Differences of morphological and ecological characters among lineages of Chilean Rhinocryptidae in relation an sister lineage of Furnariidae.

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Abstract.- Eight species of Rhinocryptidae are recognized from Chile. Moreover, morphological, ecological and behavioral differences among two lineages of *Scytalopus* and two species of *Pteroptochos* are unclear. According to our results, there are no decisive criteria differentiating among subspecific sister taxa of *Scelorchilus albicollis*, *S.rubecula* and *Pteroptochos megapodius*. Here we discuss the speciation of the chilean Rhinocryptidae based in their behaviour. We propose a new methodology based on ecological and behavioural patterns in order to understand the concept of speciation in this group of birds.

Key words: Rhynocriptidae, *Pteroptochos*, *Scytalopus*, *Scelorchilus*, *Eugralla,* behaviour, adaptation, evolutionary clues.

"*Behind the mountain range, on the northern side,*
in caves revoked with agglutinated mud, underhanded
their accesses for hirsute forests, the dumis lived."

Cuando Pilato se Opuso, Hugo Correa (1960).

INTRODUCTION

According to current classification of chilean Rhinocryptidae, there are four genera containing eight species, three of which include subspecies (Krabbe & Schulenberg 1997, del Hoyo *et al.* 2003). Six of these species are endemic of temperate forests of southern Chile (Johnson 1965).

The current classification of chilean rhinocryptids is based on their morphological characters, plumage variations, geographical dispersion (Johnson1965) and differences in vocalization patterns (Krabbe & Schulenberg 1997). In general the Rhinocryptidae (tapaculos) family is considered a monophyletic group with Furnariidae (ovenbirds), Dendrocolaptidae (woodcreepers), Formicariidae (ground antbirds), Thamnophilidae (typical antbirds) and Conopophagidae (gnateaters) (Irestdt *et al.* 2002).

The chilean Rhinocryptidae present very rapid corporal movements (Correa & Figueroa 2001) as well as highly developed exploratory vision and hearing acuity (Correa & Figueroa 2001). Their basal metabolic rates are 50-60% higher than those of other birds of similar size (Feduccia 1996), and they have omnivorous and opportunistic diets (Correa *et al.* 1990).

There is no sexual dimorphism within species of this family. Males can be distinguished due to their conspicuous vocalizations in breeding season (e.g., Correa pers. observ.). Their vocalizations are due to the presence of a modified syrinx denominated tracheophone syrinx (Ericson *et al.* 2003), that allows to produces diverse types of vocalizations and strong specifics songs in order to permit encounters among individuals of the same species (Correa, unpubl.).

The brains of Rhinocriptydae possesses strong structural and functional similarities with those of mammals, specially with regard to the structures that enable multimodal integration capacity in the telencephalon (Rehkämper & Zilles 1991, Rehkämper *et al.* 1991). Such anatomical characteristic of the Rhinocryptidae annex to omnivorous and opportunistic diet (Correa *et al.* 1990, Correa & Figueroa 2001), may be associated with behavioural abilities for exploiting diverse environments (Feduccia 1996). In turn, such behavioural plasticity might facilitate the use of diverse habitats and broad geographical distribution, as shown by the chilean species (Fig. 1).

Here we discuss the differences and similarities among the lineages of the chilean rhinocryptids introducing new information on behavioural aspects and habitat use. We carried out an integrated analysis with specie outgroup, including ecology, morphology and behaviour, to asses differences among the already described lineages.

MATERIAL AND METHODS

Fieldwork and field observation We visited most sites for several weeks during at least one breeding season (Fig. 1). The observations were carried out in 13 areas along Chile with a great diversity of landscapes. Punta Grande (PG) located in the north of Chile (23ºS, 70ºW), Freirina (FR) (28ºS, 70ºW). Valle del Elqui (VE) (29ºS, 71ºW), Catemu (CA) (32ºS, 70ºW), Farellones (FA) (33ºS, 70ºW) Cordillera de Los Andes and Lo Valdes (33ºS, 69ºW), were dominated by shrubs (sclerophyllous shrublands), cactus and trees with low canopy and with strong adaptation to dry and could climates. On the other hand Curepto (CU) (35ºS, 70ºW) región Maulina, Concepción (CO) (36ºS, 71ºW), Villarrica (VI) (39ºS, 70ºW), Lago Todos los Santos (LS) (41ºS, 71ºW), Misquihue (MI) (41ºS, 73º W), Chiloé

(CH) (42ºS, 73ºW), Cabo de Hornos (CH) (54ºS, 68ºW) had predominant vegetation consisting in great diversity of shrubs with extensive areas of native bamboo (bamboolands chusqueas) and the close rainforest with high canopy, with strong adaptation to rain and could climates.

