FINAL REPORT

FIELD ASSESSMENT OF THE WHITE-WINGED DOVE AGING TECHNIQUE

submitted to
Texas Parks and Wildlife Department

submitted by
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Abstract: Growth characteristics of eastern white-winged dove (*Zenaida asiatica asiatica*) nestlings are not well documented. A field study was conducted during the 2009 and 2010 breeding seasons to verify the accuracy of an aging key developed using nestlings hatched in captivity. Digital photography was used to monitor 89 wild nestlings to fledging (14 days) with partial data collected from an additional 43 nestlings. Characteristics assessed from the photographs included date of primary, secondary, tail, and dorsal feather emergence (eruption) and development of the white wing patch. The aging key developed using captive nestlings was tested on 25 wild nestlings randomly selected from those photographed, but it did not provide sufficient accuracy. Recursive partitioning was used on the wild nestling dataset to develop a classification tree from which an aging key was developed for younger aged nestlings (≤ 6 days old) and older aged nestlings (≥ 7 days old to fledging). The classification procedure could not classify to exact age those birds 2, 8, 11, 12, and 14 days old because of overlapping nestling characteristics. For nestlings ≤ 6 days old, the procedure had a 69–98% accuracy in correctly classifying nestlings within ± 1 day and 94–100% accuracy ± 2 days. As nestling age increased beyond 6 days, the classification procedure became more variable, reflecting the inability to effectively separate several age classes in older nestlings. The aging key was tested by an experienced observer (William Colson) utilizing 18 photographs of wild nestlings (1 singleton, 1 nestling pair with its nest mate digitally removed, and 1 nestling pair for each age class 1–6 days). All 18 pictures (100%) were scored to exact age. The key was then tested by 25 wildlife students using the same photos. Students exhibited high variability in accurately aging the nestlings, with the most variability occurring in correctly determining exact age (range 0–76% correct). However, students did better when placing the nestling age within ± 1 day (4 –92%), ± 2 days (44–100%), and ± 3 days (60–100%), suggesting that training and or experience in aging nestlings are required when using the aging key. William Colson assessed the final version of the aging key (Part B was revised, necessitating retesting) using 280 images (10 jpg computer images of singletons and 10 jpg images of paired nestlings for each age 1–14). All 20 (100%) nestlings for ages 1, 10, and 13 were correctly aged to exact hatch date; 17 of 20 (85%) were correctly scored for ages 3, 6, and 7; and 16 of 20 (80%) for age 4. Four age classes (3, 5, 8, and 12) were the most difficult to age; however, all (100%) of these could be placed with ± 2 days of actual hatching. Overall, 10 of 14 age categories were correctly scored 100% of the time to exact age or within ± 1 day of actual hatching. Those experienced in using the key should be able to age most nestlings within ± 1 day of hatching and, for those nestlings that have extensive overlap in developmental characteristics, within ± 2 days.

INTRODUCTION

The white-winged dove (*Zenaida asiatica*) is a semitropical columbid found in Central America, Mexico, some parts of the Caribbean islands and South America, Florida, and the southwestern United States (George et al. 1994). Historically, the eastern population of white-winged doves bred primarily in the Lower Rio Grande Valley of Texas (LRGVT) and the adjoining Mexican state of Tamaulipas (Cottam and Trefethen 1968, George et al. 1994). As native habitat was converted for agricultural uses, white-winged doves began to expand northward throughout central, north, and east Texas often breeding in urban areas (George et al. 1994). By 1990, estimates indicated more white-winged doves breeding north of the LRGVT than in the LRGVT (West et al. 1993). Because of their range expansion and productivity, the white-winged dove is now considered the second-most numerous migratory game bird species in North America (George et al. 1994).

Although there have been numerous studies on the ecology of white-winged doves, little information is known about the developmental sequence of nestlings. Developing an accurate aging key for nestling white-winged doves has been attempted with limited results. One rudimentary aging key for hatch-year white-winged doves exists based on an unpublished thesis, which documented daily development from 1–12 days (Alamia 1970). A more recent study (Fedynich and Hewitt 2009) monitored the development of 19 captive nestlings from 1–14 days. While the latter study documented the developmental sequences from which an aging key was developed, captive nestlings were used. A concern of using captive birds to assess feather development is whether the optimal conditions in captivity of both adults and their offspring biases the results. Consequently, it is necessary to field-test the aging key that used captive nestlings and, if needed, make further refinements so that an aging key can be used by biologists and researchers involved in the study of nestling wild white-winged doves.

BACKGROUND SUMMARY OF RESEARCH

The present study continues the assessment of white-winged dove nestling development by photo monitoring wild nestlings and comparing their development to nestling development progression found in the captive white-winged dove aging project *Developing an Aging Criteria for Hatch-Year White-winged Doves* by Fedynich and Hewitt (2009). The captive study was funded in 2006 by Texas Parks and Wildlife Department (TPWD), with supplemental funds provided by the Harvey Weil Sportsman Conservationist Award and ExxonMobil's Summer Intern Program.

Undergraduate student William Colson was hired in 2007 to support the captive white-winged dove aging project. William graduated in May 2008 and entered the graduate program at Texas

A&M University-Kingsville (TAMUK) in August 2008 to continue studying aging characteristics of nestling white-winged doves. William plans to graduate in May 2012 in which the thesis material from the present study will be used in partial fulfillment of the M.S. degree requirements. The first field season in 2009 was funded by the Caesar Kleberg Wildlife Research Institute and supplemented with technician support from ExxonMobil's Summer Intern Program. Beginning on September 1st 2009, the project was supported by a grant from TPWD to Alan Fedynich entitled *Field Assessment of the White-winged Dove Aging Technique*, which covered costs associated with a second field season and completion of the study.

OBJECTIVES

The overall objective was to determine whether the aging key developed using known-age captive nestlings can be used to accurately determine age of nestlings hatched in the wild. The objectives outlined in the proposal are as follows:

1. The aging key developed with captive nestling white-winged doves produced during 2008 by Fedynich and Hewitt (2009) will be used on known-age wild nestlings photographed in the field during 2009 and 2010 to determine the suitability of the aging key in determining the age of nestlings in the wild.
2. If the captive nestling key does not accurately reflect wild nestling ages during 2009, adjustments to the aging key will be made to increase its accuracy for field applications in 2010. Although it is desirable to have high accuracy (> 97%) in a nestling aging key, accuracy cannot be determined until the field-collected data are compared to the aging key. Therefore, it is possible that the most accurate aging key at the end of the study may be (1) the same key developed using captive nestlings (e.g., accurately ages wild nestlings), (2) a combination of features obtained from captive and wild nestlings, or (3) characteristics found only for wild nestlings (e.g., the captive nestling aging key does not accurately age wild nestlings and, thus, data from 2009 and 2010 are more useful in developing an aging key).

Expected Results and Benefits

The expected result from this study is a validated aging key that can accurately estimate the age of wild nestling white-winged doves. Information provided by an aging key has important management implications for TPWD, which is responsible for managing white-winged doves in the state. Field biologists using the aging key will be able to determine white-winged dove nest initiation, egg laying, incubation, and hatch dates from examination of selected characteristics of the wild nestlings and back-dating, which will allow more accurate models describing white-winged dove productivity and annual population structure. By having population-level information, TPWD biologists will be able to better manage the eastern white-winged dove population in Texas.

