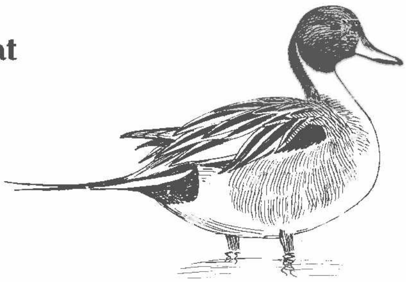
Diurnal activity budgets and habitat functions of Northern Pintail *Anas acuta* wintering in Sinaloa, Mexico



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We determined the activity budgets and habitat use patterns of Northern Pintail wintering in the Ensenada del Pabellón Coastal System in Sinaloa, Mexico, over the winters of 1989-90, 1990-91 and 1991-92. Radio-marked females (n = 47-59/year) were used to lead observers to Pintail flocks, where time budget data were collected. Dominant daytime activities were resting (47%), feeding (20%), preening (17%) and locomoting (13%). Annual variation was high and depended on the availability and functional use of four habitat types. Natural fresh-brackish marshes were used for resting (34-58%), feeding (6-39%), and social activity (0.4-6%). Ephemeral ponds also were used for feeding (7-43%) and social activity (0.3-4%) during some wintering periods, but they generally functioned as resting areas (31-71%). Mangrove mudflats were used for resting (51-79%), whereas reservoirs were used for resting (44-54%) and social activity (1-5%), particularly during midwinter. Management recommendations include enhancing rice availability, but also improving quality of natural marshes via control of Cattail.

Keywords: Activity Budget, Habitat, Mexico, Northern Pintail, Sinaloa, Winter

Northern Pintail *Anas acuta* (hereafter Pintail) populations are circumpolar throughout the northern hemisphere and, in North America, are considered a species of priority concern under the North American Waterfowl Management Plan (United States Fish and Wildlife Service [USFWS] and Canadian Wildlife Service 1986). Breeding populations of Pintail in North America have averaged about two million during the 1990s, which is some 50% below long-term numbers as tallied since 1955 (Dubovosky et al. 1993). Pintail were classified as a priority following this dramatic decline in numbers, which has induced increased management and research attention (Ducks Unlimited 1990).

Along the west coast of Mexico, annual aerial surveys on the Upper Mainland West Coast (UMWC) indicated the special significance of this area to wintering waterfowl, particularly Pintail (Kramer & Migoya 1989). For example, annual aerial surveys conducted during January from 1970 through to 1988 indicate that 12-23% of the Pintail population in North America winters in Mexico (USFWS, Laurel, Md., unpubl. data). Field studies conducted in the winter of 1987-88 also identified western Mexico as an important wintering habitat for Pintail (Migoya 1989), an observation later corroborated by band-return analyses (Hestbeck 1993). The Ensenada del Pabellón Coastal System (hereafter Pabellón) in the state of Sinaloa is of particular importance to wintering Pintail; midwinter surveys have averaged >100,000 Pintail since 1965 (USFWS, unpubl. data), and we recorded as many as 1,500,000 Pintail at Pabellón in February 1990. Hence, Pabellón is clearly the major Pintail wintering wetland in Mexico, and among the most important wintering sites on the North American continent.

Analyses of band-recovery data identified the Central Valley of California as the most important wintering area for Pintail in North America (Hestbeck 1993). However, the Central Valley has lost 95% of its original wetlands (Gilmer *et al.* 1982, Heitmeyer *et al.* 1989), whereas wetland systems on the UMWC of Mexico are largely pristine because coastal wetlands have not incurred much drainage from agricultural practices. Therefore, given the deterioration of habitat conditions in California and the continental decline in Pintail numbers, it is increasingly important to determine the functional role of wetlands in the UMWC of Mexico as wintering waterfowl habitat.

Pintail are among the first species of waterfowl to arrive in large numbers on wintering grounds and are philopatric to wintering sites (Hestbeck 1993). Pintail also