We embalm someone specimens in the study area and register the colour of the feathers (e.g., Correa pers. com.). On the other hand, we obtained information of the characters of the plumage from the collection of Rhinocryptidae specimens deposited at the Museo Nacional de Historia Natural, Chile and the Instituto de Zoología, Universidad Austral, Valdivia, Chile (1989) (Table 1) and the morphometrics measurement in specimen of genera *Scytalopus* (Correa *et al*, 2008). In each study sites, we registered the number of individuals observed or heard. Nonetheless, we registration the habitat use of each species and we took notes of activity and behaviour (Table 2), the birds were identified with the use binoculars or by their songs (*sensu* Egli 1985).

Data review. In order to evaluate the current classification of chilean Rhinocryptidae species, we first reviewed data on their ecology, plumage, and behavioural traits as reported by a variety of authors (Reynolds 1932, Goodall *et al.* 1946, Johnson 1965, Short 1969, Meyer de Schauensee 1970, Feduccia & Olson 1982, Araya & Millie 1986, Narozky & Izurieta 1987, Correa *et al.* 1990, Fjeldså & Krabbe 1990, Sibley & Ahlquist 1990, Sabag 1993, Arctander & Fjeldså 1994, Ridgley & Tudor 1994, Rozzi *et al.* 1996, Krabbe & Schulenberg 1997, Venegas & Shiefeld 1998, Correa *et al.* 1990, Correa 1999, Sieving *et al.* 2000, De Santo *et al.* 2002; Correa & Figueroa 2001, 2003; del Hoyo *et al.* 2003, Correa, Bardon, Willson and De Santo, unpubl.).

Similariy indexes. From these data, we applied a Russel & Rao similarity index, based on analysis of attributes or qualities among pairs of individuals (Rao 1952, Jacquard 1966, Jacquard 1973) to calculate genetic distances (Penrose 1954, Gover 1971). For example, it is possible to express the presence or absence of a phenotype pattern by numerical codes and consider these numerical codes like justified measures (Sokal & Sneath 1963).

From these data we construct at cluster tree in comparison with sistergroup relationship of Furnariidae (Irestedt *et al.* 2002, Ericson *et al.* 2003). Nonetheless, we compare with the Gray-flanked Cinclodes (*Cinclodes oustaleti*) (Furnariidae) (Fig. 2) and we make an integrated analysis of ecological, morphological (plumage) and behavioural characters (Fig. 4). Additionally, to reinforce these results of the test of Russel & Rao index by means of an analysis of conglomerates (neighbor-joining boostrap trees software systat 8.0) (Fig. 3 and Fig. 5).

RESULTS

The cluster tree analysis (Fig. 2 and Fig. 3) of data of Table 1 show no evidence supporting subspecific differentiation of White-throated Tapaculos (*S.albicollis*), Chucao Tapaculos (*S.rubecula*), Moustached Turcas (*P.megapodius*). Nonetheless, between each pair of sister races of White-throated Tapaculos, Chucaos Tapaculos and Moustached Turcas, the values of Russel & Rao indexes were 1.0 (Fig. 2), in relation with sisterspecie outgroup the Gray-flancked Cinclodes (*Cinclodes oustaleti*) and the value in bootstrapping support is 0 (Fig. 3), indicating that the sister lineages of these species cannot be distinguished using studied characters. Additionally, the two species of *Scytalopus* genera, the Magellanic Tapaculos (*S.magellanicus*) and the Dusky Tapaculos (*S. fuscus*) did not show significant differences, with a similarity rate of 0.90 and value of 0.53 in bootstrapping support (Fig. 2, Fig. 3 and Table 3). The species of Black- throated Huet-huet (*Pteroptochos tarnii*) vs Chestnut-throated Huet-huet (*P. castaneus*) differed somewhat, with a similarity of rate value of 0.58 and 1.2 in bootstrapping support (Fig. 2, Fig. 3 and Table 3). Differences between them are their plumage (17 of a total of 26 traits) and the fact that they inhabit different geographical regions (Fig.1). Also, these superspecies are considered conspecific (del Hoyo *et al*. 2003).

Our classification of chilean Rhinocripydae is based on behavioural traits in addition to ecological and plumage character (Fig. 4, Fig. 5 and Table 4). We applied a Russel & Rao rate and constructed a clustre tree (Fig. 4) and reinforced the clades by bootstrapping support (Fig. 5) which indicates White- throated Tapaculos, Chucaos Tapaculos and Moustached Turcas present no supporting evidence for separating sister lineages data (Fig. 4, Fig. 5). The data obtained in the comparison of different species using the above test showed similarity indexes with high values (Table 4). These values indicate, in a certain way, that there exists a high degree of similarity between the species whose behaviours in a specific habitat were compared. For example, similarity between Black-throated Huet-huets vs Chestnut-throated Huet-huets, two lienages considered as separate species under the current classification, has a rate value of 0.71 (Table 4) and value of 1,26 in bootstrapping support. Both species live in different geographical regions (del Hoyo *et al*. 2003). Differences are plumage characters (12 of a total of 26 traits), involving only the extension of the reddish brown plumage to cover the entire throat and sides of the head in Chestnut-throated Huet-huets (Goodall *et al*. 1946, Johnson *et al*. 1967). The similarity index in the cladogram involves different species (Fig. 4, Fig. 5). However, both lineages live in the understory of the temperate rain forest and in the chusqueas bamboolands in the south of Chile, occupying the same ecological niches and possess identical behavioural traits (e.g., Correa pers. com.).

