ORNITOLOGIA NEOTROPICAL 22: 39–57, 2011

NESTING ECOLOGY OF THE ENDANGERED AZURE-RUMPED TANAGER (*TANGARA CABANISI*) IN GUATEMALA

Knut Eisermann[1], Susanne Arbeiter[1,2], Gerardo López[3], Claudia Avendaño[1], Josué de León Lux[3], Andy Burge[3], Aaron de León Lux[3], & Everilda Buchán[3]

[1] PROEVAL RAXMU Bird Monitoring Program, Cobán, Alta Verapaz, Guatemala. c/o P.O. Box 98 Periférico, Guatemala City, Guatemala. *E-mail:* knut.eisermann@proeval-raxmu.org

[2] University of Applied Sciences Eberswalde, Friedrich-Ebert-Str. 28, 16225 Eberswalde, Germany.

[3] Los Tarrales Reserve, Km 164.2 Ruta Nacional 11, Patulul, Suchitepéquez, Guatemala.

Resumen. – Ecología de anidación de *Tangara cabanisi* en Guatemala. – La Tángara de Cabanis (*Tangara cabanisi*) es una especie poca estudiada y en Peligro de Extinción, con un área de distribución restringida a las tierras altas de la vertiente Pacífica de Guatemala y Chiapas, México. Estudiamos la ecología de anidación de esta especie en la vertiente sur-este del volcán Atitlán, departamento de Suchitepéquez, Guatemala. Un total de 32 nidos fue registrado en Guatemala en los años 2001–2009, de los cuales 30 fueron observados en volcán Atitlán. La altitud de los lugares de anidamiento varió entre 860 y 1850 m. Quince nidos fueron localizados en bosque latifoliado con una distancia hasta la orilla del bosque más cercano variando entre 0–700 m. Otros 17 nidos se encontraron en plantaciones de café y hábitat de huertas caseras con una distancia variable de 5–130 m hasta la orilla del bosque más cercano. Registramos tángaras anidando exitosamente en bosque primario latifoliado, pero también en plantaciones con dosel superior muy reducido o ausente de árboles latifoliados nativos. Los 32 nidos fueron ubicados en 20 especies diferentes de árboles. La anidación se observó en todos los meses de abril a septiembre y estuvo sincronizada con la época lluviosa. Un nido proveyó datos desde el primer día de construcción hasta cuando los juveniles salieron. La construcción del nido tardó seis días, la incubación 14 días y la crianza de los pichones 17 días, lo cual es un tiempo más largo de crianza de pichones en la Tángara de Cabanis que el reportado en Chiapas y otras especies del mismo género en el neotrópico. Usando el método Mayfield para calcular la sobrevivencia de nidos desde el inicio de incubación hasta la salida del primer pichón del nido, el éxito de anidación fue de 16% (intervalo de confianza de 95%: 5–45%). Nuestros descubrimientos proveen una base para medidas prácticas de conservación en el paisaje dominado por plantaciones de café en la vertiente Pacífica de las tierras altas de Guatemala y Chiapas.

Abstract. – The Azure-rumped Tanager (*Tangara cabanisi*) is a little studied and endangered species restricted to the Pacific slope mountains of Guatemala and Chiapas, Mexico. We studied the nesting ecology of this species on the south-eastern slope of Atitlán volcano, dpto. Suchitepéquez, Guatemala, and compiled information of other nesting sites. Thirty-two nests were recorded in Guatemala from 2001–2009, of which 30 were observed at Atitlán volcano. The altitude of nesting sites ranged from 860 to 1850 m. Fifteen nests were located in broadleaf forest with a distance to the nearest forest edge ranging from 0–700 m. Another 17 nests were in coffee plantations and orchard-like habitat with a distance from the nearest forest ranging from 5–130 m. We recorded tanagers nesting successfully in primary broadleaf forest, but also in plantations with a greatly reduced or absent upper canopy of native broadleaf trees. The 32 nests were placed in 20 different tree species. Nesting was observed in all months from April through September and was synchronized with the wet season. One nest provided data from the first day of nest-building to the fledging of juveniles. Nest-building took six days, incubation 14 days, and brooding 17 days, which is longer than the nestling period observed previously for the Azure-rumped Tanager in Chiapas and for congeners throughout the Neotropics. Using the Mayfield method for calculating nest survival from onset of incubation to the fledging of the first young, nest success was 16% (95% confidence interval: 5–45%). Our findings provide a base for practical conservation measures in the coffee-dominated landscape of the Guatemalan and Chiapan Pacific slope highlands. *Accepted 31 January 2011.*

Key words: Azure-rumped Tanager, *Tangara cabanisi*, broadleaf forest, coffee plantation, cooperative breeding, natural history, nest site selection, nest success.

INTRODUCTION

The Azure-rumped Tanager (*Tangara cabanisi*) is restricted to the Pacific slope mountains of Guatemala and Chiapas, Mexico, where it has been reported in a narrow altitudinal belt at 860–1900 m (Parker III *et al.* 1976, Hilty & Simon 1977, Heath & Long 1991, Eisermann *et al.* 2011). The tanager is considered Endangered at the global level because of its small range size and loss of habitat, primarily through the replacement of broadleaf forests by coffee plantations (Collar *et al.* 1992, BirdLife International 2008, Eisermann *et al.* 2011). Due to the limited distribution and few observations, to date little has been published on the ecology and behavior of the Azure-rumped Tanager.

Available information on habitat use originates from observations in the Sierra Madre de Chiapas (Brodkorb 1939, Heath & Long 1991) and from recent studies in Guatemala (Cooper 2003, Eisermann *et al.* 2011). Existing information on nesting is limited to a few nests which were observed in humid broadleaf forest in Chiapas in the early wet season (April–June; Isler & Isler 1987, Long & Heath 1994). Gómez de Silva Garza (1997) observed an additional nest in coniferous forest from April to May. In Guatemala, only two nests have previously been reported, from Atitlán volcano and from Santa María de Jesús, Quetzaltenango (Eisermann & Avendaño 2007).

Conservation planning for threatened species requires information on their natural history. Previously we described the current distribution of Azure-rumped Tanager in Guatemala, the extent of remaining prime habitat, population size, and vocalizations (Eisermann *et al.* 2011, in press). Within the present study we gathered information on how tanagers use the remaining habitat. We examined preferences in nest site selection, nesting season, and nest success. Nesting sites are key elements for species conservation (BirdLife International 2004). This is the first compilation of nesting data for the Azure-rumped Tanager in Guatemala, which is a stronghold for the conservation of this endangered species. Our observations provide a basis for recommendations for the management of coffee plantations in order to support the long-term survival of this species.

METHODS

Study area. The Azure-rumped Tanager's area of distribution in the western Pacific slope mountains of Guatemala is characterized by a chain of several major volcanoes. The altitudinal belt between 1000 and 1900 m is characterized by steep slopes of > 30%. The mean annual rainfall in the entire distribution range of the tanager in Guatemala amounts to 2000–4600 mm, but can locally reach a maximum of 6000 mm. The wet season extends from April to November with a mean monthly precipitation of 150–800 mm, and the dry season from December to March with mean monthly precipitation 5–150 mm (MAGA 2002). Annual mean minimum temperature is 15ºC; annual mean maximum is 25ºC (MAGA 2002). Landcover in the entire range of Azure-rumped Tanager in Guatemala is dominated by coffee plantations (68%), humid broadleaf forest (21%), scrub and secondary forest (3.2%), mixed broadleaf-coniferous forest (2.4%), and corn fields (1.6%) (Eisermann *et al.* 2011).

We conducted nest searches on the southeastern slope of Atitlán volcano (14º32'N, 91º10'W), in an area which included parts of the private nature reserves Los Tarrales, Los Andes, and San Jerónimo Miramar, dpto. Suchitepéquez. The natural climax vegetation in this area is humid evergreen broadleaf forest, and broadleaf-coniferous forest in higher and less humid areas. Landcover in a rectangle of 1950 ha encompassing all trails used for nest searches was as follows: broadleaf forest 1411 ha (72% of the study area), intensive coffee plantations 337 ha (17%), non-intensive coffee plantations 105 ha (5%), other intensive plantations (ponytail *Beaucarnea recurvata*, tea *Camellia sinensis*, and others) 59 ha (3%), scrub 12 ha (1%), and orchard-like settlements 14 ha (1%) (Eisermann *et al.* 2011). All coffee plantations within the study area were shaded monocultures according to a classification by Philpott *et al.* (2008), with a shade cover of 10–30% and 1–5 species of shade trees. Within the study area, we discriminated between intensive and non-intensive coffee plantations, classified by differences in shade coverage and density of coffee shrubs. Non-intensive coffee plantations had a low density (10–20%) of coffee shrubs in the understory, where they compete with native shrubs and herbs. Herbs were absent in intensive coffee plantations because of the intensive use of herbicides, and coffee shrubs covered about 50% of the understory. In non-intensive plantations, the 15 m tall canopy of shade trees, with coverage of 20–30%, was dominated by *Inga* trees. Coverage of shade trees in intensive coffee plantations was 10–20% and *Inga* trees were heavily pruned, and these plantations also had non-native species of shade trees (*Acrocarpus fraxinifolius*, *Eucalyptus* sp.).

