The colorful eggs of the tinamous

Kurt Schläpfer

Prof. Dr. K. Schläpfer
St. Gallerstrasse 60, CH-9032 Engelburg, Switzerland
E-Mail: schlaepfer@datacomm.ch

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1. Taxonomy

The tinamou family (*Tinamidae*) consists of 47 species and 125 subspecies in nine genera. This classification is based on the *IOC World Bird List* v. 7.3 (2017).

Genus	**Species**	**Subspecies**
Crypturellus	21	55
Eudromia	2	12
Nothocercus	3	7
Nothoprocta	6	17
Nothura	5	13
Rhynchotus	2	3
Taoniscus	1	0
Tinamotis	2	0
Tinamus	5	18
Total	**47**	**125**

Two other international checklists (*BirdLife International Checklist of the Birds of the World, Version 9,* and the *Handbook of the Birds of the World Alive*) list 48 species. In these checklists, the additional species is *Crypturellus occidentalis*. This species is listed in the *IOC World Bird*

List v. 7.3 as subspecies *Crypturellus cinnamomeus occidentalis.*

The following table shows the 47 species of the *Tinamidae* family:

Common name	**Scientific name**
Black-capped Tinamou	Crypturellus atrocapillus
Bartlett's Tinamou	Crypturellus bartletti
Berlepsch's Tinamou	Crypturellus berlepschi
Slaty-breasted Tinamou	Crypturellus boucardi
Rusty Tinamou	Crypturellus brevirostris
Barred Tinamou	Crypturellus casiquiare
Cinereous Tinamou	Crypturellus cinereus
Eastern Thicket Tinamou	Crypturellus cinnamomeus
Grey-legged Tinamou	Crypturellus duidae
Red-legged Tinamou	Crypturellus erythropus
Choco Tinamou	Crypturellus kerriae
Yellow-legged Tinamou	Crypturellus noctivagus
Brown Tinamou	Crypturellus obsoletus
Small-billed Tinamou	Crypturellus parvirostris
Tepui Tinamou	Crypturellus ptaritepui
Little Tinamou	Crypturellus soui
Brazilian Tinamou	Crypturellus strigulosus
Tataupa Tinamou	Crypturellus tataupa
Pale-browed Tinamou	Crypturellus transfasciatus
Undulated Tinamou	Crypturellus undulatus
Variegated Tinamou	Crypturellus variegatus
Elegant Crested Tinamou	Eudromia elegans
Quebracho Crested Tinamou	Eudromia formosa
Highland Tinamou	Nothocercus bonapartei
Tawny-breasted Tinamou	Nothocercus julius
Hooded Tinamou	Nothocercus nigrocapillus
Brushland Tinamou	Nothoprocta cinerascens
Curve-billed Tinamou	Nothoprocta curvirostris
Ornate Tinamou	Nothoprocta ornata
Andean Tinamou	Nothoprocta pentlandii

Chilean Tinamou	Nothoprocta perdicaria
Taczanowski's Tinamou	Nothoprocta taczanowskii
White-bellied Nothura	Nothura boraquira
Chaco Nothura	Nothura chacoensis
Darwin's Nothura	Nothura darwinii
Spotted Nothura	Nothura maculosa
Lesser Nothura	Nothura minor
Huayco Tinamou	Rhynchotus maculicollis
Red-winged Tinamou	Rhynchotus rufescens
Dwarf Tinamou	Taoniscus nanus
Patagonian Tinamou	Tinamotis ingoufi
Puna Tinamou	Tinamotis pentlandii
White-throated Tinamou	Tinamus guttatus
Great Tinamou	Tinamus major
Black Tinamou	Tinamus osgoodi
Solitary Tinamou	Tinamus solitarius
Grey Tinamou	Tinamus tao

2. The colors of the tinamou eggs

To describe the colors of tinamou eggs, an obvious approach is to measure eggs from museum collections. However, as eggshell pigments are natural dyes, they have a relatively low resistance to light and storage. In nature this is not relevant, because the function of the eggshell colour becomes obsolete after the chick has hatched. For the egg collectors and museums, however, the low colour fastness is a serious problem. Despite proper storage, many museum eggs do not show the colour that the eggshell had when the egg was laid. Some freshly laid eggs lose their coloration often in the first days after being laid. An example for this are the tinamou eggs of the genus *Crypturellus,* which have a purple coloration when freshly laid and tend to look brownish after a short time. But not all color shades tend equally to discoloration.