Interesting is the case of Moustached Turcas that possess a high value of 1.0 an value of 0 in bootstrapping support (Fig. 4, Fig. 5 and Table 4). They occupy the same ecological niches and habitat of the andean mountainous sclerophyllous shrublands of the coastal range but are located in different geographical regions (del Hoyo *et al*. 2003) (see

Fig.1). The plumage of *P.m.atacamae* is significantly paler specially bellow, lacks rufous tinge on underparts, has lower underparts much whiter and smaller corporal size than *P.m.megapodius* (Goodall *et al.* 1946, Johnson *et al.* 1967). In fact high index of similarity for these sister lineages did not justify a taxonomic separation (Fig. 4, Fig. 5).

Two species of particular interest are the Magellanic Tapaculos vs the Dusky Tapaculos, two lineages considered as separate under the current classification. The rate value of main similarity index is 0.94 (Fig. 4) an 0.53 value of bootstrapping support (Fig. 5). However these two species differ in some plumage aspects, because the Dusky Tapaculo possess as brown colorations with spotted light brown in the loin, breast and in the crown, while the Magellanic Tapaculo has a gray brown plumage coloration and differs in some morphometric parameters, for example the difference in "thigt length" between the two *Scytalopus* species (Correa *et al.* 2008), would suggest a major locomotry difference between them (the data in Tab. 2 would suggest thight/tarsus ratio 0.43 in the Dusky Tapaculos, versus 0.69 in Magellanic Tapaculos). Nevertheless, suggest that the Magellanic Tapaculos are better adapted to the forest understory and chusquea bamboolands habitats in south of Chile. Both Rhinocryptidae species of the *Scytalopus* genus cover Chile in nearly all its geographic (al extension (del Hoyo *et al.* 2003) (Fig. 1), specially the Magellanic Tapaculo in the south austral region due to lower habitat specifity. Also both are sympatric at least from Bio-bio to Santiago (possibly to Aconcagua) (Fjeldså & Krabbe 1990), although the calls of these species are very different (Riveros & Villegas 1994, Krabbe & Schulenberg 1997). In fact the cluster tree indicated that separation exists among these lineages, although it would exist the probability that these characters may not be sufficient to separate them as species.

An interesting similarity rate value of 1.0 and 0 in bootstrapping support (Fig. 4, Fig. 5 and Table 2) is obtained for Chucao Tapaculos subspecies mentioned in the current classification which occupy similar ecological niches in the understory of the temperate rain forest and chusquea bamboolands, but are located in different geographical regions (del Hoyo *et al.* 2003). Although, as shown by different authors, the mochae subspecies of the Chucao Tapaculos is significantly larger than the rubecula subspecies (Goodall *et al.* 1946, Johnson *et al.* 1967), their high index of similarity suggests a weak taxonomic separation (Fig. 3).

In the case of lineages of White-throated Tapaculos that possess a high similarity rate of 1.0 and 0 in bootstrapping support (Fig. 4 and Fig. 5), they occupy the same ecological niches of the andean mountainous sclerophyllous shrublands and the coastal range but are located in different geographical regions (del Hoyo *et al.* 2003). The plumage of *S.a.atacamae* is significantly paler, without brownish upperparts, and its bill is shorter than *S.a.albicollis* (Goodall *et al.* 1946, Johnson *et al.* 1967). In fact the high index of similarity for these sister lineages does not justify a taxonomic separation (Fig. 4, Fig. 5 and Table 8).

A notable and special case occurs when comparing Ochre-flanked Tapaculos (*Eugralla paradoxa*), in sites LS, CO, CU, CO, MI, CH, see Fig. 1) and White- throated Tapaculos (CA, FA, LV) with high similarities indexes of 0.51 (Fig. 4, Table 4). These lineages are located in different geographical areas and live in different habitats. Their similarity can be attributed to the fact that they possess the same behavioural traits. Ochre-flanked Tapaculos nest near path in shrubs of the rainforest of southern Chile. They are distributed from Maule region (35ºS, 71ºW) to Chiloé (41ºS, 73ºW) and Isla Mocha (38ºS, 74ºW), and in Argentina (35ºS, 41ºS) whereas White-throated Tapaculos occupied ecological niches near shrubs along roads and paths of andean mountainous sclerophyllous shrublands and in coastal range. These lienages have not been reported sharing the same habitat or in the same geographical region. However their similarity index could indicate that they have a similar life mode and in comparison with Gray-flanked Cinclodes (sister outgroup relationships), value are 0.27, 0.29 respectively, the low value are due to the differences in the behaviours, could confirm that they have a different life mode with otugroup sister specie (Fig. 4, Table 4).