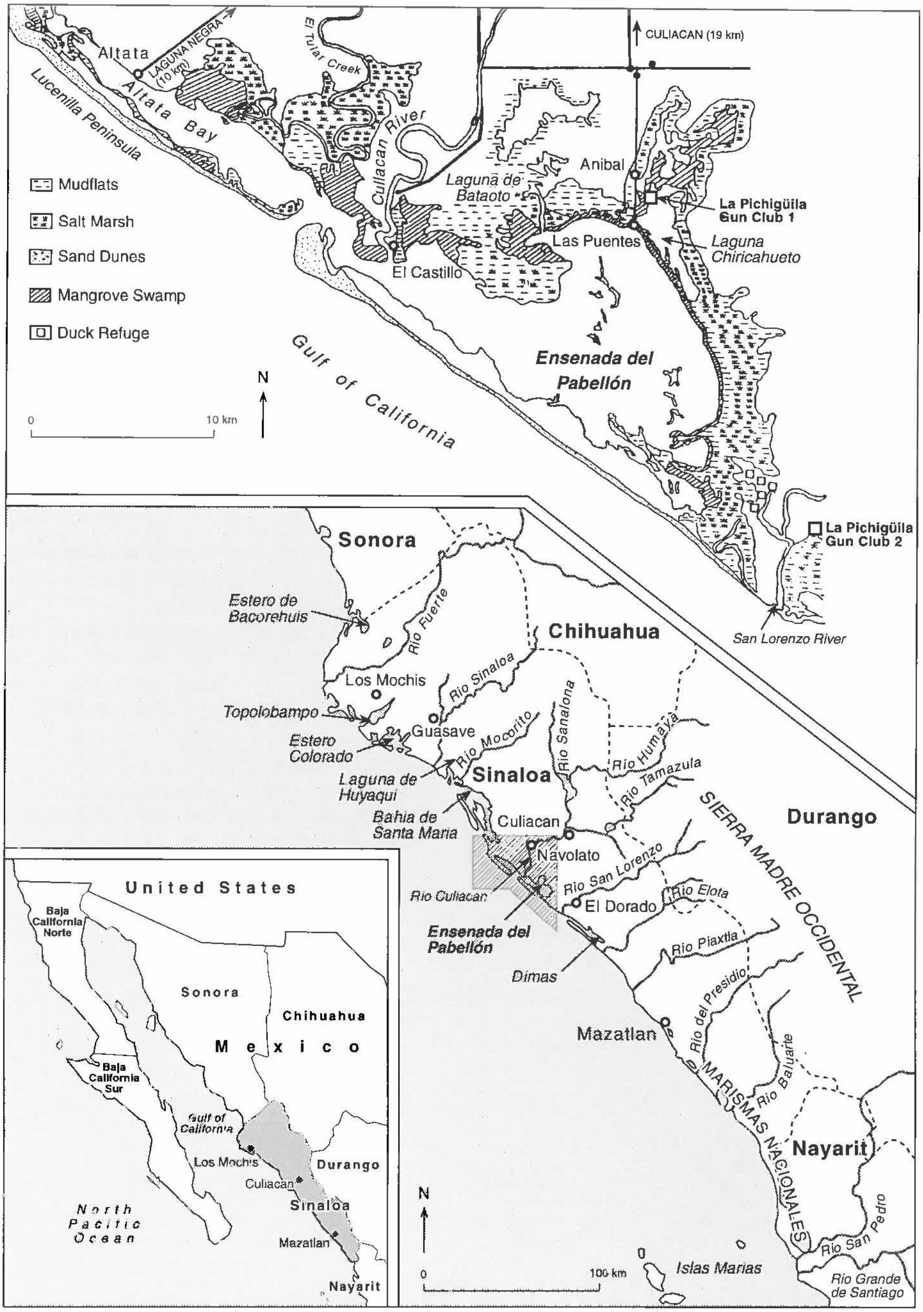

Figure 1. Study area map of the wetland complexes and surrounding area in Sinaloa, Mexico.

spend longer periods of time on specific wintering areas than most other ducks, hence they may be more dependent on the abundance and quality of winter habitat (Ducks Unlimited 1990). Accordingly, an understanding of the ecological requirements of Pintail at important wintering sites is a critical step for the conservation of this species.

We designed this study to determine sea-

Table 1. Rice production on the Culiacán agricultural district, and associated midwinter populations of Northern Pintails in Sinaloa, Mexico, during the winters of 1989-90 to 1991-92.

	Rice planted (ha)[a]	Harvest (metric tons)[a]	Numbers of-Pintail
1989-90	50,000	400,000	880,000
1990-91	7,026	18,594	288,000[b]
1991-92	23,500	103,245	310,000

[a]Secretaria de Promoción Económica, Subsecretariat for Agriculture, Sinaloa State Government, 1991, (Culiacán, Sinaloa).
[b]U.S. Fish and Wildlife Service (1991). Portland, Oregon, U.S.A. unpublished.

sonal and diurnal activity budgets and habitat use patterns of Pintail in Pabellón as a means of evaluating the functional significance of habitats most frequently used by Pintail at this site.

Study area

We conducted our study over three winters (November-March 1989-92) in Sinaloa, the most important rice-growing state in western Mexico. The specific study area was Pabellón, which is a brackish marsh complex of 80,000 ha situated between the towns of Navolato and El Dorado, and on the coastal plain bordered to the west by coastal bays and to the east by the Sierra Madre Occidental (**Figure 1**). The northern and eastern edge of Pabellón was bordered by narrow bands of Red Mangrove *Rhizophora mangle* and Black Mangrove *Avicennia germinans* forest; shallower areas contained salt flats and tidal pools.

