SHORT COMMUNICATIONS

Mechanics of Steaming in Steamer-ducks

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Steamer-ducks (*Tachyeres*) comprise three flightless species, distributed in the marine littoral environments of southern Chile and Argentina (*T. pteneres, T. leucocephalus*) and the Falkland Islands (*T. brachypterus*), and one flying species (*T. patachonicus*), which occurs in both freshwater and marine situations throughout the same region (Murphy 1936, Humphrey and Thompson 1981). All members of the genus are diving ducks that feed primarily on molluscs, crustaceans, and insects.

From as early as 1579 (Sarmiento de Gamboa 1895: 53), the turbulent surface swimming or "steaming" of steamer-ducks was noted by many early voyagers to the Falkland Islands, southern Chile, and Tierra del Fuego (Pernety 1769: 570; Byron 1773: 50; Clayton 1776: 104; Cook 1777: 186, 1778: 727; Forster 1777: 492; Darwin 1839: 257; Fitzroy 1839: 35; Coppinger 1883: 61). Despite the conspicuousness of steaming and its frequent description by naturalists, the mechanics of this behavior have been debated, and the adaptive significance of steaming has remained unclear.

Most previous observers agreed that steaming birds power themselves rapidly over the surface of the water using their feet and wings, producing substantial spray and turbulence. Steaming birds attain estimated speeds of up to 24 kph (Murphy 1936: 959), and we have seen birds steam without pause for 1 km or more. Steaming is used both for escape and for attack during territorial encounters (Pettingill 1965: 75, Weller 1976: 51).

A number of naturalists likened the wing movements of steaming birds to the rotation of side-wheels of steamboats, the basis for their common name (Fitzroy 1839: 35, Cunningham 1871: 96, Townsend 1910: 6, Phillips 1925: 294, Murphy 1936: 951). Others described the wing motions variously as flapping (Clayton 1776: 104; Darwin 1839: 257; Coppinger 1883: 39; Nicoll 1904: 49, 1908: 170; Brooks 1917: 155; Lowe 1934: 485), beating (Forster 1777: 492, Reynolds *in* Murphy 1936: 959, Woods 1975: 121), thrashing (Todd 1979: 161), paddling (Darwin 1839: 190, Coppinger 1883: 61, Blaauw 1916: 490, Brooks 1917: 155), oaring (Latham 1785: 439, Sarmiento de Gamboa 1895: 53), or rowing (Nicoll 1904: 49).

Darwin (1839: 258), Gould (1841: 136), Townsend (1910: 6), and Johnson (1965: 195) stated that a steaming *T. pteneres* moves its wings alternately. Todd (1979: 161) described alternate wing strokes during steaming in all species of *Tachyeres*. Phillips (1925: 294), Coppinger (1883: 39), and Cawkell and Hamilton (1961: 14), however, reported that the wings are moved simultanteously in *T. pteneres* and *T. brachypterus*. Vallentin (1904: 35) and Cobb (1933: 81) concluded that *T. brachypterus* ordinarily uses its wings simultaneously but strokes them alternately when startled or when steaming at high speeds.

During recent studies of steamer-ducks in Argentina, we made special efforts to observe and photograph steaming. We studied Magellanic Flightless Steamer-Ducks (*T. pteneres*) and Flying Steamer-Ducks (*T. patachonicus*) at Ushuaia, Tierra del Fuego, during December 1980–January 1981; Flying Steamer-Ducks at Puerto Deseado, Santa Cruz, during January–Febraury 1981; and White-headed Flightless Steamer-Ducks (*T. leucocephalus*) and Flying Steamer-Ducks at Puerto Melo, Chubut, during February and December 1981 and January 1982. Detailed observations of birds were made from land with binoculars and spotting scope and from boats during collecting expeditions. In addition, steaming *T. pteneres* and *T. leucocephalus* were pursued and photographed from boats using a motor-driven 35-mm camera.

We confirmed photographically for *T. pteneres* that steaming birds use their wings simultaneously and that the wings are used as oars rather than simply flapped as in a take-off run. Virtually all propulsion and turbulence results from deep alternate strokes of the feet. Often the foot paddles break the surface of the water behind the birds, and the arc of paddle movement sometimes ends above the level of the back, as noted by Reynolds (1934: 351). Oaring of wings and upright posture of the head and neck probably keep the birds from being driven underwater by the powerful thrusts of their feet.