Ochre-flanked Tapaculos and Andean tapaculos have a similarity index of 0.51 (Fig. 4, Table 4). This suggests that they possess similar life mode. They have a low specificity of habitat (Venegas 1998, Vergara 2003, Correa & Rozzi in prep.) along with similar behavioural traits which may indicate in part the great similarity between these lineages. In comparison with Gray-flanked Cinclodes, value are 0.27, 0.29 respectively, the low value are due to the differences in the behaviours, confirm that they have a different life mode with outgroup sister specie (Fig. 4, Table 4).

Additionally, the similarities among species that shared the same habitat indicate a high degree of interaction between them because they have similar behavioural traits and lifes modes. Similarities between Magellanic Tapaculos and Black-throated Huet-huets, between Magellanic Tapaculos and Chucao Tapaculos, and between Black-throated Huet-huets and Chucao Tapaculos (VI, LS, CH, MI in Fig. 1) that share the same habitats indicate high grade of interaction among them, all of them occupy the exuberant understory of the temperate rain forest and the bamboolands of *Chusquea valdiviensis*. Similarity rate values are 0.46, 0.44, 0.46, respectively (Table 4) with local sympatry between them (Short 1969, Correa & Figueroa 2001, 2003) and in comparison with Gray-flanked Cinclodes, value is 0.29 respectively, the low value is due to the differences in the behaviours, could indicate that they have a different life mode with specie outgroup (Fig. 4 and Table 8). We have observed Ochre-flanked Tapaculos, Andean Tapaculos, Chestnut-throated Huet-huets and Chucao Tapaculos coexisting locally in similar habitats of the cordillera of the central coast (Vergara *et al.* 2003). In fact we found a high degree of interaction among these lineages in the same habitat (in sites CU, CO) with similarity and rates of 0.51, 0.44, 0.46, 0.40, 0.44, and 0.48, respectively (Table 8), because the behavioural traits are identical. In relation with outgroup sister specie, value are 0.29 respectively, the low value are due to the differences in the behaviours, could indicate that they have a different life mode with outgroup sisterspecie (Fig. 4, Table 4).

Andean Tapaculos and Moustached Turcas, Andean Tapaculos and White-throated Tapaculos, Moustached Turca and White-throated Tapaculos, have similarity indexes of 0.44, 0.42 and 0.48, respectively (Table 4), due great interaction between them and their habitat, because possess the same behavioural traits and lifestyle. They occupy the mountainous sclerophyllous shrublands of the Andes (LV, FA) and the cordillera of the central coast (CA) (Fig. 1 and Table 7). They can also been found on the Pacific coast in Quebrada de Cordova (QC) (33ºS, 71ºW), (Armesto & Medina pers. observ). Also in comparison with the Gray-flanked Cinclodes (sister specie outgroup), rates are 0.27, 0.29 respectively, the low value are due to the differences in the behaviours, could indicate that they have a different life mode with outgroup sisterspecie (Fig. 4, Table 4).

DISCUSSION

Our results indicate the lack of clear-cut criteria to establish differences among the following three subspecific sister taxa of the current classification of Chilean passerine Rhinocryptidae (White-throated Tapaculos, Moustached Turcas, Chucao Tapaculos) since the differences are obscure. Also, among the sister species of the lineages of *Pteroptochos* and *Scytalopus* genera there is no significant evidence significatives that they are distinct species although, according to our analyses, they affear to be different species. Our methodology, allows to compare alredy established outgropup sisterspecie in this case the Gray-flanked Cinclodes (Furnariidae) (Fig. 4). Furthermore, the comparison with sister outgroup Furnariidae, explain clearly how the behaviour shorten the distance among sister lineages in Rhinocryptidae and how the behaviour separe the distances with the outgroup sisterspecie the Gray-flanked Cinclodes.

Moreover, the integration of behavioural, ecological and morphological characters (plumage) allows us to conclude that there is a decrease in the distances among sister lineages in the cluster tree (Fig. 4), further supporting the notion that the current classification of the chilean Rhinocryptidae should be revised and modified. On the other hand the analysis of bootstrapping support to reinforce the similarity test of Russel & Rao index. This bootstrapping support doesn't make any discrimination when the behavioural patterns are used added as variable (Correa *et al.* 2008) (Fig. 3 and Fig. 5). Nonetheless is probably that shows inconsistency likelihood when integrating certain type of data, due to evolutionary heterogeneity (Kolaczkowski & Thornton 2004).

Aditionally, it possible that the great similarity in the behaviours among these species is due to their peculiar lifestyle (del Hoyo 2003). Nonetheless, when we observe these birds in his environment, we are convinced that the behaviour is a character that implies evolutionary clues in the speciation in chilean Rhinocryptidae and an important factor that determine this taxonomic group, due a strong interaction that exists among these lineages and his environment. This group of undergrowth inhabitants are strongly adapted to restricted habitat (eg., Correa pers. com.), due to their behaviour and lifestyles since they are vulnerable to extinguish. Also these species of birds that have been able to be dispersed in a wide geographical area in Chile Fig. 1, in consequence it is a clear example of allopatric speciation (Mayr 1970).

