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DOCUMENTING MOLT-MIGRATION IN WESTERN KINGBIRD (*TYRANNUS VERTICALIS*) USING TWO MEASURES OF COLLECTING EFFORT

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Abstract.—We used museum specimens to describe the timing and location of the postbreeding molt in Western Kingbird (*Tyrannus verticalis*), an insectivore that breeds in arid lowlands of western North America, where late summer conditions are exceedingly dry. Like many other western migrants, adult Western Kingbirds depart their breeding grounds and move to molt in the Mexican monsoon region. By contrast, juveniles stay on the breeding grounds in late summer, delaying their eccentric primary molt and body molt until after undertaking part of their fall migration. The high number of juvenile specimens collected on the breeding grounds in late summer confirms that the decrease in adults, measured as the percentage of all Western Kingbirds that are adults, is not an artifact of inactive collectors. We also demonstrate adult departure using museum databases to calculate the percentage of all passerines collected in breeding areas outside the southwestern molting grounds that were adult Western Kingbirds. The close correlation between these indices validates the use of total number of passerines as an index of the collecting effort targeting a specific passerine. Our results provide another example of the importance of the Mexican monsoon region for molting passerines, highlighting the need to preserve habitat in this region. *Received 9 August 2007, accepted 10 October 2008.*

Key words: collecting effort, Mexican monsoon, molt-migration, *Tyrannus verticalis*, Western Kingbird.

Documentación de la Muda de *Tyrannus verticalis* durante la Migración Usando dos Medidas del Esfuerzo de Colección

Resumen.—Usamos especímenes de museo para describir el momento y lugar de la muda que ocurre después de la reproducción en *Tyrannus verticalis*, un ave insectívora que anida en zonas áridas del oeste de Norte América donde el final de verano es extremadamente seco. Como en muchas otras aves migratorias del oeste, los adultos de *T. verticalis* dejan las áreas de anidación y se dispersan para mudar en la región monzónica mexicana. En contraste, los juveniles se quedan en las áreas de cría al final del verano, retrasando la muda de las primarias externas y de las plumas del cuerpo hasta arribar a su hábitat de invierno. El alto número de especímenes juveniles coleccionados en las áreas de cría al final del verano confirma que la disminución en el porcentaje de individuos adultos no es un artefacto causado por inactividad de los colectores. También demostramos la salida de los adultos usando bases de datos de museo para calcular el porcentaje de todos los paserinos coleccionados en las áreas de cría ubicadas fuera de las áreas de muda del suroeste que correspondía a adultos de *T. verticalis*. La correlación estrecha entre estos índices valida el uso del número total de paserinos en las colecciones como un índice de esfuerzo de colección enfocado en un paserino específico. Nuestros resultados son otro ejemplo de la importancia de la región monzónica mexicana para la muda de los paserinos, lo que resalta la importancia de preservar el hábitat en esta región.

Fourteen migratory passerine species that breed in western North America migrate to the region of the Mexican monsoon for their annual postbreeding molt. Adults that migrate before molting were first discovered in some western *Empidonax* spp. (Johnson 1963) and in Bullock's Oriole (*Icterus bullockii*; Rohwer and Manning 1990). Such movements are now known to characterize more than half of western migrant passerines but are found in <10% of eastern passerines that winter south of the United States (Rohwer et al. 2005). To conceptualize differences in the scheduling of molt and migration, Rohwer et al. (2005) elaborated the "push–pull" hypothesis, which states that dry conditions in the western lowlands "push" molt-migrants away from their breeding grounds at the same time that the Mexican monsoon (Comrie and Glenn 1998) generates a flush of productivity that "pulls" these migrants to eastern Arizona, New Mexico, and northwestern Mexico. The recent discovery of this molt-migration system likely has important conservation implications (Butler et al. 2002, Leu and Thompson 2002).