Photographs of steaming *T. leucocephalus* show actions of wings and feet similar to those of *T. pteneres* and provide additional details on body postures (Fig. 1). At the beginning of the downstroke, the wings are completely extended, making a 45° angle with the water surface. The head and neck are held relatively low and forward, and the chest almost touches the water. During the donwstroke, the wings are still fully extended and strike the water first with the manus and primaries. The wings then move posteriorly through the water and are drawn up half-folded during the recovery stroke. During the downstroke, the head and neck are progressively raised and are extended almost vertically upward when the wings strike the water. The downstrokes also lift the breast farther from the surface. The individuals pictured (Fig.

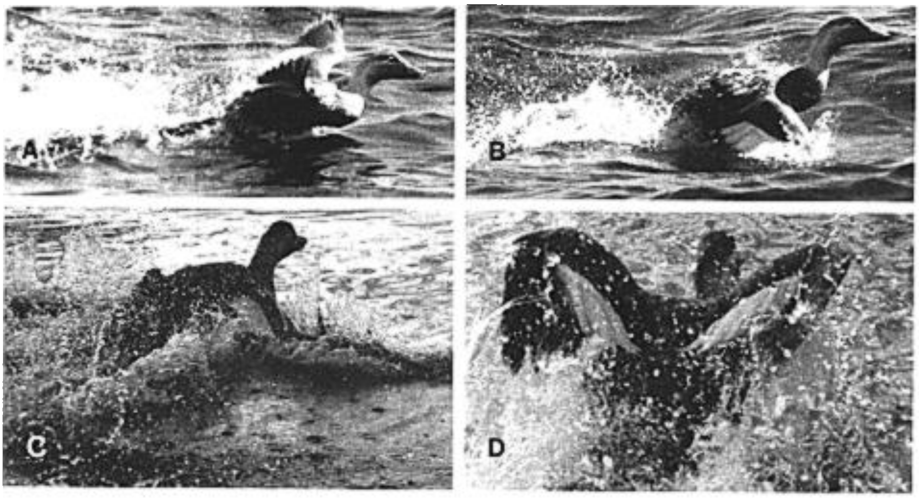

Fig. 1. Photographs of steaming White-headed Flightless Steamer-Ducks. Photos A and B are frames 3 and 4 of a sequence; photos C and D are of another bird and are frames 16 and 17 of a sequence. During the downstroke (A), the fully extended wings are brought down to the water simultaneously (B, C), and the forearm, manus, and distal remiges are driven below the surface. At the beginning of the recovery stroke (D), the wings are half-folded, but are extended again as they are brought forward to begin another downstroke. The turbulence behind the birds is produced primarily by deep alternate strokes of the feet. (Photos by Livezey.)

1) completed approximately two cycles of wing movement per second.

Reynolds (*in* Lowe 1934: 474) observed that *T. patachonicus* steams more buoyantly, more quickly, and with less splashing than the heavier *T. pteneres.* Woods (1975: 123) stated that *T. patachonicus* steamed higher in the water than *T. brachypterus.* Beck (*in* Murphy 1936: 966) found that *T. brachypterus* rose higher from the water during steaming than the larger *T. pteneres,* prompting Murphy to conclude that *T. brachypterus* was functionally intermediate between *T. pteneres* and *T. patachonicus.* Beck (*in* Murphy 1936: 970) also noted that ". . . when Flying Steamer Ducks steam, they often end by lifting themselves until their bellies and feet are just clear of the water, and then proceed at this level, with the tips of their wings barely touching the surface at every stroke." Blaauw (1912: 48, 1916: 492, 1921: 58) also described this type of steaming in *T. patachonicus,* calling it (1916: 492) ". . . a way of flying over the water . . . ."

These descriptions and our own observations suggest that buoyancy of steaming is inversely proportional to body weight. Although the erect head and neck and oaring of wings of steaming birds differ from the forward-thrust head and full wing flaps of birds in take-off runs, we feel that descriptions of unusually high "steaming" in *T. patachonicus* refer to take-off runs. We observed individuals of *T. patachonicus* steaming that subsequently switched to a take-off run and took flight. Heavy wing loadings and wind conditions can make flight difficult or even impossible in some Flying Steamer-Ducks (Humphrey and Livezey 1982), making such steaming-like runs quite long. This confusion is worsened by the fact that all three flightless species of *Tachyeres,* depending on conditions of wind and water, can steam buoyantly and on occasion may become airborne for very brief periods (Woods 1975: 121; pers. obs.).