2009 ACTIVITIES

Undergraduate Student Hired

Joshua Berckenhoff was hired to assist William Colson in conducting field work related activities during the summer.

Field Equipment and Use

A digital camera owned by William Colson was used with a remote trigger mounted on a collapsible metal poll to take pictures of the nestlings. The camera was a Sony A-100 10.2-megapixal digital SLR camera. The remote trigger was attached using electrical tape to the camera and the camera had an 18–70 mm lens that was set to a fixed focal length for depth of field consistency across photos. A digital web camera (Microsoft LifeCam NX-3000 Webcam) was attached atop the Sony camera; a USB cable extended from the web camera to a PC laptop. The entire camera setup was mounted on a modified tripod. The modified tripod was attached to the top of an 18 ft extendable paint pole.

When a candidate nest was found, the pole was extended near the nest by William while the technician watched the laptop monitor. The technician would tell William which direction to face the camera for taking pictures of the nest. We attempted to limit photography to 3 minutes; this time frame included the moment the pole was extended until we either took photographs and/or time expired. The 3-minute time frame was used to limit nest disturbance. In some cases, nestlings were difficult to photograph because of obstruction by branches or leaves, as well as defensive behavior of the adults.

In conjunction with the digital photographs, we attempted to record video of nest defensive behavior by adults or nestling behavior. Video footage was not the primary source of photographs examined in this study because the resolution was insufficient to note most nestling attributes.

During the first field season, we tested different approaches to safely and effectively photograph nestling development to be better prepared for the 2010 breeding season. Improvements made included securing cables for shutter control and the web-based camera to the extendable pole used to photograph nestlings as well as removing any unnecessary parts from the camera tripod adapter to prevent damaging the camera or inadvertently damaging nests or knocking nestlings from their nests.

Field Monitoring Activities and Data Collected

Nest searches began in Kingsville on June 10th. The first nest found was on June 11th; the first nestling hatched was on June 15th. Nests with eggs were monitored to hatching so that only known age nestlings were used in the study. Nests that had hatchlings of unknown hatching date were excluded from the study. Known age nestlings were photographed every other day from the day of hatching to fledging or their disappearance from the nest. We attempted to take photographs at a down-angle of 30–45° to provide as much of the side and top profile of the nestlings as possible. In some cases, only a side profile or top profile was available due to branches blocking the camera. Additionally, we recorded hatch date, hatch sequence, and brood size.

Field monitoring activities ended when no nests with eggs were found and the last monitored nestling was no longer present in the nest (September 4th). Once a nest was no longer active (predation, severe weather, eggs or nestlings missing, nestling reached age sufficient to fly and was missing), we collected GPS coordinates and height of the nest for possible ancillary research and publications on nesting densities and distribution of nests within the habitat.

Poor nesting conditions resulting from drought conditions occurred in the study area, greatly reducing the number of nesting attempts of white-winged doves. Nineteen nestlings (11 nests) were monitored to fledging (11–14 days), with partial data collected on 14 additional nestlings (10 nests) that disappeared from the nest before reaching fledging age, representing information collected on 9 singletons and 12 pairs of nestlings. In addition, 15 nests were found in various stages of construction, but no eggs were observed. Four monitored nests (8 eggs) were destroyed by weather or predation events.

Database Development

Photographic data were downloaded from the digital camera to a laptop computer and backed up to external disks. Review of photo and video images and database development were initiated. Data from the photographs and video were collected on the same variables used to characterize nestling development of captive white-winged doves (Fedynich and Hewitt 2009), which included the following measured in days: eyes slightly open, eyes fully open, emergence of primary feathers, emergence of secondary feathers, emergence of tail feathers, start of primary feather unfurling, emergence of back feathers, beginning appearance of white on wing, full white on wing, and fully feathered. The dataset was still being compiled from the photo and video images at the end of 2009. Over 1,100 photos were collected as well as 10–15 minutes of video test-shots, nestlings, and a clip of an adult dove protecting the nest with wing-flapping.

Information Transfer

A research summary of the study entitled *Field Testing the Captive Aging Key for Wild White-winged Dove Nestlings* by W. C. Colson, J. A. Berckenhoff, A. M. Fedynich, D. G. Hewitt, and S. Kremer was included in the Caesar Kleberg Wildlife Research Institute's (CKWRI) 2008–2009 Current Research report, which was distributed to stakeholders and individuals requesting copies. Additionally, the Current Research report was posted as a downloadable PDF file on CKWRI's web site: http://www.ckwri.tamuk.edu/.

2010 ACTIVITIES

Undergraduate Student Hired

Trevor Kalich was hired in June to assist in field collection of data and he continued through September when the field season ended.

Field Monitoring Activities and Data Collected

In April, nest searches began in Kingsville. Additionally, it was decided to expand nest searches to other cities in case nesting activity in Kingsville was poor, similar to what occurred in 2009. During the first week of July, we began searches in San Diego, George West, Alice, Hebbronville, Bishop, and Corpus Christi.

In some cases, nestlings as early as 10 days old could not be properly photographed due to nestlings attempting to move from the camera towards the edge of the nest. Whenever nestlings were noted as becoming “jumpy” or sitting on the edge of their nest, no photographs were taken using the camera pole setup to ensure the nestlings did not fall from the nest; instead, photographs were taken using a telephoto lens when possible (if nestlings were not obscured by branches or leaves).

As more nests were added to the observation roster, we began to opportunistically photograph some nestlings every day because we were already in the area photographing nestlings or photographing nestlings in other nests within the same tree. This allowed us to collect more photographic data than originally planned.

The first nest was located on April 27th; the first nestling hatched on May 7th. Over 350 active white-winged dove nests were found. This count included empty white-winged dove nests, nests with eggs, and nests that already had nestlings in them when first found. In addition to the active nests found in the Kingsville area (n = 318), we found and monitored a few nests in San Diego (n = 4), George West (n = 1), Corpus Christi (n = 6), and Alice (n = 24); no nests were found in Hebbronville or Bishop where we had property access.

Seventy nestlings were monitored to fledging, with partial data collected on 29 nestlings and represents data collected on 19 singletons and 40 pairs of nestlings. Partial data obtained on the 29 nestlings resulted when nestlings disappeared from the nest before being able to fly. As the end of breeding season approached, we noticed fewer nests being constructed and by the end of August, no new nests were found. More than 10,000 pictures and almost 15 minutes of video of nestlings and adult defensive behavior were taken during the second field season.

We documented the loss of 106 eggs. These eggs were knocked out of the nest from unknown causes (i.e., eggs found on the ground), failed incubation, or apparent predation. In one area within the city of Alice, we documented the loss of 6 of 7 active nests over the course of several days. For one of these, we observed an eastern fox squirrel (*Sciurus niger*) proceeding to a nest and eating both eggs; we documented this predation event using a digital camera. Eggs in a nest found on the TAMUK campus showed signs of being predated upon by a bird; the eggs appeared to have been pecked on one end as opposed to being torn apart by mammalian predators such as squirrels.

Once a monitored nest was no longer active, we collected GPS coordinates and height of the nest for possible ancillary research and publications on nesting densities and distribution of nests within the habitat (data file: Nests_GPS_Ht.xlsx on hard drive supplied to TPWD).