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After extensive field surveys throughout the past six years, Rohwer and collaborators (unpubl. data) have found that many of the 14 western passerine species that molt in the monsoon region are concentrated in lowland deciduous thorn forests of northwestern Mexico. Dry tropical deciduous forest is one of the most endangered habitats in the world (Janzen 1988), and its loss in Mexico has been dramatic. Trejo and Dirzo (2000) estimated that only 27% of the original area of this forest was still intact at the beginning of the 1990s, 50% was fragmented or degraded, and 23% had been completely lost to other land uses. In the state of Morelos, they estimated that 1.4% of dry tropical forest was lost per year. Although we could find no figures for the coastal plain of Sinaloa and Sonora, we presume that the loss of dry deciduous forest in this region has been even greater because the recent construction (1970s) of large reservoirs and cement-lined canals probably accelerated its conversion to irrigated farmland. No conservation reserves exist in this region. The conversion of coastal thorn forests to agriculture has potentially large effects on molting populations of Gray Flycatcher (*Empidonax wrightii*; Johnson 1963), Bullock's Oriole (Rohwer and Manning 1990), Painted Bunting (*Passerina ciris pallidior*; Thompson 1991), Western Tanager (*Piranga ludoviciana*; Butler et al. 2002), Ash-throated Flycatcher (*Myiarchus cinerascens*; Butler et al. 2006), Lucy's Warbler (*Vermivora luciae*; Rohwer et al. 2007), Black-headed Grosbeak (*Pheucticus melanocephalus*; D. R. Froehlich unpubl. data), and Lark Sparrow (*Chondestes grammacus*; S. Rohwer and V. Rohwer unpubl. data), all of which our surveys have shown to be abundant molt-migrants in this lowland region of northwestern Mexico. To better assess the conservation implications of these massive land-use changes for birds, we need many more descriptions of the molt and migration schedules of birds of western and southwestern North America.

Phillips et al. (1964) described two waves of Western Kingbirds (*Tyrannus verticalis*; hereafter "kingbirds") migrating through Arizona. In the first wave, kingbirds become abundant in southeast Arizona in mid-July (as well as throughout Sonora; Russell and Monson 1998). The second wave occurs in September, and by early October, nearly all individuals have left Arizona (Phillips et al. 1964). These two waves suggest separate movements of adults and juveniles from the northern breeding grounds, the first wave coinciding with adult migration and the second with juvenile migration. The ecology of kingbirds is also typical of many North American molt-migrants: they breed in open, arid habitats across the western lowlands of the United States and Canada and winter on the Pacific slope of Central America from southern Mexico to Costa Rica.

We tested the hypothesis that kingbirds molt-migrate to the Mexican monsoon region. First, we report our observations of flocks of ≤200 molting kingbirds in the Southwest during the monsoon season. Second, we used museum specimens to illustrate seasonal and geographic patterns in the timing and location of molters and nonmolters in late summer.

Seasonal and geographic collecting biases need to be considered when using specimens as a basis for describing molt-migrations, because collecting activity has traditionally peaked in early spring and summer and then declined in late summer, when plumages become worn and less useful for studies of geographic variation and when specimens are difficult to collect and prepare (Leu and Thompson 2002, Rohwer et al. 2007). Thus, a seasonal decrease in specimen records could be a result of low collecting effort and not of migratory departure. Consistent with the general trend of reduced collecting activity in late summer, we found only 24 molting adult kingbirds in the 10 museums we visited. Because juvenile kingbirds linger on the breeding grounds for about two months after the adults depart, we used the percentage of all kingbirds from the same geographic region and period that were adults to assess a new and more general index of collecting effort. This new index is the percentage of all passerine specimens from the same geographic region and period that are adult kingbirds. We explore this index because it could help evaluate departure times in species in which adults and juveniles migrate together (e.g., Butler et al. 2006, Rohwer et al. 2007).

Methods

Sources of Molt Data

We examined 483 specimens, most collected between 1 June and 30 October, from 10 North American collections (see Acknowledgments). We scored each specimen for molt in the flight and body feathers. In these collections, we found only 24 adult kingbirds that were molting flight feathers. We supplemented these data with a sample of 54 adults collected on recent University of Washington Burke Museum (UWBM) expeditions to the monsoon region. All these adults were molting, and all are included in our assessment of the percentage of adults molting in the monsoon region (Table 1). This is valid because neither age nor molt status affected the decision to collect these specimens. This was a substantial amount of collecting directed at kingbirds in the region where they were molting, but it was balanced by efforts of two of the authors to collect adult kingbirds in Washington in July, where we found no molting adults and only juveniles. Our experience collecting the series in the Southwest demonstrated that molting kingbirds perch conspicuously because of their foraging habits and, thus, are easy to collect. The absence of adults in the north is not because of the skulking, retired habits of many molting birds, but because adults had departed their northern breeding range. We did not evaluate the potential effect of sex on the scheduling of migration, but it is unlikely to be a significant factor in the results.