Therefore in this respect there is necessity to preserve the natural habitat of these species (Armesto *et al.* 1998) since, in this way, we may be able to understand with greater accuracy their behavioural adaptive patterns and to what, extent they adjust to their environment. We may them gain a better understanding of the triggering mechanisms of animal perception (Uexküll 1921), that induce behavioural changes (Lorenz 1971, 1978) and permit a deeper understanding of problems concerning species evolution and behaviour.

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FIG. 1. Rhinocryptidae family living throughout Chile's long latitudinal extension and observation sites.

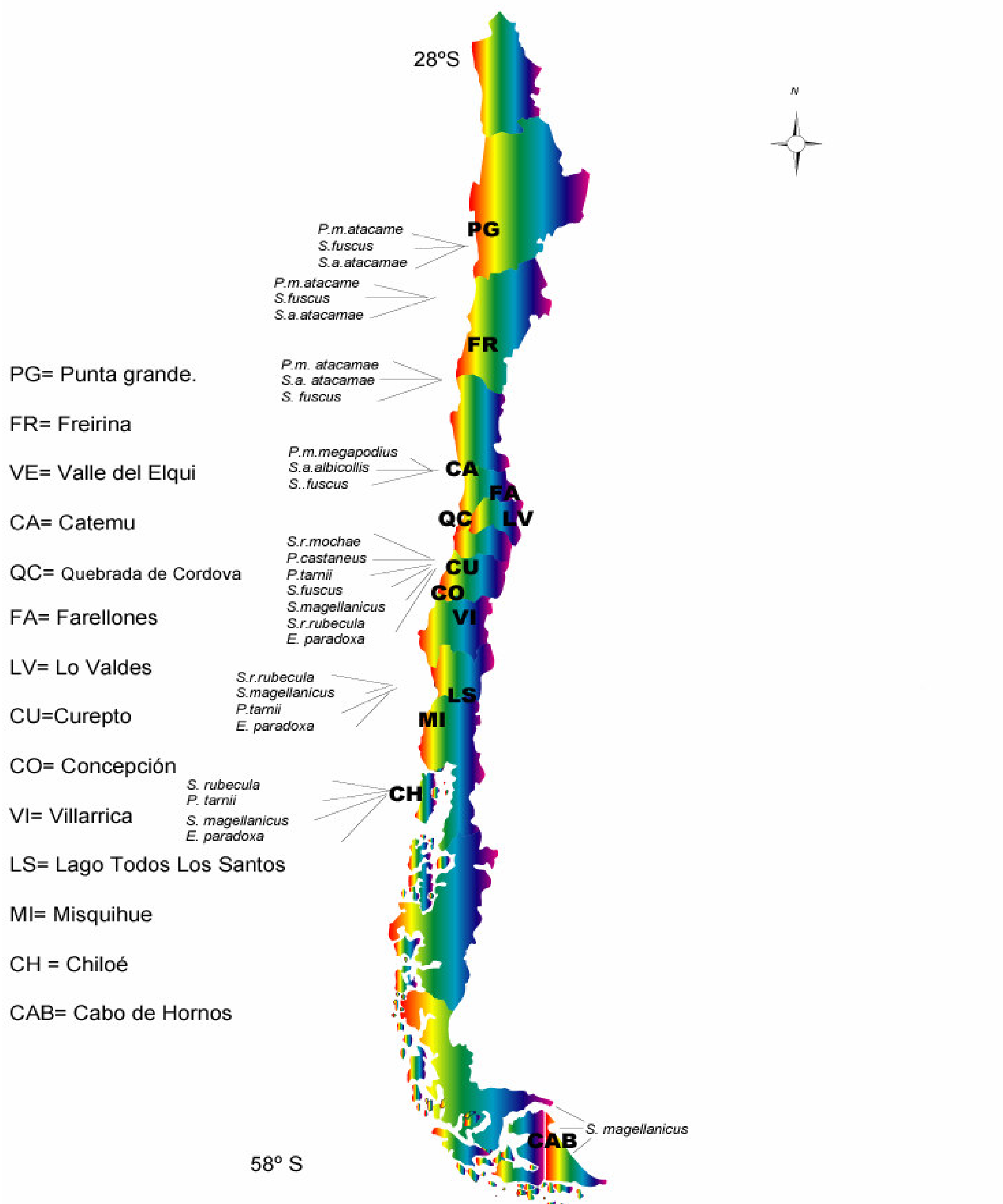


Fig. 2. Cluster tree (Russel & Rao index) of chilean Rhinocryptidae based on ecological and plumage characters with sister outgroup.