Nest searches. Nest searches were carried out by walking along trails watching out for territorial and/or nesting behaviors. Detectability of Azure-rumped Tanager vocalizations was high over a distance of 30 m (Eisermann *et al.* 2011). Total trail length was 18.4 km; thus, with the total strip width of sampled habitat being 60 m, the total areas of sampled habitats were as follows: 66 ha of broadleaf forest, 19 ha of non-intensive coffee plantation and orchard-like settlement, and 25 ha of intensive coffee plantation. Searches were conducted over a period of 17 months from May 2008 to September 2009. To determine nesting season and nest success, nests were revisited at mean intervals of 2.6 ± 3.6 days (SD) (range 1–22 days) and observed between 30 min and 10 h in each session. We used 8× and 10× binoculars and a 20–60× spotting scope to observe the nests from a distance. Tanagers did not appear to be sensitive to human presence at a distance of more than 30 m from the nest. We recorded the time that tanagers spent incubating, their feeding rates, and the food items brought to the nest. Genders were not distinguishable from our observation posts.

In addition to the nests encountered during the study period, we compiled data from nests previously encountered during occasional observations. Geographic coordinates and elevation of nesting sites were determined with a handheld GPS device (Garmin 60CSx) with an accuracy of 5 m. We measured the distance to the forest edge using a Laser field ranger (Nikon ProStaff Laser 440) at close range with an accuracy of 1 m, or in cases where the forest edge was out of view it was determined based on orthoimages from December 2005 (MAGA 2010) with an accuracy of 5 m combined with ground-truthing.

Nest and tree height was determined with a Laser field ranger. Because nests were located high in the trees, the number of eggs could not be determined. Causes of nest failure remained unknown, with a few exceptions.

Trees with tanager nests were identified based on Standley & Steyermark (1946 and following volumes) and Parker (2008), taking into account recent taxonomic revisions (Berg 2007, de Laubenfels 2009). Voucher specimens were archived in the herbarium BIGU, School of Biology of San Carlos University, and in the herbarium AGUAT, Faculty of Agronomy of the San Carlos University, both located in Guatemala City.

Vegetation structure. We produced foliage-height profiles of the nest surroundings modified after Blondel & Cuvillier (1977) by determining vegetation density in 20 strata. We used a 9 m long telescopic pole which was marked from 0.5 to 9 m, and a Laser field ranger. At nesting sites, between two and six evenly spaced radial lines were laid out at each nest tree. Foliage coverage was measured at the radii of 10, 20, and 30 m. At each point the telescopic pole was positioned vertically, noting whether plants touched the pole on marks at 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, and 9 m. Above this height, we used the Laser field ranger to determine whether plants touched at the imaginary elongation of the pole at 10, 12, 15, 20, 25, 30, 35, and 40 m. All measurements were taken by the same observer (KE). The percentage of the number of touches of plant in the different strata was used as a vegetation density index. Measurements were taken after nesting had finished or after nest failure was noticed, in order to avoid disturbance at nest sites.

Statistical analyses. To determine nest habitat preferences of the Azure-rumped Tanager, we used a Chi-Square Goodness of Fit test to compare the numbers of nests detected in each habitat. Expected numbers of nests were calculated based on the area sampled as equivalent to expected proportions. Because one expected value was < 5, we applied a Monte Carlo simulation of the multinomial sampling distribution with 10,000 random samples using software VassarStat (Lowry 2010). The extension of the Fisher test (permutation test) with $\alpha = 0.05$, computed with SsS software (Engel 1998), was used to calculate the significance of nest tree selection divided into two categories of nest success (fledged/unknown, failed) for each tree species. The mean vegetation density between nesting sites was compared using a randomization test with $\alpha = 0.05$, computed with SsS software (Engel 1998).

Because nests were high in trees, we were unable to see the nest contents. We derived dates of the first egg laid and young hatched from the adults' behavior. We calculated nest success for the period from onset of incubation to fledging of the first young. Because the total number of nests was rather small, we used the Mayfield (1961, 1975) method to calculate nest success, which is adequate for small sample sizes (Johnson 2007). The daily survival probability (s) was calculated by: $s = (ND - losses)/ND$, where ND is number of nest days of exposure and losses is number of failed nests (Mayfield 1975). Survival probability for the nesting cycle from onset of incubation to fledging of the first young was calculated by $(\text{Daily Survival Probability})^t$, where *t* is number of days of incubation and brood rearing. Variance (V) of the estimated survival probability (s) was calculated by $V = [(ND - losses) \times losses]/ND^3$ (Johnson 1979), the standard error (SE) being the square root of variance. Approximate 95% confidence limits were calculated by $s \pm 2SE$ (Johnson 1979).

Incubation constancy was calculated according to Skutch (1962): T = 100 x S/

(S+R), where T is percentage of time spent incubating, S is mean duration of incubation sessions, and R is mean duration of recesses. Mean number of nest visits by adults was compared with a randomization test with α = 0.05 using SsS software (Engel 1998).

RESULTS

Nesting sites. Thirty-two nests of Azure-rumped Tanager were recorded in Guatemala from 2001–2009, of which 30 were observed at Atitlán volcano, one in Unión Victoria, Mun. Pochuta, dpto. Chimaltenango (D. Ruby, pers. com.), and one at Finca Los Pirineos, Mun. El Palmar, dpto. Quetzaltenango (J. Berry, pers. com.). All nests were cup-shaped and located in the upper part of trees with a diameter at breast height (DBH) > 33 cm. Most of the nests were located in a fork of a branch, and some of them were also supported by epiphytic ferns and orchids (Fig. 1). The mean elevation (± SD) of all nesting sites was 1459 ± 210 m (n = 32), with the lowest nest found at 860 m and the highest one at 1850 m (Appendix).

Fifteen nests were located in broadleaf forest. Mean distance (± SD) from the forest edge was 174 ± 242 m (range 0–700 m). Four of these nests were located in the forest interior > 400 m from the forest edge. Another 13 nests were located in non-intensive coffee plantation, two in intensive coffee plantation, and two in orchard-like settlement. The mean distance (± SD) to the nearest forest edge of these 17 nests was 40 ± 28 m (range 5–130 m).

Along transects 25 nests were detected, 13 nests in forest (2.0 nests 10 ha^{-1}), 10 in non-intensive coffee plantation and orchard-like settlement (5.3 nests 10 ha^{-1}), and 2 in intensive coffee plantation (0.8 nests 10 ha^{-1}). Significantly more nests were found in non-intensive coffee plantation (combined with number of nests in orchard-like settlement) (χ^2 = 10.13, df = 2, P < 0.01, based on Monte Carlo simulation of the multinomial sampling distribution with 10000 random samples).

Vegetation structure within a radius of 30 m around nest trees differed greatly among nesting sites (Fig. 2). Azure-rumped tanagers also nested successfully on sites with greatly reduced or absent upper canopy of native broadleaf trees (Fig. 3). Taking into account the four successful nests from Fig. 3, mean vegetation coverage in the canopy and midstory were significantly different between coffee plantation and forest: canopy (randomization test, difference in means 0.32, P < 0.005, n = 500 permutations), midstory (randomization test, difference in means 0.31, P < 0.05, n = 500 permutations), and understory (randomization test, difference in means 0.02, P = 0.85, n = 500 permutations). This indicates that the tanager's successful nesting is independent from certain vegetation structures. Tanagers were also generalists in their nest tree selection; the 32 nests were located in 20 different tree species (Appendix), among them a conifer (*Neocupressus lusitanica*) and two introduced, non-native species (*Acrocarpus fraxinifolius*, *Eucalyptus* sp.). The number of nests per tree species, classified by two categories (fledged/unknown, failed) was not significantly different (extension of Fisher test: n = 669,999 permutations, P = 0.1). Mean nest height (± SD) above ground was 21 ± 12 m (range 7.5–68 m, n = 30). Mean relative nest height (± SD) in the nest trees was 78% ± 26, with lowest nests located at 44% of tree height and highest nests being in the tree top level.

