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On the standardization of nest descriptions of neotropical birds

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ABSTRACT. Different authors have used different methods and nomenclatures to describe bird nests of the Neotropical region, leading to muddled terminology which makes comparisons among published data difficult. The present study suggests a standardization and a hierarchy of criteria which make easier to understand nest structures and allow direct comparisons among data from different authors in reports on bird evolution, conservation, phylogeny, etc. For that, the nest has been defined as any place where the eggs are laid. Four elementary nest standards are proposed: *simple* (when eggs rest on an unlined or roughly lined floor), *cup* (any basket or bowl-like form), *closed* (when the walls completely cover the incubatory chamber), and *cavity* (when they are placed inside natural or artificial cavities). The *simple* standard has two variants: *unlined* and *platform*. The *cup* standard has two variants: *high cup* and *low cup*; the *closed* standard has six variants: *long, globular, furnace, irregular, ovoid* and *retort*. The *cavity* standard presents *simple, cup*, or *closed* nests inside, each one with or without an access tunnel to its interior. When hierarchically ordered, these four elementary standards, their variants and the four main ways by which nests are attached to substrate (by their *bases*, by their *laterals*, by a branch *fork*, or *pensile*) proved to be efficient for the description of neotropical nests, as shown by the examples given in the text including 97 species, 88 genera, and 33 families from more than 9 countries. These combinations, totaling 30 basic nest types, allow easy evaluation of important inter- and intra-specific differences and of the evolutionary processes which are relevant to taxonomy and conservation. In addition, suggestions for making and keeping scientific nest collections are presented.
KEY WORDS: nest, birds, Neotropical region

RESUMO. **Sobre a padronização da descrição de ninhos de aves neotropicais.** Devido à falta de um sistema que uniformize os critérios para a descrição dos ninhos das aves, particularmente os das espécies neotropicais, métodos e nomenclaturas independentes foram utilizados por diferentes autores, resultando em uma confusa terminologia que se acumula na literatura e dificulta a comparação dos dados publicados. O presente trabalho propõe uma padronização das descrições e uma hierarquia de critérios que permitem e simplificam substancialmente a compreensão da estrutura dos ninhos, bem como a fácil e imediata comparação entre os dados de diferentes autores, facilitando sua utilização em estudos sobre evolução, conservação e filogenia de aves. Para tanto, definiu-se ninho como qualquer local onde os ovos sejam postos. Quatro padrões elementares de ninhos são propostos: *simples* (quando a postura é feita sobre uma superfície nua ou pouco forrada), *cesto, fechado* (quando as paredes envolvem completamente a câmara incubatória) e *cavidade* (dentro de cavidades naturais ou artificiais). O padrão *simples* apresenta duas variantes: *desnudo* e *plataforma*. Para o padrão *cesto* foram reconhecidas as variantes *cesto baixo* e *cesto alto*; para o padrão *fechado*, propõe-se as variantes *alongado, esférico, forno, irregular, ovalado* e *retorta*. O padrão *cavidade* apresenta em seu interior ninhos *simples, cestos* ou *fechados*, qualquer deles com ou sem túnel de acesso ao seu interior. Esses quatro padrões elementares e suas variações, associados aos 4 tipos de apoio dos ninhos (pela *base*, pela *lateral*, em *forquilha* ou *pendente*), quando usados segundo essa hierarquia, mostraram-se eficazes para a descrição dos ninhos neotropicais, conforme exemplos discutidos no texto (97 espécies, 88 gêneros e 33 famílias de mais de 9 países). Essas combinações, que totalizam 30 tipos básicos de ninhos, favorecem a compreensão de importantes diferenças inter e intra-específicas e de processos evolutivos importantes para a taxonomia e a conservação da avifauna neotropical. Adicionalmente, propõe-se um método para a criação de coleções científicas de ninhos.
PALAVRAS-CHAVE: ninhos, aves, região Neotropical

Nests have always raised great interest among ornithologists due to their importance for the reproductive cycle of species, since they are built according to environmental requirements for reproduction (Skutch 1976, Collias and Collias 1984 for a comprehensive review). They have also been studied to support phylogenetic analyses (Ihering 1904, Vaurie 1980, Traylor 1977, Lanyon 1986, 1988a,b,c, Prum and Lanyon 1989, Zyskowski and Prum 1999) and discussions of adaptive processes (Brewer 1878, Crook 1963, Skowron and Kern 1980, Barba and López 1990, Pacheco and Simon 1995). Such studies are based on the general nest form, on which there is extensive bibliography for many different species.

The main general studies on the subject for the neotropical region are those of Euler (1900), Ihering (1900, 1914), Pinto (1953), Skutch (1960, 1967, 1969a), Narosky *et al*. (1983), Oniki (1986), Peña (1987) and Sick (1997), who reported on nests of a large number of species. There are also numerous studies on one or more species providing, in different degrees, details on their nests (Allen 1905, Reed 1919, Serié and Smyth 1923, Devincenzi 1925, Smyth 1928, Sick 1948, Marchant 1960, Skutch 1968, Masramón 1971, Rutkis 1972, Bokermann 1978a,b, Oniki and Willis 1982a,b,c, 1983a,b, Ramo and Busto 1984, Studer and Vielliard 1988, Straube and Teixeira 1992, Bencke 1995, Pacheco and Simon 1995, Simon and Pacheco 1996a,b, Simon 1997, Ribon and Simon 1997, Simon *et al*. 1999).