Location and Scheduling of Molt

Primary molt.—We illustrated molt-related movements on maps by plotting locations where specimens were collected to the nearest county or city on the basis of localities noted on specimen

Table 1. Primary molt status of adult Western Kingbirds within or outside the region of the Mexican monsoon (Comrie and Glenn 1998) from 16 July to 15 October. Values given in parentheses include 54 individuals collected during recent University of Washington Burke Museum expeditions; the contrast is highly significant without these new specimens ($P = 0.007$), and more so with them (Fisher's exact tests, $P < 0.0001$).

	Number molting	Number not molting	Percentage molting
Within monsoon	9 (54)	4 (0)	69 (94)
Outside monsoon	9	27	25

tags. We outlined the geographic distribution of the peak Mexican monsoon precipitation (Comrie and Glenn 1998) to judge whether or not the individuals were molting in the Mexican monsoon region. In our maps, specimens collected between 1 May and 15 July represent the breeding season, and specimens collected between 16 July and 15 October represent the molting period. We chose the dates for the molting season because a regression by Pimm (1976) estimated that the average adult molting in southern Arizona starts primary molt on 19 July and finishes on 27 September (V. Rohwer unpubl. data).

Extralimital records are excluded from our analyses; these include three adults and five juveniles from New England and the Atlantic provinces, two juveniles from the Bahamas, and two juveniles from Florida. Kingbirds are found regularly in small numbers in Louisiana during fall migration (Lowery 1974); therefore, we included those records.

Body molt.—We quantified progression of body molt in juveniles by scoring three regions of the body: crown, breast, and back. The aspect (percentage of feathers replaced) for each region was recorded from 0 to 100% in increments of 10%. We averaged the aspect scores to determine the overall percentage of juvenal plumage replaced in the three regions for each specimen. Adult body molt was scored for the presence or absence of active replacement.

Field Observations of Molt

From 11 to 19 September 2002, we conducted opportunistic point counts of kingbirds at 18 localities in Arizona, Sonora, Chihuahua, and Texas. We recorded observations when we spotted groups of kingbirds along the roadside. Our sample sizes range from 1 to 26 because of variation in local abundance, number of observers, time of day, and ability to score tail molt. We scored each bird for the presence or absence of active tail molt. Detecting primary molt in the field can be challenging, but in this case scoring of tail molt was easily accomplished, because kingbirds forage almost entirely by sallying from exposed perches. As in most passerines, the duration of tail molt in kingbirds is contained within the time-frame of primary replacement (Rohwer 2008). Therefore, we assumed that any adult that was molting rectrices was also molting primaries. From 2004 to 2007, we recorded molt data, in a less systematic fashion, south of the kingbird breeding range in coastal Sinaloa.

Assessing Collecting Effort

We assessed collecting effort of adult kingbirds using two indices computed from specimens collected in the same period and geographic area: the percentage of all kingbirds that were adults, and the percentage of all passerines that were adult kingbirds. We used data from seven museums with online databases, counting their specimens of passerines and kingbirds from Washington, Oregon, California, Idaho, Montana, Wyoming, Utah, Colorado, and Nevada. Counts were tallied in weekly intervals from 8 July (when young kingbirds were first collected) until 15 August. After 15 August, we binned the data into two-week intervals through October. We assigned ages to the kingbird specimens by the presence or absence of an orange crown patch, because juveniles lack a prominent orange crown patch (Pyle 1997).

To test the validity of "total passerines" as a measure of collecting effort, we compared the percentage of kingbirds that were adults with the percentage of all passerines that were adult kingbirds. If total passerines is a reliable index of collecting effort, the percentage of all passerines that are adult kingbirds should correlate well with the percentage of all kingbirds that are adults for the same periods and regions. Because the abundance indices were based on counts of adults or juveniles, we evaluated the association between the two percentages using logistic regression (R, version 2.4.0; R Foundation for Statistical Consulting, Vienna).