At two nest sites, nesting was recorded several times in subsequent years, suggesting nest site fidelity. Nests 21 and 32 were located in the same tree in 2008 and 2009 respectively. Nests 3, 5, 6, 7, 8, 9, 24, and 25 were in the same general area with the greatest distance between nest trees of 65 m. In five cases, nesting attempts were recorded near nests which

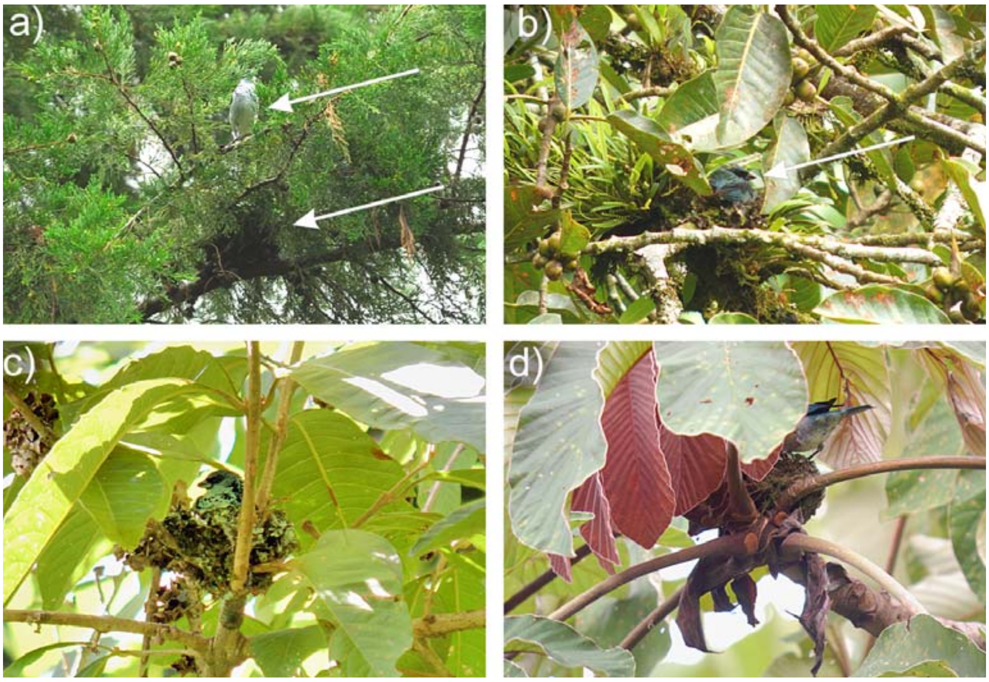

FIG. 1. Azure-rumped Tanager (*Tangara cabanisi*) nest sites at Atitlán volcano, Guatemala. a) Nest 9 in *Neocupressus lusitanica* (arrows pointing to the nest and to the adult, of which breast and belly are visible), phase of nest-building, 13 July 2008. b) Nest 21 supported by epiphytic ferns and orchids in branches of *Ficus aurea*, adult in nest (arrow pointing to the bill), 7 September 2008. c) Nest 12 in *Aegiphila valerioi*, adult incubating, 6 August 2008. d) Nest 13 in *Cecropia obtusifolia*, caudoventral view at the adult standing on nest rim, 7 August 2008. Photos: K. Eisermann.

had been abandoned shortly before, probably indicating repeated nesting attempts after nest failure: nest 9 after nest 8 in a distance of 15 m, nest 25 after nest 24, and nest 31 after nest 30. The shortest distance between synchronically active nests was 40 m (nest 11 and nest 12).

Nesting season. Nesting of Azure-rumped tanagers was observed in all months from April through September. Nest 2 was the earliest nest, with nest-building observed on 14 April, followed by nest 14 with an adult incubating on 25 April. This nest must have been built in the second or third week of April. Latest nests were nest 21 with eggs presumably hatched on 28 August, and nest 7 with adults feeding young only a few days old on 8 September. The nestlings would have fledged in the last week of September. The nesting season coincided with the wet season (Fig. 4).

Nest attendance. At nest 9, located in a non-intensive coffee plantation 30 m from the border of broadleaf forest, we were able to observe the timing of nesting activity through all stages.

The nest was attended by three adults (the pair and a helper) from the beginning of nest-building on 11 July 2009 to fledging on 18 August 2009. Nest-building took six days (11–16 July). During 7.75 h (08:15–16:00 h

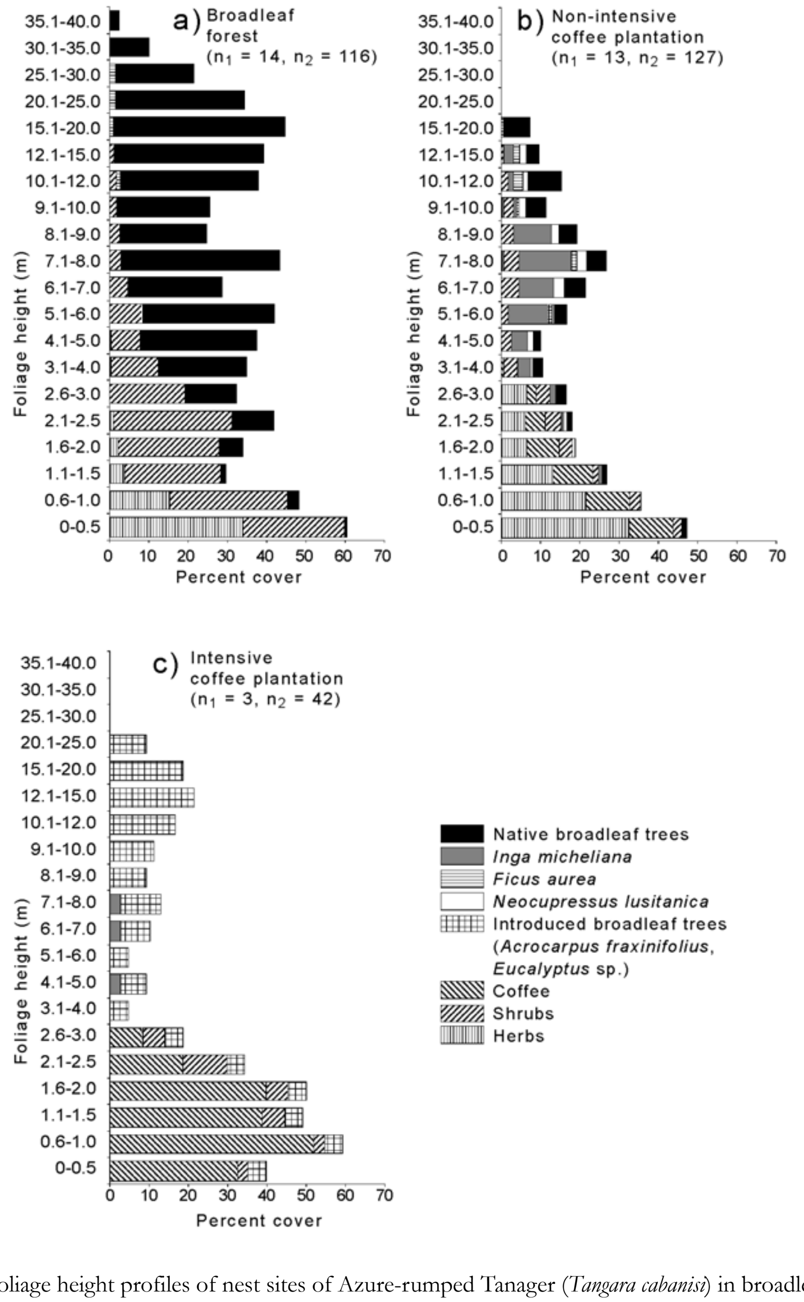

FIG. 2. Foliage height profiles of nest sites of Azure-rumped Tanager (*Tangara cabanisi*) in broadleaf forest, non-intensive, and intensive coffee plantations (n_1 = number of nest sites, n_2 = number of points where vegetation cover was measured) at Atitlán volcano, Guatemala, 2008–2009. Data from 23 nests are included. Data from nest sites at the edge between different habitats were treated in each habitat class separately. Percent cover represents the mean percentage of plant touches on a pole in the indicated height classes.