The lack of hierarchy of criteria and of standard nomenclature for nest descriptions makes difficult any comparisons among the data available in the literature. For example, the nest of *Tolmomyias sulphurescens* (Tyrannidae) is referred to as bag-shaped (Lencioni Neto 1994), retort (Skutch 1960) or

pendant (Traylor and Fitzpatrick 1982), although all these authors describe the same structure. Similarly, the nest of *Leptopogon amaurocephalus* (Tyrannidae) has been referred to as ellipse-shaped (Bertoni 1918), spherical (Moore 1944) and bag-shaped (Ihering 1900, Sick 1997). The same occurs for many other species, whether they are Passeriformes or not. Another example is the suboscine family Furnariidae, where a wide range of terms has been used for each different type of nest, such as furnace, piled up brushwood, egg-shaped, spheroid, basket, in hollows, underground and open (Vaurie 1980, Sick 1997), without any effort towards nomenclature standardization. The situation becomes worse as data accumulate and nests are increasingly used to back up studies of phylogenetic relationships, adaptive strategies and habitat demands (Crook 1963, Skutch 1976, Collias and Collias 1984, Zyskowski and Prum 1999).

Up to now, no comprehensive and objective standardization of nest nomenclature, particularly those of the neotropical avifauna, has ever been published. This study attempts to establish basic standards for nests of neotropical birds, the variants for each standard and their support types, suggesting a standardized and hierarchical nomenclature for nest quotations or descriptions, in order to significantly reduce the messy terminology on the subject. Additionally, guidelines for the creation of scientific nest collections are suggested, taking into account the challenges in nest storage and conservation.

METHODS

This study defines a *nest* as any place selected by a bird for laying its eggs, regardless of how much digging, cleaning, lining, or building it performs (or not). The activity of constructing a nest is referred to as *nest-building*, to avoid the ambiguity of the words nesting and nidification, which have been used as synonyms of nest, nest-building, and reproduction, and quotations on presence/absence of a nest in one single species (Skutch 1976, Collias and Collias 1984, Novaes and Carvalho 1957, Bokermann 1978a,b, Sick 1997). Species nomenclature in this work follows Meyer de Schauensee (1966) and Sick (1997).

The standards, their variants, and support types suggested in this study are based on the information gathered from a comprehensive review of the literature, from collections at Museu Nacional (Rio de Janeiro, RJ) and Museu de Biologia Mello Leitão (Santa Teresa, ES), and based on the authors two decades of field experience with nests of both Passeriformes and non-Passeriformes (*e.g.* Pacheco and Simon 1995, Simon and Pacheco 1996a,b, Ribon and Simon 1997, Simon and Bustamante 1999, Simon *et al.* 1999). The nests collected during this period were deposited at the Museu de Zoologia João Moojen de Oliveira, Universidade Federal de Viçosa (Viçosa, MG).

A search for the elementary standards was initially performed to establish the basic nest categories. Subsequently, the basic standards were divided into variants. Finally, nest attachment to supporting substrates (their support types) was studied. These criteria, when hierarchically combined, have served the purpose of simplifying and standardizing the description of the architectural diversity of nests. Other criteria have also been tried, as for example the habitat type (wood, thicket, marsh etc), the construction site (ground, branches, in hollows on abrupt declivities etc) or the materials used (mud, straw, silk cotton, feathers etc), but with unsatisfactory results. Consequently, these three criteria were the basis for the proposal presented in the next section, with examples from 97 species, 88 genera and 33 families from more than 9 neotropical countries.

Supplementary Nest Data - Although the suggested standardized nomenclature is suitable for the majority of nests encountered in the neotropical region, full nest descriptions still remain desirable, since there are mixed forms and additional structural features that can improve the picture of the nest general architecture. These additional details may describe whether the entrance tunnel or tube is horizontal, vertical or inclined, the presence or absence of an awning above the entrance of a *closed* standard, and if the entrance passage is placed in the lower, medium or upper part of the construction etc.

The following data should therefore be added to any nest description in order to improve it: 1- form of access to its interior (when applicable); 2- materials used and how they are arranged in sections or layers; 3- dimensions of the different axes, including frontal and lateral intersections; 4- if the pendant feature is primary or secondary (Zyskowski and Prum 1999); 5- height above ground or water; 6- total or partial reconstruction or simple re-use; 7- if the nest is single or within a colony; 8- characteristics of the surrounding habitat and microhabitat etc. Accordingly, a schematic drawing or representative photography should be provided, especially when dealing with peculiar structures.

RESULTS

Based on bibliographic, museum and field data, four elementary nest standards could be established for the neotropical birds: *simple, cup, closed* and *cavity*. These four standards, together with their variants, as well as with their support types, form the basic nest types proposed in this study (Appendix 2 provides a list of the basic nest types in Portuguese, English and Spanish).

I- *Basic types of the elementary standard "simple"*. The *simple* standard (figure 1) refers to nests where the eggs are laid on the substrata (ground, trunk, leaves etc), with little or no lining. It has two variants with respect to the presence of lining: *unlined* and *platform* (appendix 1).

The *simple/unlined* type is a place with eggs on rocks, trunks, aquatic vegetation etc, where no conspicuous construction can be seen, even if some digging or cleaning has

