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An experimental soft-release of oil-spill rehabilitated American coots (*Fulica americana*): I. Lingering effects on survival, condition and behavior

D.W. Anderson [a,*], S.H. Newman [b], P.R. Kelly [c], S.K. Herzog [a], K.P. Lewis [a]

[a]*Department of Wildlife, Fish, & Conservation Biology, University of California, Davis, CA 95616, USA*
[b]*Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, CA 95616, USA*
[c]*Office of Oil Spill Prevention & Response, California Department of Fish & Game, PO Box 944209, Sacramento, CA 94244, USA*

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"Capsule": *The long-term effects of oil-spilled rehabilitation on American coots is determined.*

Abstract

In spring 1995, we studied survival, condition and behavior of 37 oiled/rehabilitated (OR) American coots (*Fulica americana*) (RHB) and compared them to 38 wild-caught, non-oiled and non-rehabilitated coots (REF). All coots were wing-clipped to prevent long-range dispersal, mixed equally and randomly and soft-released into two fenced marshes. Twenty RHB + 20 REF coots were subjected to handling and sampling four times during the 4-month study and the remainder were left undisturbed. The study ended before any coots dispersed following remige regrowth. Overall survival was significantly lower for RHB coots, regardless of the way survival was viewed (four Chi^2 tests varied between $p < 0.045$ and $p < 0.006$). Mortality was 2.1 times higher in RHB coots: 51% mortality in RHB coots and 24% in REF coots (4 months total). RHB coots began the experiment 9% lighter in mean body condition indices (BCI = a standardization that corrected for different-sized birds) than REF coots, but REF coots also needed a period of adjustment to captivity. BCIs then varied ($p < 0.02$) similarly among both groups throughout the experiment. Initially, RHB coots lost more weight in comparison to REF coots (although RHB coots fed more), but those RHB coots that did survive recovered to REF-comparable BCIs after about 6 weeks: both higher and equivalent at the beginning of moult and then both equivalent but lower through the moulting period. Long-term RHB coot and REF coot survivors both had significant ($p < 0.001$) positive correlations between their initial and ending body weights. A similar relationship was also suggested for the non-surviving REF coots, but could not be tested for statistical significance. In contrast to all other groups, however, non-surviving RHB coots failed to show any relationship between their initial and ending body weights ($p > 0.10$), indicating that non-surviving RHB coots were unable to gain or maintain body condition for about 2–3 months following their oiling/rehabilitation experience. Throughout the experiment, RHB coots preened more on water and on land, bathed more, slept less during the day, and exhibited feeding and drinking behaviors more frequently or of greater duration than REF coots (all statistical tests with Bonferroni-corrected $p < 0.05$).

Keywords: American coots; *Fulica americana*; Waterbirds; Oil-spill rehabilitation; Body condition; Survival; Behavior

1. Introduction

Following past oil-spill incidents, many oiled/rehabilitated (OR) waterbirds, when released back into the wild, suffered continuing impairments in survivability as well as behavioral changes when these birds were compared to unoiled, untreated comparisons or reference groups (Collins et al., 1994; Anderson et al., 1996; Sharp, 1996; Wernham et al., 1997; Camphuysen et al., 1997; Partridge, 1997; Grunsky-Schöneberg and Hüppop, 1997; and references cited therein). Yet, some authors have reported successful rehabilitation, especially notable being a high level of success involving African penguins (*Spheniscus demersus*) (Underhill et al., 1997, 1999; and references cited therein) and possibly also in some instances involving common murres (*Uria aalge*) (Harris and Wanless, 1997). Our main objective here was to study and document the response of American coots (*Fulica americana*, hereafter called 'coots') to OR experience.

* Corresponding author. Tel.: +1-530-752-2108; fax: +1-530-752-4154.
E-mail address: dwanderson@ucdavis.edu (D.W. Anderson).

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Coots are widespread and abundant and they are well suited for studies in aquatic environments. In recent years coots have also been frequently impacted in California by oil spills (J. Mazet, personal communication). In 1995, an oil spill in California did impact coots and we obtained access to cleaned, cared-for and releasable coots. These coots provided us with the opportunity to further investigate post-release survivability, behavior, and physiological condition of OR coots in a situation where we could obtain detailed data on treatment fates, behaviors, and physiological health parameters. Here, we tested the following predictions: (1) that survivability and body condition of rehabilitated coots would be less than that of individuals from a reference wild-caught population under the same conditions; and (2) that comfort-related behaviors (preening, sleeping, etc.) and behaviors indicative of health, well-being, or food needs (maintenance, feeding, drinking, aggression, etc.) would vary between rehabilitated (RHB) and reference (REF) coots.