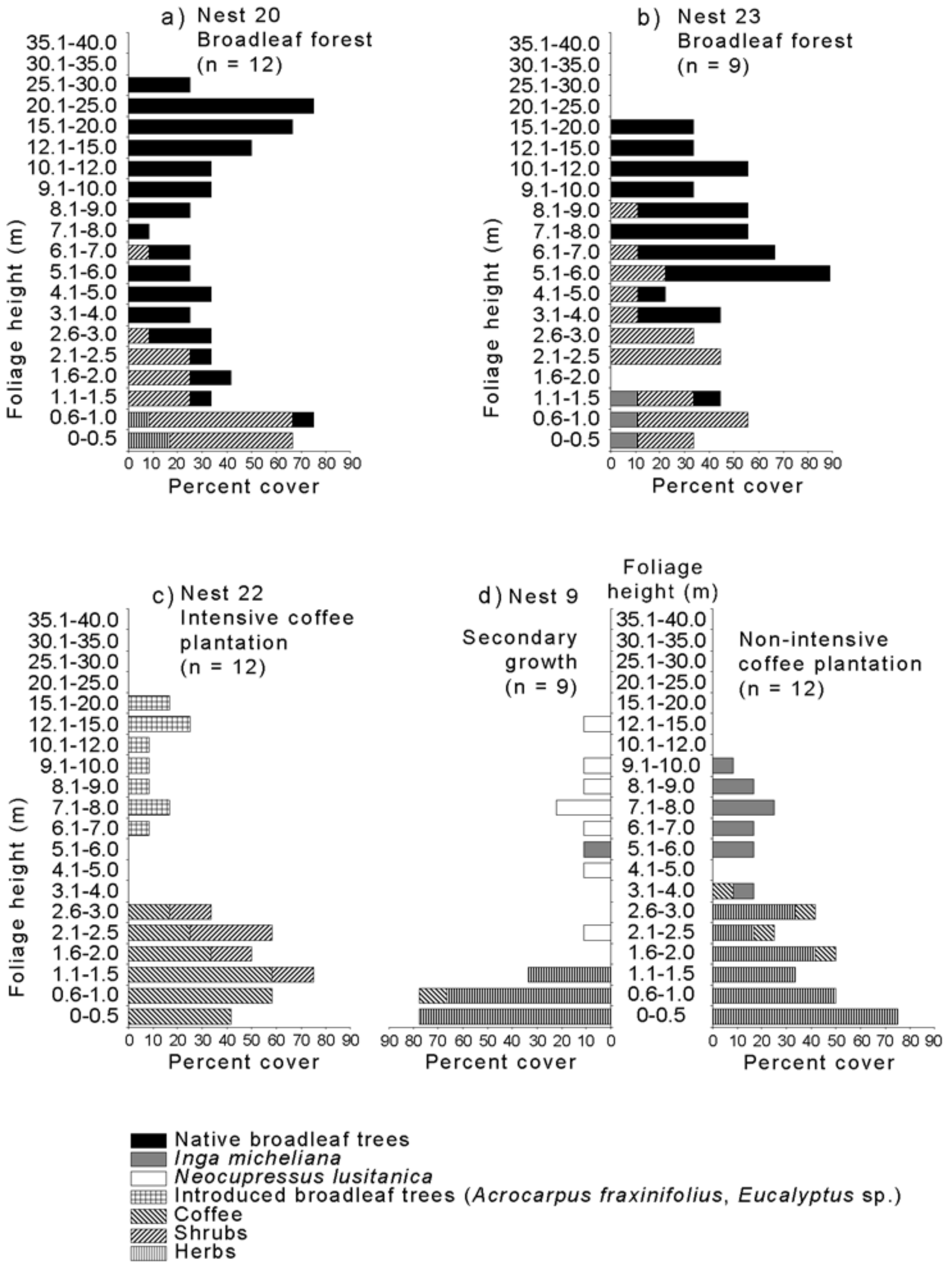

FIG. 3. Foliage height profiles in four successful nests of Azure-rumped Tanager (*Tangara cabanisi*) at Atitlán volcano, Guatemala, 2008–2009, two in broadleaf forest, one in intensive coffee plantation, and one on the edge between non-intensive coffee plantation and secondary growth (n = number of points where vegetation cover was measured).

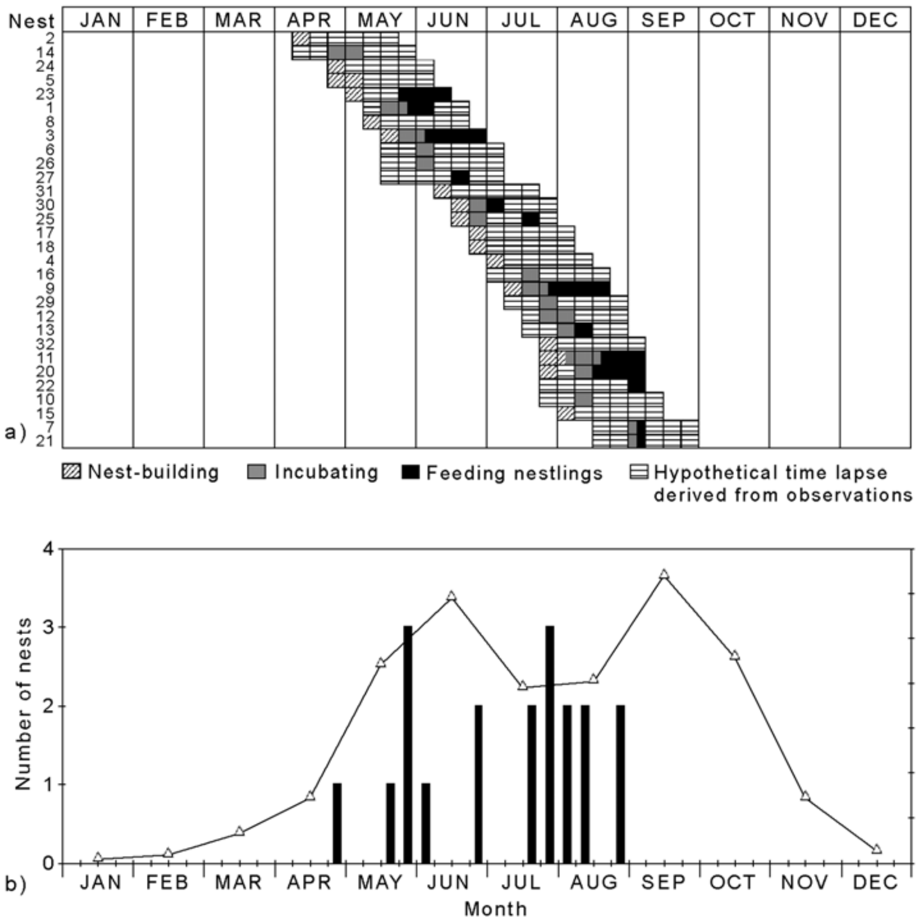

FIG. 4. Nesting season of Azure-rumped Tanager (*Tangara cabanisi*) in Guatemala ranged from April to September and coincided with the wet season. a) Timing of 30 nests encountered with at least one observation of adults attending the nest. b) Time of egg laying on 19 nests (columns) and mean monthly amount of rainfall (triangles: data from the weather station in the Los Tarrales Reserve, 1989–2009; Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología INSIVUMEH, unpubl. data).

CST) of observation on 13 July, adults went 23 times (on average once every 20 min) to the nest tree for nest-building. We observed tanagers collecting and carrying moss, lichen, rootlets of small epiphytic ferns (*Pleopeltis angusta*), and soft cotton-like material for nest-building. Material was collected in the nest tree and in trees up to 30 m or more from the nest tree. Repeated copulations in or near the nest tree were observed on 13 and 14 July. Once the helper approached the pair closely during copulation, but the male chased the helper away. We were unable to see inside the nest cup, but based on prolonged stays of an adult in the nest on the sixth day (16 July), we assume that this was the day the first of presumably two eggs was laid. The incubation period began on 17 July and lasted for 14 days (until 31 July). During 14 hours of observation on 7 days, incubation constancy was 76% and the mean length (± SD) of incubation sessions was 23 ± 15 min (n = 22, range 1–58 min), and recess lasted 7 ± 5 min (n = 27, range 1–21 min). During the incubation period, an adult was occasionally observed feeding the incubating adult. Brooding lasted for 17 days (31 July–17 August). During 35 hours of observation on 12 days (2–18 August), mean number of nest visits (± SD) per hour of adult birds including helper was 11.2 ± 7.0 (n = 368 visits). The helper, distinguished by a less intensive dark spotting on the chest plumage, visited 1.7 ± 1.8 times per hour (n = 69). Occasionally, the helper did not join the other adults on flights to bring food, instead staying near the nesting tree. Adults were frequently seen with their bills full of pieces of red fruit of *Ficus* spp. and imagos of sciarid flies (Diptera: Sciaridae) which were abundant in the foliage of *Inga micheliana* shade trees. Adults were also seen collecting unidentified green Lepidoptera larvae from the leaves of *I. micheliana*. The first juvenile fledged on 17 August at 10:00 h, the second left the nest on the following morning at 07:50 h. On that day the young birds moved in a radius of 30 m around the nest tree. On 19 August the young were seen at 50 m from the nest tree, and on 20 August at about 100 m.