Most behavioural observations were conducted within Laguna de Chiricahueto (hereafter Chiricahueto), a 63-km^2 fresh-brackish marsh on the eastern lobe of Pabellón. Extensive rice fields bordered the northern and eastern shores of this lagoon (**Table 1**). Observations in 1989-90 were made exclusively in Chiricahueto, whereas 1990-91 observations also included the 5-km^2 El Alhuate Reservoir located 25 km east of Chiricahueto; the reservoir contained 57,000-152,000 Pintail during 1990-91. The El Alhuate and five other reservoirs collected irrigation water from larger reservoirs located on the Sierra Madre Occidental foothills. Observations in 1991-92 were conducted at Chiricahueto, El Alhuate Reservoir and surrounding ephemeral ponds on salt flats and agricultural fields (mainly rice and corn) flooded

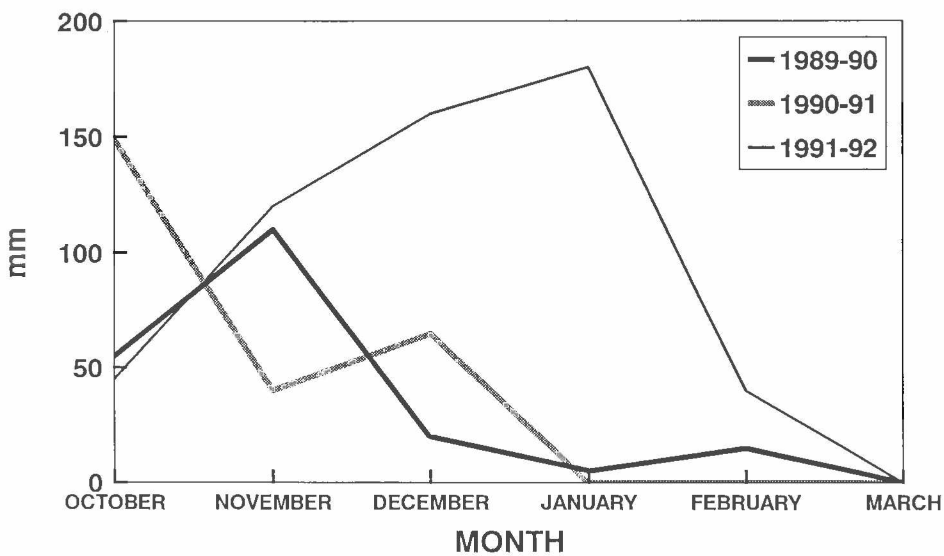

Figure 2. Fall and winter precipitation at the Culiacán agricultural district during the winters of 1989-90 through to 1991-92. Data from Secretariat for Agriculture and Hydraulic Resources, Departamento de Hidrometría, Culiacán, Sinaloa.

by the heaviest winter rainfall in Sinaloa during the past 30 years (**Figure 2**). Local farmers indicated that ephemeral ponds in flooded agricultural fields used by Pintail and Whistling Ducks *Dendrocygna autumnalis* and *D. bicolor* were natural marsh areas cleared for agriculture.

Methods

Radiotelemetry

Female Pintail were fitted with 21-g back-mounted radiotransmitters (Dwyer 1972) during the nonbreeding seasons of 1989-90 through to 1991-92. All females were captured by rocket-netting at sandy beaches or small islands at Chiricahueto. We attempted to radio-mark 50% juveniles (HY) and 50% adult females (AHY), but combined age classes for presentation and analysis of data; birds were aged using Duncan's procedure (Duncan 1985). We allowed each bird 48 hours to adapt to the radio-package before we began data collection (Gilmer *et al.* 1974).

Radio-marked Pintail were tracked four days per week using null-peak receiving systems from trucks mounted with 4-element Yagi antennas. A random sampling schedule was designed to alternately encompass half of a 300-km road route during the morning time period (0700-1200 h), and the remaining half during the afternoon time period (1200-1900 h). This sampling regime provided 47-75% of yearly locations where triangulations (0.1 km accuracy) were obtained (White & Garrott 1990). Other bird locations (5-27%/year) were obtained either by homing with a 3-element hand-held antenna ≤300 m from radio-marked Pintail, or by triangulation using 12-element, tower-mounted antennas inside Chiricahueto (0.1 km accuracy). Aerial telemetry flights (20-26% locations/year) were conducted monthly to track female Pintail outside of telemetry road routes (Gilmer *et al.* 1981). Aerial tracking error was approximately 0.5 km (White & Garrott 1990), and allowed assigning radio-marked birds to each of the four major habitat types used by Pintail.

Activity budgets and habitat use

Radio-marked birds were used to lead observers to Pintail flocks (Losito *et al.* 1989) where activity budget data were collected using the focal-bird method (Altmann 1974). We randomly selected three days per week to sample birds, but because activity budgets of waterfowl vary with time of day (Paulus 1988) we divided every day into three time blocks: (1) morning (dawn-0930 h), (2) midday (0930-1400 h) and (3) late afternoon (1400 h to dusk).

Focal birds were selected for observation by pointing a 15-60X spotting scope at the flock and then choosing the individual closest to the center of vision. Subsequent focal birds were selected by pointing the scope sequentially at the individual closest to the previous bird observed, alternating between males and females. However, to obtain independent focal birds, no two members of the same pair were sampled sequentially. When flock members were using more than one physical substrate (e.g. open water, sand bar), we used a weighting formula to determine the number of birds sampled from each substrate (see Losito *et al.* 1989).

Focal birds were observed for five minutes, and six different behaviours were recorded instantaneously every 15 seconds: (1) feeding, (2) resting (sleep, loaf), (3) locomotion, (4) preening (preening and comfort movements), (5) alert and (6) social (courtship, agonistic and aggressive behaviour). Pair status was classified following Hepp & Hair (1983).