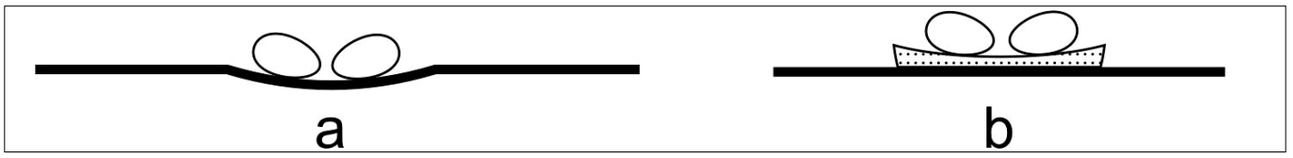

Figure 1. Elementary standard *"simple"* (with eggs): a) *unlined*, b) *platform.*

been done and even if the birds never take care of the nest (figure 1a). It suits, for instance, the nests of the Caprimulgidae *Lurocalis semitorquatus* (Simon and Bustamante 1999), *Hydropsalis climacocerca* (Bokermann 1978a), *Hydropsalis brasiliana* (Belton 1994), *Nyctidromus albicollis* (Alvarenga 1999), *Nyctiphrynus ocellatus* (Bokermann 1978a) and *Macropsalis creaga* (Moraes and Krul 1995, Pichorim 2002), and the Charadriidae *Charadrius collaris* and *Vanellus chilensis* (Belton 1994), but is also found in other families: *Jacana jacana* (Jacanidae) (Euler 1900), *Nyctibius griseus* (Nyctibiidae) (Sick 1997), *Crypturellus parvirostris* (Tinamidae) (J. E. S. and S. P., pers. obs.), since the material arranged under or around the eggs is but a slight preparation or covering of the laying place. Consequently, the nests of *Crypturellus tataupa* (Tinamidae) (Euler 1900) described as a "pit" and Tinamidae nests described as "natural depression on the ground" (Sick 1997) belong to the *simple/unlined* standard, since the eggs are laid directly on the substrate. Indeed, the "non-evidence of a structure that could be considered nest" in *Podager nacunda* (Caprimulgidae) (Belton 1994) is still a nest of the *simple/unlined* type, situated on a rocky surface. *Chordeiles pusillus* (Caprimulgidae) also has a *simple/unlined* nest. Although Leite *et al.* (1997) reported on this species as not having a nest, they did observe that the parents cared for the eggs and the nestling.

The *simple/platform* type refers to nests where feathers, grass, dead leaves, sticks etc. are either piled or loosely interlaced to form a platform that cushions the eggs (figure 1b). Such nests are present in *Leptotila verreauxi* (Columbidae) (Sick 1997, J. E. S., per. obs.), *Megarynchus pitangua* (Tyrannidae) (Euler 1900), *Lipaugus vociferans* (Cotingidae) (Sick 1997), *Amazonetta brasiliensis* (Anatidae) (Belton 1994, J. E. S., pers. obs.), *Rhea americana* (Rheidae) (Sick 1997), *Hirundinea ferruginea* (Tyrannidae) and many others.

II- *Basic types of the elementary standard "cup"*. The *cup* standard (figure 2) resembles a basket or bowl and is said to be *low cup* when the nest total height is less than or equal to its external diameter (Figure 2a) and *high cup* when the total height is greater than the diameter (figure 2b), no matter how shallow or deep the incubatory chamber is. The *cup* can be supported from its bottom (*low cup/base*) (figure 2c), by a branch *fork* (*e.g. low cup/fork*) (figure 2d), by its *lateral*, when attached to supports other than forks (*e.g. high cup/lateral*) (figure 2e) or be *pensile* (*e.g. high cup/pensile*). Low cup/pensile and bottom supported high cup nests apparently do not occur among neotropical birds. Thus there are six basic nest types for the *"cup"* elementary standard (appendix 1).

The *low cup/base* type is illustrated by nests of the Ardeidae *Syrigma sibilatrix* (Belton 1994) and *Agamia agami* (Nascimento 1990), and by those of *Accipter superciliosus* (Accipitridae) (Oniki and Willis 1982b), *Cariama cristata* (Cariamidae) (Euler 1900), *Columbina talpacoti* (Columbidae) (Carvalho 1957, Pinto 1953), *Jabiru myctreria* (Ciconiidae) (Sick 1997), *Sterna trudeaui* (Laridae) (Peña 1987) and *Tyrannus melancholicus* (Tyrannidae) (Euler 1900), regardless of the amount of material used in their building. Thus, terms like "bowl", used for the nest of *Neothraupis fasciata* (Emberizidae) by Alves and Cavalcanti (1990) and for *Knipolegus nigerrimus* (Tyrannidae) by Pichorim *et al.* (1996), "globet", used for *Caryothraustes canadensis* (Emberizidae) by Borges and Cardoso (1995) and "platform", used for *Cianocorax caeruleus* (Corvidae) by Anjos (1991) are replaced by the l*ow cup/base* type, as all of them refer to the same basic construction.

Low cups, attached by their sides (*low cup*/*lateral*) occur in *Agelaius ruficapillus* (Emberizidae) (Fallavena 1988) and *Chaetura andrei* (Apodidae) (Sick 1950), among others. *Low cups* attached to branch forks (*low cup/fork*) appear, for instance, in *Chiroxiphia caudata* (Pipridae) (Euler 1900) and *Thamnophilus punctatus* (Thamnophilidae) (Oniki 1975) (both to horizontal forks) and also in *Heliactin cornuta* and *Colibri serrirostris* (Trochilidae) (Ruschi 1982) (both to vertical forks).

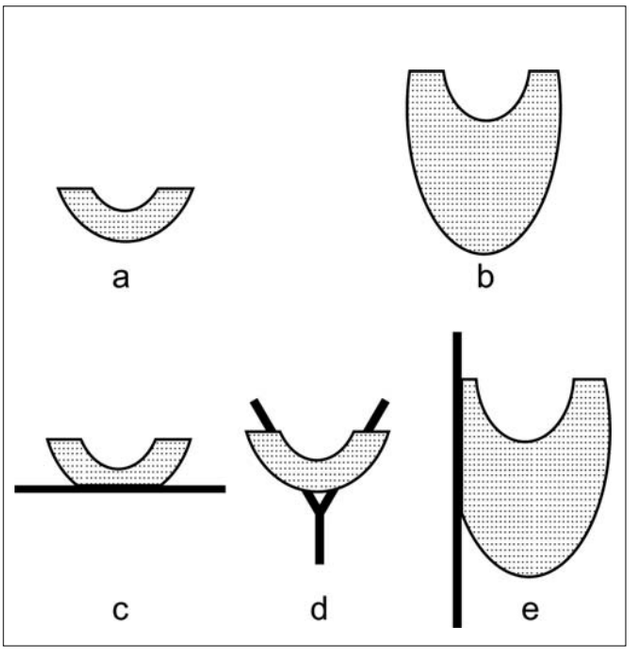

Figure 2. Elementary standard *"cup"*, its variants and some of the derived basic nest types: a- *low cup*; b- *high cup*; c- *low cup/base*; d- *low cup/fork*; e- *high cup/lateral* (nests in vertical intersection).