Results

Location and Scheduling of Molt

Primary molt.—From 1 May to 15 July, nonmolting adult kingbird specimens were distributed evenly throughout the breeding range (Fig. 1A). By contrast, examination of specimens taken from 16 July to 15 October suggests that most adults breeding in the north depart their breeding grounds before molting (Fig. 1B). In this period, 5 of 20 adults collected north of 38°N were molting, whereas 70 of 86 adults collected south of 38°N were molting (Fisher's exact test, $P < 0.001$). In older collections, an absence of adult specimens from the northern portion of the breeding range is apparent by mid-July (when we were also unable to find adults in Washington), but there is little evidence of large numbers of molting birds in the monsoon region, presumably because of minimal collecting there in late summer. However, our recent surveys and collecting showed adult kingbirds to be abundant and molting in the monsoon region in late summer (Table 2 and Fig. 1B inset). We also observed several concentrations of 100–200 molting adult kingbirds in late July in successive years in northern Sinaloa.

Many juveniles were collected on the breeding grounds during the period of 16 July–15 October, when are molting in the Southwest (Fig. 1C); therefore, collectors were active north of the monsoon region in the molting period and would likely have collected more adult kingbirds if they were still present. In older collections, adults were almost significantly less likely to be collected outside, rather than within, the monsoon region during this time. From 16 July to 15 October, only 23% of all kingbirds collected outside the monsoon region were adults, but 36% of all kingbirds collected within the monsoon region were adults (Table 3; one-tailed Fisher's exact test, $P = 0.067$).

Although most adults move to the monsoon region in late summer, this movement could be coincident with molt and not necessarily related to it. Thus, we compared the frequencies of collection of molting specimens outside and inside the monsoon region between 16 July and 15 October. During this period, 25% of the 36 adults outside the monsoon region were molting. By contrast, 69% of the 13 adults collected within the monsoon region were molting (Table 1; Fisher's exact test, $P = 0.007$). Including the recently collected UWBM specimens, 94% of the 67 adults from the monsoon region were molting (Table 1; Fisher's exact test, $P < 0.0001$). Eight molting adults collected outside the monsoon region were at very early stages of molt, still growing P1. Three of the four nonmolting adults from the monsoon region were collected in late July, so they may have been late breeders that had just arrived in the area. Virtually all adults are in

