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Reproductive biology of the endangered wattled curassow (*Crax globulosa*; Galliformes: Cracidae) in the Juruá River Basin, Western Brazilian Amazonia

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ABSTRACT

The reproductive biology of *Crax globulosa* is virtually unknown, this knowledge comprised of only a few anecdotal notes. We found nine nests of *Crax globulosa* in the middle section of the Juruá River, western Brazilian Amazon, during the dry season. Nests averaged 22.5 m from water and 13.3 m above the ground. We observed two nest types: five made of twigs, leaves and vines, and four within a bromeliad. All nests contained two eggs, but six (67%) were subsequently predated. A female tagged with a transmitter nested twice during the same breeding season. A chick was monitored together with its parents for > 10 months. In addition to hunting and habitat loss, nest predation could be another threat to this endangered species.

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Bromeliad; chicks; nest; predation; hatching success

The wattled curassow (*Crax globulosa*) is endemic to the western Amazon basin, occurring in western Brazil, southern Colombia, eastern Ecuador (problaly extirpated), eastern Peru and northern Bolivia (Bennett 2000; Brooks et al. 2006; Haugaasen and Peres 2008). The species is considered Endangered due to hunting, habitat loss and a small population size, estimated to have undergone a very rapid decline in numbers and range size (Brooks et al. 2006; BirdLife 2015). *Crax globulosa* may be elevated from Endangered in the near future, if new data suggest that the reduction in global population size is greater than current estimates (BirdLife 2015).

The species is a year-round resident in lowland forests and river islands (Begazo 1997; Santos 1998; Bennett 2003; Alarcón-Nieto and Palacios 2005). *Crax globulosa* appears to have a non-uniform distribution in lowland forest (Begazo 1997), mainly due to water restrictions during the dry season (Hill et al. 2008). Compared to other species of curassow, *Crax globulosa* is more arboreal due to a lack of dry land in the floodplain

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forest during the rainy (high-water) season (Garcia and Brooks 1997; Santos 1998; Bennett 2003).

Cracid reproduction may vary depending upon the season, among other factors, with most tropical species typically breeding during the rainy season (Delacour and Amadon 2004). It was once thought that most cracids were monogamous (Sick 1997), but there are anecdotal field observations of some species showing signs of polygyny, with one male and two or more females (Brooks et al. 2006; Gastañaga-Corvacho et al. 2011; Luna-Maira et al. 2013). Studies focused on the reproduction of wild cracid populations are scarce. In the case of curassows, only *C. daubentoni* has been studied intensively (Kvarnbäck et al. 2008). Details of *C. globulosa* reproduction have not been documented in detail until now.

Herein we provide the first qualitative descriptions of the nest, clutch size and reproductive period of *C. globulosa*. This information is important in planning for conservation and management of this rare species.

Methods

Study area

The study was conducted along 11 km of both sides of two tributaries of the Juruá River (Marari and Macaco) within the Sustainable Development Reserve Uacari (Figure 1). This