On the other hand, the nests of the Trochilidae *Phaetornis ruber* (Oniki 1970) and *Glaucis hirsuta* (Novaes and Carvalho 1957) are examples of *high cups* attached by their sides (*high cup/lateral*). *Platyrinchus leucoryphus* (Tyrannidae) (Clay and Madroño Nieto 1997) builds a *high cup* nest, attached to a vertical fork (*high cup/fork*). The nest of *Polysticus superciliaris* (Tyrannidae), described by Vasconcelos and Lombardi (1996) as a "goblet" form, is a *high cup*, attached to a fork (*high cup/fork*). Other Trochilidae, as *Phaetornis pretrei*, build *high cup* nests hanging from palm leaves or from electrical cables (*high cup/pensile*) (Ruschi 1982, J. E. S. and S. P., pers. obs.).

III- *Basic types of the "closed" elementary standard.* The *closed* standard (figure 3) refers to nests where the walls completely shelter the incubatory chamber. It presents six variants: *globular*, when the external diameters are approximately identical (figure 3a); *ovoid*, when the length is up to twice the width (figure 3b); *long* (in vertical, horizontal or inclined direction), when the length is more than two times the width (figure 3c); *furnace*, if the outline resembles a dome (figure 3d); *retort*, when there is an external "neck of a bottle", like access tube to the incubatory chamber which can be directed downward, upward or stretch out in horizontal direction (figure 3e) and *irregular*, when the outline has no definable form (figure 3f). These variants can be supported from their *base* (for example, *closed/furnace/base)*, by their *laterals* (*e.g. closed/globular/lateral*) (figure 3g) by a *fork* (*e.g.* c*losed/ovoid/fork*) (figure 3h), or can be *pensile* (*e.g. closed/retort/pensile*) (figure 3i). Fifteen basic nest types for the *"closed"* elementary standard have been found among neotropical birds so far (appendix 1). Other combinations do not seem to occur.

At this point it is important to call attention to the fact that the tube, as found in the *closed/retort* variant must not be confused with two other different tunnel-like structures. Tube is an outward extension of the nest entrance, built with sticks and other plant materials (as in *Synallaxis* spp.). Tunnels are: a) the entrance passage to the underground or tree cavities, regardless the nest type placed inside, and b) inward extension of the entrance passage, entirely imbedded within the nest structure, as in *Cranioleuca pallida* (Furnariidae) (Sick 1997). Furthermore, tubes and tunnels must be cited in a standard way. For that, the direction from the brood chamber to the outside is here proposed. For instance: a vertical/upward tube has its entrance above the chamber.

The nest of *Arremon taciturnus* (Emberizidae) (Sick 1997), placed amongst the dead leaves on forest floors and bushes (that is, the saplier or substrate), can be described as *closed/globular/base*. On the other hand, the nests of the Furnariidae *Phleocryptes melanops* and *Limnornis curvirostris* (Sick 1997, Narosky *et al.* 1883) are *closed/globular/lateral*, while that of the Tyrannidae *Pachyramphus validus* is *closed/globular* attached to a *fork* (*closed/globular/fork*) (J. E. S. and S. P., pers. obs.).

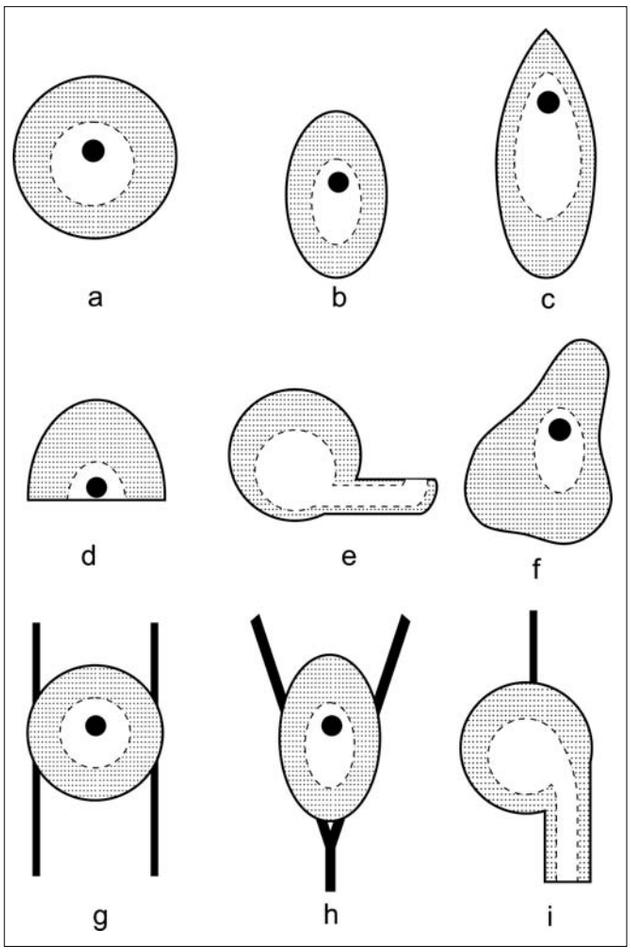

Figure 3. Elementary standard *"closed"*, its variants and some of the derived basic nest types: a- *closed/globular*; b- *closed/ovoid*; c- *closed/long* (in vertical position); d- *closed/furnace;* e- *closed/retort* (with tube in horizontal position); f- *closed/irregular;* g) *closed/globular/lateral*; h- *closed/ovoid/fork*; i- *closed/retort/pensile* (nests in frontal view, except for "e" and "i", which are drawn in lateral intersection) (the small dark circle indicates nest entrance; the broken line stands for the incubatory chamber).