Database Development and Analysis

The photographic and video dataset for 2009 was completed in 2010 as well as data from the 2010 nesting season. Because of the low sample size in 2009 (19 nestlings monitored to completion and partial data on 14 nestlings), we did not compare the captive nestling aging key with the 2009 dataset (as per first part of Objective 2). We decided to wait to make comparisons once the entire database was completed using both field seasons, which would provide for stronger computational analyses. Summary statistics for the entire 132 nestling dataset, representing findings from 2009 and 2010, are presented in Table 1 and Figure 1.

Information Transfer

A poster was presented using data collected in 2009 (before TPWD funding) at the annual meeting of the Southwestern Association of Naturalists entitled *Determination of Growth Characteristics of Wild White-winged Dove Nestlings* by W. Colson and A. Fedynich. Two research summaries entitled *Field Testing the Captive Aging Key for Wild White-winged Dove Nestlings* by W. C. Colson, T. Kalich, J. A. Berckenhoff, A. M. Fedynich, D. G. Hewitt, and S. Kremer and *Assessing Defensive Behaviors Exhibited by Nesting White-winged Doves* by J. A. Berckenhoff, W. C. Colson, and A. M. Fedynich (data from summer 2009) were submitted for publication in CKWRI's 2009–2010 Current Research report. The Current Research report was distributed to stakeholders and individuals requesting copies and posted as a downloadable PDF file on CKWRI's web site: http://www.ckwri.tamuk.edu/.

2011 ACTIVITIES

Data Analysis and Key Testing

Dr. Andrea Litt (CKWRI statistician) was scheduled to help William Colson perform statistical analyses, but left the position at the end of 2010 before any progress could be made. Dr. David Wester, Andrea's replacement, arrived at CKWRI on June 1st. Before his arrival, we attempted to evaluate the white-winged dove captive nestling aging key using a sample of 50 wild nestlings that used the entire criteria of 10 diagnostic characteristics. There was an overall accuracy of 64% suggesting a more comprehensive analysis was needed, which required a statistician.

Detailed data analysis began with Dr. Wester in which the captive nestling aging key was tested using at least 10 wild nestlings from each age class (i.e., Day 1, Day 2, etc.). By increasing the sample size for each age class, we believed this would increase the accuracy of the captive nestling aging key. This did not prove to be the case. Results from younger nestlings aged less than 6 days old suggested an accuracy of at least 90% at ± 2 days of age, whereas older nestlings were keyed with less accuracy even with the increased range of ± 2 days. These findings suggested that the key developed from captive nestlings was not appropriate for aging wild nestlings.

We began to develop a new aging key during July 2011, based on the wild nestling data and separating nestlings into younger and older nestlings, since key characteristics of one age group do not fit well or were not applicable for the other age group. This required reducing the number of characteristic variables in the aging key (10 variables were originally monitored in the captive and wild nestling studies). We created 5 simplified keys based on the pertinent variables for younger and older nestlings. These keys used a range of ± 2 days, but high accuracy could not be achieved across all age classes. We then reanalyzed the accuracy of the new key using discriminate analysis based on a random sample size of 49 nestlings. This data were then used to create a classification tree that classified age class first into younger and older nestling groups and then with sub-classifications of each group. Though accuracy was increased slightly, older nestlings still were not accurately aged, particularly for nestlings older than 8 days.

Based on the above findings that the key needed to be partitioned into younger and older nestlings, we incorporated the entire database of wild nestlings and used recursive partitioning and classification tree statistical procedures to separate and assess the accuracy of identifying younger nestlings ($\leq$ 6 days; Figure 2, Part A; Table 2) and older nestlings ($\geq$ 7 days; classification tree not presented here as this part was subsequently revised; see Table 5 for final version) from which the new aging key was constructed.

William Colson initially tested the key to determine how accurately he could age nestlings, given his multiple years of experience with nestlings. Because William originally took the photos of the nestlings to be used in the test, we attempted to minimize bias by having a volunteer select digital images of wild nestlings representing singletons and pairs corresponding to each age class. Additionally, we wanted to determine if nest mates influenced the aging ability of the observer (e.g., could an observer use characteristics of both nest mates to determine age, given that nestlings are typically separated by 1 day in age). William digitally removed one of the nestlings from each digital image containing the paired nestlings. Thus, the test included nestling photographs (singletons, one nestling digitally removed from the nestling pair, and nestling pairs), which represented 3 photos of nestlings in each age class. Additionally, after printing the images for the test, volunteers placed each of the photos into individual file folders. The folders were then randomly shuffled before being numbered. Approximately 4 days elapsed before William tested the key using these photos; this lapse in time reduced the chances of him retaining short-term memory of select features of the photos that might help him age the nestlings from the paired nestling images. Because the aging key regarding the older-aged nestlings was revised, only data from the younger aged birds are presented in Table 3. William was able to age nestlings to exact age with 100% accuracy (Table 3).

A second test was performed to access the aging ability of marginally trained individuals using the same set of photographs that were previously used by William Colson. For this test, a visual aid was developed that had a picture of both a younger and older nestling in which key characteristics of both age groups were noted and was attached to the aging key. The Wildlife Management Techniques class at TAMUK tested the aging key as part of an instructional exercise in wildlife aging techniques. During the class period, William provided the students with a brief description of the key and outlined the testing procedures. Thirty-five students participated in the class exercise from which 25 responses were usable. Results from this test of the aging key were analyzed for accuracy for each nestling age class, arranged by percentage of students that correctly scored exact age, age within ± 1 day, age within ± 2 days, and age within ± 3 days. Students exhibited high variability in accurately aging the nestlings (Table 4). When the data were examined by whether a student could age the nestling within ± 1 day, ± 2 days, and ± 3 days of the nestling's actual age, more students were able to place the nestlings into a range of days, and placement increased as the range of days increased (Table 4). Paired nestling scores were somewhat higher than singletons. However, photographs edited to show only one nestling had mixed results.

We decided to determine if accuracy in predicting ages could be increased further and several iterations were made with recursive partitioning and classification tree analyses. There was no improvement in aging ≤ 6 day-old birds over that used to develop the aging key tested by William Colson and the students, whereas additional improvement was accomplished with Part B (Figure 2, Part B; Table 5). In this process, we decided to use characteristics that prioritized the younger nestling ages 7–10 because these nestlings were more likely to be found by field biologists and researchers, compared to the 11–14 day-old nestlings that are already flight-capable and can leave the nest.

The final version of the aging key is presented in Table 6. William Colson subsequently tested the final aging key in which 10 computer jpg images of singletons were examined for 1–14 day-old birds (140 individual images) and 10 computer jpg images of paired nestlings were examined for 1–14 day-old birds (140 individual images), totaling 280 total images scored. All 20 (100%) images for ages 1, 10, and 13 were correctly aged to exact hatch date; 17 of 20 (85%) were correctly scored for ages 3, 6, and 7; and 16 of 20 (80%) for age 4 (Table 7). Four age classes were the most variable (3, 5, 8, and 12); of these birds, all (100%) could be placed with ± 2 days of actual hatching (Table 7). Overall, 10 of 14 age categories were correctly scored 100% of the time to exact age or within ± 1 day of actual hatching (Table 7).