Curve-billed Tinamou

Great Tinamou

Chilean Tinamou

Chaco Tinamou

Elegant crested Tinamou

Hooded Tinamou

Pictures of some ground nests containing tinamou eggs (source: Internet)

A very popular tinamou egg color is the vivid green of the *Eudromia elegans* which appears even after a longer storage period almost unaffected. This is due to the fact, that the green coloration is based on a pigment containing zinc (zinc biliverdin), and this metal component contributes to a higher stability of the coloration.

In order to measure the color of freshly laid eggs, photos in the Internet are well suited. The author of this study was able to collect 60 pictures of tinamou nests from 28 species. A reliable method to measure the colour is using a *Color Picker* application. This allows to read the RGB values which can then be converted to visually perceived color coordinates. Whether the eggshell colors on these pictures are correctly rendered, depends on the illumination (daylight or sunlight) and the brightness level. Moreover, the color of the surrounding area has an influence on the egg appearance. Therefore, the aim of these measurements cannot be to attribute a particular color to a species, but to find the range in which the egg colors of the tinamous are typically located.

Appendix 1 shows the color values of the eggs of 32 tinamou species. For 29 species, the color has been measured from pictures of eggs found in ground nests. For three species, only eggshells from collections were available for color measurements. All measured colors are illustrated as color patches on the following pages. Broadly speaking, the following color shades can be distinguished:

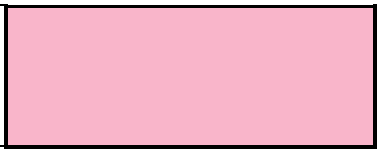
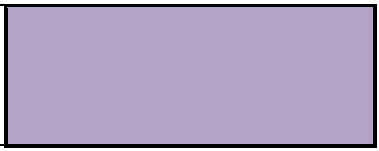
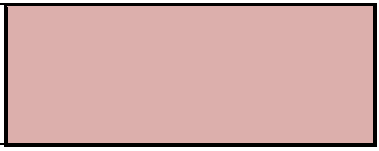
- Purple and violet eggs are typical for the genus *Crypturellus.*
- Greenish-blue or bluish-green eggs are typical for the genera *Tinamus* and *Nothocercus.*

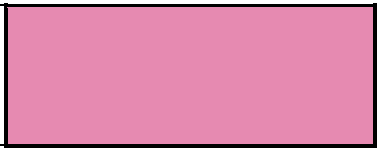
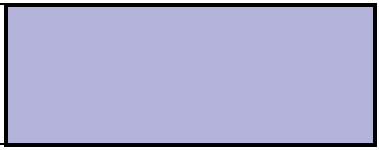
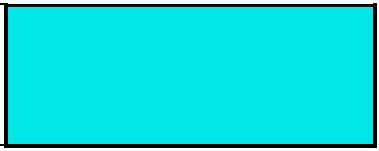
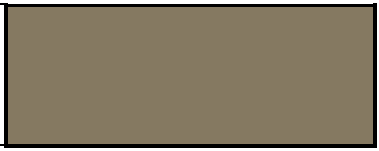
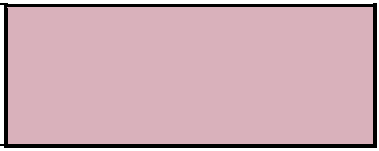
- Green and yellow-green eggs are typical for the species *Eudromia elegans, Eudromia formosa* and *Tinamotis pentlandii.*
- Brown eggs can be found for some species of the genera *Nothura* and *Nothoprocta.*

The brown color, however, can also be the result of a discoloration occurring after a certain period of storage. As mentioned above, this may occur with eggs of the genus *Crypturellus* which are purple or violet immediately after oviposition. The color shown on the next pages for the *Crypturellus cinnamomeus* could be an example, as this egg comes from a museum collection.

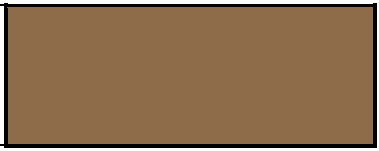
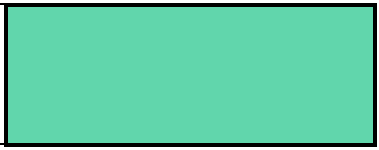
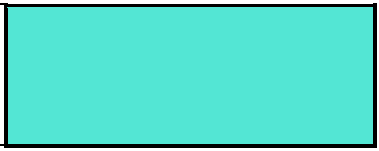
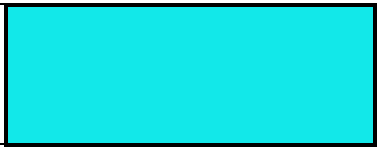
Typical colors of tinamou eggs