2. Materials and methods

2.1. Oil spill, rehabilitation, and comparison groups

On 20 February 1995, approximately 1100 barrels of San Joaquin crude oil spilled from a broken pipeline into the San Gabriel River, near Norwalk, CA, USA, moving south about 4.2 km toward Long Beach, where a channelized river empties into the Pacific Ocean (30.79° N×118.09° W to 33.35° N×118.11° W). Seventy-eight coots (plus 18 individuals of four other waterfowl species) became oiled and were captured for rehabilitation by 22 February. Birds were herded and captured in the narrow and restricted habitat of the lower 1.5 km of the channel, resulting in minimal time-intervals from oil exposure to capture and from capture to rehabilitation. Air temperatures were mild (15–25°C) during these activities. Rehabilitation efforts were initiated by the veterinary services of the California Department of Fish and Game (CDFG) Office of Oil Spill Prevention and Response (OSPR), and completed by International Bird Rescue Research Center (IBRRC), Berkeley, California, using methods described by Williams (1985).

We use the term 'rehabilitated' here to mean that coots had been oiled, cleaned, further treated and judged suitable for release. This is in contrast to the definition as used by Underhill et al. (1999) who defined rehabilitation as a treated bird that has been "subsequently resighted at a breeding colony."

Since coots are common in California, agencies involved in this effort (CDFG and the US Fish and Wildlife Service, USFWS) determined that these birds provided a unique opportunity to further study post-release survival, behavior, and long-term health impacts of OR. Forty-seven of the captured, cleaned coots (probable release rate = 60%) were transferred to the Wildlife Health Center (WHC), University of California, Davis on 28 February 1995, about 6 days after initial admission to IBRRC. RHB coots were immediately placed into a large holding pen with fresh water, heavy ground cover, and abundant food to await the arrival of a comparison group.

Forty-two coots were obtained as a reference group (REF) on 13 March 1995. They were captured with rocket nets (Schemnitz, 1994) from wild flocks at Grey Lodge Waterfowl Management Area, near Gridley, CA (39.32° N×121.87° W), approximately 425 km NNW of the site of oiling, but where coots aggregate in large numbers during breeding, migration, and post-breeding periods (Guillion, 1952). REF coots were transferred to WHC on the day of capture.

2.2. Processing and placement of coots into experimental habitat

Of the 47 RHB coots originally obtained, five were killed by unknown predators in our initial holding pen, three escaped, and two were marked, banded, and released by us to test and practice our marking system. Of the 42 wild REF coots captured, four were marked, banded and released. The remaining coots (RHB $n=37$; REF $n=38$) were used for the study. Half of the RHB coots and seven of the 38 REF coots had foot abrasions, cuts, or lesions. The foot lesions on RHB coots were judged by attending veterinarians to be due to avicultural conditions of captivity and those of the REF coots probably due to capture, captivity and transport. The severity of all these foot lesions began to subside and heal once the coots were placed into our initial outdoor holding pen.

RHB and REF coots were mixed randomly and placed into two adjacent experimental marsh systems on the campus of the University of California, Davis (Fig. 1): (1) an open pond ('Pond 4') with appropriate surrounding habitat sufficient to support wild coots and surrounded by escape-cover dominated by emergent cattail (*Typha* sp.) ($n=17$ RHB + 18 REF); and (2) an escape-proof, fenced pond with sufficient habitat dominated by blackberry, *Rubus* sp. and poison oak, *Toxicodendron diversilobum*, as escape cover and shaded by willow trees, *Salix* sp., and other brushy habitat ('Inner Sanctum') ($n=20$ RHB + 20 REF). Pond 4 consisted of 0.46 ha open water with about 1.12 ha emergent vegetation and grassland habitat; Inner Sanctum consisted of 0.46 ha open water and 0.56 ha emergent and terrestrial habitat (Fig. 1). Coots and other Rallidae typically utilize tactics that involve escape into thick vegetation or diving beneath water (Lima, 1993), and both ponds possessed abundant habitat amenable to these behaviors.

Fig. 1. Oblique aerial photograph of the experimental marsh system used to study American coots. 'Pond 4' is on the upper left and 'Inner Sanctum' is on the lower right. The photograph faces east, with north to the left. The white roof on the largest building at mid-right is 18.5 m.

Our 'release' duplicated the 'soft-release' technique (such as described by Nesbitt and Carpenter, 1993), designed to give newly released birds some time to adjust under safer than 'wild' conditions, while still being observed. The purposes of the two schemes used in this study were: (1) to provide some replication under similar conditions; but to allow one group to respond and to interact under conditions of non-handling (REF vs. RHB, Pond 4); and (2) to allow us to recapture and sample a sub-sample of the coots (REF vs. RHB, Inner Sanctum). The Inner Sanctum provided an area where coots could be safely captured and various samples obtained during the experiment (Newman et al., 1999a). Both ponds and adjacent habitat were contained within a larger fenced area, secure from unauthorized human access (Fig. 1).