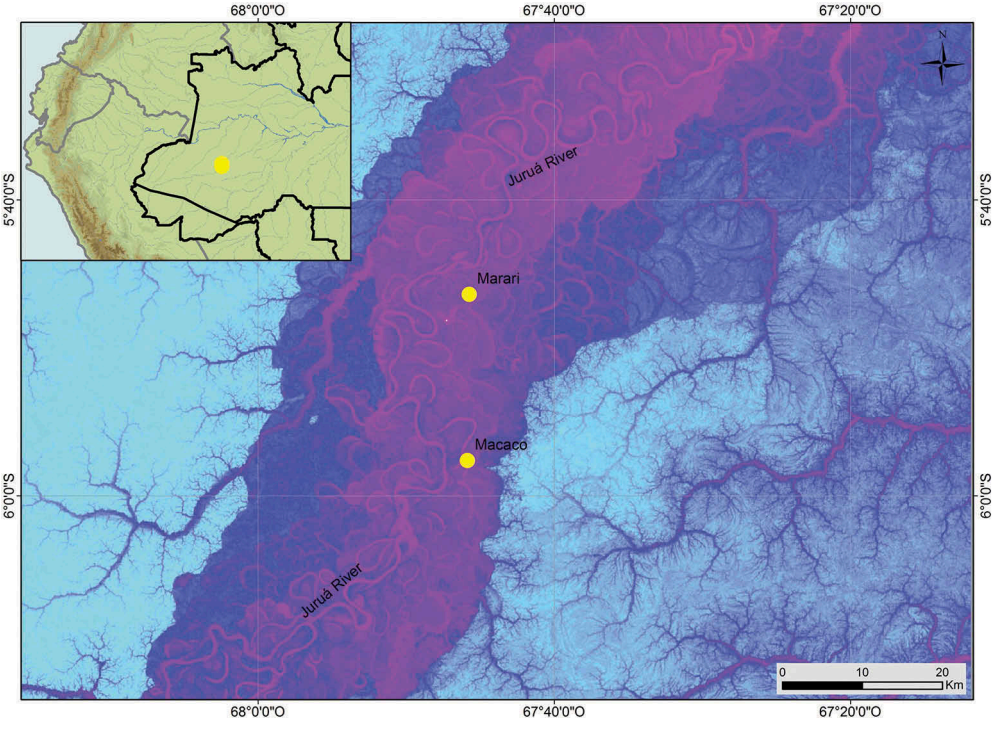

Figure 1. Main places where *Crax globulosa* nests (bullets) were found in tributaries of the Jurua River. Flooded environments (várzea and paleo floodplains) are near the river and other tributaries, while *Terra firme* farther and lighter.

is part of the Juruá River Basin, and is located 130 km south of the town of Carauari, in the state of Amazonas, Brazil (–5.7840S, –67.7500W). This region is subject to a well-defined seasonal rainfall regime, with a mean annual rainfall of 2400–2800 mm (Sombroek 2001). There is also a strong seasonal oscillation in the river water discharge, with the low-water season occurring from July to October.

Nests and chicks

An intensive systematic search effort for *Crax globulosa* nests was carried out from August 2014 to October 2015, covering > 1 continuous year to insure periods of breeding activity were captured. Nests were located by hiking the banks of the Marari and Macaco rivers Monday through Friday, 06:00–10:00 hrs. At least two people searched for nests simultaneously, ≤ 300 m from the river, following methods of Luna-Maira et al. (2013). Trees were searched along with clues of a nest, including fallen eggshells and individuals taking flight from a tree. When a female was flushed from a tree, the location was recorded with a global positioning system (GPS), and a return trip was made the following day to determine whether the female was in the same tree. If the female was relocated the following day, the tree branches were climbed to check for a nest; if no evidence was found the site was discarded.

The following variables were measured when nests were located (mean and standard deviation [SD] are given for all measurements): distance to water (m), height from the ground (m), diameter at breast height (DBH, cm) of the host tree, and nest diameter (cm), height (cm) and depth (cm). Additionally, the SD of the nearest distance to ground water and height were calculated. When the tree containing the nest could not be climbed, we used a rangefinder (Bushnell Yardage 450) to measure the height, and a camera with an 8-m stick to check the clutch size. The materials used to construct the nest (e.g. twigs, leaves, vines or other material) and clutch size were also recorded.

We put three camera traps on three nests (1 camera/nest) to monitor the presence of predators. Nests were visited every 2–3 days to see if they were still active, and which gender was incubating the eggs, based upon venter colouration (males white, or females rufous). Chick gender was also determined by venter colouration if they were old enough, and age was estimated by comparing photos of the chicks with captive individuals of known age.

Two adult females and a 3-month-old juvenile male (still associated with parents) were captured using an 'arapuca' trap (pyramid-shaped box trap made of sticks), tagged with backpack radio-transmitters (Biotrack[5] Ltd, Dorset, UK), and tracked 15 days/month for 12 months. The females were monitored to determine where and when they nested, and the young male was monitored to determine how long he stayed with his parents. Analyses of ranging behaviour will be reported elsewhere.

A non-parametric Spearman correlation test was performed to verify whether a relationship existed between distance to the nearest water body and nest height. A positive correlation is hypothesised to occur, since the greater the distance to water, the greater height of the nest needed to facilitate escape from possible predators. Additionally, nests are more exposed to predators closer to the river because the creek's banks are more visible and therefore it is easier for predators to find prey.