Ancillary Data Collection

NOAA rainfall and temperature data were collected for April–August 2009 and 2010 from Corpus Christi, Texas with the assumption that these data were comparable to our study sites. Monthly high temperatures for each breeding season and percentage of nests found in each breeding season did not appear to be correlated during either year (Figure 3). Likewise, monthly mean rainfall did not appear to have an effect on new nest establishment during either year (Figure 4). We expected to see a difference at least between drought and non-drought breeding seasons, however, unequal sampling effort and geographic coverage between years likely masked any real differences. For example, even though the percentage of new nests was highest during the drought year of 2009, the total number of nests found was also the lowest in 2009. Regardless, both graphs do show that July was the peak in new nest establishment in both years (Figures 3 and 4).

During the drought year, some nestlings seemed to take longer in reaching each of the characteristics monitored than those in the non-drought year as evidenced by elevated means and wider ranges (Figure 5). However, variation (Standard Deviation) around the means overlapped for each monitored variable between years suggesting no statistical differences (Figure 5).

Information Transfer

A poster was presented at the Texas Chapter of The Wildlife Society meeting entitled *Testing a Captive White-winged Dove Nestling Aging Key* by W. C. Colson, A. M. Fedynich, and S. Kremer. At the meeting, undergraduate technician Trevor Kalich presented a poster on some of the ancillary data entitled *Distribution of Nesting Bird Species on the TAMUK Campus* by T. Kalich, W. C. Colson, A. M. Fedynich, and S. Kremer.

Two research summaries entitled *Distribution of Nesting Bird Species on the TAMUK Campus* by T. Kalich, W. C. Colson, A. M. Fedynich, and S. Kremer and *Field Testing the Captive Aging Key for Wild White-winged Dove Nestlings* by W. C. Colson, T. Kalich, J. A. Berckenhoff, A. M. Fedynich, and S. Kremer were published in CKWRI's 2010–2011 Current Research report. The report is distributed to stakeholders and individuals requesting copies and posted as a downloadable PDF file on CKWRI's web site: http://www.ckwri.tamuk.edu/.

One article *Predation of a White-winged Dove Nest by a Fox Squirrel* by W. Colson, T. Kalich, A. Fedynich, and S. Kremer was submitted to the Bulletin of the Texas Ornithological Society and was accepted for publication. It is scheduled to appear in the Winter 2011 issue (available in spring 2012).

William Colson will be presenting the study's findings at the Texas Chapter of The Wildlife Society's annual meeting in February 2012. Furthermore, William plans to develop and present a thesis from the information obtained in this study in partial fulfillment of the requirements of a M.S. degree at TAMUK. These venues will disseminate the study's findings to researchers, biologists, stakeholders, interested individuals, and the general public.

DISCUSSION

The white-winged dove captive nestling aging key was initially evaluated on a sample of wild nestlings from the 2009 and 2010 breeding seasons in which multiple analytical attempts were made to determine the aging key's usefulness on wild nestling. In each case, the aging key developed from the captive nestlings lacked sufficient accuracy for aging wild nestlings. It is likely that captive nestlings benefited from abundant high quality food, water, and 2 parents feeding them within the aviary environment (optimal hatchling developmental conditions), compared to what nestlings experienced in the wild creating more variability in when wild nestlings obtained key characteristics being measured.

During our testing of the captive nestling aging key, it also became apparent that there was a dichotomy between young and old nestlings that needed further exploring. Recursive partitioning was used on the wild nestling dataset to classify younger aged nestlings and older aged nestlings.

However, ages 2, 8, 11, 12, and 14 could not be separated to exact age using the classification procedure, although substantial improvement occurred when estimates placed the nestling age within a range of days. This reflected the difficulty in distinguishing subtle characteristics that separate these ages from those of the day before or the day after and was demonstrated by higher accuracy obtained within a given set of ranges (± 1 day and ± 2 days).

Students exhibited high variability in accurately aging the nestlings using the key. The most variability was observed in correctly determining exact age, but the students became more successful in placing ages with a range, which increased as range of days increased from ± 1 day, ± 2 days, and ± 3 days, respectively. Paired nestling scores were somewhat higher than singletons, which suggested the possibility that having a second nestling in the nest helps to increase accuracy by contrasting characteristics of both nestlings, if only marginally. It is likely that a picture guide of each age class would have been beneficial as a diagnostic aid, where those students that are more visually oriented would be able to use the pictures to quickly narrow down the age range after which the key could be used to separate nestlings to day. These findings suggest that training and/or experience in aging nestlings are required to improve accuracy when using the aging key.

CONCLUSION

It is apparent from our study that aging a white-winged dove nestling to the exact day is more difficult than aging within a given range of days. This results from the fact that day-to-day characteristics are often subtle making it difficult to age the nestlings separated by 1 day. Additionally, one nestling may have several diagnostic characteristics concurrently, whereas another nestling may have these same characteristics separately, thereby making it difficult to correctly age the former nestling and making it easy to age the latter nestling. Although there are some issues with the aging key because of inability to exactly age some nestlings, we believe researchers and biologists who work with white-winged doves will be able to use this key successfully. Depending on the desired level or resolution of nestling age, aging to exact age will likely not be possible for nestlings that share concurrent diagnostic characteristics of day before or day after nestlings.

Expertise is an important factor in increasing the likelihood of accurately aging a nestling as demonstrated by William's ability to correctly age nestlings and minimally trained students not so well. As a way to improve the accuracy of field personnel, we recommend that the attached picture guide (Figure 6) be used as a reference to the aging key to aid in quickly narrowing down the age range after which the key can be used to separate nestlings to day. Nestlings in these photographs show specific characteristics, which are typically found for each age class. It is recommended that researchers, biologists, and their field assistants study the aging key and attached photo guide to increase their ability to accurately age wild white-winged dove nestlings. Individuals that become proficient with the aging key and the picture guide should be able to age most nestlings at least within ± 1 day of hatching and, for those nestlings that have extensive overlap of developmental characteristics, within ± 2 days.

LITERATURE CITED

Alamia, L. A. 1970. Renesting activity and breeding biology of the white-winged dove (*Zenaida asiatica*) in the Lower Rio Grande Valley of Texas. M.S. Thesis, Texas A&M University, College Station, TX.

Cottam, C., and J. B. Trefethen. 1968. Whitewings: The Life History, Status, and Management of the White-winged Dove. D. Van Nostrand Co., Inc., Princeton, NJ.

Fedynich, A. M., and D. G. Hewitt. 2009. Developing an aging criteria for hatch-year white-winged doves. Final report to Texas Parks and Wildlife Department, 22 p.

George, R. R., R. E. Tomlinson, R. W. Engel-Wilson, G. L. Waggerman, and A. G. Spratt. 1994. White-winged dove. Pages 29–50 *in* Migratory Shore and Upland Game Bird Management in North America, Second Edition, T. C. Tacha and C. E. Braun, eds. The International Association of Fish and Wildlife Agencies, Washington, DC.

West, L. M., L. M. Smith, R. S. Lutz, and R. R. George. 1993. Ecology of urban white-winged doves. Transactions of the North American Wildlife and Natural Resources Conference 58:70–77.

Table 1. Descriptive statistics measured in days for 10 developmental characteristics of 132 nestling white-winged doves.