Crypturellus bartletti -	
Crypturellus cinerus	
Crypturellus cinnamomeus	
Crypturellus noctivagus	

Crypturellus obsoletus	
Crypturellus parvirostris	
Crypturellus soui	
Crypturellus tataupa	
Crypturellus transfasciatus	
Crypturellus undulatus Wellentinamu	

Crypturellus variegatus	
Crypturellus erythropus	
Nothocercus bonapartei	
Nothocercus nigrocapillus	
Nothoprocta cinerascens	
Nothoprocta curvirostris	
Nothoprocta perdicaria	

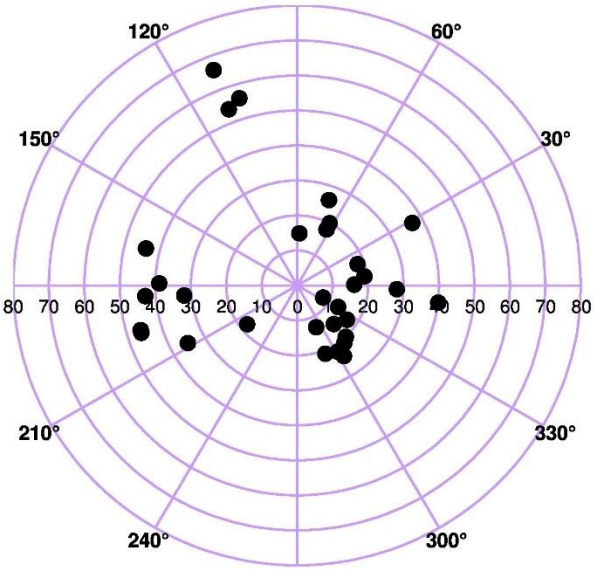
Nothoprocta pentlandii	
Nothura boraquira	
Nothura maculosa	
Nothura minor	
Rhynchotus rufescens	
Nothoprocta ornata	

Nothura darwinii	
Tinamus major	
Tinamus osgoodi	
Tinamus solitarius	
Tinamus tao	
Tinamus guttatus	
Eudromia elegans	

Eudromia formosa	

Tinamotis pentlandii	

For a numerical presentation of the eggshell colors a color circle is suited where the hue values are plotted as angular coordinates and the saturation values as radial coordinates.

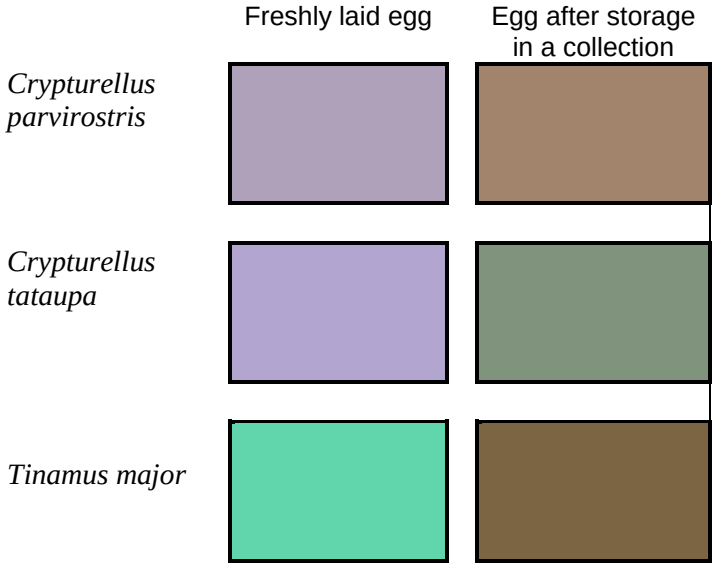


This plot shows typical values for the hue angles of some tinamou genera:

- *Crypturellus*: between 290º and 30º,
- *Tinamus* and *Nothocercus*: between 165º and 220º,
- *Eudromia* and *Tinamotis*: near 110º.

Moreover, it can be seen that the egg colors of *Eudromia* and *Tinamotis* have a clearly higher saturation than the colors of all other measured tinamou eggs.

As the author of this study has additionally measured tinamou eggs in egg collections, a comparison can be made between freshly laid eggs and eggs from collections. This shows how the eggshell colors change after a certain period of time.



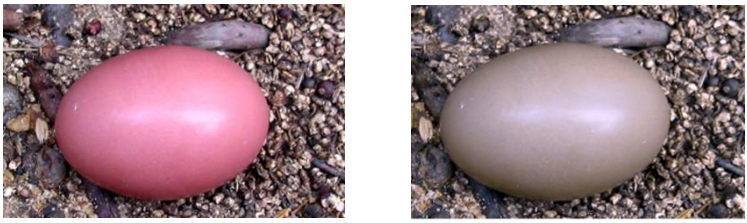
3. How egg predators perceive colors

Eggs of ground nesting birds that lack camouflage or even have conspicuous colors are exceptional. However, what we perceive as camouflaged or conspicuous, is based on the human color vision system. In contrast, most nest predators such as mammals, birds and reptiles see colors differently than humans.