The nest of *Cranioleuca pallida* (Furnariidae), described by Sick (1997) as "spheroid…with lateral entrance through a tunnel" is here classified as *closed/ovoid/base*, with an internal tunnel that leads to the incubatory chamber. *Arundinicola leucocephala* (Tyrannidae) nest is an example of the *closed/ovoid/fork* type (J. E. S. and S. P., pers. obs.), while that of *Leptopogon amaurocephalus* (Tyrannidae) is *closed/ovoid/pensile* (Simon 1997).

The *closed/long/pensile* type suits the nests of *Phacellodomus rufifrons* (Furnariidae) (Skutch 1969b), *Mionectes rufiventris* (Tyrannidae) (described as "pear-shaped" by Bencke 1995) and *Psarocolius decumanus* (Emberizidae) (Euler 1900, Ihering 1900). The nest of *Cacicus chrysopterus* (Emberizidae), described as "bag" by Sick (1997), also belongs to the *closed/long/pensile* type.

The *closed/furnace/base* type suits the nests of *Furnarius rufus* (Furnariidae) (Narosky *et al*. 1983) and the Tyrannidae *Corythopis torquata* (Oniki and Willis 1980)

and *Corythopis delalandi* (Simon and Pacheco 1996b), among others.

The Furnariidae *Synallaxis cinerascens* (Simon and Pacheco 1996a), *Synallaxis ruficapilla* (Simon *et al*. 1999) and *Poecilurus scutatus* (Teixeira and Luigi 1993) all build *closed/retort/base* nests, with horizontal tubes. *Certhiaxis cinnamomea* (Furnariidae) is a *closed/retort/base* nest, with a vertical/upward tube (Narosky *et al*. 1983, J. E. S. and S. P., pers. obs.). The nest of *Panyptila cayanensis* (Apodidae) (Sick 1997) is a *closed/retort/lateral* type, with a vertical/downward tube.

The nest of *Synallaxis spixi* (Furnariidae) is a *closed/retort/fork* type, with horizontal tube (Sick 1997; J. E. S. and S. P., pers. obs.). *Tolmomyias sulphurescens* (Tyrannidae) builds nests of the *closed/retort/pensile* type, with a vertical/downward tube (Lencioni Neto 1994). The nest of *Phacellodomus erythrophthalmus* (Furnariidae), referred to as "boot" by Ihering (1900) and Sick (1997) is also, according to this paper, a *closed/retort/pensile* type, since it has an external short horizontal access tube to the incubatory chamber. The *closed/irregular/fork* type is seen in *Phacellodomus striaticollis* (Furnariidae) (Narosky *et al*. 1983, Sick 1997).

Sometimes the nest support varies intraspecifically, as in the Tyrannidae *Pitangus sulphuratus* and *Myiozetetes similis* (Euler 1900), which are supported from their *bases* or by *forks* or by their *laterals* (*closed/globular/base* or *lateral or fork*)**;** in the Furnariidae *Anumbius annumbi* where it is supported by a fork or attached by its sides (*closed/irregular/lateral or fork*) (Devincenzi 1925, J. E. S. and S. P., pers. obs.) or in the Furnariidae *Pseudoseisura cristata* (Sick 1997) where it is supported from its base and attached by its sides (*closed/irregular/base* and *laterals*).

As already mentioned, this standardization allows supplementary nest data to be added. So, the nest of *Furnarius rufus* can be referred to as *closed/furnace/low cup/base*, as the bird builds a *low cup* inside the clay dome.

IV- *Basic types of the "cavity" elementary standard*. The *cavity* standard refers to nests where the eggs rest inside natural or artificial cavities: subterranean burrows, rock crevices, termite mounds, tree hollows, bamboo internodes, man-made structures, mammalian constructions etc. It has two variants: *without* an access *tunnel* (figure 4a) or *with* an access *tunnel* to the interior of the cavity (figure 4b, c, d). The tunnel can be in the horizontal, vertical or inclined position (figure 4b1, 2, 3). The nests in *cavities*, however, should be classified using the previously described standards, because inside them unavoidably appear either the *simple* nest (*unlined* or *platform* variants) (for example, *cavity/without-tunnel/simple/unlined*), or the *cup* nest (apparently only the *low* variant among neotropical birds) (*e.g. cavity/with-tunnel/low cup*), or apparently only the *globular* variant of the *closed* standard (*e.g. cavity/with-tunnel/closed/globular*). So, seven basic nest types can be recognized for the elementary standard "*cavity*" (appendix 1).

Cavity/without-tunnel/simple/unlined type nests (figure 4a) are found in *Colaptes campestris* (Picidae), built inside hollows in trunks or in banks (J. E. S. and S. P., pers. obs.), while the *cavity/without-tunnel/simple/platform* type can be seen in the Hirundinidae *Phaeoprogne tapera* (Sick 1997) and *Notiochelidon cyanoleuca* (which sometimes builds them inside man-made devices such as electric-light fittings) (J.E.S. and S.P., pers. obs.).