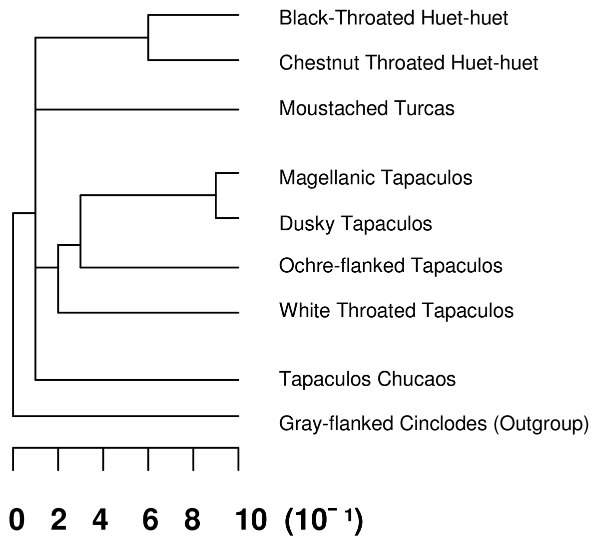
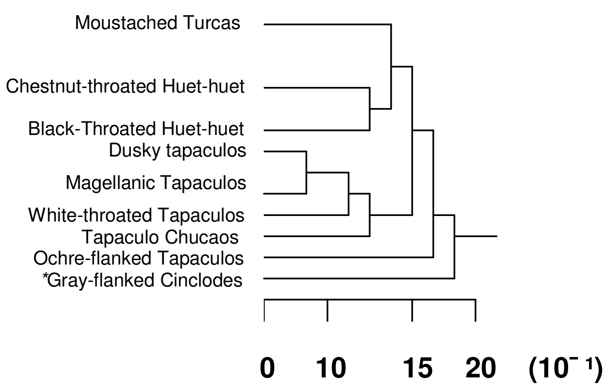


Fig. 3. Cluster tree (Bootstrapping support) of chilean Rhinocryptidae based on ecological and plumage characters with sister outgroup.



* Furnariidae

Fig. 4. Cluster tree (Russel & Rao index) of chilean Rhinocryptidae based on behavioural, in addition to ecological and plumage characters with sister outgroup.

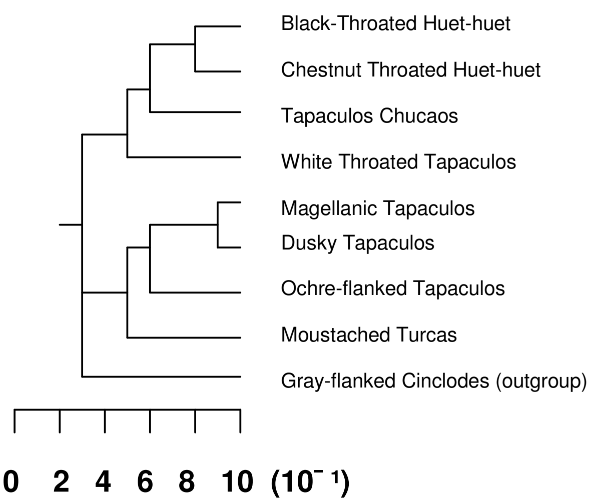
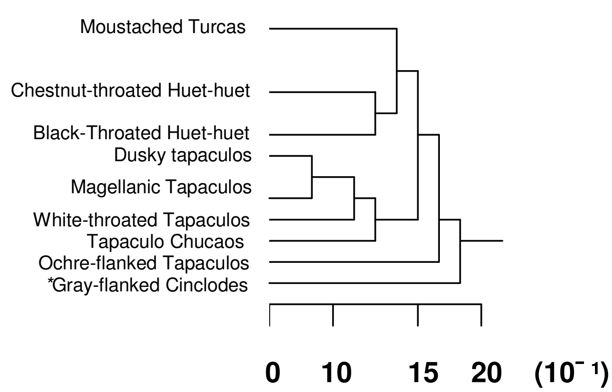


Fig. 5. Cluster tree (bootstrapping support) of chilean Rhinocryptidae based on behavioural, in addition to ecological and plumage characters with sister outgroup.



* Furnariidae

TABLE. 1. data base of phenotype traits of feathers, habitat use, diet an geographical distribution of eight species of chilean Rhinocryptidae, include specie of Furnariidae (outgroup).