Biological periods

Two criterion were used to divide the winters into meaningful biological periods: (1) waterfowl survey data collected by Velázquez-Noguerón *et al.* (1972) and Migoya (1989), as well as aerial survey data we collected throughout the winter of 1989-90, and (2) departure dates of radio-marked birds. Aerial surveys indicated that fall migration ended between 15-20 December, and that peak populations were usually present from mid-December through late January. Data from radio-marked females indicated that departure began in late-January. Therefore, winters were divided into three periods: (1) arrival, November through mid-December; (2) midwinter, mid-December through late-January and (3) departure, late-January through mid-March.

Statistical analysis

Four major Pintail habitats were identified: (1) fresh-brackish marshes, (2) mangrove mudflats, (3) irrigation reservoirs and (4) ephemeral ponds. Habitat use was estimated yearly as the percentage of all radio locations in each habitat type during each period (PROC FREQ, SAS Inst. Inc. 1990).

For each focal bird, percent time per activity was calculated by dividing the number of instantaneous recordings per activity by total recordings for all activities. Data were sorted yearly by sex and period, and one-way analysis of variance (ANOVA) was used to test for differences in Pintail activities among periods within years, and among years within periods (Kramer & Schmidhammer 1992); where appropriate, means were separated using the Tukey procedure (SAS Inst. Inc. 1990). Arcsine transformations were conducted on raw percentages to normalize the data.

Activity data between sexes and pairs within periods were compared using t-tests (SAS Inst. Inc. 1990). Percent frequency of occurrence of paired Pintail was calculated for each biological period. Due to large sample sizes associated with the time budget data, we attempted to minimize Type I errors by declaring significant differences at $P<0.01$; habitat use and all other comparisons were declared at $P<0.05$.

Results

Activity budgets by sex, pair status, and time of day

There were no differences in activity patterns between paired and unpaired birds over the three winters ($P>0.01$), and most activities were not different between sexes ($P>0.01$); differences that did occur were small. For example, during midwinter 1989-90 social activity was greater for females than males (5% *v* 3%; $P<0.01$). In midwinter 1991-92, females rested more than males (59% *v* 48%; $P<0.01$); males locomoted more (18% *v* 13%; $P<0.01$) and exhibited more social activity than females (6% *v* 3%; $P<0.01$). During departure, males also engaged in more social activity than females (3% *v* 1%; $P<0.01$) and preened more (18% *v* 13%; $P<0.01$). There were no activity differences by sex in 1990-91 ($P>0.01$). Hence, since few differences were found, data were pooled by sex and pair status for further analysis.

Activity budgets did differ with time of day during all three winters. For example, within each biological period feeding usually was highest ($P<0.05$) during the morning, whereas resting usually was highest ($P<0.05$) during midday and afternoon (Migoya 1993). However, because it is well known that activity budgets of wintering Pintail and other dabbling ducks vary with time of day (Tamisier 1976, Miller 1985, Paulus 1988), and because we were most interested in assessing trends in activities among winters, biological periods, and habitat types, we have not treated this topic in detail here; such data, however, are available elsewhere (Migoya 1993).

Activity budgets among years and biological periods

Resting, feeding and preening were the major diurnal activities on Pintail during winter in Sinaloa. Resting was the main activity of Pintail each year (38-55%), generally increased as each winter progressed, and averaged 47% over the three winters combined (**Table 2**). Resting always was highest ($P<0.01$) during the departure period, and was highest ($P<0.01$) during departure 1991-92 (59%). Among years, feeding was highest in 1989-90 (32%), lowest in 1991-92 (10%), and averaged 20% over the three winters combined. Within years, feeding was highest during midwinter 1989-90 (39%) and lowest during departure 1991-92 (6%). Preening averaged about 17% each year, and decreased from arrival to departure each year.

Among the remaining activities, locomotion (9-16%) varied among years ($P<0.01$) and was lowest in 1989-90 (**Table 2**). Alert (1-3%) comprised a small amount of the Pintail activity budget, but was highest in 1990-91 and lowest in 1991-92 ($P<0.01$); time spent alert did not vary ($P>0.01$) within years. Social activity (2-3%) was always highest ($P<0.01$) during midwinter. Pintail initiated courtship behaviour during late-December each year, and agonistic interactions, especially among males, were common until the end of January. The percent occurrence of paired Pintail was only 0-6% at arrival, but by midwinter was 35% in 1989-90, 9% in 1990-91, and 19% in 1991-92; pairing by departure was 52% in 1989-90, 10% in 1990-91, and 24% in 1991-92.

Table 2. Mean percentage of diurnal activity budgets of wintering Northern Pintail by biological periods in Sinaloa, Mexico, from 1989-90 to 1991-92.