Statistic	Eyes Slightly Open	Eyes Fully Open	Primary Feather Emergence	Secondary Feather Emergence	Tail Feathers Emergence	Primaries Start Unfurling	Back Feathers Emergence	White Patch Develops	Full White on Wing	Fully Feathered
Range	3–6	4–8	2–7	2–7	3–9	6–10	3–9	8–13	10–13	12–14
Median	4	6	3	3	5	8	5	9	12	13
Mean	4.3	5.7	3.5	3.7	4.9	7.8	5.5	9.3	11.9	13.3
Std. Dev.	0.9	1.1	1.0	1.1	1.2	0.9	1.0	1.1	0.9	0.7
*n**	23	64	105	104	93	85	92	74	31	12

* Sample size for each characteristic varies because certain nestling characteristics were blocked by branches and leaves in the photos, shadows across nestlings in photos obscured certain characteristics, behavioral factors of defensive adults or nestlings sometimes precluded photos of the nestlings, and the absence of nestlings previously photographed due to predation or leaving the nest.

Table 2. Final results of the recursive partitioning and classification tree statistical procedures for white-winged dove nestlings ≤ 6 days old.

True age	Exact age	Correct	± 1 day	Correct	± 2 days	Correct
1	107/109	98%	107/109	98%	109/109	100%
2	0/108	0%	106/108	98%	108/108	100%
3	61/100	61%	76/100	76%	100/100	100%
4	31/89	35%	61/89	69%	84/89	94%
5	1/83	1%	73/83	88%	82/83	99%
6	62/75	83%	62/75	83%	72/75	96%

Table 3. Results of the aging key assessment performed by William Colson using 18 pictures (1 singleton, 1 nestling pair with its nest mate digitally removed, and 1 nestling pair for each age class) of wild white-winged dove nestlings.

	Singleton nestlings			Paired nestlings with one nestling removed from the photograph			Paired nestlings		
	Correct			Correct			Correct		
Age in Days	Exact	± 1 day	± 2 days	Exact	± 1 day	± 2 days	Exact	± 1 day	± 2 days
1	100%	-	-	100%	-	-	100%	-	-
2	100%	-	-	100%	-	-	100%	-	-
3	100%	-	-	100%	-	-	100%	-	-
4	100%	-	-	100%	-	-	100%	-	-
5	100%	-	-	100%	-	-	100%	-	-
6	100%	-	-	100%	-	-	100%	-	-

Note: Results for bird ages 7–14 were excluded because Part B of the key was subsequently revised, thereby making those results invalid.

Table 4. Results of the aging key assessment performed by 25 wildlife students using 18 pictures (1 singleton, 1 nestling pair with its nest mate digitally removed, and 1 nestling pair for each age class) of wild white-winged dove nestlings.

	Singleton nestlings				Paired nestlings with one nestling removed from the photograph				Paired nestlings			
	Correct				Correct				Correct			
Age in Days	Exact	± 1 day	± 2 days	± 3 days	Exact	± 1 day	± 2 days	± 3 days	Exact	± 1 day	± 2 days	± 3 days
1	60%	64%	76%	96%	76%	80%	84%	96%	76%	88%	92%	96%
2	4%	44%	84%	88%	0%	60%	88%	96%	8%	60%	88%	88%
3	16%	60%	100%	-	12%	64%	92%	96%	28%	60%	88%	100%
4	40%	88%	92%	100%	40%	80%	96%	100%	36%	72%	96%	100%
5	8%	71%	83%	96%	4%	80%	96%	96%	4%	92%	100%	-
6	4%	4%	44%	60%	64%	68%	80%	100%	68%	72%	100%	-

Note: Results for bird ages 7–14 were excluded because Part B of the key was subsequently revised, thereby making those results invalid.

Table 5. Final results of the recursive partitioning and classification tree statistical procedures for white-winged dove nestlings ≥ 7 days old.

True age	Exact age	Correct	± 1 day	Correct	± 2 days	Correct
7	60/64	94%	60/64	94%	64/64	100%
8	0/52	0%	52/52	100%	-	-
9	27/42	64%	28/42	67%	42/42	100%
10	2/30	7%	25/30	83%	25/30	83%
11	0/21	0%	1/21	5%	19/21	90%
12	0/15	0%	1/15	7%	1/15	7%
13	5/11	45%	5/11	45%	5/11	45%
14	0/4	0%	4/4	100%	-	-

Table 6. Final aging key for nestling white-winged doves 1–14 days old.

Begin with Part A if primary feathers AND secondary feathers have not unfurled, otherwise proceed to Part B.

Part A*: Aging key for nestlings ≤ 6 days old.

1. Primary feathers have not emerged…..…………………...…………..………...………go to 2
   Primary feathers have emerged..…………………………………………...……..go to 5

2. Back feathers have started to emerge.…………………..……………….………age = 4 days
   Back feathers have not started emerging….……………………………….…...…go to 3

3. Secondary feathers have not started to emerge……………..…………….……..…age = 1 day
   Secondary feathers have started to emerge………………………….……………go to 4

4. Tail feathers have not started to emerge…………………….…….…………..…age = 4 days
   Tail feathers have started to emerge………....……………………..………..………age = 5 days

5. Tail feathers have not started to emerge ………...………………………….....……...go to 6
   Tail feathers have started to emerge ………………………………………...……go to 8

6. Primary feathers have started to unfurl...……………………....………………age = 6 days
   Primary feathers have not started to unfurl…...................................………………go to 7

7. Back feathers have not started to emerge …………………………....…..……age = 3 days
   Back feathers have started to emerge …………………………………………age = 4 days

8. Back feathers have started to emerge……………………………….………age = 6 days
   Back feathers have not started to emerge………………………………………go to 9

9. Primary feathers have not started to unfurl…......………………………………...age = 4 days
   Primary feathers have started to unfurl………...……………………..………..age = 6 days

*There is no classification for age 2 because of extensive overlap of nestling characteristics.

Table 6. *Continued.*

Part B:** Aging key for nestlings $\geq$ 7 days old.

1. White patch on wing not fully white ....7 days old
1. White patch on wing fully white...go to 2

2. Nestling fully feathered ....13 days old
2. Nestling not fully feathered ....go to 3

3. Tail feathers have not started to emerge ....9 days old
3. Tail feathers have started to emerge...10 days old

**There is no classification for age 8, 11, 12, or 14 because of extensive overlap of nestling characteristics.

Table 7. Results of the final version of the aging key test assessment performed by William Colson using 280 digital images of wild white-winged dove nestlings.

	Singleton nestlings*			Paired nestlings*			Total**		
	Correct			Correct			Correct		
Age in Days	Exact	± 1 day	± 2 days	Exact	± 1 day	± 2 days	Exact	± 1 day	± 2 days
1	100%	-	-	100%	-	-	100%	-	-
2	0%	100%	-	0%	100%	-	0%	100%	-
3	90%	90%	100%	80%	80%	100%	85%	85%	100%
4	90%	100%	-	70%	100%	-	80%	100%	-
5	0%	100%	-	0%	80%	100%	0%	90%	100%
6	80%	100%	-	90%	100%	-	85%	100%	-
7	90%	100%	-	80%	100%	-	85%	100%	-
8	0%	50%	100%	0%	70%	100%	0%	60%	100%
9	0%	100%	-	0%	100%	-	0%	100%	-
10	100%	-	-	100%	-	-	100%	-	-
11	0%	100%	-	0%	100%	-	0%	100%	-
12	0%	0%	100%	0%	0%	100%	0%	0%	100%
13	100%	-	-	100%	-	-	100%	-	-
14	0%	100%	-	0%	100%	-	0%	100%	-

* Ten images of singletons and 10 images of paired nestlings were examined for each age 1–14 (140 individual images for singletons and 140 individual images for paired nestlings).