Table 1. Villages interviewed about *Crax globulosa* reproduction, with interviewees' age, sex, and time living in the community.

Village	Coordinates	Age	Sex	Time living in village
Santa Barbara	−4.060°S, −66.425°W	51	M	40
Tucumã	−3.986°S, −66.471°W	69	M	65
Joanico	−3.871°S, −66.389°W	47	M	47
Arapari	−3.849°S, −66.266°W	62	M	62
Limão	−3.705°S, −66.195°W	57	M	57
Escondido	−3.589°S, −66.113°W	39	M	22
Boca do Jacaré	−3.521°S, −66.131°W	35	M	18
Gaivota	−2.975°S, −66.953°W	59	M	51
Paranagua	−3.410°S, −66.073°W	44	M	44
Antonina	−3.254°S, −66.032°W	41	M	25
Xibauazinho	−5.940°S, −67.770°W	36 and 54	M	36 and 42
Mandioca	−5.858°S, −67.790°W	57	M	42
Preguiça	−5.320°S, −67.220°W	46	M	23
Boca do Xeruã	−6.954°S, −67.813°W	28 and 49	M	28 and 32

Interviews

A total of 14 rural villages along the Juruá River were visited to conduct passive interviews with 16 residents (Table 1). The interviewed residents were selected by consulting the community, to determine which residents had the most experience hunting and fishing, as well as who had lived in the community the longest. Specific questions asked included: (1) Are you familiar with the nest of the mutum-piuri (*C. globulosa*)? and (2) Are you aware of any nests, past or present (i.e. number of nests, clutch sizes, season found, habitat type, location)?

Results

Nests

Nine active nests of *C. globulosa* were found (three in 2014, six in 2015) during the low-water season, between July and September (Table 2); two nests were in Macaco and seven in Marari (Figure 1). All nests contained two white eggs and were on average located 22.5 m (SD = 24.7 m) from the water, at a mean height of 13.3 m (SD = 6.2 m). The correlation between nest height and distance to the water was positive but not significant, and weak ($r = 0.2$, $P = 0.6$).

Five nests were built between forks in the branches of trees (Table 2; Figure 2), and four nests were built within bromeliads (*Aechmea* sp., Bromeliaceae, Figure 3; Table 2). Nests built between forks were shallow, round and basket-shaped, constructed with twigs and vines, and lined with both green and dry leaves. The bromeliad nests were built using the foundation of this epiphytic plant as a nest platform. The trees that contained nests always possessed vines, closed canopy or other individual bromeliads. Three of the bromeliad nests were 130, 175 and 210 m from one another, and found during the same week with a single vocalising male ≤ 50 m from the nests. Similarly, males were observed vocalising close to nests #1, 4 and 9. Only females incubated in all nests.

Table 2. Data for *Crax globulosa* nests in the Juruá River Basin, Amazonas, Brazil. The first date is the day the nest was found; the second date is when it was predated or abandoned (nest #3 was not tracked). Ground = height from the ground (m), water = distance to water (m), DBH = diameter at breast height, SD = standard deviation.

Nest #	Date	Fate	Coordinates	Ground	Water	Height (cm)	Diameter (cm)	Depth (cm)	Nest type	No. of eggs	Egg mass (g)	Egg size (mm)	Tree sp.	DBH (m)
1	14 August 2014 – 17 August 2014	Predated	5°46'52"S, 67° 45'44"W	9	14	23	38	6	Fork	2	136, 140	79.7 × 60.4, 80.5 × 60.6	*Eugenia* sp.	0.28
2	26 August 2014 – 5 September 2014	Abandoned	5°48'9"S, 67° 46'54"W	9.1	3.5	24	46	7	Fork	2	200, 204	93. 5 × 62.9, 91.8 × 64.4	*Cassia leiandra*	0.21
3	22 August 2014	Inspected only once	5°57'35"S 67° 45'41"W	9.6	31.6	11	34	-	Fork	2	-	-	*Sloanea rufa*	0.56
4	31 July 2015 – 19 August 2015	Predated by *Rupornis magnirostris*	5°46'52"S 67° 45'51"W	10.5	5.8	15	36	5	Fork	2	-	-	*Eugenia* sp.	0.13
5	10 August 2015 – 14 August 2015	Predated	5°45'1"S 67° 46'19"W	14.9	10.9	10	35	5	Bromeliad	2	184	88.8 × 61.4	Sapotaceae	0.5
6	8 August 2015 – 14 August 2015	Predated	5°45'1"S 67° 46'13"W	11.6	21.4	-	-	-	Bromeliad	2	-	-	*Pouteira* sp.	0.33
7	7 August 2015 – 20 August 2015	Predated	5°45'5"S 67° 46'13"W	29	89	-	-	-	Bromeliad	2	-	-	Fabaceae	0.67
8	22 August 2015 – 3 September 2015	One chick hatched, other egg abandoned and predated	5°57'34"S 67° 45'42"W	8.4	16.1	8	44	6	Fork	2	-	-	*Eugenia* sp.	0.24
9	30 September 2015 – 9 October 2015	Predated	5°46'57"S 67° 45'59"W	18	11	-	-	-	Bromeliad	2	-	-	*Sloanea rufa*	1.03
SD				**6.2**	**24.7**	**6.25**	**4.56**	**0.74**	-	-	**29.21**	**5.72 × 1.51**	-	0.26
Mean				**13.3**	**22.5**	**15.2**	**38.8**	**5.8**		**2**	**173**	**86.8 × 61.9**		0.44