			Activity[a,b]					
Year	Period	*n*	Feeding	Resting	Loco-motion	Preening	Alert	Social
1989-90	Arrival	347	31.1 Ab	33.9 Bb	10.7 Ba	22.4 Aa	1.8 A	0.4 Bc
	Midwinter	948	38.6 Aa	33.9 Cb	9.1 Ba	14.0 Bb	1.2 A	3.6 Aa
	Departure	1192	27.3 Ab	46.7 Ba	7.8 Cb	14.2 Ab	2.0 A	2.3 Ab
	Combined	2487	32.3	38.2	9.2	16.9	1.7	2.1
1990-91	Arrival	484	13.2 Bb	46.4 Ca	16.5 Aa	20.7 Aa	2.9 B	0.6 Bb
	Midwinter	727	11.1 Bb	46.4 Ba	17.7 Aa	17.4 Ab	2.8 B	4.8 Aa
	Departure	1119	21.1 Ba	49.3 Ba	12.7 Bb	13.8 Ac	2.6 B	0.9 Bb
	Combined	2330	15.1	47.4	15.6	17.3	2.8	2.1
1991-92	Arrival	666	13.8 Ba	53.1 Ab	11.1 Bb	20.4 Aa	0.8 C	1.8 Ac
	Midwinter	649	8.8 Bb	53.2 Ab	15.6 Aa	17.6 Ab	0.7 C	4.2 Aa
	Departure	915	5.8 Cb	58.9 Aa	17.5 Aa	15.4 Ab	0.7 C	2.1 Ab
	Combined	2230	9.5	55.1	14.7	17.8	0.7	2.7
1989-92	Arrival	1497	17.6	46.5	12.8	20.9	1.7	0.8
	Midwinter	2324	21.7	43.2	13.6	16.1	1.6	4.1
	Departure	3226	19.1	51.1	12.2	14.4	1.8	1.7
	Combined	7047	19.5	46.9	12.9	17.1	1.7	2.2

[a]For each activity/period combination, comparisons among years are not different (P>0.01) when uppercase letters are identical.
[b]For each activity/year combination, comparisons among periods are not different (P>0.01) when lowercase letters are identical.
[c]n = number of Pintail sampled.
[d]All comparisons among activity/periods were significantly different (P<0.01).

Habitat use

We radio-tracked 47 female Pintail during the winter of 1989-90, 57 during 1990-91, and 59 during 1991-92. Habitat use by Pintail varied among winters, but was most restricted in 1989-90 when the majority of locations were in fresh-brackish marshes

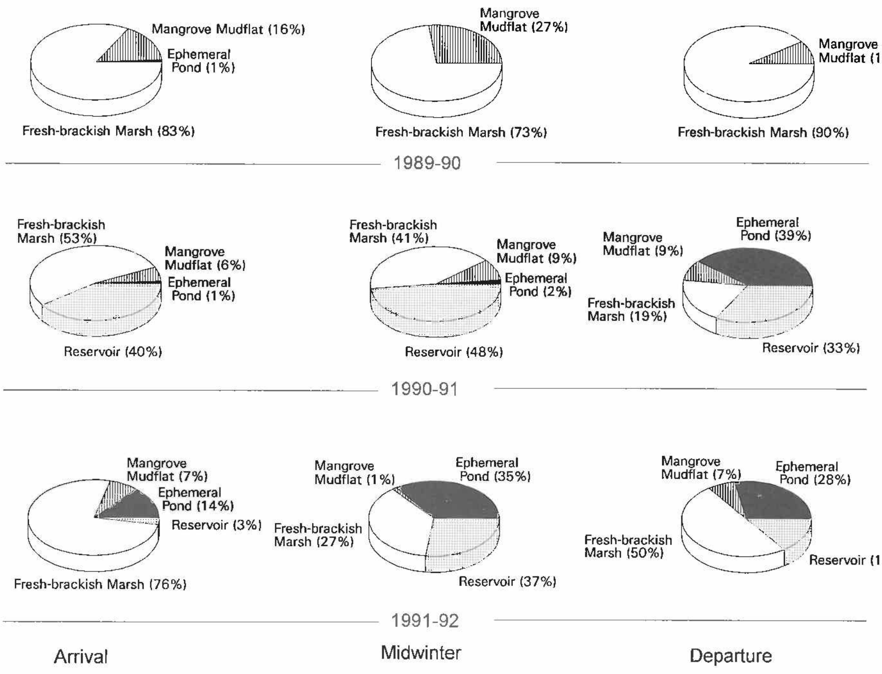

Figure 3. Percent habitat use by female Pintail wintering in Sinaloa, Mexico, 1989-92.

(73-90%) and mangrove mudflats (10-27%; **Figure 3**). Use of ephemeral ponds was rare (1%) that winter, and radio-marked Pintail never used reservoirs. In contrast, during 1990-91, 19-53% of radio locations were on fresh-brackish marshes and 5-9% on mangrove mudflats, but 33-48% were on reservoirs. Ephemeral ponds were used only 1% and 2% of the time during arrival and midwinter, respectively, but 39% during the departure period. In 1991-92, Pintail used fresh-brackish marshes (27-76%), ephem-eral ponds (14-35%), reservoirs (3-37%) and mangrove mudflats (1-7%).

Functional use of habitats

Overall, fresh-brackish marshes showed the highest feeding activity (29%, $P<0.01$; **Table 3**). In contrast, mangrove mudflats were used primarily for resting (68%); Pintail also were most alert on mudflats (3%;

Table 3. Mean percentage of diurnal activity budgets of wintering Northern Pintail within four major wetland habitats in Sinaloa, Mexico, from 1989-90 to 1991-92.