Observation blinds or vehicles on nearby trails with high-powered spotting scopes were used from a distance at both sites to minimize disturbances. Field observers quietly moved around each area from numerous vantage points to ensure independence of observations. Each pond area was supplied with commercial waterfowl food (rice) daily. Supplemental food was used because of possible crowding (40 coots per habitat, or about 76–87 individuals ha^{-1}).

2.3. Handling and physiological monitoring

Primary and secondary remiges were clipped from one wing at about one-half their lengths to render all experimental coots unable to disperse. Each bird was measured and weighed, given a physical examination by veterinarians, and 1–2 cc of blood taken prior to release into Inner Sanctum or Pond 4 on 4 April. Feet and legs of all coots were examined for abrasions, swelling, and inflammations. Additional follow-up examinations, weights, and feather and blood samples were obtained on 18 April, 13 May, 9 June, and 11 July, 1995. Blood samples were analyzed for hematologic and serum biochemical parameters to assess the physiological health of sampled individuals (these results are reported elsewhere by Newman et al., 1999a). All coots prior to release were metal-banded, fitted with a numbered, colored leg band on the opposite leg, and fitted with a small, 20-g radio-transmitter (as described by Mauser and Jarvis, 1991; Wheeler, 1991; Pietz et al., 1995; Newman et al., 1999b). All coots were also fitted with colored, numbered neck collars to facilitate identifications (after Bartelt and Rusch, 1980).

2.4. Documenting survival and behavior

2.4.1. Behavioral descriptions

We divided each coot's actions into primary (I) and secondary (II) behaviors, with secondary behaviors often occurring during the primary behavior. For instance, preening could take place while a bird was standing, roosting, or swimming. Dual activities were then additionally coded as 'preen-water' or 'preen-land', for example. We recorded the following behavioral actions in one of the two protocols described in (1) and (2) below: primary behaviors—roosting (apparently resting, not up on feet), standing (with eyes open), walking, wading, swimming, flying, and 'other' (anything else, with a notation); secondary behaviors—sleeping on land, sleeping on water, preening on land, preening on water, feeding on land, feeding on water, bathing, stretching, wing-flapping, drinking, aggressive donor, aggressive recipient, charging (more intense), chasing (most intense), being charged, being chased, and 'other' (anything else, with a notation). Courtship and chick-interaction activities (e.g. Salathé and Boy, 1987) were seldom seen by us and not included in our behavioral analyses.

2.4.2. Protocols

Daily protocols involved the following activities from mid-April through mid-July, 1995 (3 months of intensive behavioral observation):

1. We conducted daily behavioral scans (Lehner, 1979, pp. 122–123) at various times during daylight. Although wild coots have not previously shown time-dependent behavior patterns during the day in other studies (Ryan and Dinsmore, 1979), we still varied our behavioral scans over the midday period (roughly 08:00–15:00). Behavioral scans were conducted on coots in the Inner Sanctum or opportunistically at Pond 4, and they were used to obtain percentages of occurrence of frequently observed behaviors. In scan-sampling, short-duration and infrequently occurring actions are not likely to be adequately sampled, and we omitted such data from our analyses. Thus, only

frequent actions are given, and sums will not equal 100%. Each scan lasted approximately 5 min but these were extended if few coots were visible (median scan-time = 5 min, range = 3–20 min). We recorded each bird only once per scan and waited at least 30 min between scans. Sample sizes represent number of scans, not individual birds observed (10–60 coots $scan^{-1}$, median number of birds $scan^{-1} = 21$). Zeroes for various behavioral categories on any given scan among 479 scans were regarded as missing values. No scans with < 10 birds were allowed, resulting in 435 acceptable scans for data analysis. Activities (2) and (3) below were conducted between these behavioral scans.

2. We also conducted focal observations on individual coots each day (Lehner, 1979, pp. 115–117), by identifying an individual and spending 2–5 minutes focused on that bird while recording all activities with their times of initiation and cessation (as well as their frequencies in some cases, such as pecking at food). The intent of the focused observations was to obtain the added dimension of episode frequency (episodes 5-min^{-1}) and duration (s h^{-1}) for as many behavioral actions as possible. In cases where frequencies were obtained, the behavior itself (such as 'drinking' comprised of one or more instances of dipping and swallowing) was timed as an 'episode'. We obtained about five focused observations for each group (RHB and REF) each day of observation. Sample sizes represented number of focal observations among totals of 394 for REF coots and 339 for RHB coots, or about 61 h of observation over a 3-month period.
3. Finally, we conducted radio-telemetry scans between 12:00 to 15:00 each day to confirm the presence and determine the status of each coot. Radios were equipped with a mortality switch so carcasses could be recovered and necropsies performed to determine causes of death. Every radio-marked coot was accounted for and there were no transmitter failures or unexplained losses of signals.