In the human visual system, there are three color receptors and, as a consequence, any color can be defined by three attributes, for instance hue, saturation and brightness. This is called trichromatic color vision or trichromacy. In the world of animals, color vision systems can (apart from trichromatic) be monochromatic, dichromatic, tetrachromatic and even pentachromatic, where the prefix mono-, di-, tri-, tetra- and penta- refer to the number of available color receptors. Monochromatic and dichromatic vision also occur in the human color vision, if one or two color receptors are defective. Therefore, monochromacy, dichromacy and trichromacy are well investigated. The number of color receptors has a decisive influence of the number of perceived colors. Under average illumination conditions one color receptor can discriminate about 50 thresholds. A dichromat (an animal with dichromatic color vision) can therefore perceive $50 \times 50 = 2{,}500$ colors, a trichromat 125,000 colors, a tetrachromat 6,250,000 colors and a pentachromat 312,500,000 colors.

Most mammals are dichromats, meaning that they have only two types of color receptors. When considering the mammalian families representing the most important avian nests predators, there is variation in the sensitivity of their color receptors. But the restricted perceivable color gamut is common to all dichromats. The comparison

below clearly shows that dichromats perceive an egg color as far less conspicuous then humans do.



Egg of the Crypturellus variegatus on a forest floor: On the right is simulated, how this egg appears to most of the mammalian dichromats.

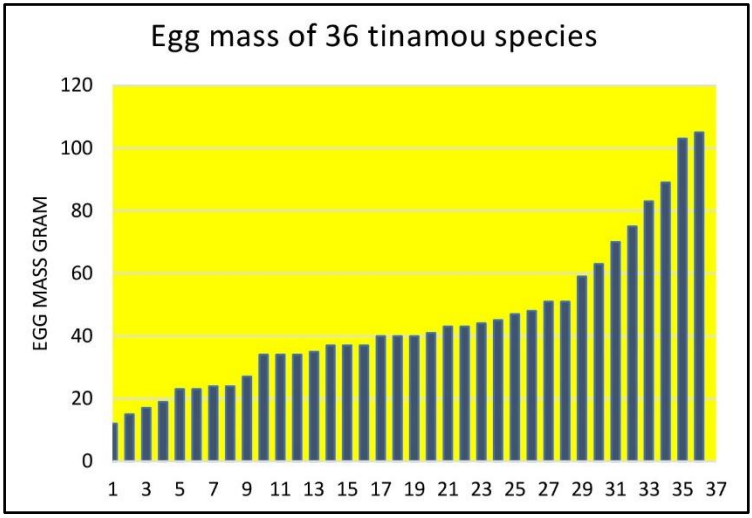
Primates are also common nest predators. However their visual system can be, depending on the family and species, either trichromatic or dichromatic.

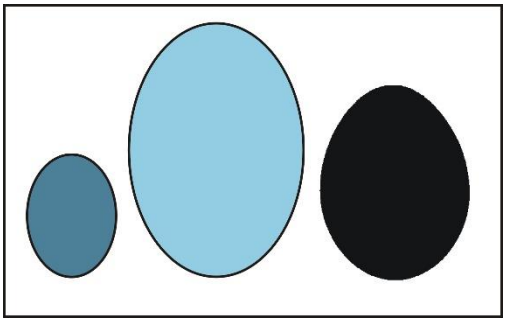
Color vision	**Color receptors**	**Receptor carriers**
Monochromacy	1	marine mammals
Dichromacy	2	most terrestrial non-primate mammals
Trichromacy	3	humans, most primates, some insects (such as honeybees)
Tetrachromacy	4	most reptiles, amphibians, birds and insects
Pentachromacy	5	some insects (specific species of butterflies), some birds (pigeons for instance)

Other than mammals, birds possess four color receptors and have tetrachromatic vision. The fourth receptor is sensitive to UV light, meaning that birds see wavelengths which are invisible to humans.

4. The size of tinamou eggs

The author was able to collect eggshell data (length, width, egg mass) from 36 tinamou species (see appendix 2). Most data originate from Schönwetter's *Handbuch der Oologie* (1960-1992). These data are statistically reliable, because they are based on 843 measured eggshells. The egg mass values range from 12 g (*Taoniscus nanus*) to 105 g (*Nothocercus bonapartei*). Compared with a hen's egg of 60 g, the eggs of 29 tinamou species are smaller.