Nest 12 was located in broadleaf forest, and incubation constancy there was 68%, with incubation sessions of 17 ± 8 min (n = 20) and recesses of 8 ± 6 min (n = 22). Nest 23 was a successful brood without helper at the nest. During 16.25 hours of observation on 7 days (29 May–11 June 2009), mean number of nest visits (± SD) per hour of adult birds was 8.2 ± 1.2 (n = 140 visits). Mean number of visits of adult birds to nest 23 was not significantly lower than at nest 9, where a helper assisted (randomization test, difference in means 3.038, $P = 0.2$), and also counting exclusively visits of the parent birds (randomization test, difference in means 1.298, $P = 0.6$). Helpers were recorded at only two of eight nests (nest 9 and nest 27) where feeding adults were observed on several dates for several hours.

Nest success. Nest success among 32 encountered nests was rather low. Incubating or feeding adults were recorded at 20 nests, and for 12 nests it remained unknown if eggs were laid. Of the 20 nests where eggs had been laid, data of repeated visits were collected at 18 nests. Using the Mayfield (1961, 1975) method, daily survival probability (s) of these 18 nests was 0.94 ± 0.02 (SE). Using a nesting period of 31 days from onset of incubation to fledging of the first young (based on data from Nest 9), survival probability for the entire nesting period was 0.16 (0.9435^{31}). Thus nest success was 16% (95% confidence interval: 5–45%).

The cause of nest failure could not be determined for any of these nests. At nest 21, the young died in the nest for an unknown reason. A day after adults were observed feeding the nestlings, an adult stayed in the nest without feeding for 3 h. Through the spotting scope we saw from a distance a large wasp (Hymenoptera) and shortly after a fly (Diptera) entering the nest (KE and GL, pers. obs.), indicating that dead nestlings were probably there. At nest 12, an Emerald Toucanet (*Aulacorhynchus prasinus*) was seen on 6 August 2008 perched in the canopy at a distance of about 5 m from the tanager nest, apparently observing the nest. A day later the nest was abandoned, presumably predated. The Bushy-crested Jay (*Cyanocorax melanocyaneus*) was the only bird species we observed depredating on the Azure-rumped Tanager. On 19 August 2009, two jays were seen in the canopy of broadleaf forest at 1750 m, one of them carried in its bill a young Azure-rumped Tanager with half grown flight feathers, de-predated from an unknown nest (ALL and GL pers. observ.). Two adult tanagers were mobbing the jays.

Noteworthy behavioral observations. One pair of Azure-rumped tanagers was observed constructing two nests synchronously (SA & GL pers. observ.). On 1 August 2008, nest 15 was found at construction stage. On 8 August, the pair was still nest-building. In addition to the nest observed a week earlier, a second nest was built 1 m apart from the first nest. During 2.5 h of observation (08:25–10:55 h), 17 visits were recorded for one of the nests and 19 for the other. The pair moved together back and forth to bring nest material, but each bird to a different nest. On one visit, both birds went together to the second nest, and on another visit they went first to each other's nest and gathered then at the new nest. The outcome of this nesting attempt remains unknown.

Incubating adults were repeatedly observed calling. A soft *pip*-call was given apparently as a contact call. Sometimes a loud and excited trill was given, apparently to communicate with the other parent and the helper, or in response to other birds intruding the general nest area.

Azure-rumped tanagers showed different reactions to intruders of other bird species in the nest territory. Sometimes they ignored the close approach of Paltry Tyrannulet (*Zimmerius vilissimus*), Yellow-winged Tanager (*Thraupis abbas*), and Blue-tailed Hummingbird (*Amazilia cyanura*), and did not react at all. In most cases, however, they chased intruding small birds away, including Paltry Tyrannulet, Band-backed Wren (*Campylorhynchus zonatus*), Rufous-and-white Wren (*Thryothorus rufalbus*), Brown-backed Solitaire (*Myadestes occidentalis*), Black-and-white Warbler (*Mniotilta varia*), Slate-throated Redstart (*Myioborus miniatus*), Yellow-winged Tanager, White-winged Tanager (*Piranga leucoptera*), and Lesser Goldfinch (*Spinus psaltria*). Adults became alert, jumping nervously between twigs when flocks of calling Pacific parakeets (*Aratinga strenua*) were flying high overhead. Adult tanagers observed alertly Bushy-crested jays and Emerald toucanets moving near the nesting territory. Once they stopped a routine of intensive feeding when a flock of Bushy-crested jays was in the nest territory. They avoided approaching their nest and feeding their young until the jays were gone.

DISCUSSION

Nesting sites and nesting season. The Azure-rumped Tanager has been reported to be a specialist of humid broadleaf forest from Chiapas (Heath & Long 1991) and Guatemala (Eisermann *et al.* 2011). Nesting had previously been reported only from forest habitats (Long & Heath 1994, Gómez de Silva Garza 1997). Thus, nesting in coffee plantations in our study area at Atitlán volcano is noteworthy and suggests that the species may in fact be adapted to disturbance. The number of nests 10 ha^{-1} was highest in non-intensive coffee plantation. A preference of non-intensive coffee plantation over forest can not be concluded, because nest detectability is likely much lower in the taller and denser forest than in non-intensive coffee plantation. Noteworthy, however, is the greater number of nests 10 ha^{-1} in non-intensive coffee plantation compared to intensive coffee plantation. Nest detectability can be expected to be higher in intensive plantations because of a less dense vegetation structure (Fig. 2). Nesting outside the prime habitat could be caused by increased competition for nesting sites because of forest fragmentation, including interspecific competition (Martin & Martin 2001). Potential competitors of the Azure-rumped Tanager could be the sympatric Yellow-winged Tanager and Blue-gray Tanager (*Thraupis episcopus*). There might also exist some advantages of nesting sites in plantations, such as lower predation pressure or competition, thus combining favorable nest sites with favorable foraging sites in nearby forest. Available data on causes of nest failure in Azure-rumped Tanager are insufficient to address these questions.

Nesting of the Azure-rumped Tanager was previously recorded at 1200–1500 m (Long & Heath 1994, Gómez de Silva Garza 1997). Recent census data from Atitlán volcano showed that the tanager prefers forest at elevations 1400–1900 over forests at 900–1300 m (Eisermann *et al.* 2011). Our observations of nest sites in the same area, combined with census data (Eisermann *et al.* 2011), expand the altitudinal range of records to 860–1900 m.

In Chiapas, nesting activity was observed from April to June, based on observations in all months except January, July, and August (Long & Heath 1994). Based on more extensive observations in all months at Atitlán volcano we recorded nesting from April to September. The relatively long nesting season might include more than one brood per season, which has also been reported from congeners, such as Golden-hooded (*Tangara larvata*) (3 broods), Bay-headed (*T. gyrola*) (3 broods), and Silver-throated Tanager (*T. icterocephala*) (2 broods) (Skutch 1954, 1981). At Atitlán volcano, nesting season seems to be linked with the fruiting season of *Ficus aurea*, a common tree in this forest providing large fruit (1–2 cm in diameter) as a food source. Most observations of feeding tanagers along transect counts during the nesting season were made on this tree species (Eisermann *et al.* 2011). In Chiapas, Long & Heath (1994) reported a linkage between the tanager and *Ficus cookii*, which belongs to the species group of *Ficus aurea* (Berg 2007).