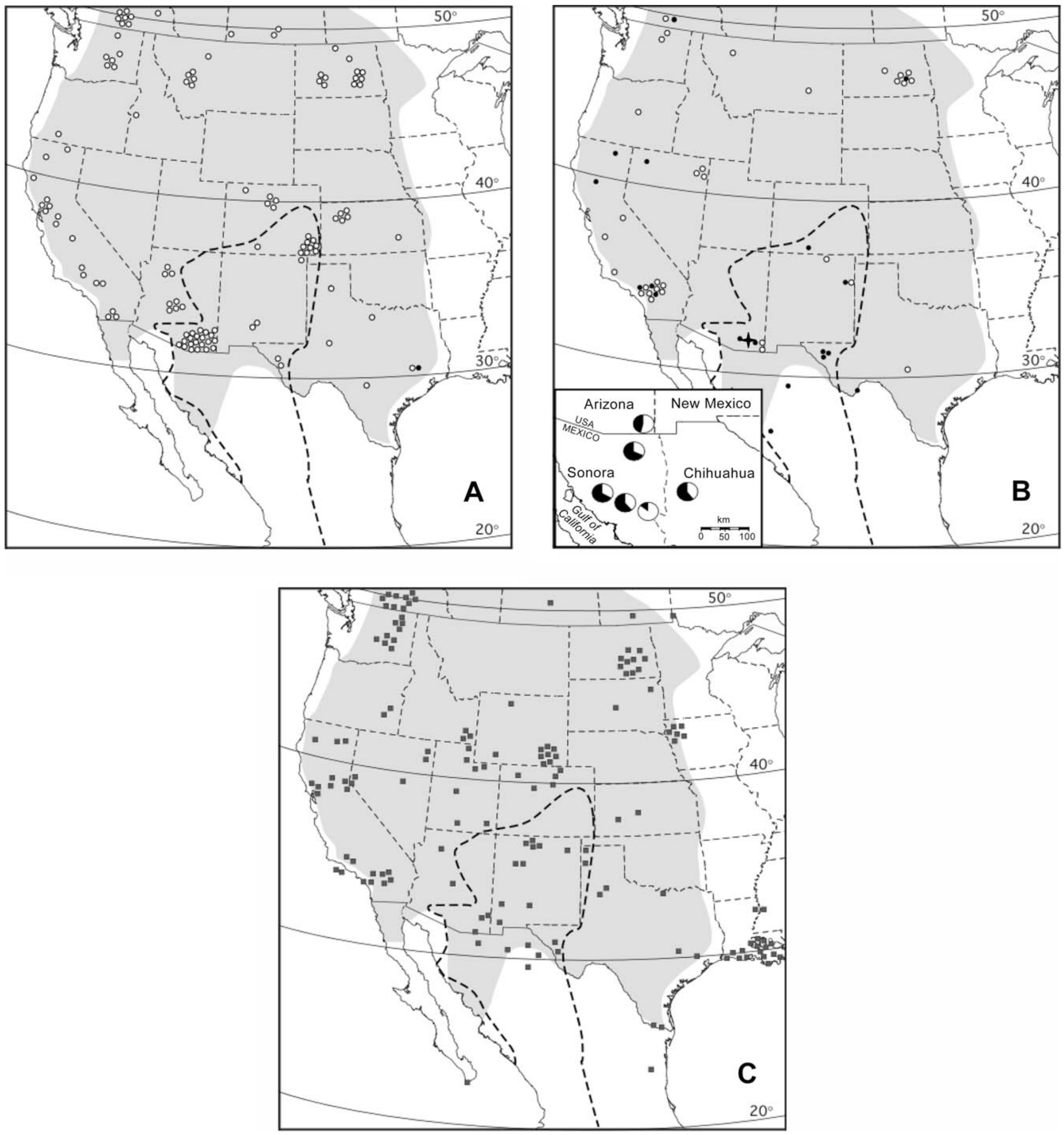

FIG. 1. (A) Nonmolting (white circles) and molting (black circle) adult Western Kingbird specimens collected between 1 May and 15 July. The breeding range (shaded area) and the Mexican monsoon region (heavy dashed line; Comrie and Glenn 1998) are indicated. Although there is some concentration of birds in southeast Arizona, the museums we sampled held adults collected from 1 May to 15 July in about equal density from throughout the breeding range. (B) Nonmolting (white circles) and molting (black circles) adult Western Kingbird specimens collected between 16 July and 15 October. The star represents 57 molting adults collected on a recent University of Washington Burke Museum expedition. In contrast to (A), this map shows that few adult kingbirds are collected north of the monsoon region during the molting season. Inset: proportions of Western Kingbirds molting rectrices from surveys during 11–18 September 2002 (see Table 1); only adults molt their rectrices. (C) Juvenile Western Kingbirds collected between 16 July and 15 October, when adults would be molting (black squares). In contrast to (B), this map shows that collectors were still taking juvenile Western Kingbirds north of the monsoon range during the adult molting season; therefore, the absence of adults may be attributable, at least partly, to their departure for the Mexican monsoon region.

Table 2. Numbers of free-living adult Western Kingbirds observed molting or not molting rectrices in southeastern Arizona (11 September 2002), northern Sonora (13–16 September 2002), and western Chihuahua (18 September 2002). We did not distinguish age classes in the field, so these values underestimate molt by adults because juveniles, which do not molt rectrices, begin to arrive in numbers in September.

	Day in September 2002						
	11	13	14	15	16	18	Total
Number molting	2	17	2	22	2	6	61
Number not molting	14	8	1	14	12	4	53
n	26	25	3	36	14	10	114
Percentage molting	46.2	68.0	66.7	61.1	14.3	60.0	53.5

Table 3. Counts of adult and juvenile Western Kingbirds collected within or outside the Mexican monsoon region (Comrie and Glenn 1998), 16 July–15 October (one-tailed Fisher's exact test, $P = 0.067$).

	Number of adults	Number of juveniles	Percentage adults
Within monsoon	13	23	36.1
Outside monsoon	36	123	22.6

fresh plumage when they arrive on the wintering grounds (Fig. 2). Our sample of 30 adults from the wintering grounds, collected between 15 October and 31 December, included 28 adults that had completed molt, one specimen that was still growing its outermost primary, and one that apparently had suspended or arrested its molt at P6 (Fig. 2).