2.4.3. Data treatment and analysis

Body weights were standardized where necessary, using the body condition index (BCI) described by Anderson et al. (1996). The BCI standardizes body size through culmen (CUL) measurements. In the case of coots, we used the 'bill-shield' measurement described by Gullion (1952). All data were first tested for normality and either log transformed, or analyzed using non-parametric methods (Bryman and Cramer, 1996). Coot behavioral and BCI data were examined over time to determine if changes occurred during the 4-month experiment; if not, data were combined. Statistical tests follow MINITAB as described by Ryan and Joiner (1994), except that in cases involving multiple comparisons, we selected a significance test-level of $p < 0.05$, based on Bonferroni corrections (Rice, 1990), as our cut-off for statistical significance. All Chi^2 tests reported here have one degree of freedom.

3. Results and discussion

3.1. Mortality and survival

In efforts to test the hypothesis of increased RHB mortality rates in a species such as the American coot with naturally high mortality rates anyway, large samples are needed (Burton, 1959, estimated annual adult mortality rates of US Midwestern coots as $57 \pm 6\%$; 95% CL); and it is possible that this high mortality might mask any differences between RHB and REF coots caused by the oil exposure and/or rehabilitation, especially with small samples (Samuel and Fuller, 1994). Yet, in all possible combinations (considering mortality throughout the entire experiment, or being more conservative to exclude all mortalities in the first 7 days from the test ('adjustment period'), or excluding all mortalities due to suspected predation, or considering only the Inner Sanctum coots) mortality rates among the RHB coots were consistently higher ($p < 0.006$ to $p < 0.045$; Table 1). Overall survival comparing the two groups was 49% in RHB and 76% in REF, or about twice as high among REF coots.

Table 1
Mortality of American coots after soft-release into an experimental marsh ecosystem, using Chi^2 tests (df = 1) and variations in data criteria to test the null hypothesis that survival was the same between rehabilitated (RHB) and reference (REF) test populations

Criterion	No. RHB in test	No. REF in test	Chi^2-value	p-value
Time post-release in experiment (all coots)	37	38	7.29	<0.01
Time post-release in experiment after 7-day adjustment period	27	34	4.05	<0.05
Time in both ponds, excluding suspected predation	29	32	5.65	<0.02
Time in Inner Sanctum only	26[a]	25[a]	7.60	<0.01

[a] During the course of the experiment, six RHB and five REF coots moved from Pond 4 to the Inner Sanctum fence of their own volition (Fig. 1), and were put in. This increased the sample size category.

Extrapolated to annual mortality rates, and assuming elevated mortality had completely subsided for RHB coots by the end of our experiment (a total of 4 months), REF mortality rates were more comparable, but still above those previously reported for a hunted, midwestern US population of wild coots (Burton, 1959): annual mortality rates for REF versus RHB coots would be projected as 65 and 89% year^{-1}, respectively, for REF and RHB coots, compared to 51–63% year^{-1} in the previously mentioned wild population.

3.2. Temporal or seasonal changes in body weights and condition

Body conditions in both categories, RHB and REF, varied significantly over the experimental period [analyses of variance (ANOVAs): REF BCI, $F=4.84$, $p<0.004$; RHB BCI, $F=3.56$, $p<0.02$]. These data (representing all birds early in the experiment but only survivors toward the end) (Table 2) indicated that body condition was complex and varied in relation to both the captive conditions and the expected seasonal variability of wild coots. First, RHB coots were slightly underweight as compared to wild REF (9.1% less, comparing BCIs, Table 2) at the beginning of the experiment, but they later gained condition. Second, both RHB and REF coots experienced declines in BCI during the earlier parts of the experiment, with both RHB and REF coots being at low BCIs in mid-April (feather moult activity was detected in only one of 19 birds examined at that time, however). Third, both RHB and REF coots had regained body weight by early June prior to extensive moult (six of 23 birds examined had active moult, mean score [ranked low/high from one to 10] = 0.5). But both groups again lost weight prior to dispersal and during much more active feather moult in mid July (17 of 23 birds examined had moult activity at this time, mean score = 1.6, $p>0.05$), and there were no differences between RHB and REF coots. The change of moulting activity among all the coots over this experimental period, from start to finish, was highly significant ($p<0.01$, $Chi^2=9.52$). Many coots in both experimental groups were still actively moulting at the end of the study, and none had yet dispersed; but in the days and months following, nearly all surviving coots left.

Since both RHB and REF coots were essentially following the same body-condition pattern by early June (Table 2), we assumed that BCI changes by this time represented normal seasonal declines associated with their increased moult activity. Although there are few studies to substantiate this specifically in wild American coots, decline in body weight is a common phenomenon among many waterfowl species at this time in their annual cycle (e.g. Panek and Majewski, 1990; Thompson and Drobney, 1996).