Figure 2. Nest #2 built in the fork, with two eggs.

Six of the nine nests had their two eggs subsequently predated (67%), one had a chick hatch (11%), and one was abandoned (11%; Table 2). Of the nine nests, containing a total of 18 eggs, only one chick hatched (6% hatch rate); the other egg in that clutch did not hatch and the egg was predated after the female abandoned the nest to care for the new chick (Table 2). A camera trap placed on nest #4 filmed a roadside hawk (*Rupornis magnirostris*) attacking the female curassow, which flew to the ground, whereupon the hawk consumed both eggs. The same female of nest #4 was marked with a very high frequency (VHF) transmitter and recorded incubating a new clutch (nest #9) after a 38-day interval. The new nest was 100 m from nest #4 and was in a different species of tree, but again was predated (Table 2).

Chicks

On 5 October 2014, a chick of approximately 1 week of age was encountered with its parents in Marari. On the same day at a distance of 350 m, a young male (approximately 3 months old) was observed vocalising on top of a *Byrsonima* sp. tree.

Also in October 2014, a pair of adults was observed with two juvenile males of about 3 months of age in Marari. One of the juvenile males was captured and tagged with a VHF transmitter and monitored for 1 year, always in the company of an adult female and the other juvenile male, and on some occasions also with an adult male. This young male accompanied his mother until July 2015 (at approximately 1 year of age), when we

Figure 4. Chick of *Crax globulosa*, approximately 10 days old, on 3 September 2016 in Macaco.

began to see this individual alone or with other groups. On 3 September 2015, a chick of about 10 days old (Figure 4) was found with two adult females and one male in Macaco.

Interviews

Interviews with 16 local informants from 14 villages resulted in 151 nest reports, always in várzea. Virtually all respondents (99%) reported two eggs per clutch, with only two nests containing three eggs. Respondents invariably indicated that the breeding season is always during the dry season (June–October), and nests were always built ≤ 50 m from water and supported by at least five different species of trees (*Eugenia sp., Vitex cimosa, Ocotea sp., Ficus sp. and Byrsonima sp.*).

Discussion

The breeding season of *Crax globulosa* in the Jurua River during the dry season is consistent with Caquetá River reports in Colombia (Bennett 2000). Wattled curassows only reproduced when land was available, following the receding floodwaters in várzea floodplain forest. This is important so that chicks could walk after hatching, and were old enough to fly once the water level began to rise again, creating flooded forest conditions.

Figure 3. Nest #5 built in *Aechemea* sp. post-predation.

The location of the nests can be attributed to wattled curassows' close association with water, or in floodplain forest habitats with a high density of plants and vines that would help conceal the nest from predators (Hill et al. 2008; Luna-Maira et al. 2013), as well as a safe location high above ground. Such nest locations are also important to permit a quick escape route, flying across a stream, which would be difficult for a terrestrial predator to track. Another species of curassow, *C. daubentoni*, usually builds nests along forest edges in order to hide from potential predators (Kvarnbäck et al. 2008).