Characters**/species*	A	B	C	D	E	F	G	H	I	J	K	L
Forehead	1	1	35	5	11	11	14	14	17	17	8	15
Shoulders	1	1	5	5	11	11	14	14	12	12	5	43
Mantle	1	1	8	6	5	5	14	14	12	12	22	15
Tail	1	1	7	7	5	5	14	14	12	12	5	43
Breast	34	34	35	35	2	2	5	5	22	41	22	46
Throat	13	13	8	5	11	11	5	5	12	12	4	45
Beak	3	3	3	3	7	7	7	7	6	6	6	15
Foot	3	3	3	3	7	7	7	7	7	7	48	43
Wings	1	1	12	10	5	5	14	14	12	12	22	15
Bridles	1	1	3	3	11	11	5	5	12	12	22	11
Belly	37	37	36	36	11	11	38	38	16	16	4	47
Nape	1	1	5	5	11	11	14	14	12	12	22	43
Und. coverts	1	1	3	10	5	5	14	14	42	41	5	15
Sec. feathers	1	1	3	10	5	5	14	14	13	13	5	15
Prim. feathers	1	1	3	3	5	5	14	14	13	13	5	43
Flanks	1	1	7	7	5	5	14	14	27	27	27	34
Inferior parts	9	9	13	13	9	9	22	22	22	22	23	43
Crown	1	1	8	6	11	11	14	14	10	41	18	44
Eyebrow	29	29	3	5	11	11	27	27	12	12	10	43
Ear coverts	14	14	8	3	5	5	15	15	12	12	10	44
Loin	27	27	5	5	5	5	15	15	42	41	22	43
Upper. coverts	1	1	5	28	28	28	15	15	42	41	22	15
Lower breast	31	31	5	30	32	32	33	33	7	7	23	47
Rump	1	1	35	40	39	39	15	15	27	27	27	45
Coverts feathers	1	1	12	10	5	5	14	14	42	41	22	43
Tertial feathers	1	1	12	10	5	5	14	14	12	12	22	45
Habitat use	20	20	21	21	20	20	21	21	20	20	21	20
Geogr. dist.	18	18	18	18	18	18	18	18	19	19	18	19
Diet	24	24	26	26	24	24	26	26	24	24	24	24

Specimens*, N= 97

A=*P.m.megapodius*	E= *S.a.albicollis*	I= *S.magellanicus*
B=P.m. atacamae	F= *S.a. atacamae*	J= *S. fuscus*
C=*P.tarnii*	G= *S.r. rubecula*	K= *E. paradoxa*
D=*P.castaneus*	H= *S.r. mochae*	L= *C. oustaleti*

Ecological and plumage characters**

1 = smoky brown	17 = white silver on same individuals	33 = gray feath. with bla. and whi. irreg. bars
2 = reddish brown dark	22= slaty-gray	34= rufous brown
3= blackish	23= light slaty gray	35= chestnut
4 = light gray	27= rufous	36 =barred black
5= reddish brown	28 = reddish brown intense	37= whitish barred rufous and dusky
6= slaty black	18 = endemic	38 = dark gray
7 = gray- slaty- black	19= austro southamerican	39 =rufous brown
8= slaty	20= shrubs, meadows, mountains, forests	40=barred black
9 = white- brown, black	21= forest -shrubs	41=brown with spotted light brown
10 =black gray	24= insectivorous	42= gray brown
11 = whitish	25 = insectivorous, granivorous	43= blackish brown
12 = nearly black	26= insectivorous, frugivorous, granivorous	44= dark greyish brown
13 = brown tendency	29 = white	45= whitish with dark sacalloping
14 = brown smoking	30 = reddish brown less	46= dark gray brown
15 = dark brown	31 = white with brown and black bars	47= paller and browner
16 = gray	32 = white cream with dark brown bars	48= yellow

TABLE. 2. data base on; behaviour traits, habitat use and diet of species of Rhinocryptidae, include one specie of Furnariidae (outgroup).

Characters**/species*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*
Habitat use	1	1	2	2	1	1	2	2	1	1	2	2
Use of water courses	3	3	3	3	3	3	3	3	3	3	3	3
Use of holes for shelter	4	4	4	4	4	4	4	4	4	4	5	4
Breeding period	6	6	6	6	6	6	6	6	6	6	6	6
Diet	7	7	7	7	7	7	7	7	7	7	7	25
Curiosity	8	8	8	8	8	8	8	8	8	8	8	8
Aggressiveness	9	9	9	9	9	9	9	9	9	9	9	9
Nest construction	10	10	10	10	10	10	10	10	10	10	10	26
Climbing behaviour	11	11	11	11	11	11	11	11	11	11	11	27
Vocalisation behaviour	12	12	12	12	12	12	12	12	12	12	12	28
Type of flight	13	13	13	13	13	13	13	13	13	13	13	29
Escape movement	14	14	14	14	14	14	14	14	14	14	14	30
Family interaction	15	15	15	15	15	15	15	15	15	15	15	15
Use of foot paths	16	16	16	16	16	16	16	16	16	16	16	1
Ritual Movements	17	17	17	17	17	17	17	17	17	17	17	17
Visual sensitivity	18	18	18	18	18	18	18	18	18	18	18	18
Acoustic sensitivity	19	19	19	19	19	19	19	19	19	19	19	19
Corporal movements	20	20	20	20	20	20	20	20	20	20	20	20
Territoriality	21	21	21	21	21	21	21	21	21	21	21	21
Coop. in the nest	22	22	22	22	22	22	22	22	22	22	22	22
Chick feeding	23	23	23	23	23	23	23	23	23	23	23	23
Habit schedule	24	24	24	24	24	24	24	24	24	24	24	24