Nest attendance and nest success. While the nesting season of Azure-rumped tanagers was longer and nesting sites more variable in Guatemala than previously reported from Chiapas, nest attendance by adults was similar to observations in Chiapas (Long & Heath 1994) and indeed very similar to other *Tangara* species. Nest-building at one nest at Atitlán volcano took 6 days. Skutch (1954) reported a period of 4–12 days for the Golden-hooded Tanager and Wood *et al.* (1992) at least 8 days in the Paradise Tanager (*Tangara chilensis*). The incubation period of 14 days agrees with other studies of *Tangara* species with incubation periods of 13–17 days (Golden-hooded, Bay-headed, and Speckled Tanager *T. guttata*, Skutch 1954; Azure-rumped Tanager; Long & Heath 1994; Paradise Tanager, Wood *et al.* 1992; Black-capped Tanager *T. heinei*, Freeman & Greeney 2009). Incubation constancy at two nests at Atitlán volcano was 68% and 76% respectively, similar to two nests in Chiapas with 74% and 82% (Long & Heath 1994), and similar to congeners with incubation constancies 65–82% (Golden-hooded, Speckled, and Silver-throated Tanager, Skutch 1954; Black-capped Tanager, Freeman & Greeney 2009). Incubation sessions of between a few minutes and an hour are common (Skutch 1954, Long & Heath 1991, Wood *et al.* 1992, Freeman & Greeney 2009), the longest session of 134 min was observed in the Bay-headed Tanager (Skutch 1954). Brooding lasted 17 days at a nest at Atitlán, which is longer than reported from Chiapas (15 days; Long & Heath 1994) or from other congeners (14–16 days in Golden-hooded and 15–16 days in Bay-headed Tanager, Skutch 1954; 14 days in Golden Tanager, Gelis *et al.* 2006). Feeding rates of the Azure-rumped Tanager of 8–11 nest visits per hour were similar to Golden-hooded (9–16 visits h^{-1}) and Speckled (5 visits h^{-1}; Skutch 1954), Beryl-spangled (4–12 visits h^{-1}; Sheldon & Greeney 2007), and Black-capped Tanager (6 feeds h^{-1} per nestling; Freeman & Greeney 2009).

During nest watches, genders of Azure-rumped Tanager were not distinguishable from a distance. However, we observed occasional feeding of an incubating adult by a second adult. According to observations on other passerines (Skutch 1957), occasional feeding of the incubating adult by its partner indicates that only the female incubates. This behavior has been found in a number of congeners, such as Golden-hooded, Speckled, Plain-colored (*T. inornata*), Bay-headed, Silver-throated (Skutch 1954), Flame-faced (*T. parzudakii*) (Arcos-Torres & Solano-Ugalde 2007), and Black-capped Tanager (Freeman & Greeney 2009).

We observed cooperative breeding on two of eight nests with extensive observations of attending adults. Helpers at the nest have been reported previously for at least 10 tanager species (Thraupidae *sensu* American Ornithologists' Union 1998, Chesser *et al.* 2010) (Skutch 1954, Brown 1987, Alves 1990, Skutch 1999, Gelis *et al.* 2006), including the Azure-rumped Tanager (Long & Heath 1994). Benefits of cooperatively breeding are manifold and include increased productivity, improved territory defense, load-lightening for parents, learning of skills, access to mates, and territories for helpers (Cockburn 1998). We observed no significant difference in the number of nest visits by parent birds during brood rearing between a nest with helper and a nest without helper. The helper, however, was observed to stay occasionally in the nest territory, thus apparently benefiting nest defense. As flights between the nest and food sources become longer, parent birds spend consequently more time traveling and less time defending the nest.

Noteworthy was the vocalization activity of incubating Azure-rumped tanagers, because incubating passerine birds usually remain motionless in order to escape the detection by predators (Deeming 2002). Calls of incubating Azure-rumped tanagers have also been reported from Chiapas (Long & Heath 1991). In Paradise tanagers, Wood *et al.* (1992) observed calling birds only at some distance from the nest. Libsch *et al.* (2008) showed in several Neotropical passerine species that nest predation occurs usually during daytime. In addition, predation risk increases with parental activity (Martin *et al.* 2000). Vocalizations of incubating Azure-rumped tanagers might call the attention of predators in the same way as it called our attention to locate nests. We suspect, however, that the function of these vocalizations is to improve nest defense by communication between parents and helpers. Long & Heath (1994) supposed that social groups of tanagers could feed more than one brood at a time. The marking of individuals could reveal more data on this specific social system.

Nest success of the Azure-rumped Tanager was rather low at Atitlán volcano (5–45% according the Mayfield method), which is not unusual for Neotropical birds (Skutch 1985, Robinson *et al.* 2000, Lindell & Smith 2003, Young *et al.* 2008). A comparison of our calculation of nest success of the Azure-rumped Tanager with other locations and congeners is difficult because little information is available. Long & Heath (1994) supposed that young fledged from 29–43% of the nests (2–3 of 7 nests) in Chiapas. Skutch (1981) reported success in 10 of 35 nests (24%) of Golden-hooded Tanager and 19 of 35 (54%) in Silver-throated Tanager. Using an uncorrected calculation similar to Skutch (1981) and Long & Heath (1994), 4 of 18 (22%) encountered nests at Atitlán volcano were successful, 4 (22%) had an unknown fate, and 12 (66%) failed. Consequently, maximum number of successful nests was 44%. In addition to predators, such as the Bushy-crested Jay, mammals, and snakes, the open-cup canopy nests of Azure-rumped tanagers are exposed to torrential rain storms as potential threat. How the different nesting habitats, e.g., forest vs coffee plantation, influence nesting success, remains unknown. More nest observations are required to address this question.

Conservation implications. Forests have been reduced to only 21% of the Azure-rumped Tanager's potential area of distribution in Guatemala, and coffee plantations cover 68% of this area (Eisermann *et al.* 2011). Although it remains unknown if Azure-rumped tanagers nest in coffee plantations because of negative effects of broadleaf forest fragmentation or for reason that the species is ecologically more adaptable than previously assumed, our data establish an important base for practical conservation measures for this endangered species. Coffee plantations in close neighborhood to broadleaf forest can provide valuable habitat for the tanager, as long as they have a well developed canopy of shade trees (even a monoculture of *Inga* trees) with some taller trees providing nest sites and fruit trees as food source (especially trees of the *Ficus aurea* complex). We found tanagers nesting only in canopy trees, therefore only coffee plantations with shade trees can provide potential nesting sites. Moreover, tanagers were observed collecting nest material (epiphytic mosses and rootlets) near the nest site. Thus they can probably not find sufficient nest material in intensively managed coffee plantations without epiphytes (Philpott *et al.* 2008), because of heavily pruned shade trees and the extensive use of herbicides. The following conservation measures are recommended to meet critical habitat needs: 1) protection of existing broadleaf forest in the potential area of distribution, 2) reforestation with local broadleaf tree species, 3) enhancement of the structural complexity of intensive coffee plantations by planting trees, 4) recruitment of more landowners into non-intensive coffee-growing schemes, and 5) avoidance of the conversion of shaded to unshaded coffee plantations. Habitat restoration measures should be accompanied by population monitoring of the Azure-rumped Tanager.

The necessity of conservation efforts in human-altered landscapes in Guatemala has been recognized during the identification of Important Bird Areas (Eisermann & Avendaño 2009a, b) and also on a regional scale in Mesoamerica (Harvey *et al.* 2008, Chazdón *et al.* 2009, Gardner *et al.* 2009). Since conservation is costly (Balmford & Whitten 2003), the Azure-rumped Tanager could be used as a flagship and indicator species for biodiversity-friendly management of coffee plantations in the Chiapas and Guatemala Pacific slope mountains. Maintaining shade coffee plantations as habitat for the Azure-rumped Tanager would certainly promote biodiversity conservation on a broader scale (Tejeda-Cruz & Sutherland 2004, Philpott *et al.* 2008). The tanager could be incorporated into local coffee certification schemes (Harvey *et al.* 2008).

Repeated nesting on the same nesting site (same tree or tree nearby) by Azure-rumped tanagers at Atitlán volcano over several years suggests nest site fidelity, which can be verified by future studies using individually marked birds. Nest site fidelity has also been suggested in a pair of Grass-green Tanager (*Chlorornis riefferii*; Greeney & Gelis 2006). Known nesting sites should receive special consideration by land owners. Based on the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), threatened species are legally protected from illegal trade in Guatemala but the country lacks a legal framework to protect them from other threats, such as habitat destruction and disturbances at nest sites. This leaves a high responsibility on landowners to enforce the protection of sensitive sites. The Azure-rumped Tanager is a target species for birdwatchers. Land owners, birding guides, birdwatchers, and photographers should take care that nests of Azure-rumped tanagers are not approached closely, because disturbance of nest sites could potentially lead to reduced nest success and population decline. Through birdwatching, however, Azure-rumped Tanager can develop as a flagship species for conservation, getting landowners to take pride in having the species breeding on their land, thus encouraging habitat protection, active nest-site protection, and less intensive coffee-growing.