The clutch size of two eggs we observed is consistent with other species in the genus *Crax* (Brooks et al. 2006; Kvarnbäck et al. 2008), as well as a female wattled curassow observed with two chicks on a fluvial island in the Caquetá River (Luna-Maira et al. 2013). Our observations show that the female incubates the eggs while the male remains close by to help guard the nest, as observed in other species of curassows (Delacour and Amadon 2004).

In captivity the females may have more than one clutch per season when eggs are removed or broken, but there are no reports of multiple clutches in wild populations (Todd et al. 1992). This behaviour was observed only in *Mitu salvini* and *Crax alector* after a 20-day interval following nest predation, with the new nest built higher than the first nest (Delacour and Amadon 2004), as noted herein for *C. globulosa*.

The 13.3 m mean nest height from the ground is greater than the average of other *Crax* nests studied to date (9–11 m); however, the nest diameter, height and depth are

similar (Delacour and Amadon 2004; Kvarnbäck et al. 2008). The two differently structured nest types seem to be a first for the genus, and we report the first observed use of a bromeliad (Delacour and Amadon 2004; Kvarnbäck et al. 2008). However, nesting in a bromeliad has been reported for other cracids including *Penelope*, *Ortalis*, *Chamaepetes* and *Oreophasis* (Greeney and Erazo 2005; Londoño et al. 2007; Toledo-Lima et al. 2013).

Reproductive success is almost unknown for most of the species in the family, with the exception of *Ortalis vetula*, of which 65% of 135 monitored nests were successful with chicks hatched (4% abandoned, 30% predated) (Marion and Fleetwood 1978). Nest predation by capuchin monkeys (*Cebus* spp.) was reported in *Crax daubentoni*, *C. alector* and *C. blumenbachii* (Delacour and Amadon 2004; Kvarnbäck et al. 2008; Canale and Bernardo 2016). Of all nests we followed throughout the incubation period, only one chick hatched, accounting for only a 6% reproductive success rate. The high predation rate may be due to the high abundance and diversity of terrestrial and arboreal predators in the Juruá River Basin (Patton et al. 2000). We recorded several bands of monkeys of various species (*Cebus albifrons*, *Saimiri sciureus* and *Alouatta seniculus*), as well as individual marsupials (*Didelphis marsupialis*), snakes (*Boa constrictor*, *Epicrates cenchria*) and birds of prey, including the *R. magnirostris* that predated one of the clutches.

Polygyny in *C. globulosa* seems likely given the observation of three females attending nests close to one another at the same time, with a single male in the area, although only paternity analyses can confirm polygamy with certainty. In Colombia and Bolivia, a male was found with multiple females (Bennet 2000; Hill et al. 2008; Luna-Maira et al. 2013). Most researchers report that cracids are monogamous, but a few observations show that polygamy may occur in the family, with species such as *Oreophasis* and *Ortalis* in addition to other species of curassows exhibiting this mating strategy (Sick 1997; Brooks et al. 2006).

The separation of the male chick after staying with the mother in the natal range for 10 months may have been due to an adult male ousting the chick at the onset of the breeding season. Alternatively, this period may be linked to the seasonally inundated várzea forest where the species lives, because during the wet season we observed flocks of ≥ 5 individuals feeding on several species of fruiting trees.

Hunting and habitat loss are the main reasons for rapid declines in cracid populations. For example, during a single year (2008) the Jurua River basin experienced 3.2% forest loss totaling 6194 km (Trancoso et al. 2009). As *C. globulosa* is naturally rare and restricted to seasonally flooded lowland forest, it has a limited window of opportunity for reproductive activity, combined with a high predation rate. Consequently, the species is teetering on the threshold of unsustainable population recruitment, assuming that these populations are still demographically viable. The combination of unsustainable harvest, habitat loss and high levels of nest predation may well continue to drive many remaining populations of this species to extinction in the future.

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References

Alarcón-Nieto G, Palacios E. 2005. Confirmation of a second population for Colombia of the Wattled Curassow (*Crax globulosa*) in the lower Caquetá River. Ornitol Col. 3:97–99.

Begazo AJ. 1997. [News about the Wattled Curassow (*Crax globulosa*) in Peru]. Bull Cracid Spec Group. 5:1–18.