		Activity[a]					
Habitat	*n*	Feeding	Resting	Locomotion	Preening	Alert	Social
Mangrove mudflat	356	5.7 BC	68.4 A	8.7 B	13.1 B	2.6 A	1.8 A
Ephemeral pond	1137	14.0 B	62.1 A	6.0 C	14.9 B	1.2 C	2.0 A
Fresh-brackish marsh	3990	28.7 A	40.5 B	10.8 B	16.3 B	1.7 B	2.2 A
Reservoir	1564	3.6 C	50.0 C	23.7 A	18.2 A	1.9 B	2.9 A

[a]For each activity, means in a column denoted by the same letter are not different ($P>0.01$).
n=number of Pintail sampled.

Table 4. Mean percentage of diurnal activity budgets of wintering Northern Pintail in Sinaloa, Mexico, by year, habitat type, and period, from 1989-90 to 1991-92.

				Activity[ab]					
Year	Habitat	Period	*n*[c]	Feeding	Resting	Loco-motion	Preening	Alert	Social
1989-90	Mangrove mudflat	Departure	182	0.5	78.9	5.9	9.7	2.9	2.5
	Fresh-brackish marsh	Arrival	347	31.1 A	33.8 A	10.8 A	22.4 A	1.8	0.4 A
		Midwinter	948	38.6 B	33.9 B	9.1 A	14.0 B	1.2	3.6 B
		Departure	1010	32.1 A	40.9 B	8.1 B	15.1 B	1.9	2.3 C
1990-91	Mangrove mudflat	Arrival	72	1.9	66.4	11.3	17.1	3.4	0.2
		Midwinter	102	17.7	50.8	12.0	16.4	1.7	1.8
	Ephemeral pond	Departure	266	7.0	71.4	4.1	15.1	2.3	0.3
	Fresh-brackish marsh	Arrival	225	22.4 A	36.9	16.2 A	21.5 A	2.5	0.8 A
		Midwinter	179	23.4 A	38.1	16.5 A	13.5 B	3.2	5.6 B
		Departure	527	38.5 B	35.2	12.0 B	11.4 C	2.6	0.6 A
	Reservoir	Arrival	187	6.4	50.1	18.9	21.1	3.2	0.6 A
		Midwinter	446	4.7	48.8	19.5	19.2	2.8	5.3 B
		Departure	326	4.7	54.0	20.7	16.5	2.6	1.9 A
1991-92	Ephemeral pond	Arrival	118	43.2 A	30.5 A	8.2	17.8 A	0.5	0.1 A
		Midwinter	383	12.8 B	59.6 B	6.5	16.4 A	0.8	4.1 B
		Departure	370	11.1 B	67.9 C	6.2	12.4 B	1.0	1.7 C
	Fresh-brackish marsh	Arrival	548	7.5	57.9	11.7	20.9	0.9	1.4 A
		Departure	206	5.5	53.2	15.9	20.4	1.0	4.3 B
	Reservoir	Midwinter	266	3.2	44.0 A	28.8	19.5 A	0.6	4.3 A
		Departure	339	0.1	52.5 B	30.7	15.7 A	0.2	1.2 B

[a]For each activity/habitat/year combination, means in a column denoted by the same letter are not different(P>0.05).
[b]Data were not collected over certain periods and habitat types when access was not feasible or Pintail did not use habitats at that time.
[c]n = number of Pintail sampled.

Table 5. Sex ratios of Northern Pintail wintering in Sinaloa, Mexico by biological periods, 1989-92

Year	Period	n^a	Mean[bc]	Std Err
1989-90	Arrival	326	0.38 Aa	.02
	Midwinter	915	0.35 Aa	.01
	Departure	1176	0.54 Ab	.01
1990-91	Arrival	484	0.44 Aa	.01
	Midwinter	688	0.55 Bb	.01
	Departure	1106	0.66 Bc	.01
1991-92	Arrival	584	0.46 Aa	.03
	Midwinter	589	0.61 Cb	.01
	Departure	792	1.00 Cc	.02
1989-92	Arrival	1394	0.43 a	.01
	Midwinter	2192	0.48 b	.01
	Departure	3074	0.70 c	.01

[a] n=number of 10 m^2 samples.
[b] Uppercase letters indicate significant differences within periods among years.
[c] Lowercase letters indicate significant differences among periods within years.

$P<0.01$). Ephemeral ponds also functioned as resting areas (62%), but additionally were used for feeding (14%) and preening (15%). Reservoirs were used more ($P<0.01$) for locomotion (24%), and preening (18%) than other habitats ($P<0.01$).

Data analysis by years and periods, however, revealed annual variation in habitat functions not shown when years were pooled (**Table 4**). For example, in 1989-90 and 1990-91, feeding activity was high on fresh-brackish marsh throughout all three periods (22-39%) and peaked at midwinter, but feeding in fresh-brackish marsh in 1991-92 was only 6-7%. During 1991-92, most feeding occurred on ephemeral ponds. Feeding on mangrove mudflats averaged 6% overall, but reached 18% during midwinter 1990-91.

