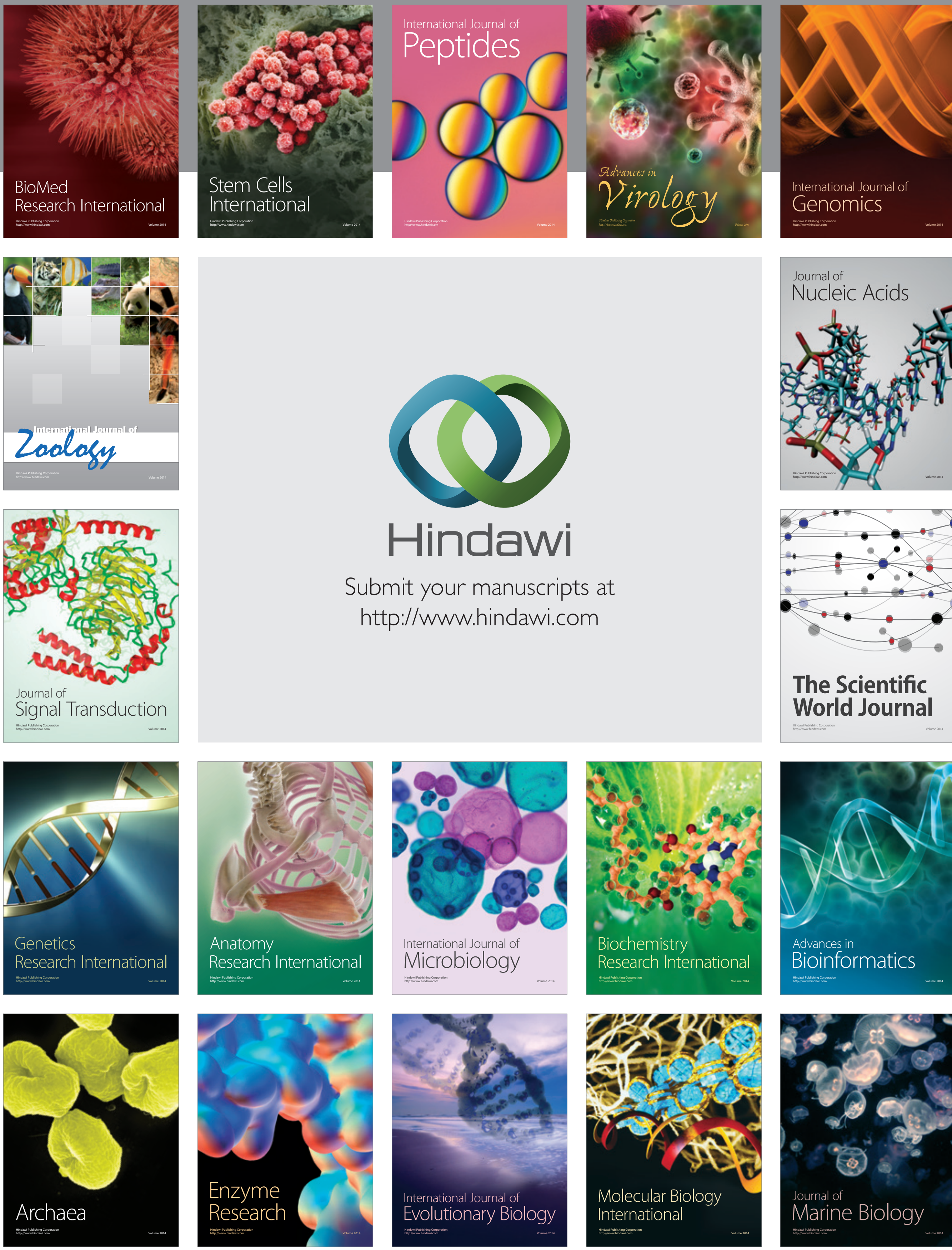
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