** Total represents the combined scores for singletons and paired nestlings; 20 images for each age 1–14 (280 total images).

Figure 1. Graphical representation of 10 developmental characteristics measured in days of 132 nestling white-winged doves.

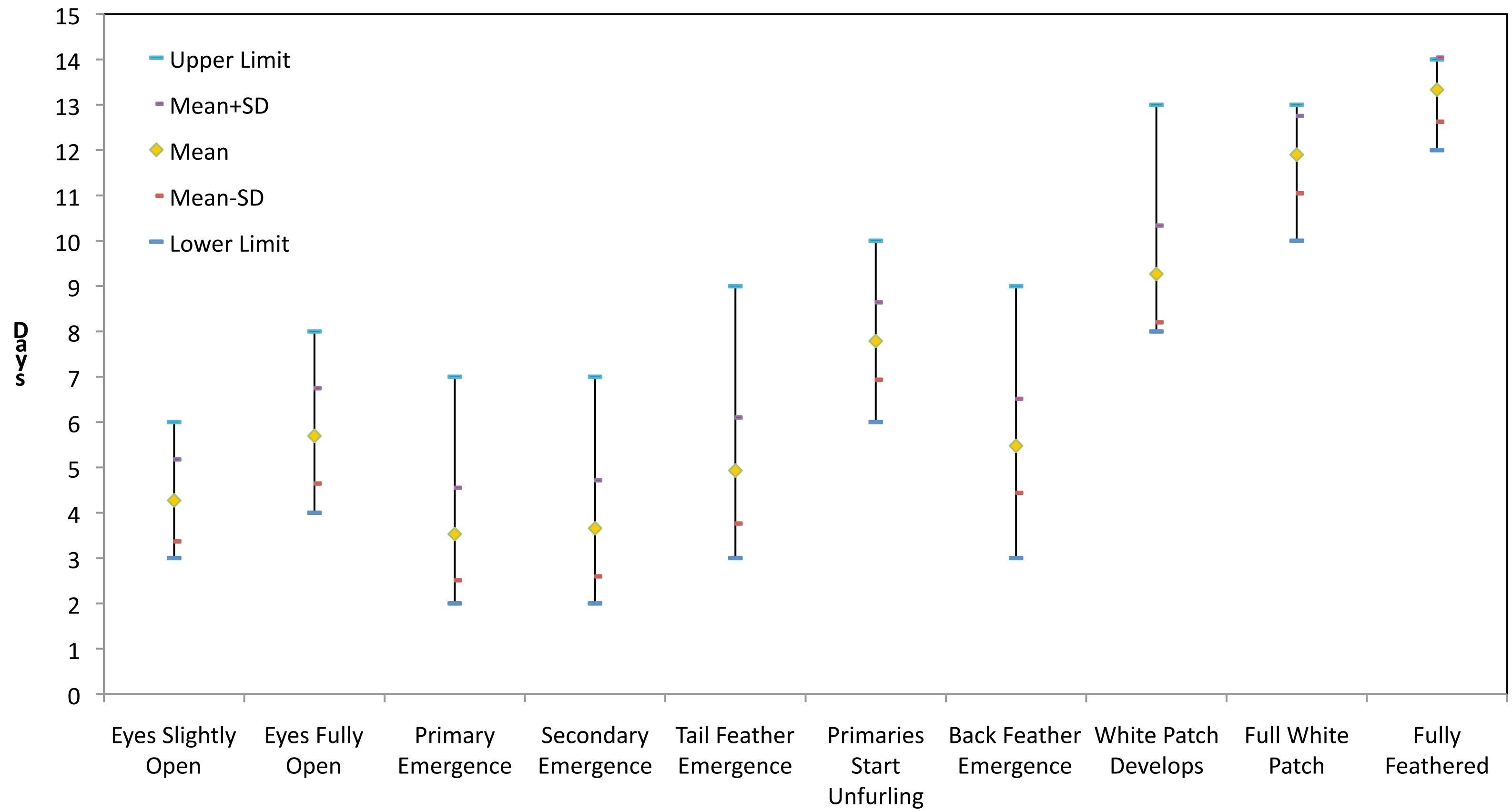

Figure 2. Classification tree partitioning of variables for white-winged dove nestlings ≤ 6 days old (A) and nestlings ≥ 7 days old (B).