Resting was particularly high (68-71%) in ephemeral ponds during departure 1990-91 and 1991-92 when we sometimes observed ≥90,000 individuals using this habitat type. Reservoirs also were important resting habitats (50%), but Pintail rarely fed there (4%). Pintail numbers peaked at 152,000 individuals on El Alhuate Reservoir during midwinter of 1990-91. Social activity peaked at midwinter each year and was an important activity on fresh-brackish marshes (3 years), reservoirs (2 years), and ephemeral ponds (1 year).

Discussion

Habitat interactions

Thompson & Baldassarre (1991) determined the time budgets of Pintail using mangrove estuaries in Yucatán, Mexico, and suggested that low thermal stress caused the lack of variation in behaviour they observed within and among winters. In Sinaloa, however, Pintail were exposed to similar ambient temperatures as Yucatán (20°C-28°C), but we observed much greater variability in activity budgets among years, biological periods, and time of day.

In contrast to Yucatán where Pintail wintered exclusively in natural, mangrove wetlands that did not vary in quality among years, we believe that variation in activity budgets of Pintail in Sinaloa occurred due to the availability of a greater diversity of wetland and agricultural habitats.

However, because the availability of these habitats varied annually, we found that Pintail varied their habitat use patterns and diurnal activity budgets dependent on the interaction of four major factors: (1) proximity of rice to wetlands, (2) ecological condition of coastal marshes, (3) availability of ephemeral ponds and open-water areas and (4) flock size and pair formation.

(i) Proximity of rice to wetlands

Our data indicate that the number of wintering Pintail at Pabellón is correlated with rice availability and that Pintail select resting habitats in close proximity to rice fields. For example, in December 1989, we observed 282,000 Pintail at the Soyotita Estuary next to flooded rice fields, but only 21,000 Pintail were there in December 1990 when rice was absent. In December 1989 we observed 82,000 Pintail at Estero Colorado, when rice was present nearby, compared to only 17,000 birds in December 1990 when rice was not grown. Likewise, there were 152,000 Pintail at El Alhuate Reservoir in midwinter 1990-91 compared to 75,000 at Chiricahueto, when rice fields were closer to the reservoir that winter. However, in 1989, more Pintail (308,000) were found at Chiricahueto in December when rice was located in adjacent fields. Overall, we observed the most Pintail at Pabellón in 1990, the year when the most rice was planted (50,000 ha) and reflooded (*c* 30,000 ha) in the Culiacán Agricultural District.

In the presence of an abundant and available agricultural food, resting was the dominant daytime activity of Pintail in Sinaloa (38-55%), which compliments results observed for wintering Pintail on wildlife refuges adjacent to rice fields in California and Louisiana (Tamisier 1976, Miller 1985). However, feeding was the dominant diurnal activity (42-48%) of Pintail wintering in natural mangrove wetlands on the Yucatán Peninsula of Mexico. Time spent resting in Yucatan was only 19-23% (Thompson & Baldassarre 1991), but Pintail did not have access to any agricultural foods. Thus, because agricultural foods are usually more available than natural foods in wetlands, feeding time is reduced (Baldassarre & Bolen 1984). Nevertheless, cereal grains do not contain all the nutrients required by waterfowl, which then must supplement their diets with natural foods (Baldassarre *et al.* 1983). Indeed, of the four habitat types in Sinaloa, time spent feeding was highest in natural, fresh-brackish marsh. However, although Sinaloa is the peak rice producing state in Mexico, yearly production depends heavily on national and international market economies; hence, the availability of rice is not guaranteed annually for wintering Pintail or other waterfowl.

(ii) Ecological condition of coastal marshes

Time budget results indicated that Pintail can satisfy all their winter requirements within fresh-brackish marshes. Interspersion of open spaces, cover, dry resting areas, and natural foods probably favoured the use of this habitat. Indeed, Chiricahueto, was used frequently despite hunting activities that took place daily from 1 November 1989 through to 28 February 1990.

However, ecological conditions at Chiricahueto changed over the duration of our study, and likely will affect habitat functions in the future. For example, growth of Cattail *Typha dominghensis* inside Chiricahueto is about 1.68 m^2/year, apparently the result of increased input of fresh water from irrigation and accompanying fertilizer (Martínez Morales 1991, Comisión de Ecología Gobierno del Estado de Sinaloa, pers. comm.). Additionally, silt deposition from soil erosion is gradually closing open spaces favoured by Pintail. For example, the southern portion of Chiricahueto historically contained vast extensions of sand flats where thousands of dabbling ducks roosted. However, most of these areas are now covered by cattails, and Pintail flocks have since shifted to more northern marsh areas. Larger sections of open water and open sandy beaches were present at Chiricahueto as recently as the late 1980s (Migoya 1989). Additionally, the obstruction of water flow appears to be altering natural plant and invertebrate communities due to increasing eutrophication.