ACKNOWLEDGMENTS

SA, KE, and CA are grateful to Andy Burge and Mónica Barrios for preparing a temporary home at El Vesubio/Los Tarrales. We thank Olga Hazard, Jaime Freire, Mark Brissani, and Arnoldo Villagrán for granting research permission in Los Andes and San Jerónimo Miramar private reserves. We appreciate the hospitality by Olga Hazard and Jaime Freire and field assistance by Jesús Lucas Yuxón, Juan Calvo Cortéz, Carsten Loth, Juan Mejía, and Gilberto de León. Jason Berry, Douglas E. Ruby, Aaron H. Johnston, and Dan Davis contributed additional nest data. We thank Juan José Castillo Mont, Mario Veliz, and David Mendieta for the identification of plant specimens, and Enio Cano for the identification of Diptera. The Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (INSIVUMEH) provided climate data. We appreciate critical comments on the manuscript by Oliver Komar, André Weller, and two anonymous reviewers, and the revision of English usage of an earlier version by Peter Lowther through the Association of Field Ornithologists' program of editorial assistance. Optics for the Tropics donated binoculars. This study was financially supported by Cayaya Birding, Los Tarrales Reserve, and the PROEVAL RAXMU Bird Monitoring Program.

REFERENCES

Alves, M. A. S. 1990. Social system and helping behavior in the White-banded Tanager (*Neothraupis fasciata*). Condor 92: 470–474.

Arcos-Torres, A., & A. Solano-Ugalde. 2007. Notas sobre la anidación de tres especies del género *Tangara* (Thraupidae: Aves) en el noroccidente de Ecuador. Bol. SAO 17: 133–137.

American Ornithologists' Union (AOU). 1998. The American Ornithologists' Union check-list of North American birds. 7th ed. American Ornithologists' Union, Washington, D.C., USA.

Balmford, A., & T. Whitten 2003. Who should pay for tropical conservation, and how the costs be met? Oryx 37: 238–250.

Berg, C. C. 2007. Proposals for treating four species complexes in *Ficus* subgenus *urostigma* section *americanae*. Blumea 52: 295–312.

BirdLife International. 2004. State of the world's birds 2004: indicators for our changing world. BirdLife International, Cambridge, UK.

BirdLife International [online]. 2008. Species fact sheet: *Tangara cabanisi*. Dowloaded on 17 June 2008 from http://www.birdlife.org/datazone/species/index.html.

Blondel, J., & R. Cuvillier. 1977. Une méthode simple et rapide pour décrire les habitat d'oiseaux: le stratiscope. Oikos 29: 326–331.

Brodkorb, P. 1939. Rediscovery of *Heleodytes chiapensis* and *Tangara cabanisi*. Auk 56: 447–450.

Brown, J. L. 1987. Helping and communal breeding in birds: ecology and evolution. Princeton Univ. Press, Princeton, New Jersey, USA.

Chazdon, R. L., C. A. Harvey, O. Komar, D. M. Griffith, B. G. Ferguson, M. Martínez-Ramos, H. Morales, R. Nigh, L. Soto-Pinto, M. van Breugel, & S. M. Philpott. 2009. Beyond reserves: a research agenda for conserving biodiversity in human-modified tropical landscapes. Biotropica 41: 142–153.

Chesser, R. T., R. C. Banks, F. K. Barker, C. Cicero, J. L. Dunn, A. W. Kratter, I. J. Lovette, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, D. F. Stotz, & K. Winker. 2010. Fifty-first supplement to the American Ornithologists' Union check-list of North American birds. Auk 127: 726–744.

Cockburn, A. 1998. Evolution of helping behavior in cooperatively breeding birds. Annu. Rev. Ecol. Syst. 29: 141–177.

Collar, N. J., L. P. Gonzaga, N. Krabbe, A. Madroño Nieto, L. G. Naranjo, T. A. Parker III, & D. C. Wege. 1992. Threatened birds of the Americas: the ICBP/IUCN Red Data Book. Smithsonian Institution Press, Washington, D.C., USA and International Council for Bird Preservation, Cambridge, UK.

Cooper, D. S. 2003. New distributional and ecological information on birds in south-western Guatemala. Cotinga 19: 61–63.

de Laubenfels, D. J. 2009. Nomenclatural actions for the New World cypresses (Cupressaceae). Novon 19: 300–306.

Deeming, D. C. 2002. Behaviour patterns during incubation. Pp. 63–87 *in* Deeming, D. C. (ed.) Avian incubation, behaviour, environment, and evolution. Oxford Univ. Press, New York, New York, USA.

Eisermann, K., & C. Avendaño. 2007. Lista comentada de las aves de Guatemala - Annotated checklist of the birds of Guatemala. Lynx Edicions, Barcelona, Spain.

Eisermann, K., & C. Avendaño. 2009a. Conservation priority-setting in Guatemala through the identification of Important Bird Areas. Proceedings of the Fourth International Partners in Flight Conference, Tundra to Tropics: 315–327.

Eisermann, K., & C. Avendaño. 2009b. Guatemala. Pp. 235–242 *in* Devenish, C., D. F. Diaz Fernández, R. P. Clay, I. Davidson, & I. Yépez Zabala (eds) Important Bird Areas Americas, priority sites for biodiversity conservation. BirdLife Conservation Series 16. Birdlife International, Quito, Ecuador.

Eisermann, K., S. Arbeiter, G. López, C. Avendaño, & J. de León Lux. 2011. Distribution, habitat use, and implications for the conservation of the globally threatened Azure-rumped Tanager *Tangara cabanisi* in Guatemala. Bird Conserv. Int. 21: doi:10.1017/S0959270910000638.

Eisermann, K., G. López, J. Berry, J. de León Lux, & A. Burge in press. Vocalisations and juvenile plumage of the Azure-rumped Tanager. Cotinga 33: – .

Engel, J. 1998. SsS. Rubisoft Software, Eichenau, Germany.

Freeman, B. G., & H. F. Greeney. 2009. Parental care of the Black-capped Tanager (*Tangara heinei*) in northeastern Ecuador. Bol. SAO 19: 32–37.

Gardner, T. A., J. Barlow, R. Chazdon, R. M. Ewers, C. A. Harvey, C. A. Peres, & N. S. Sodhi 2009. Prospects for tropical forest biodiversity in a human-modified world. Ecol. Lett. 12: 561–582.

Gelis, R. A., H. F. Greeney, & C. Dingle. 2006. Cooperative breeding and first nest description for Golden Tanager *Tangara arthus*. Cotinga 26: 79–81.

Gómez de Silva Garza, H. 1997. Further observations on the nesting of the Azure-rumped Tanager. Bull. Br. Ornithol. Club 117: 16–18.

Greeney, H. F., & R. A. Gelis. 2006. Two nests of Grass-green Tanager *Chlorornis riefferii* on the ground. Cotinga 25: 86.

Harvey, C. A., O. Komar, R. Chazdon, B. G. Ferguson, B. Finegan, D. M. Griffith, M. Martínez-Ramos, H. Morales, R. Nigh, L. Soto-Pinto, M. van Breugel, & M. Wishnie 2008. Integrating agricultural landscapes with biodiversity conservation in the Mesoamerican hotspot. Conserv. Biol. 22: 8–15.

Heath, M., & A. Long. 1991. Habitat, distribution and status of the Azure-rumped Tanager *Tangara cabanisi* in Mexico. Bird Conserv. Int. 1: 223–254.

Hilty, S. L., & D. Simon. 1977. The Azure-rumped Tanager in Mexico with comparative remarks on the Gray-and-gold Tanager. Auk 94: 605–606.

Isler, M. L., & P. R. Isler 1987. The tanagers: natural history, distribution and identification. Smithsonian Institution Press, Washington, D.C., USA.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96: 651–661.

Johnson, D. H. 2007. Estimating nest success: a guide to the methods. Stud.Avian Biol. 34: 65–72.

Libsch, M. M., C. Batista, D. Buehler, I. Ochoa, J. Brawn, & R. E. Ricklefs. 2008. Nest predation in a Neotropical forest occurs during daytime. Condor 110: 166–170.

Lindell, C., & M. Smith. 2003. Nesting bird species in sun coffee, pasture, and understory forest in southern Costa Rica. Biodivers. Conserv. 12: 423–440.

Long, A. J., & M. F. Heath. 1994. Nesting ecology and helping behavior in the Azure-rumped Tanager in Mexico. Condor 96: 1095–1099.

Lowry, R. [online]. 2010. VassarStats: website for statistical computation. Downloaded on 9 November 2010 from http://faculty.vassar.edu/lowry/VassarStats.html.

MAGA. 2002. Atlas de Guatemala. CD-Rom. Ministerio de Agricultura, Ganadería y Alimentación (MAGA), Guatemala City, Guatemala.