We also asked if long-term survivors possessed some characteristics in body condition that would predict their ultimate survival, such as the ability to maintain or gain body weight (a correction for potential differences in body size was not necessary for this comparison because individuals were only being compared to themselves). We obtained representative samples and, therefore, were able to compare individual initial body weights to their later body weights, comparing: (1) long-term RHB or REF survivors and (2) RHB or REF non-survivors (using the measurements obtained at their most recent capture or death) (Table 3, Fig. 2).

RHB survivors maintained body condition but non-surviving RHBs did not, although the non-surviving RHB coots started heavier (Table 3). The RHB survivor weight histories also most closely paralleled those of REF survivors (Fig. 2a vs. c). REF non-survivors indicated a pattern similar to RHB and REF survivors, but the data on this subgroup were few and not independent, precluding any statistical testing (Fig. 2d, Table 3).

Table 2
Body condition indices (BCIs)[a] in surviving American coots sampled in a soft-release situation between the beginning and end of the post-oil spill/rehabilitation period

Measure	Period[b]			
	1 E-APR	2 M-APR	3 E-JUN	4 M-JUL
REF $\bar{x}$ BCI ± SE	108.9 ± 2.2	104.5 ± 2.5	112.7 ± 3.5	97.2 ± 2.9
n	36	7	12	17
RHB $\bar{x}$ BCI ± SE	99.0 ± 2.3	94.5 ± 3.0	113.6 ± 4.4	97.4 ± 5.1
n	31	11	6	6
p[c]	< 0.003	< 0.04	NS[d]	NS[d]

[a] Body condition index (BCI) = weight (g)/culmen length (cm).
[b] E, early; M, mid-.
[c] Significance levels are given on vertical comparisons, using Mann–Whitney two-sample rank tests.
[d] NS, not significant.

Table 3
Changes in body condition indices (BCIs) of rehabilitated (RHB) and reference (REF) American coots, comparing individuals with known histories of survival throughout the experiment

Status (measurement)	n[a]	Means ± 95% CL			
		Beginning	Ending[b]	Signif.	% Change
RHB survivors					
BCI (g cm^{-1})	9	95.1 ± 6.7A	102.8 ± 8.2*X*	$p = 0.17$	+8.0
Bill-shield (cm)	9	4.45 ± 0.18J	–	–	–
RHB non-survivors					
BCI (g cm^{-1})	14	112.0 ± 7.3B	96.4 ± 3.2*Y*	$p < 0.003$	−13.9
Bill-shield (cm)	14	4.43 ± 0.15J	–	–	–
REF survivors					
BCI (g cm^{-1})	19	109.4 ± 5.2B	104.4 ± 5.8*X*	$p = 0.25$	−4.6
Bill shield (cm)	19	4.58 ± 0.12K	–	–	–
REF non-survivors[c]					
BCI (g cm^{-1})	7	106.8 ± 10.0AB	–	–	–
Bill-shield (cm)	7	4.56 ± 0.15K	–	–	–

[a] Means that share a common letter vertically are significantly different ($p < 0.05$) by Mann–Whitney rank tests and t-tests.
[b] In RHB non-survivors, this value represents the last measurement before documented death.
[c] Since most of the REF coots that died in captivity did so mostly in the first 2 weeks of the experiment (six out of seven), this negated any statistical testing, so only initial values are given.

Gullion (1952) and Alisauskas (1987) demonstrated that bill-shield measurements were indicative of body size and sex in coots, larger measurements belonging to larger males and mature, fully grown birds. All of the coots in this study were of mature size, and since bill-shield measurements (culmen = CUL) between the two RHB groups were not different (Table 3) we could eliminate the possibility that their body condition differences might somehow have been caused by sex bias within the samples.

Foot lesions rapidly healed in our RHB birds, but at the last sampling, healed scars could still be detected in some individuals; it is possible, therefore, that this condition served as a chronic source of inflamation and/or infection. Blood parameters indicated that infections and other physiological changes (internal lesions and electrolyte imbalances) may have contributed to mortality in RHB coots (Newman et al., 1999a). Differences between original foot lesion scores of RHB survivors (RHBs) versus RHB non-survivors (RHBn) were not statistically significant, however (Mann–Whitney rank tests: $p = 0.63$, mean no. lesions bird^{-1} ± 95% CI = 4.9 ± 1.4 and 6.5 ± 2.3, respectively, RHBs and RHBn). Because non-surviving coots could not maintain their body weights at a time of the year when REF and RHB survivors were in better body condition (as would be expected for wild coots in a period of food abundance plus additional supplemental food of the soft-release), this suggests that physiological problems rather than food shortage were related to this condition.