Juvenile kingbirds are known to undergo an eccentric molt, in which a variable number of the central or distal primaries are replaced, after departing the breeding grounds. This molt is suspended from November to February and finished in spring (Pyle 1998). Corroborating Pyle's (1998) results, we found no juveniles molting primaries from 16 July to 31 December in the breeding range ($n = 136$), but where juveniles undergo their eccentric primary molt is unclear. Some juveniles clearly molt on the wintering grounds, where we found 19 specimens in primary molt. Two of three juveniles netted on 21–22 September in Sinaloa were in eccentric molt, and many more may molt in this region, where there has been little collecting in September (Rohwer et al. 2007). None of the 39 juveniles collected on the wintering grounds from November to February was in active molt. These juveniles had replaced from one to seven inner primaries, and a few had replaced P8, but none had replaced P9 or P10.

Body molt.—Of adults collected in the breeding range outside the monsoon region that had not initiated primary molt, 28% had initiated body molt before migrating to the monsoon region. However, most of the adult body molt takes place in the monsoon region, as shown by the intense body molt in the recent UWBM sample. Juveniles collected in the breeding range had completed very little body molt (Fig. 3). On average, juveniles collected in the breeding range had replaced just 2% of their juvenal plumage. Most had replaced none, and three replaced 75–80% ($n = 103$; Fig. 3). Juveniles collected on the wintering grounds between 1 October and 31 December had

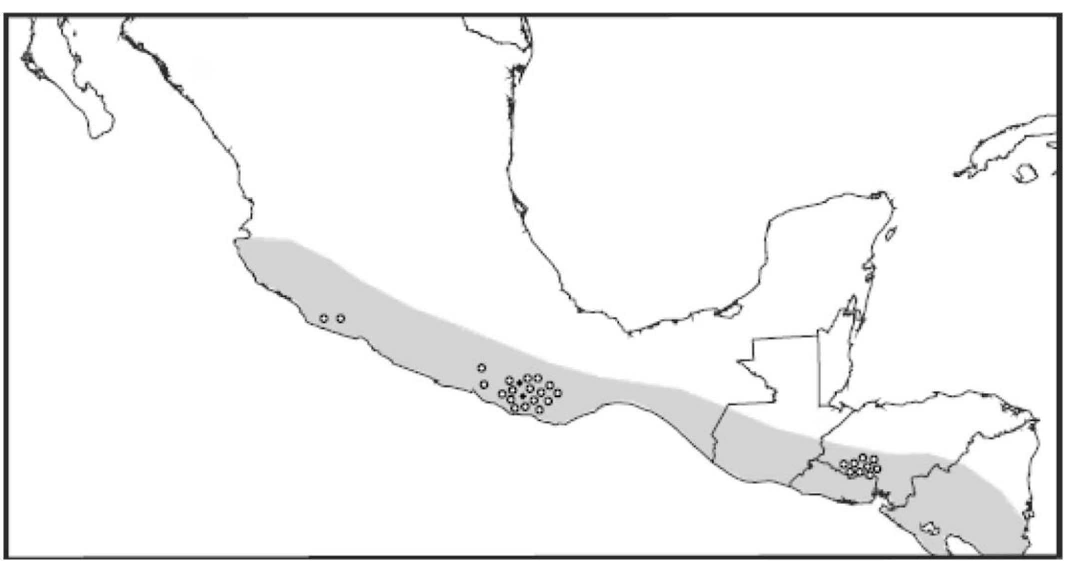

Fig. 2. Adult Western Kingbirds in fresh plumage, nonmolting (white circles) and molting (two black circles) on wintering grounds, 16 October–31 December. Not shown are two adults taken on 23 October in southeast Arizona that were still molting in the monsoon region (LSUMNH 40839 and LSUMNH 40840).