MAGA in press. Obtención de imagenes digtales de la República de Guatemala del año 2006. Ministerio de Agricultura Ganadería y Alimentación (MAGA), Guatemala City, Guatemala

Martin, P. R., & T. E. Martin. 2001. Ecological and fitness consequences of species coexistence: a removal experiment with wood warblers. Ecology 82: 189–206.

Martin, T. E., J. Scott, & C. Menge. 2000. Nest predation increases with parental activity: separating nest site and parental activity effects. Proc. R. Soc. Lond. B 267: 2287–2293.

Mayfield, H. F. 1961. Nesting success calculated from exposure. Wilson Bull. 73: 255–261.

Mayfield, H. F. 1975. Suggestions for estimating nest success. Wilson Bull. 87: 456–466.

Parker, T. 2008. Trees of Guatemala. The Tree Press, Austin, Texas, USA.

Parker III, T. A., S. Hilty, & M. Robbins. 1976. Birds of the El Triunfo cloud forest, Mexico, with notes on the Horned Guan and other species. Am. Birds 30: 779–782.

Philpott, S. M., W. J. Arendt, I. Armbrecht, P. Bichier, T. V. Diestch, C. Gordon, R. Greenberg, I. Perfecto, R. Reynoso-Santos, L. Soto-Pinto, C. Tejeda-Cruz, G. Williams-Linera, J. Valenzuela, & J. M. Zolotoff. 2008. Biodiversity loss in Latin American coffee landscapes: review of the evidence on ants, birds, and trees. Conserv. Biol. 22: 1093–1105.

Robinson, W. D., T. R. Robinson, S. K. Robinson, & J. D. Brawn. 2000. Nesting success of understory forest birds in central Panama. J. Avian Biol. 31: 151–164.

Sheldon, K. S., & H. F. Greeney. 2007. Nest and parental care of the Beryl-spangled Tanager (*Tangara nigroviridis*) in northeastern Ecuador. Ornitol. Neotrop. 18: 603–606.

Skutch, A. F. 1954. Life histories of Central American birds, families Fringillidae, Thaupidae, Icteridae, Parulidae and Coerebidae. Pac. Coast Avifauna 31. Cooper Ornithological Society, Berkeley, California, USA.

Skutch, A. F. 1957. The incubation patterns of birds. Ibis 99: 69–93.

Skutch, A. F. 1962. The constancy of incubation. Wilson Bull. 74: 115–152.

Skutch, A. F. 1981. New studies of tropical America birds. Publ. Nuttall Ornithol. Club 19: 1–281.

Skutch, A. F. 1985. Clutch size, nesting success, and predation on nests of Neotropical birds, reviewed. Ornithol. Monogr. 36: 575–594.

Skutch, A. F. 1999. Helpers at birds' nests: a worldwide survey of cooperative breeding and related behavior. Univ. of Iowa Press, Iowa City, Iowa, USA.

Standley, P. C., & J. A. Steyermark. 1946. Flora of Guatemala. Fieldiana: Botany Vol. 24, Part IV. Chicago Natural History Museum, Chicago, Illinois, USA.

Tejeda-Cruz, C., & W. J. Sutherland. 2004. Bird responses to shade coffee production. Anim. Conserv. 7: 169–179.

Wood, T., F. Gallo, & P. K. Donahue. 1992. Observations at a Paradise Tanager nest. Wilson Bull. 104: 360–362.

Young, B. E., T. W. Sherry, B. J. Sigel, & S. Woltmann. 2008. Nesting success of Costa Rican lowland rain forest birds in response to edge and isolation effects. Biotropica 40: 615–622.

APPENDIX. Characteristics of nesting sites of the Azure-rumped Tanager in Guatemala. +Diameter at breast height of the tree trunk. *Nest tree over-hanging at a very steep slope, numbers indicate tree height and in parenthesis height of tree top over ground. Habitat: BF = broadleaf forest; IC = intensive coffee plantation; NIC = non-intensive coffee plantation; OS = orchard-like settlement; SF = secondary forest.

Nest	Year	Locality	Elevation (m a.s.l.)	Nest tree* (family)	Habitat	DBH (cm)+	Tree height (m)	Nest height (m)	Distance to forest edge (m)
1	2001	Finca Los Pirineos (14°41'N, 91°33'W)	1100	*Heliocarpus* sp. (Tiliaceae)	SF	-	10	9	50
2	2006	Los Tarrales Reserve (14°33'N 91°10'W)	1510	*Neocupressus lusitanica* var. *lindenii* (Cupressaceae)	NIC	-	-	-	35
3	2006	Los Tarrales Reserve	1510	*Inga micheliana* (Mimosaceae)	NIC	35	8	7.5	35
4	2007	Unión Victoria (formerly Finca El Salvador) (14°34'N, 91°03'W)	1260	*Ficus* sp. (Moraceae)	BF	80	22	-	0
5	2007	Los Tarrales Reserve	1510	*Neocupressus lusitanica* var. *lindenii*	NIC	50	20	17	30
6	2007	Los Tarrales Reserve	1510	*Neocupressus lusitanica* var. *lindenii*	NIC	50	20	18	30
7	2007	Los Tarrales Reserve	1510	*Neocupressus lusitanica* var. *lindenii*	NIC	50	20	18	30
8	2008	Los Tarrales Reserve	1510	*Neocupressus lusitanica* var. *lindenii*	NIC	50	20	18	30
9	2008	Los Tarrales Reserve	1500	*Neocupressus lusitanica* var. *lindenii*	NIC	50	18	18	30
10	2008	Los Tarrales Reserve	1480	*Grevillea robusta* (Proteaceae)	NIC	95	30	17	21
11	2008	Los Tarrales Reserve	1540	*Ulmus mexicana* (Ulmaceae)	BF	70	22	18	12
12	2008	Los Tarrales Reserve	1540	*Aegiphila valerioi* (Verbanaceae)	BF	35	24	18	36
13	2008	Los Tarrales Reserve	1320	*Cecropia obtusifolia* (Cecropiaceae)	NIC	38	27	25	17
14	2008	Los Tarrales Reserve	860	*Coccoloba escuintlensis* (Polygonaceae)	BF	45	25	23	40
15	2008	Los Andes Reserve (14°33'N, 91°11'W)	1700	*Ficus* sp.	BF	285	40	35	550
16	2008	Los Tarrales Reserve	1570	*Ficus aurea* (Moraceae)	NIC	120	24	23	24
17	2008	San Jerónimo Miramar Reserve (14°34'N, 91°10'W)	1460	*Eucalyptus* sp. (Myrtaceae)	IC	35	25	15.5	40
18	2008	Los Tarrales Reserve	1340	*Ocotea sinuata* (Lauraceae)	NIC	66	20	9	62
19	2008	Los Tarrales Reserve	1820	*Cornus disciflora* (Cornaceae)	BF	100	40	32	500

APPENDIX (Continuation).

Nest	Year	Locality	Elevation (m a.s.l.)	Nest tree* (family)	Habitat	DBH (cm)[+]	Tree height (m)	Nest height (m)	Distance to forest edge (m)
20	2008	Los Tarrales Reserve	1780	*Sideroxylon portoricense* ssp. *minutiflorum* (Sapotaceae)	BF	60	34	28	450
21	2008	Los Tarrales Reserve	1530	*Ficus aurea*	BF	420	40	20	80
22	2008	San Jerónimo Miramar Reserve	1400	*Acrocarpus fraxinifolius* (Fabaceae)	IC	35	20	17	130
23	2009	Los Tarrales Reserve	930	*Ficus crassiuscula* (Moraceae)	BF	120	25 (50)*	30	16
24	2009	Los Tarrales Reserve	1500	*Neocupressus lusitanica* var. *lindenii*	NIC	63	25	21	5
25	2009	Los Tarrales Reserve	1510	*Neocupressus lusitanica* var. *lindenii*	NIC	50	18	13	30
26	2009	Los Tarrales Reserve	1540	*Cedrela salvadorensis* (Meliaceae)	BF	120	25	11	0
27	2009	Los Tarrales Reserve	1850	*Chiranthodendron pentadactylon* (Sterculiaceae)	BF	≈ 50	20 (70)*	68	700
28	2009	Los Tarrales Reserve	1400	*Cedrela pacayana* (Meliaceae)	BF	100	38	35	80
29	2009	Los Tarrales Reserve	1370	*Ulmus mexicana*	BF	65	28	25	12
30	2009	Los Tarrales Reserve	1400	*Neocupressus lusitanica* var. *lindenii*	OS	33	11.5	10.5	60
31	2009	Los Tarrales Reserve	1400	*Persea americana* (Lauraceae)	OS	60	14	8	70
32	2009	Los Tarrales Reserve	1530	*Ficus aurea*	BF	420	40	20	80