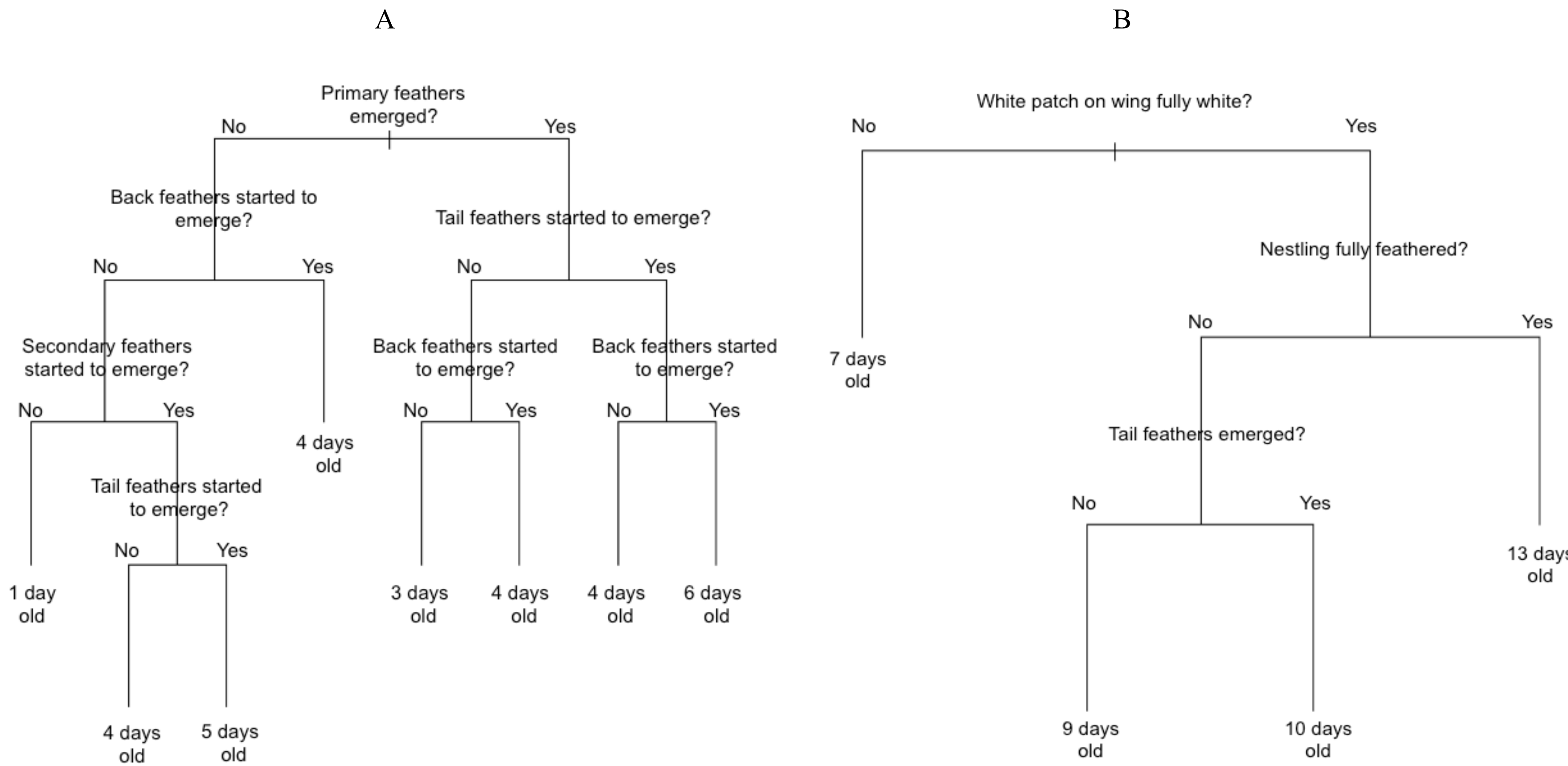

Figure 3. Monthly mean high temperatures (F°) compared to percentage of nests found per month from April–August for 2009 and 2010.

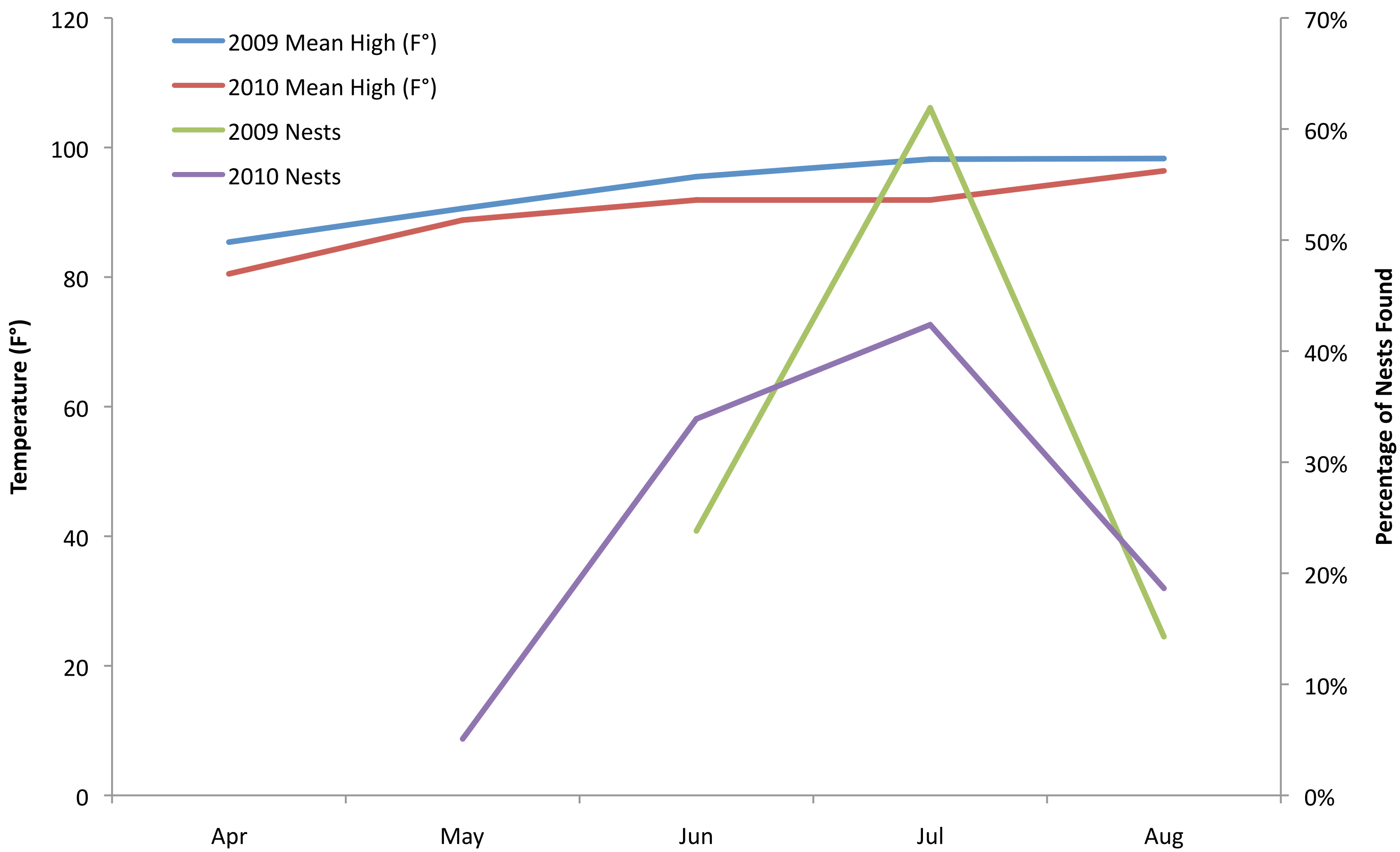

Figure 4. Monthly mean rainfall, in inches, compared to percentage of nests found per month from April–August for 2009 and 2010.