Cavity/without-tunnel/low cup type is found, for example, in *Troglodytes aedon* (Troglodytidae) inside hollows in trunks or wooden boxes (Lange and Lange 1992).

C*avity/with-tunnel/simple/unlined* type nests (figure 4b1) are found in *Chelidoptera tenebrosa* (Bucconidae), *Baryphthengus ruficapillus* (Momotidae) and *Ceryle torquata* (Alcedinidae) (Euler 1900, Ihering 1900, Sick 1997), built inside burrows under the ground or banks (Sick 1997), all with an horizontal access tunnel. *Aratinga cactorum* (Psittacidae) (Naka 1997) and *Trogon surrucura* (Trogonidae) (Sick 1997) nests are also of the *cavity/with-tunnel/simple/unlined* type, built inside tree termite mounds, with a vertical/downward tunnel. The Psittacidae nests of *Pionus maximiliani* (Toyne and Jeffcote 1994, J. E. S. and S. P., pers. obs.), *Propyrrhura maracana* (J.E.S., pers. obs.) and *Aratinga leucophthalmus* (Sick 1997) are also of the *cavity/with-tunnel/simple/unlined* type, the first two found inside trunks with vertical/upward tunnels and the last one with horizontal tunnel, found in declivities (J.E.S., pers. obs.).

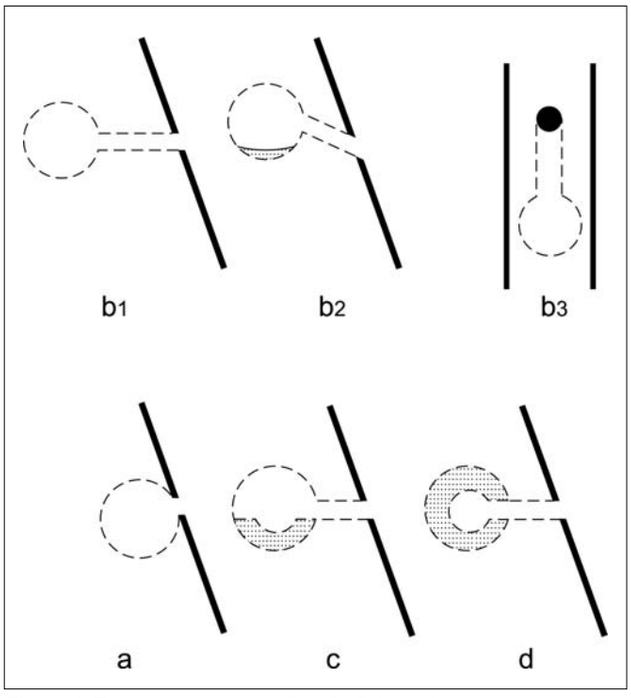

Figure 4. Elementary standard *"cavity"*, its variants and some of the basic nest types: a- *cavity/without-tunnel/simple/unlined*; b- *cavity/with-tunnel* (showing tunnel: b1- in horizontal position; b2- inclined; b3- vertical); b1- *cavity/with-tunnel/unlined*; b2- *cavity/with-tunnel/platform*; c- *cavity/with-tunnel/low cup*; d- *cavity/with-tunnel/closed/globular* (nests drawn in vertical intersection, from cavities inside banks, except for "b3", which is from a tree cavity).

Cavity/with-tunnel/simple/platform nests (figure 4b2) are found in *Lepidocolaptes angustirostris* (Narosky *et al*, 1983) and *Xiphocolaptes major* (Dendrocolaptidae) (Peña 1987), both with vertical/upward tunnels, and in *Automolus leucophthalmus* (Furnariidae) (Novaes 1961) with an horizontal tunnel.

The nests of *Stelgidopteryx ruficollis* (Hirundinidae) (Euler 1900), found in banks, are of the *cavity/with-tunnel/low cup* type (figure 4c), with horizontal access tunnels, while that of *Myiarchus ferox* (Tyrannidae) belongs to the same type although the tunnel is vertical/upward (Tubelis 1998). The nest of *Cinclodes* (Furnariidae) reported by Sick (1997) as "underground, with a gallery that widens at its end and a bowl in its interior" is also of the *cavity/with-tunnel/low cup* type, with an horizontal tunnel.

The nest of *Lochmias nematura* (Furnariidae) (Narosky *et al*, 1983, reported by Sick 1997, as "closed globe-like nest") is indeed of the *cavity/with-tunnel/closed/globular* type (figure 4d), with an inclined/downward tunnel built in banks.

DISCUSSION

Nest descriptions, when based on a common terminology and reasonable amount of detail, are a valuable contribution to scientific development. However, independent terminology and/or classification methods have been employed for nests of neotropical birds, resulting in a muddled literature on this subject. So, it is desirable to develop a standard system for referring to nests which would allow meaningful comparisons among papers, in order to contribute to evolutionary**,** ethological**,** systematic and conservational studies. However, no such system has yet been presented, especially for the Neotropical Region, where the greatest variety of nests occurs, as it shelters the greatest bird diversity on the planet.

The present standardization proposal, based on four elementary nest standards (*simple cup, closed* and *cavity)*, plus their variants and their support types, suits the different structures built by neotropical birds, bringing the desirable uniformity to descriptions and making it easier to compare data from different authors. It is important to notice that the chosen standards can be a shape (as for *"cup"*) or a status (as for *"closed"*), the same holding for their variants.

However, there are few species that build odd nests. Even so, the proposed system can be applied to them, as for instance the nest of *Estrilda astrild* (Estrildidae) (Sick 1997, J. E. S., pers. obs.) which can be described as two *closed/globular* constructions, one on top of the other, both supported from their bottoms (*two closed/globular/base*).