3.3. Behavioral contrasts and similarities between RHB and REF treatment groups

Although coots utilized their supplemental food frequently, we also observed them eating aquatic insects and other invertebrates, aquatic vegetation, and sprouting terrestrial plants (mostly grasses and forbs) throughout both areas (as expected for wild coots; Lang, 1991). Natural coot densities in breeding habitat (when animals would be expected to be much more pugnacious and territorial; Ryan and Dinsmore, 1979) have been reported at around 4–8 breeding individuals ha^{-1} (Sugden, 1979). Therefore, we did not expect our coots to attempt to breed under their high experimental densities, which resembled communal, flocking conditions rather than more dispersed breeding conditions (76–87 individuals ha^{-1}).

Time plots on all recorded coot actions or behaviors did not indicate any significant time-related changes during our observation period (e.g. Fig. 3, $p > 0.05$, visually comparing time plots, then testing each behavioral action by Mann–Whitney rank tests or t-tests, comparing data for the April–May and June–July parts of the experimental period). Scan data (reporting percentages of occurrence for various behavior categories during daylight) indicated that RHB coots were generally more active during our observations than REF coots (Table 4, category I behaviors), that they slept less, preened and bathed more on the water, and fed more both on land and in the water (Table 4, category II behaviors). It follows then that REF coots could have

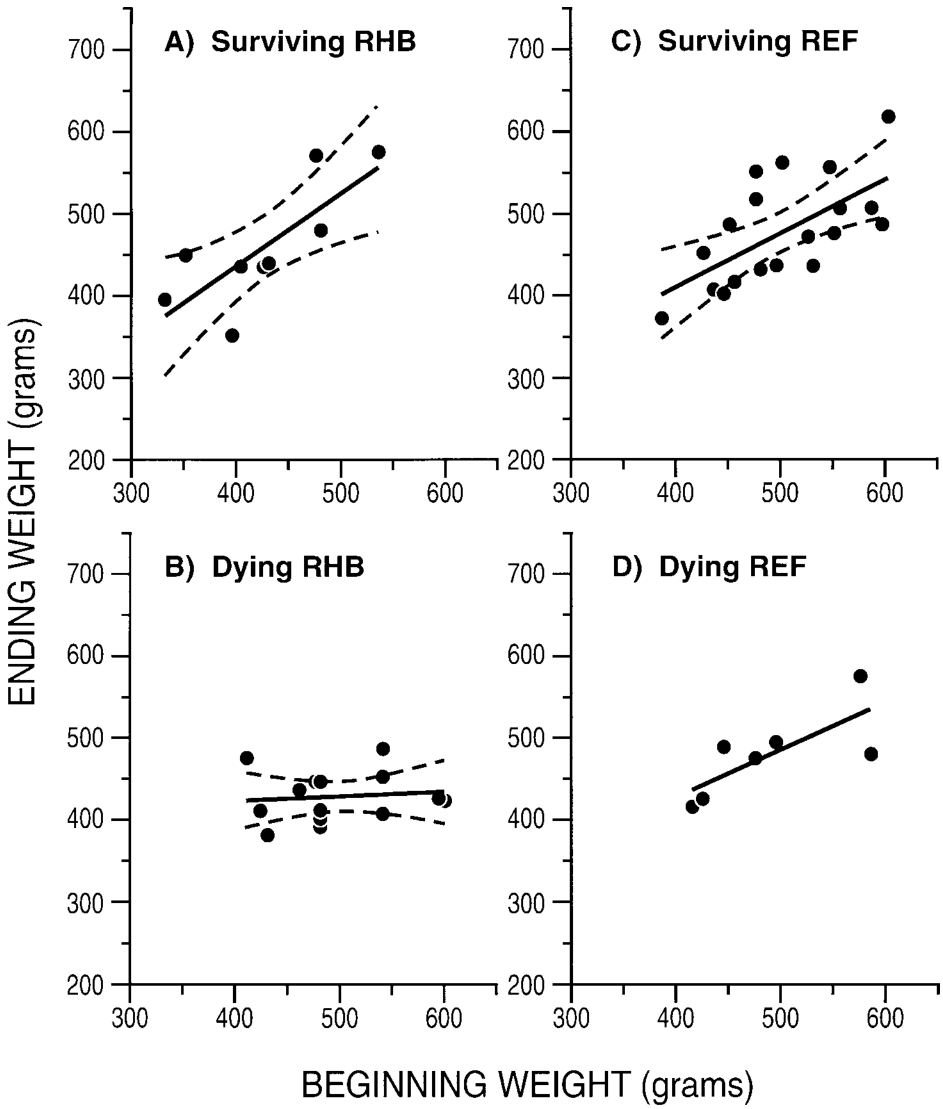

Fig. 2. Relationships between beginning and ending body weights of rehabilitated (RHB) coots that (A) survived through the soft-release and (B) those that did not, as well as (C) reference (REF) coots that did and (D) did not survive. Dashed lines on either side of the regression lines in A–C represent 95% confidence intervals (CIs).

spent more time on such activities as sleeping (Table 4) and other activities.