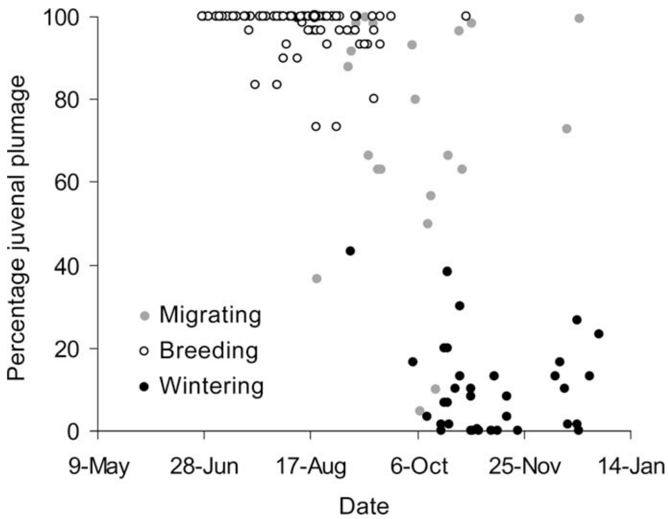

FIG. 3. Progression of post-juvenile molt in juvenile Western Kingbirds subdivided by region of collection. White circles represent individuals collected in the breeding range. Gray circles indicate juveniles collected outside the breeding range and north of the wintering range. Black circles represent individuals collected on the wintering grounds. We examined too few juveniles taken south the breeding range to determine where most juveniles replace their body plumage or whether they molt during migration.

replaced 90% of their juvenal plumage, and it is likely that some of those would have continued their molt. Juveniles collected in the fall between the breeding and wintering range had replaced 72%, which suggests that they interrupt migration to molt during this period.

Field Observations of Molt in Adults

Our monsoon-region surveys of 11–18 September 2002, in the middle of the molting period (16 July–31 October), showed that 54% of 114 kingbirds were molting rectrices (Table 2 and Fig. 1B inset). These data compensate for the lack of collecting in the monsoon region during molt. Our assessments of the percentage of birds in molt are conservative, because they were collected late enough in September that adults nearly finished with the rectrix molt would not have been scored as molting, and because some juveniles, which do not molt their rectrices, were already present in the flocks we scored.

Although we did not systematically survey kingbirds for molt in coastal Sinaloa from 2004 to 2007, we frequently observed large numbers of molting adults in this region in July and August. On 28 July 2005, following a night of heavy rain, we counted >150 kingbirds perched in the sun to dry near El Fuerte, Sinaloa. Some could be seen molting, but most were too far away to assess. At the same location on 30 July 2006, we counted >200 kingbirds, most of which were in active flight-feather molt.

Assessing Collecting Effort Using Total Passerines

Our two indices of adult abundance, the percentage all kingbirds that were adults and the percentage of all passerines that were adult kingbirds, were strongly associated (logistic regression, df = 5, $P = 0.013$, with residual deviance of 3.175). Although we had frequency data for 10 periods, there were no adult kingbirds in four of those periods, which forced us to drop them from the analysis. Adults constituted 62% of kingbirds collected outside the monsoon region until mid-August, when the percentage of adults dropped to nearly zero (Table 4). The percentage of adult kingbirds among all passerines in those same collections also declines sharply in mid-August (Table 4). The strong correlation between these indices of adult presence in the states we surveyed north and west of the monsoon region and the fact that both drop in mid-August suggest that total passerines is a useful general measure of collecting effort. The fairly abrupt drop in total passerines in August in the collections we surveyed likely reflects collectors' lack of interest in molting birds.

DISCUSSION

We have made three major points in the present study. First, we have demonstrated that adult Western Kingbirds move to the Mexican monsoon region to molt. Second, we have shown that juvenile

TABLE 4. Counts of Western Kingbirds and total passerines from seven online museum databases, outside (north and west) of the Mexican monsoon region. Percentage of adults is calculated as a fraction of all kingbirds (adults and juveniles) and total passerines. Both measures drop sharply in August, when adults depart for the monsoon region to molt. Few adults were collected after August, but there was still active collecting, because the number of total passerines remains high. Therefore, total passerines can be used as a measure of collecting effort in species in which juveniles migrate with adults; however, age ratios cannot be used to assess collecting effort.

Period	Total passerines	Total kingbirds	Percentage of all kingbirds that were adults	Percentage of all passerines that were adult kingbirds
July 8–15	3,220	16	50.0	0.25
July 16–23	3,531	20	85.0	0.48
July 24–31	4,994	7	57.1	0.08
August 1–7	2,906	9	44.4	0.14
August 8–15	2,916	5	40.0	0.07
August 16–31	4,497	17	0.0	0.00
September 1–15	3,256	7	14.3	0.03
September 16–30	3,556	2	0.0	0.00
October 1–15	4,917	0		0.00
October 16–31	4,464	0		0.00

kingbirds linger on the breeding grounds for one to two months after adults depart the northern part of the breeding range, but juveniles do not use this time to replace their body feathers. Finally, we have used the presence of juveniles on the breeding grounds in late summer to validate the use of total passerines in collections as a measure of collecting effort.