Species*

A=*P.m.megapodius*
B=P.m. atacamae
C=*P.tarnii*
D=*P.castaneus*
E= *S.a.albicollis*
F= *S.a. atacamae*
G= *S.r. rubecula*
H= *S.r. mochae*
I= *S.magellanicus*
J= *S. fuscus*
K= *E. paradoxa*
L= *C. oustaleti*

Number of individuals observed or heard, N= 1.079

Ecological and behavioral characters**

1 = shrubs, meadow, mountains
2= trees, shrubs, mountains
3= near streams
4 = nests, burrows, trees, cliffs
5= in shrubs
6 = same season
7= omnivorous
8 = to reply vocalis. of ind.
9= during the breeding season
10= similar structure
11= in rocks, branches, trees.
12 = conspicuous in males
13 = short and intense bursts
14 = fast response
15 = during the breeding season
16= during the breeding season
17= during the breeding season
18= high
19= high
20= very fast
21= dur. bre. sea.
22 = both adults
23 = both adults
24 = along of his life
25= Insectivorous
26= in branches of high trees and in high rock fissure
27= fly drifting from rock to tree
28= indistinguishable among mate
29= width flying
30= speed flying
31= misfortunately in the territory in breeding.

TABLE. 3. Data matrix show indexes Russel & Rao of chilean Rhinocryptidae based on ecological and plumage characters with sister outgroup.

SP.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*
A	-	1.00	0.10	0.10	0.13	0.13	0	0	0.06	0.06	0.06	0
B	1.00	-	0.10	0.10	0.13	0.13	0	0	0.06	0.06	0.06	0
C	0.10	0.10	-	0.58	0.07	0.07	0.10	0.10	0.10	0.10	0.10	0
D	0.10	0.10	0.58	-	0.10	0.10	0.13	0.13	0.00	0.00	0.06	0
E	0.13	0.13	0.07	0.10	-	1.00	0.10	0.10	0.03	0.03	0.17	0.03
F	0.13	0.13	0.07	0.10	1.00	-	0.10	0.10	0.03	0.03	0.17	0.03
G	0	0	0.10	0.13	0.10	0.10	-	1.00	0.07	0.07	0.10	0.03
H	0	0	0.10	0.13	0.10	0.10	1.00	-	0.07	0.07	0.17	0.03
I	0.06	0.06	0.10	0	0.03	0.03	0.07	0.07	-	0.90	0.17	0.03
J	0.06	0.06	0.10	0	0.03	0.03	0.07	0.07	0.90	-	0.10	0.03
K	0.06	0.06	0.10	0.06	0.17	0.17	0.10	0.10	0.17	0.17	-	0
L	0	0	0	0	0.03	0.03	0.03	0.03	0.03	0.03	0	-

Species*

A= P.m.megapodius	*D=P.castaneus*	*G= S.r.rubecula*	*J=S. fuscus*
B= P.m.atacamae	*E= S.a. albicollis*	*H= S.r. Mochae*	*K= E. paradoxa*
C= P.tarnii	*F= S.a. atacamae*	*I=S. magellanicus*	*L= C. oustaleti*

TABLE. 4. Data matrix show indexes Russel & Rao of chilean Rhinocryptidae based on behavioural, in addition to ecological and plumage characters with sister outgroup.

SP*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*
A	-	1.00	0.46	0.46	0.48	0.48	0.40	0.40	0.44	0.44	0.44	0.27
B	1.00	-	0.46	0.46	0.48	0.48	0.40	0.40	0.44	0.44	0.44	0.27
C	0.46	0.46	-	0.71	0.44	0.44	0.46	0.46	0.46	0.46	0.46	0.29
D	0.46	0.46	0.71	-	0.46	0.46	0.48	0.48	0.40	0.40	0.44	0.29
E	0.48	0.48	0.44	0.46	-	1.00	0.46	0.46	0.42	0.42	0.51	0.29
F	0.48	0.48	0.44	0.46	1.00	-	0.46	0.46	0.42	0.42	0.51	0.29
G	0.40	0.40	0.46	0.48	0.46	0.46	-	1.00	0.44	0.44	0.46	0.29
H	0.40	0.40	0.46	0.48	0.46	0.46	1.00	-	0.44	0.44	0.46	0.29
I	0.44	0.44	0.46	0.40	0.42	0.42	0.44	0.44	-	0.94	0.51	0.29
J	0.44	0.44	0.46	0.40	0.42	0.42	0.44	0.44	0.94	-	0.51	0.29
K	0.44	0.44	0.46	0.44	0.51	0.51	0.46	0.46	0.51	0.51	-	0.27
L	0.27	0.27	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.27	-

Species*

A= P.m.megapodius *D=P.castaneus* *G= S.r.rubecula* *J=S. fuscus*
B= P.m.atacamae *E= S.a. albicollis* *H= S.r. Mochae* *K= E. paradoxa*
C= P.tarnii *F= S.a. atacamae* *I=S. magellanicus* *L= C. oustaleti*