Since we knew that REF coots were slightly larger (by 2.8%) than RHB coots (Table 3, bill-shield measurements), this could be hypothesized to have given them some competitive advantage in feeding. Although sample sizes were small ($n = 25$ vs. $n = 14$), we found no differences ($p > 0.05$) in four aggressive behavior categories between REF and RHB coots among the following: aggression-donor, aggression-recipient, charging, and chasing. And, as already seen, RHB coots actually fed more than REF coots, and supplemental feeding and abundant natural food likely eliminated the potential effect of interference competition among coots in this study. Although differences between RHB and REF coots were obvious in many cases (Table 4), the reader should be aware that the nature of scan-sampling does not allow accurate estimates of time-activity. Focal data can, therefore, help answer additional questions.

In 35 tests for differences in the durations of different coot behavioral actions, only three were statistically significant (Bonferroni-corrected $p < 0.05$) (Table 5). Again, the major differences were mostly related to comfort movements, such as preening. RHB coots both on the land and in the water, despite a greater percentage occurrence of preening on land by REF coots (Table 4), preened for greater durations (Table 5, Fig. 3). Although the occurrence of drinking was not statistically significant between REF and RHB coots (Table 4), duration of drinking was (Table 5, Fig. 4), indicating that RHB coots, overall, drank more.

Another interesting behavior seen from focal sampling (but minor according to the number of times seen) when comparing REF and RHB coots, was the frequency of

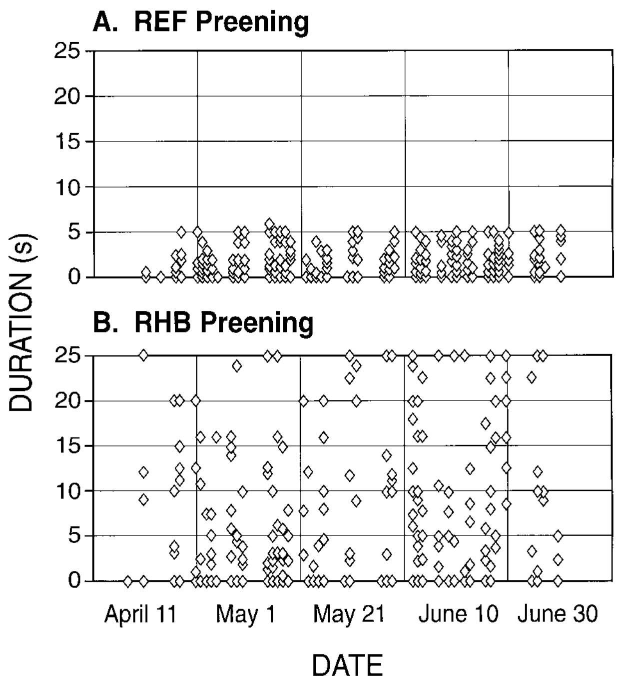

Fig. 3. Time courses of duration of preening on land in (A) reference (REF) coots and (B) rehabilitated (RHB) coots, as an example showing the obvious differences and their consistency throughout the 3-month soft-release. Duration is expressed as the number of seconds of preening activity per 5-min interval; vertical lines represent dates shown below.

allopreening (not seen in scan sampling). Here, REF coots preened conspecifics more often than RHB coots did (means ± 95% CL): REF = 15.6 ± 3.6 episodes h^{-1}, $n = 8$; RHB = 10.8 ± 1.2 episodes h^{-1}, $n = 3$; $p < 0.04$ (tested alone after deriving the hypotheses of increased aggression above). We have no explanation for differences in this behavior, although one might speculate that lower levels of self-preening in REF coots somehow allowed more opportunity for allopreening.

In summary, the overall observations were that RHB coots were more active and slept less, they preened and bathed more, and they fed and drank more than REF coots. Thus, RHB coot activity and probably their energetic needs were greater; and added feather maintenance was possibly also required due to the OR experience. Burger and Tsipoura (1998) reported increased preening and feather maintenance behavior in wild sanderlings (*Calidris alba*) experimentally exposed to oil, but not rehabilitated; Burger (1997a) also reported greater preening rates (but lower feeding rates and presumed energetic losses) in oiled, non-rehabilitated, migrating sanderlings and semi-palmated plovers (*Charadrius semipalmatus*). Since it is reasonable to assume that all extraneous oil had been sufficiently removed from our RHB coots, we hypothesize that these increased rates of preening and feather maintenance in OR experienced birds most likely represented the need for restoration of normal feather oils and

Table 4
Daylight scan-samples for reference (REF) and rehabilitated (RHB) American coots over the RHB post-rehabilitation period, comparing frequently occurring activities (Category I) and comfort-related actions (Category II) for each group [a]