Adult kingbirds from the breeding grounds become relatively rare in collections after 15 July (compare Fig. 1A and B). Yet from 16 July to 15 October, juveniles were regularly collected in the breeding range. This contrast demonstrates the early postbreeding departure of adults from the breeding range. Late-summer collecting has been very limited in the monsoon region; therefore, no influx of adults is apparent in Figure 1B unless the new UWBM collections from Arizona are considered. Our field surveys also showed that large numbers of adult kingbirds were present in the monsoon region in late summer (Table 2). An overwhelming 94% of adult kingbird specimens from the monsoon region were molting (Table 1). There are at least two possible explanations for the nine adults molting outside the monsoon region (five from California and one each from Nevada, British Columbia, and North Dakota; Fig. 1B and Table 1). First, all these birds were in early stages of molt (still growing P1); therefore, they probably could have undertaken the relatively short migration to the monsoon region to complete their molt without serious aerodynamic costs. Second, the intensity and timing of the monsoons vary annually, which makes it likely that monsoon-molters facultatively respond to late-summer conditions that are favorable to molting even if they have not yet arrived in the monsoon region (Butler et al. 2002).

Juvenile kingbirds linger in the north but replace little of their juvenal plumage before migration. Other species in which juveniles stay on the breeding grounds typically replace a large portion of juvenal feathers before migration (Rohwer et al. 2005). Where the juvenal body plumage is replaced is unclear. Juveniles collected in the north had replaced <20% of their juvenal body plumage, whereas juveniles from the wintering grounds had replaced 98% of their juvenal body plumage (Fig. 3). We found very few specimens partway through molt. Twenty-two juveniles collected during migration, south and southeast of the breeding range in Louisiana and northern Mexico, were in active molt and had replaced a mean of 72% of their juvenal plumage. Unfortunately, all these juveniles were slightly off the typical migration path when collected, but they raise the possibility that juveniles may molt body feathers during migration. It seems more likely that most juvenile body molt takes place in the monsoon region, but there has been too little collecting in this region in August and September to test this hypothesis (Rohwer et al. 2007).

Among molt-migrants, Rohwer et al. (2005) showed that the juvenal body feathers of species in which juveniles molt on the breeding grounds have fewer, less well-connected barbs than species in which juveniles migrate in juvenal plumage, and they suggest that migrating with a fluffy juvenal plumage would create excessive drag. Because juvenile kingbirds postpone their post-juvenile molt until after their departure from the breeding grounds, we predicted and found their juvenal plumage to be relatively high in quality; for juvenal flank feathers, the mean number of barbs per distal centimeter of feather was 16.0 ± 1.1; $n = 7$), compared with an adult barb count of 18.2 ± 2.1; $n = 3$) (L. Butler unpubl. data). Juveniles have 88% as many barbs as adults, which is high compared with juveniles in species that replace their body feathers before migration (Rohwer et al. 2005).

In general, collecting effort has been particularly low in the monsoon region during the molting season (Leu and Thompson 2002). The world's collections hold only 273 passerines collected in Sonora in September and only 381 collected in Sinaloa in August, accounting for <4% of all specimens from these states (Rohwer et al. 2007). Thus, plots of specimen distributions that do not account for differences in collecting effort may fail to distinguish departures and arrivals from inactive collecting. Because juvenile kingbirds migrate later than adults (Fig. 3), we used counts of juveniles collected on the breeding grounds as a measure of late-summer collecting effort, under the assumption that this collecting should also have produced adult kingbirds had they not departed the breeding grounds. The contrast in departure dates for adult and juvenile kingbirds also allowed us to evaluate a new measure of collecting effort, the percentage of total passerines represented by a particular group of birds (in this case, adult kingbirds). The percentage of all kingbirds that are adults is closely correlated with the percentage of all passerines collected in the same areas and periods that are adult kingbirds (Table 4). Thus, total passerines appears to be a good index of collecting effort directed at adult kingbirds. Using total passerines as an index of collecting effort is valuable for studies of the timing of migration in species such as Ash-throated Flycatcher (Butler et al. 2006) and Lucy's Warbler (Rohwer et al. 2007), in which adults and juveniles depart the breeding grounds simultaneously. As online databases develop functions for viewing multiple species and variable descriptors of time and area simultaneously, they will become much more useful for large-scale projects.

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