So far only Euler (1900) had proposed a general nest classification for the neotropical birds, comprising four basic categories: type 1- cavity; type 2- closed bags/spheres; type 3- open bowls/crucibles; type 4- diggings in the ground. Euler's classification, however, is confined just to these categories, disregarding variants and support types, except for type two, for which fixed or hanging supports are suggested. However, these categories are unsuitable for many nests, as for instance those where the eggs rest directly on the ground or on leaves on water surface (*e.g. Crypturellus parvirostris*, *Vanellus chilensis*, *Jacana jacana*). Euler's proposal is also unsuitable for species such as those of the genus *Synallaxis,* classified in type 2 (closed sphere-like bags), despite the conspicuous access tube to the nest chambers (making them a *retort*, according to the present paper). Clearly, the standardization proposed in this paper is more comprehensive than Euler's, although his paper has been the starting point for this paper.

There are two other relevant studies on classification of neotropical bird nests: Ruschi (1986) and Sick (1997). Ruschi (1986) acknowledged three basic nest types and some sub-types for Trochilidae based on form, attachment to the substrate and building materials. It is a remarkable standardization but specific to Trochilidae, which build quite uniform nests. However, Ruschi's proposal agrees with this study which, in turn, has the advantage of being applicable to all families. For instance: Ruschi's 3rd type, 1st subtype (base-supported bowl as in *Melanotrochilus fuscus*) is a *low cup/base*, while the 2nd type (long shaped, as in *Phaethornis pretrei*) is a *high cup/pensile* type.

Sick (1997) published a nest classification for several families, based on shapes and on support types, without establishing a clear hierarchy between these criteria. As a result**,** structurally different nests were classified as the same type, disregarding the presence or absence of an access tube (as in *Synallaxis* and *Tolmomyias* spp.) or tunnel to the incubatory chamber (as in the Momotidae *Baryphthengus ruficapillus* and the Furnariidae *Automolus leucophthalmus*). Besides, one and the same name, for example, "bag", is applied to structurally different nests throughout the book, making comparisons quite difficult. Another example is the nests of *Campylorhynchus* sp., described as "ball", which are all of the *closed* standard, each of them being further classified according to their variants and support types. Anyway, each one of Sick's types can be fitted in with the present standardization, as for instance the "hanging bag" (type 3 of Sick's Tyrannidae classification) which is indeed a *closed/ovoid/pensile* type. On the other hand, *Cacicus* (Emberizidae) nest, also a "hanging bag" according to Sick, is indeed a *closed/long/pensile* type.

When parasitism occurs, the nests of the invaded birds can still be described. For example, *Legatus leucophaius* (Tyrannidae) is the brood parasite of *Phacellodomus rufifrons* and of *Cacicus cela* (Emberizidae) nests (both *closed/long/pensile*) (Skutch 1972, Sick 1997); *Tapera naevia* (Cuculidae) (Salvador 1982) parasitizes the Furnariidae *Synallaxis frontalis* and *Synallaxis albescens* nests (both *closed/retort/base*), and *Molothrus bonariensis* (Emberizidae) lays its eggs in the *low cup/base* nest of *Zonotrichia capensis* (Emberizidae) (Sick 1997).

As already mentioned, any reference to the basic nest type should be completed with additional data for a better understanding of every construction. So, for *Lochmias nematura* (*cavity/with-tunnel/closed/globular* nest type) it should be mentioned, among other data, its dimensions, the inclined/downward tunnel starting from the incubatory chamber (Narosky *et al.* 1983) and the habitat (banks), while for *Phacellodomus rufifrons* (*closed/long/pensile* type) the internal nest division should be reported, among other details (Skutch 1969b).

As it can be seen from the text, the most basal (primitive) bird families build simple nests (*e.g.* Rheidae, Caprimulgidae, Anatidae, Jacanidae, Nyctibiidae), while the most evolved ones build more complex structures, although showing adaptive reversals as well (*e.g.* Tyrannidae). So, it seems that nest evolution occurred from *simple/unlined* to *simple/platform*, then to *cup* and finally to *closed*, in two parallel environments: open air and cavity. Each one of these environment shows also two parallel habitats: ground and tree (bush). In fact, *cavity* nests can be found underground (subterranean burrows, rock crevices, termite mounds etc) or inside tree hollows (or bamboo internodes etc), while open air nests are placed on the ground surface or on branches of trees or bushes. Nests in man-made devices are just opportunistic extensions of the two main evolution lines and their subdivisions. If it is desirable, the system proposed in this paper allows for such additions (*e.g. Furnarius rufus* nest can be described as *closed/ furnace/low cup/tree).*

Suggestions for the creation of scientific nest collections. As any other bird attribute (skin, skeleton etc), the nest should always be collected and kept for teaching and research. This is not an easy task due to the nature of the material (which can decay or deform easily) and possibly to the lack of guidelines for curators. Although Bendire (1891) and Hostos (1947) have already approached the subject, they provided only short guidelines for gathering and preserving nests.

During this study, different storage procedures have been tested for nest preservation in museums. So, they were wrapped in paper, cotton, boxes, plastic bags etc (following Bendire 1891 and Hostos 1947), kept in drawers and treated with sprays, glues etc (Hostos 1947), with unsatisfactory results. The unfeasibility of such treatments was due to the decay of their materials (*e.g.* moss, silk cotton, leaves, brushwood etc), which become even more fragile as time goes by, and due to changes in dimensions that occur during handling. Also, due to their physical nature and/or size, many nests can not be dislodged from their original places to be brought to laboratories, not to mention the space they would need for proper storage.