Size comparison between the smallest (Taoniscus nanus) and the largest tinamou egg (Nothocercus bonapartei) compared with a hen's egg.

Appendix 1: Color values of tinamou eggs (32 species)

The values H (hue), L (luminance) und C (chroma) are the coordinates of the CIELAB color space. RGB are the coordinates of the sRGB color space.

N/C: egg from a nest (N) or a collection (C)

Species	H	L	C	R	G	B	N/C
Crypturellus bartletti	294	78	13	193	191	215	N
Crypturellus cinerus	29	73	37	244	155	147	N
Crypturellus erythropus	292	74	21	180	180	218	N
Crypturellus obsoletus	358	80	28	249	181	202	N
Crypturellus tataupa	303	70	24	178	165	208	N
Crypturellus cinnamomeus	63	49	18	139	110	89	C
Crypturellus noctivagus	179	69	39	63	187	166	N
Crypturellus parvirostris	313	68	15	176	161	186	N
Crypturellus soui	309	69	21	180	163	199	N
Crypturellus transfasciatus	335	77	8	201	185	196	N
Crypturellus undulatus	332	84	13	228	205	223	N
Crypturellus variegatus	353	68	40	230	138	177	N
Eudromia elegans	111	68	66	156	176	43	N
Eudromia formosa	111	61	54	141	156	53	N

Species	H	L	C	R	G	B	N/C
Nothocercus bonapartei	208	77	35	81	207	219	N
Nothocercus nigrocapillus	196	83	46	1	231	231	N
Nothoprocta cinerascens	88	51	15	133	121	97	N
Nothoprocta curvirostris	1	76	16	217	177	187	N
Nothoprocta ornata	6	73	24	224	164	176	N
Nothoprocta pentlandii	20	55	18	162	120	121	N
Nothoprocta perdicaria	301	52	22	127	118	155	N
Nothura boraquira	313	55	20	143	124	156	N
Nothura darwinii	70	78	26	142	108	73	C
Nothura maculosa	325	48	17	130	106	130	N
Nothura minor	63	55	20	158	125	101	C
Rhynchotus rufescens	8	68	19	202	155	163	N
Tinamotis pentlandii	107	84	56	211	215	104	N
Tinamus guttatus	197	84	46	18	232	233	N
Tinamus major	166	78	44	97	214	172	N
Tinamus osgoodi	218	63	18	110	162	173	C
Tinamus solitarius	184	84	43	83	230	212	N
Tinamus tao	185	74	32	98	198	186	N

Appendix 2: Size of tinamou eggs

The following data of 36 tinamou species origin (with three exceptions) from *Schönwetter* (Handbuch der Oologie, Vol. 1, 41-46). Where *Schönwetter* has listed data for different subspecies, those of the subspecies with the largest eggs are used.

Species	Egg length mm	Egg width mm	Egg mass gram
Crypturellus bartletti	54	37	40
Crypturellus berlepschi	44	39	35
Crypturellus boucardi	42	32	23
Crypturellus cinerus	48	39	40
Crypturellus cinnamomeus	46	39	37
Crypturellus erythropus	54	41	48
Crypturellus noctivagus	52	41	47
Crypturellus obsoletus	53	37	41
Crypturellus parvirostris	39	28	17
Crypturellus soui	41	32	24
Crypturellus strigulosus	51	37	37
Crypturellus tataupa	41	30	19
Crypturellus transfasciatus	51	40	44
Crypturellus undulatus	54	40	45
Crypturellus variegatus	52	37	37
Eudromia elegans	56	41	51
Nothocercus bonapartei	74	51	105
Nothocercus nigrocapillus	69	47	89
Nothoprocta cinerascens	48	37	34
Nothoprocta curvirostris	54	37	40
Nothoprocta ornata	56	38	43
Nothoprocta perdicaria	50	36	34
Nothoprocta pentlandii	51	35	34
Nothura boraquira	46	33	27
Nothura darwinii	45	32	23
Nothura maculosa	44	32	24
Nothura minor	37	28	15

Species	Egg length mm	Egg width mm	Egg mass gram
Rhynchotus rufescens	60	44	59
Taoniscus nanus	35	26	12
Tinamotis ingoufi	57	41	51
Tinamotis pentlandii	54	38	43
Tinamus guttatus	55	46	63
Tinamus major	59	48	75
Tinamus osgoodi	54	49	70
Tinamus solitarius	67	48	83
Tinamus tao	65	54	103