(iii) Availability of ephemeral ponds and open-water areas

Ephemeral ponds also were important daytime feeding areas, particularly during 1991-92. As most hunting occurs in natural marshes (Migoya & Baldassarre 1993), Pintail can use ephemeral ponds and other open-water habitats (i.e. reservoirs) as refuge areas for protection from hunting pressure. Nevertheless, water availability on ephemeral ponds depended on the amount of winter rainfall and/or reflooding of rice fields. For example, abundant rainfall during 1991-92 (9.2 cm *v* 3.4 cm in 1989-90 and 4.0 cm in 1990-91) created thousands of hectares of ephemeral ponds that extended several kilometres east and west of the Río Culiacán and flooded agricultural fields adjacent to Laguna Caimanero and Laguna de Bataoto south to Pabellón (**Figure 1**). Miller (1985) also found that variability in activity budgets of Pintail wintering in the Central Valley of California was affected by differences in precipitation among years. Hence, activity budget data on Pintail from several major wintering areas demonstrate that this species is extremely flexible in adjusting behaviour in response to variation in habitat diversity, abundance, and quality. In California, such flexibility has allowed Pintail to remain an abundant wintering species despite the loss of most natural wetland habitat (Miller 1985). However, poor habitat conditions resulting from reduced rainfall can affect dynamics of body and lipid mass of wintering Pintail (Miller 1986), and Pintail wintering in California may be more vulnerable to hunting during dry winters (Raveling & Heitmeyer 1989).

Gray *et al.* (1986) also indicated that management efforts on waterfowl wintering areas have been focused on providing feeding habitats, without regard to the functional and seasonal role of other habitats. For example, ephemeral ponds and mangrove mudflats were important resting habitats in Sinaloa because these areas contained sand flats, grass clumps, levees, and other loafing sites. Resting was somewhat lower on reservoirs because these habitats had deeper water and lower availability of shoreline loafing areas. Nonetheless, open areas are important to wintering Pintail (Guthery *et al.* 1984), which further emphasizes the adverse effects of expanding Cattail communities in Pabellón. We also observed as many as 100,000-500,000 Pintail resting on floating mats of Water Hyacinth *Eichhornia crassipes* in the fresh-brackish marshes of Chiricahueto. Gray *et al.* (1986) found that Pintail and Green-winged Teal *Anas crecca* preferred to rest on floating mats of vegetation when using open-water areas within coastal marshes of South Carolina.

(iv) Flock size and pair formation

Every year, we observed Pintail congregating into one or more large flocks of 90,000-120,000 individuals, where a high amount of social activity was observed. Miller (1985) also observed increased courtship activities in Pintail flocks numbering 50,000-100,000 individuals in California, and Tamisier (1976) obtained similar results in Louisiana.

However, compared to the Sacramento Valley of California where 93% of Pintail were paired by late-December (Miller 1985), only 9-35% of Pintail in Sinaloa were paired by midwinter. Fewer Pintail formed pairs in 1990-91 (8%) when precipitation was lowest and fewer rice fields were flooded compared to 1989-90 (38%) and 1991-92 (17%). Habitat quality as influenced by low precipitation decreased courtship among Pintail in California (Miller 1985).

Another factor that may reduce pairing among dabbling ducks wintering in the Neotropics is dominance relationships between males and females. Specifically, Thompson & Baldassarre (1992) found that only 2.5% of female Pintail in Yucatán were paired by February, and because females won more aggressive interactions they suggested that delayed pairing in the Neotropics may have occurred because females would not gain benefits in dominance rank from pairing. A further comparison was that Miller (1985) observed 70 Pintail copulations over two winters in California, whereas we only observed three copulations in Sinaloa over three winters.

Importance of Sinaloa for the North American Pintail population

The Pabellón Wetland Complex, and other areas used by Pintail in Sinaloa (Kramer & Migoya 1989), constitute a high quality wintering region within North America because of the availability of a mosaic of habitats, especially the combination of large natural wetlands and extensive rice culture. Mild temperatures also minimize thermoregulatory costs, which is a clear benefit to Nearctic waterfowl wintering in the Neotropics (Thompson & Baldassarre 1990). Further, Pintail were very flexible in adjusting their time budgets to the variable habitat conditions, and yet experienced high survival rates every year (Migoya 1993). In addition to wintering habitat, our population surveys in February 1990 at Pabellón indicate that Sinaloa coastal wetlands also function as spring staging areas.

Habitat modifications occurring over the past six years, however, indicate the need for management actions. The large size of Pabellón (80,000 ha) likely affords some time before habitat deterioration reaches an extent that affects large numbers of Pintail, but current agricultural and water-use practices indicate that management activities are inevitable if the quality of the area is to be maintained. Management that refloods rice fields would provide an abundant agricultural food source to supplement the natural food base of Pintail in Sinaloa, but management also must be directed at restoring open water and sandy beaches that are being eliminated by growth of Cattails in natural wetlands. Mechanical removal is an expensive option, but control of excessive runoff of fertilizer and pesticides must be addressed because it is the major cause of cattail growth.

Overall, we concur with Raveling & Heitmeyer (1989) in that management of Pintail wintering habitat deserves increased attention since it is more closely related to Pintail recruitment than harvest variables. Hence, conservation and management practices in the UMWC of Mexico designed to maintain high quality habitat appear essential to the North American Pintail population, especially considering that this area contains some of the largest and most pristine wetland complexes in the Western Hemisphere.

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