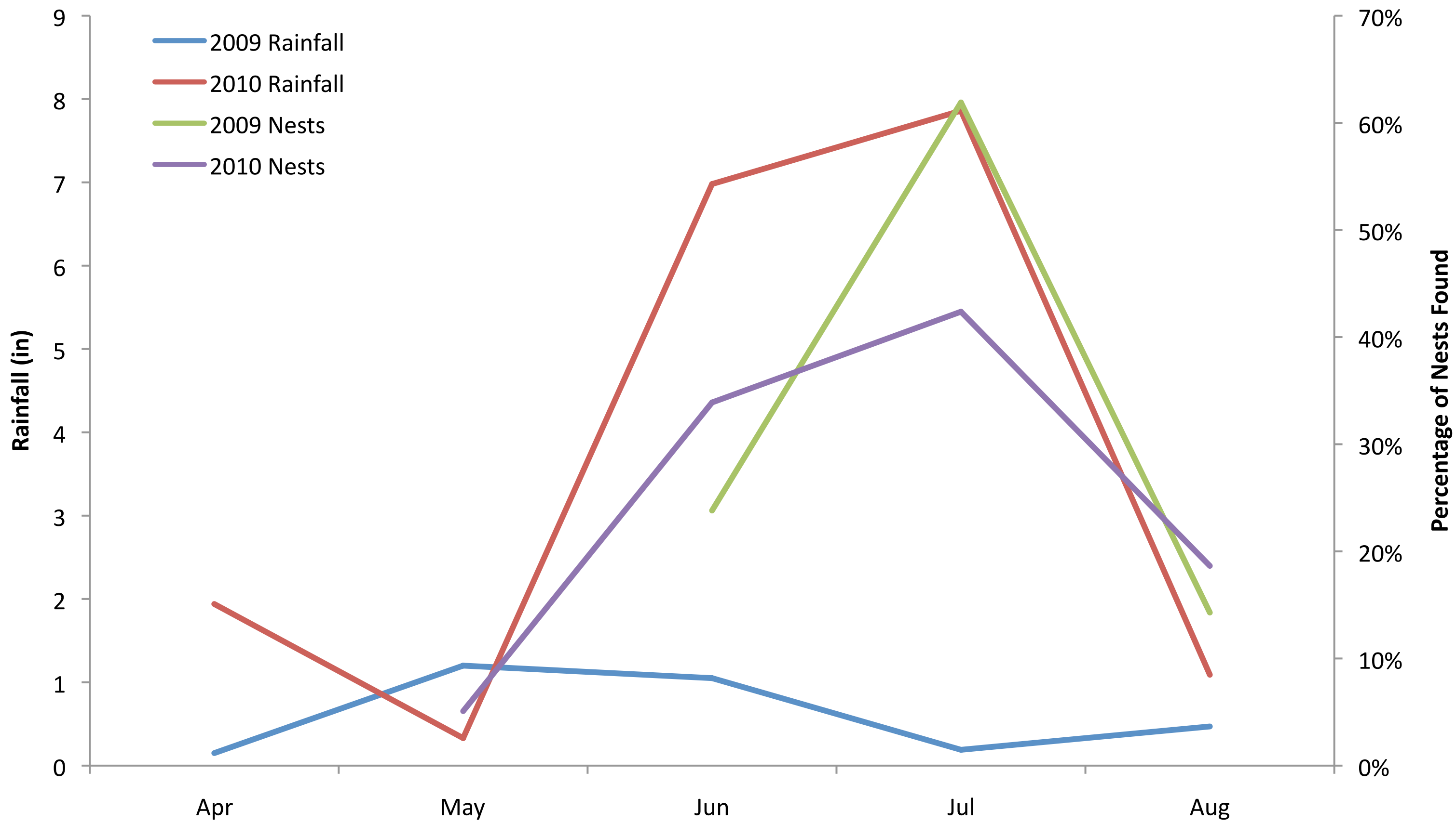

Figure 5. Comparison of traits in days for 2009 and 2010. Rainfall is in inches (Y-axis).

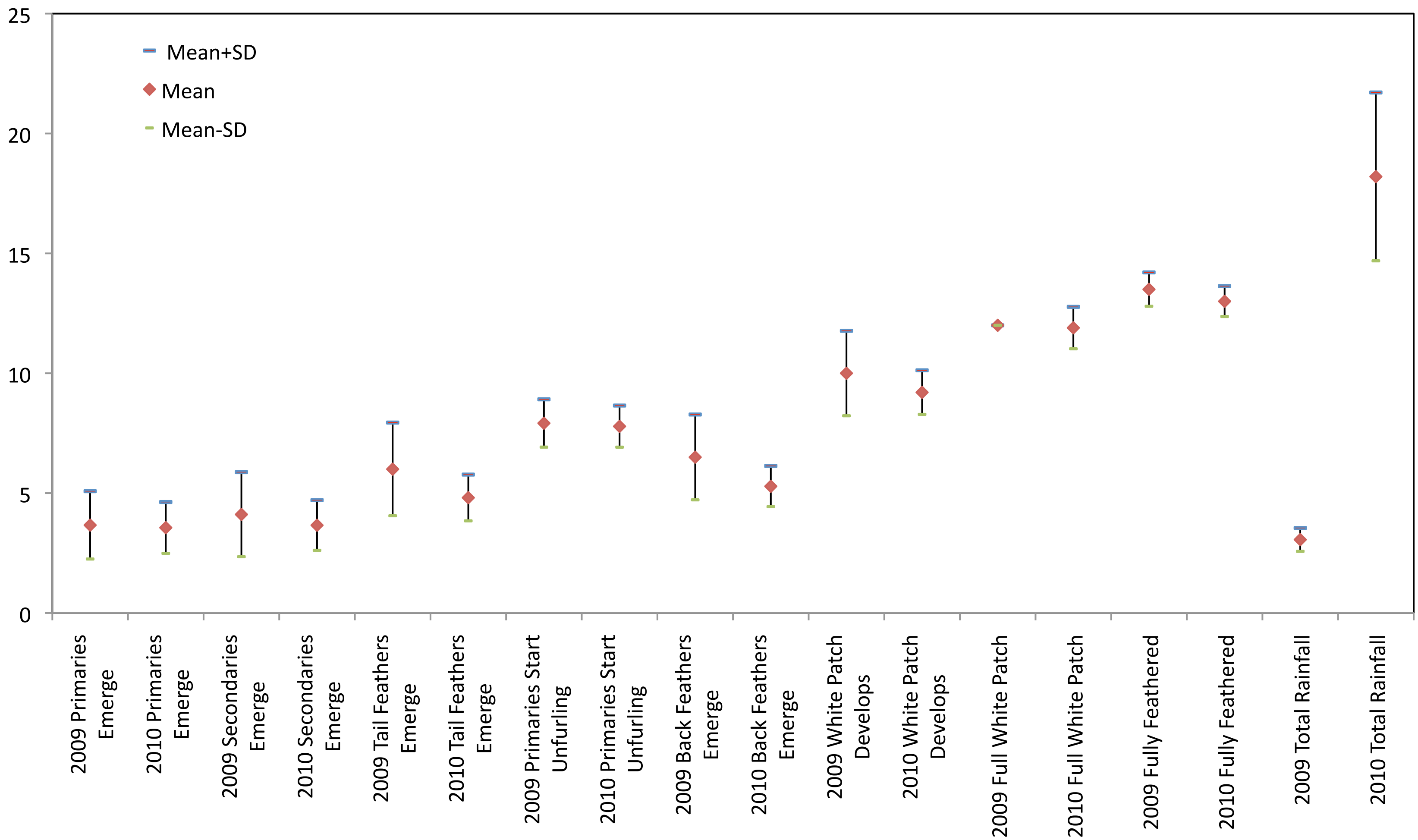

Figure 6. Visual characteristics for white-winged dove nestlings from 1–14 days old.

Day 1: Nestling is covered in downy feathers. Head is normally tilted to one side because neck is not strong enough to support its head for extended periods of time.

Day 2: In paired nestlings, second nestling usually hatches the second day. A 2 day-old nestling is generally a little larger than its nest mate. Primary feathers may have begun emerging.

Day 3: Primary and secondary pin feathers have started to emerge. Tail feathers may or may not be emerging.

Day 4: Primary and secondary feathers are more pin-like. Tail feathers have begun emerging.

Figure 6. *Continued.*

Day 5: Back feathers have begun emerging. Primary and secondary feathers are very long but have not unfurled.

Day 6: Primaries may or may not have begun to unfurl.

Day 7: Primary and secondary feathers have begun unfurling.

Day 8: Primaries continue to unfurl. White patch on wing may become visible.

Figure 6. *Continued.*

Day 9: White patch on wing becoming more prominent on wing.

Day 10: White patch on wing filling in. From Day 10 onward, nestling may leave nest if disturbed. Caution should be used.

Day 11: Feathers along back continue to fill in. For pairs, both nestlings may or may not be in nest. Look near adjacent branches for second nestling.

Day 12: Back feathers have filled in. Nestlings are prone to flitter-fly from nest to ground.

Figure 6. *Continued.*

Day 13: Feathers almost fully developed on head (foreground nestling).

Day 14: Nestling may not be present in nest; may be perched nearby in adjacent branches. Nestlings may or may not be perched together. Nestlings are flight capable and fully feathered. White patch is fully formed.