The adaptiveness of steaming as an escape behavior is not clear. We agree with Murphy (1936: 959) that the energy expenditure from steaming probably equals if not exceeds that of aerial flight. Rapid steaming is slower than flight and visually more conspicuous than flight or diving. Steaming probably is derived from the take-off run, despite differences in posture between the two behaviors, and may be associated with evolutionary increases in wing-loading and loss of flight. Although steamer-ducks suffer mortality from several terrestrial (*Dusicyon* spp., Todd 1979: 162) and aerial predators (Pettingill 1965: 77) during nesting and brood rearing, the primary nonhuman predators of *Tachyeres* are probably submarine vertebrates (Straneck et al. in press). We speculate that steaming functions, in part, as a rapid, distracting, and target-obscuring method for escape from underwater predators.

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Records of Migrant Hawks from the North Atlantic Ocean

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Long-distance water crossings by migrating raptors are believed to be limited to Ospreys (*Pandion haliaetus*), some falcons, and a few other species (Brown and Amadon 1968, Henny and Van Velzen 1972, Beamon and Galea 1974, Walter 1979). Most diurnal raptors depend on soaring flight, which makes use of convective currents, during migration. Flights over water, usually devoid of atmospheric convective currents (Woodcock 1975), are energetically expensive and potentially dangerous when great distances are involved. Consequently, many raptors circumvent water barriers, which results in large aggregations such as those along the shores of the Great Lakes (Haugh and Cade 1966, Mueller and Berger 1967). Other species make short-distance crossings at narrows such as the Straits of Gibraltar (Evans and Lathbury 1973) and Whitefish Point, Michigan in Lake Superior (Kerlinger MS). Even at crossing sites, the frequency of attempted crossings varies with respect to species, visibility, wind velocity, and distance (Kerlinger MS). Here, we present records of raptors seen during spring and fall migration off the northeastern coast of the United States and discuss these sightings with regard to possible migration routes. Other than the present study, there are few records of raptors from the North Atlantic Ocean (Scholander 1955, Larkin et al. 1979).

While participating in a survey of the distribution and abundance of pelagic birds from Cape Hatteras (35°00′N) to the Bay of Fundy (44°00′N) and from the coast seaward to 65°00′W, representatives of Manomet Bird Observatory observed raptors in offshore waters from 1976 to 1980. Cruises were mostly restricted to the continental shelf. Observers were stationed on National Marine Fisheries research and U.S. Coast Guard vessels. The geographical and temporal distribution of the observational effort is reported in detail by Powers (in press) and Powers and Cherry (in press). In addition to making regular counts of pelagic birds, observers recorded the following data for non-pelagic birds: species, number, time of day, and latitude-longitude. Hawks were seen only during May, June, September, and October. The number of cruises and total days of observations for these months are given in Table 1.

In 10 field seasons, 102 hawks of five species were recorded. The species and totals are given in Table 1. Most of the hawks were seen during the fall (95%). On the fall cruises 0.3 hawks/ship/day were seen as compared with 0.03 hawks/ship/day on spring cruis-

TABLE 1. List of hawks seen in waters off the coast of the northeastern United States and at a coastal hawk lookout. The offshore data are from 19 spring cruises with 204 cruise-days and 26 fall cruises with 138 cruise-days. The coastal data show the mean number (total seen/5) of each species seen in the five fall migrations from 1976 to 1980 at Cape May Point, New Jersey (from Dunne 1976–1980).

	Offshore					Coastal	
	Number of hawks		Proportion of fall total	Mean distance from land (±1 SD)	Percentage with land visible	Mean number of hawks	Proportion of total
Species	Spring	Fall					
Peregrine Falcon	1	17	17.9	84 ± 50	11.1	149	0.3
Merlin	0	25	26.3	87 ± 56	4.3	862	1.5
Osprey	5	19	20.0	118 ± 53	4.3	1,170	2.0
Sharp-shinned Hawk	0	15	15.8	91 ± 81	38.5	41,876	72.6
American Kestrel	1	19	20.0	86 ± 66	18.8	13,643	23.6