Therefore, the most detailed transfer of every datum to a chart or individual file card is suggested (computer-adapted or not) soon after the discovery or collection of the nests, including a detailed description of the materials used by the birds (whether or not they can be brought to the laboratory) with schematic drawings and/or photographs and filming. This method should provide the most reliable descriptive archive of the collection. Furthermore, collected nests that do not need to be sectioned for drawings or that are easily stored should be fully preserved, despite any possible decay, as a testimony of their structures for as long as possible.

Of course, nest collections must follow the usual procedures for zoological material (Martins 1994). Thus, the data recorded on nest cards must include, among others: taxon, collector, date, habitat, construction site, basic nest type (appendix 1), *in situ* dimensions, composition and organization of the building materials (Hostos 1947).

A properly kept nest collection is a valuable source of information on bird reproductive and evolutionary biology, so far not well studied in the Neotropical Region.

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Appendix 1- Nests of neotropical birds, according to the three basic criteria proposed in this study. Examples of species for each nest type are given in the text. See also figs. 1-4.

Elementary standard, their variants and support types			**Nest types recorded for neotropical birds: combinations among the criteria**	**Total number of the variant-type combinations**
Elementary standard	**Variant of the elementary standard**	**Type of support of the nest**		
Simple	Unlined		Simple/unlined	2
	Platform		Simple/platform	
Cup	Low	Base	Low cup/base	6
		Lateral	Low cup/lateral	
		Fork	Low cup/fork	
	High	Pensile	High cup/lateral	
			High cup/fork	
			High cup/pensile	
Closed	Globular	Base	Closed/globular/base	15
	Ovoid	Lateral	Closed/globular/lateral	
	Long	Fork	Closed/globular/fork	
	Furnace	Pensile	Closed/ovoid/base	
	Retort		Closed/ovoid/fork	
	Irregular		Closed/ovoid/pensile	
			Closed/long/pensile	
			Closed/furnace/base	
			Closed/retort/base	
			Closed/retort/lateral	
			Closed/retort/fork	
			Closed/retort/pensile	
			Closed/irregular/base	
			Closed/irregular/lateral	
			Closed/irregular/fork	
Cavity	Without tunnel		Cavity/without-tunnel/simple/unlined	7
	Simple unlined		Cavity/without-tunnel/simple/platform	
	Simple platform		Cavity/without-tunnel/low cup	
	Low cup			
	With tunnel			
	Simple unlined		Cavity/with-tunnel/simple/unlined	
	Simple platform		Cavity/with-tunnel/simple/platform	
	Low cup		Cavity/with-tunnel/low cup	
	Closed/globular		Cavity/with-tunnel/closed/globular	

Appendix 2 - Nest types of neotropical birds: correspondence of terms in English, Portuguese and Spanish. For details about the basic nest types see text, Appendix 1 and figs. 1-4.

English	Portuguese	Spanish
Simple/unlined	Simples/desnudo	Simples/desnudo
Simple/platform	Simples/plataforma	Simples/plataforma
Low cup/base	Cesto baixo/base	Cesto bajo/base
Low cup/lateral	Cesto baixo/lateral	Cesto bajo/lateral
Low cup/fork	Cesto baixo/forquilha	Cesto bajo/horquilla
High cup/lateral	Cesto alto/lateral	Cesto alto/lateral
High cup/fork	Cesto alto/forquilha	Cesto alto/horquilla
High cup/pensile	Cesto alto/pendente	Cesto alto/colgado
Closed/globular/base	Fechado/esférico/base	Cerrado/esférico/base
Closed/globular/lateral	Fechado/esférico/lateral	Cerrado/esférico/lateral
Closed/globular/fork	Fechado/esférico/forquilha	Cerrado/esférico/horquilla
Closed/ovoid/base	Fechado/ovalado/base	Cerrado/aovado/base
Closed/ovoid/fork	Fechado/ovalado/forquilha	Cerrado/aovado/horquilla
Closed/ovoid/pensile	Fechado/ovalado/pendente	Cerrado/aovado/colgado
Closed/long/pensile	Fechado/alongado/pendente	Cerrado/alargado/colgado
Closed/furnace/base	Fechado/forno/base	Cerrado/horno/base
Closed/retort/base	Fechado/retorta/base	Cerrado/retorta/base
Closed/retort/lateral	Fechado/retorta/lateral	Cerrado/retorta/lateral
Closed/retort/fork	Fechado/retorta/forquilha	Cerrado/retorta/horquilla
Closed/retort/pensile	Fechado/retorta/pendente	Cerrado/retorta/colgado
Closed/irregular/base	Fechado/irregular/base	Cerrado/irregular/base
Closed/irregular/lateral	Fechado/irregular/lateral	Cerrado/irregular/lateral
Closed/irregular/fork	Fechado/irregular/forquilha	Cerrado/irregular/horquilla
Cavity/without-tunnel/simple/unlined	Cavidade/sem túnel/simples/desnudo	Cavidad/sin túnel/simples/desnudo
Cavity/without-tunnel/simple/platform	Cavidade/sem túnel/simples/plataforma	Cavidad/sin túnel/simples/plataforma
Cavity/without-tunnel/low cup	Cavidade/sem túnel/cesto baixo	Cavidad/sin túnel/cesto bajo
Cavity/with-tunnel/simple/unlined	Cavidade/com túnel/simples/desnudo	Cavidad/com túnel/simples/desnudo
Cavity/with-tunnel/simple/platform	Cavidade/com túnel/simples/plataforma	Cavidad/com túnel/simples/plataforma
Cavity/with-tunnel/low cup	Cavidade/com túnel/cesto baixo	Cavidad/con túnel/cesto bajo
Cavity/with-tunnel/closed/globular	Cavidade/com túnel/fechado/esférico	Cavidad/con túnel/cerrado/esférico