Corrected activity category significance	Median percent occurrence			
	n	REF	*n*	RHB
I. Roosting ($p < 0.05$)	67	11.8	61	20.0
I. Standing (alert) ($p < 0.05$)	156	11.1	62	14.3
I. Walking ($p < 0.05$)	125	8.3	68	12.5
I. Swimming (NS)	391	37.5	279	40.0
II. Sleeping (land) ($p < 0.05$)	32	10.8	17	0.3
II. Preening (water) ($p < 0.05$)	101	8.3	42	12.5
II. Preening (land) (NS)	259	30.0	161	33.3
II. Bathing ($p < 0.05$)	73	6.9	27	12.5
II. Drinking (NS)	17	7.0	7	8.3
II. Feeding (water) ($p < 0.05$)	296	17.9	191	22.2
II. Feeding (land) ($p < 0.05$)	130	12.9	82	20.7

[a] In scan-sampling, short duration and infrequently occurring behaviors are not likely to be sampled or are omitted here due to small sample sizes; therefore, only frequently occurring behaviors are given, and percentages will not sum to 100%. The notation "NS" denotes not significant at $p < 0.05$, where Mann–Whitney two-sample rank tests were used to determine differences. The total sample size (n) was 435 scans.

maintenance of feather structure rather than a continuing need to remove oil, as observed in wild, non-rehabilitated birds just mentioned. Although the proximate causes for increased preening activity in RHB coots were therefore likely different, this type of behavioral activity continued well past the oiling and rehabilitation phase and likely imposed an energetic and temporal cost on RHB coots.

4. General discussion and summary

Mortality data, condition data and behavior suggested (as reported by Anderson et al., 1996 for brown pelicans, *Pelecanus occidentalis*) that RHB (OR) coots experienced a lengthy (in this study, months) post-release recovery period. Our data also suggested that REF coots, at least initially, had a stressful adjustment period when they first entered captivity, in that they lost weight initially and overall in the experiment failed to survive at a rate equivalent to that previously reported for a hunted, wild population. Both RHB and REF coots experienced early weight losses in captivity (Table 2) at a time when wild coots would be expected to be maintaining body-weight (Alisauskas and Ankney, 1985; Arnold and Ankney, 1997). But, the conservative conditions of the 'soft-release' technique also worked to the probable advantage of all coots over what they would have experienced under conditions experienced in the wild. Furthermore, even if we assume that those

Table 5
Focal-sample behavior durations that were different between rehabiltated (RHB) and reference (REF) American coots

Behavioral action	Duration of behavior (s h^{-1})				
	RHB coots		REF coots		
	n	Mean ± 95% CL	*n*	Mean ± 95% CL	Corrected f
Preen on land	178	616.2 ± 70.2	232	149.4 ± 12.6	< 0.05
Preen on water[a]	43	24.0	64	16.7	< 0.05
Drinking	25	21.0 ± 4.8	31	< 1.9[b]	< 0.05

[a] Medians are given for data not normally distributed.
[b] The symbol "<" in this case indicates that the durations were in some cases too short to record accurately and were given 'trace' values; therefore, the mean given is likely somewhat smaller.

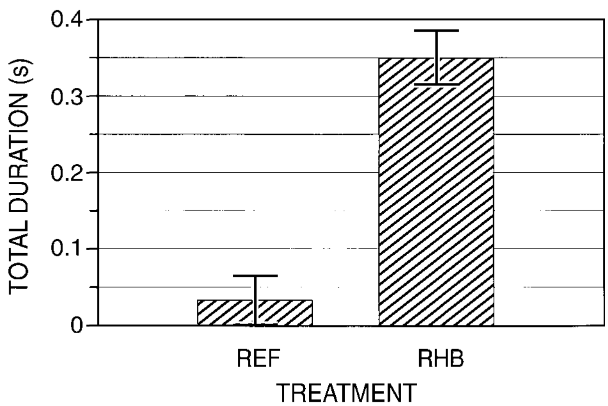

Fig. 4. Comparison between reference (REF) and rehabilitated (RHB) coots in duration of drinking, expressed as number of seconds in a 5-min interval. The vertical lines atop each bar represent 95% CI.

surviving RHB coots had fully recovered their OR experience by the end of the experiment, we still have overall mortality rate comparisons that indicate long-term losses would have most severely depressed the RHB population cohort. Whether success rates of released OR birds comparable to wild reference populations should always be a goal of rehabilitation is, however, still a question open to debate.

BCI measurements (also supported by the hematological analyses of Newman et al., 1999a) suggested that RHB survivor coots were similar to REF coots at the end compared to the beginnings of our experiment, and that a fraction of RHB coot survivors had indeed 'recovered' from the OR experience.

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