Bennett SE. 2000. The status of the Piuri (*Crax globulosa*) in Colombia - a brief overiew. Bull Cracid Spec Group. 10:18–22.

Bennett SE. 2003. The Wattled Curassow (*Crax globulosa*) on Isla Mocagua, Amazonas, Colombia. Bull Cracid Spec Group. 16:21–28.

Birdlife International [Internet]. 2015. Species factsheet: *Crax globulosa*; [cited 11 Nov 2015]. Available from: http://www.birdlife.org/.

Brooks DM, Cancino L, Pereira SL. 2006. Conserving cracids: the most threatened family of birds in the Americas. Houston (TX): Misc. Publ.Houston Mus. Nat. Sci.

Canale GR, Bernardo CS. 2016. Predator-prey interaction between two threatened species in a Brazilian hotspot. Biota Neotrop. 16:1–4.

Delacour J, Amadon D. 2004. Curassows and related birds. Barcelona (Spain): Lynx Edic.

Garcia C, Brooks DM. 1997. Evolution of *Crax* sociobiology and phylogeny using behavioral and ecological characters. In: Strahl SD, Beaujon S, Brooks DM, Begazo AJ, Sedaghatkish G, Olmos F, editor. The Cracidae: their biology and conservation. Bellingham (WA): Hancock House Publ.; p. 401–410.

Gastañaga-Corvacho M, Macleod R, Brooks DM, Hennessey B. 2011. Distinctive morphology, habitat and vocalizations of *Pauxi (unicornis) koepckeae*: evidence for species rank. Ornitol Neotrop. 22:267–279.

Greeney HF, Erazo SL. 2005. A nest of the Sickle-winged Guan (*Chamaepetes goudotii tschudii*). Bull Cracid Spec Group. 21:43–46.

Haugaasen T, Peres CA. 2008. Population abundance and biomass of large-bodied birds in Amazonian flooded and unflooded forests. Bird Cons Intl. 18:87–101.

Hill DL, Aranibar-Rojas H, Macleod R. 2008. Wattled Curassows in Bolivia: abundance, habitat use, and conservation status. J Field Orn. 79:345–351.

Kvarnbäck J, Bertsch C, Barreto G. 2008. Nest site selection and nesting success of the Yellow-knobbed Curassow (*Crax daubentoni*) in a fragmented landscape in the Venezuelan Llanos. Ornitol Neotrop. 19:347–352.

Londoño GA, Muñoz MC, Rios MM. 2007. Density and natural history of the Sickle-winged Guan (*Chamaepetes goudotii*) in the Central Andes, Colombia. Wilson J Orn. 119:228–238.

Luna-Maira L, Alarcón-Nieto G, Haugaasen T, Brooks DM. 2013. Habitat use and ecology of Wattled Curassows on islands in the lower Cauetá River, Colombia. J Field Orn. 84:23–31.

Marion WR, Fleetwood RJ. 1978. Nesting ecology of the plain Chachalaca in south Texas. Wilson Bull. 90:386–395.

Patton JL, da Silva MNF, Malcolm JR. 2000. Mammals of the Rio Juruá and the evolutionary and ecological diversification of Amazonia. Bull Am Mus Nat Hist. 244:1–306.

Santos PMRS. 1998. The Wattled Curassow (*Crax globulosa*) at Mamirauá (Amazonas, Brazil). Bull Cracid Spec Group. 7:13–19.

Sick H. 1997. Ornitologia brasileira. Rio de Janeiro: Nova Fronteira.

Sombroek W. 2001. Spatial and temporal patterns of Amazon rainfall - Consequences for the planning of agricultural occupation and the protection of primary forests. Ambio. 30:388–396.

Todd W, Plasse C, Eckart C. 1992. Curassow husbandry manual. Houston (TX): Houston Zool. Gardens.

Toledo-Lima GS, Junior TMO, Macario P, Oliveira DV, Pichorim M. 2013. Notes on reproductive biology of two species of cracids in northeastern Brazil. Wilson J Orn. 125:665–666.

Trancoso R, Carneiro Filho A, Tomasella J, Schietti J, Forsberg BR, Miller RP. 2009. Deforestation and conservation in major watersheds of the Brazilian Amazon. Environ Cons. 36:277–288.