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Tawny Fish Owl activity pattern.—Fish owls, often regarded as nocturnal counterparts of the diurnal Osprey (*Pandion haliaetus*), fish eagles *Ichthyophaga* spp., and sea eagles (*Haliaeetus* spp.), consist of four species in the genus *Ketupa* from Asia and three species in the genus *Scotopelia* in Africa (Fogden 1973). Little is known about the natural history of the rare, seclusive Tawny Fish Owl (*Ketupa flavipes*) (Voous 1988). To date, no consensus has been reached regarding the circadian rhythm of the Tawny Fish Owl. Ali (1986), Severinghaus (1987), and Meyer De Schauensee (1984) described the owl as crepuscular and partially diurnal in habit. In Taiwan, Chang (1985) noted that Tawny Fish Owls were nocturnal, whereas Yeng (1985) reported them to be diurnal or crepuscular (Wang et al. 1991). These discrepancies are likely based on the results of scanty observations. In this paper, we examine the activity pattern of this species.

Methods.—We conducted field studies at Fusan, Nanshih Stream, 350 m in elevation, approximately 30 km south of Taipei, Taiwan. Vegetation consisted mostly of tropical rainforest formations dominated by *Ficus* and *Lauraceae* on the east and south banks of the stream (Taiwan Forestry Bureau 1995), whereas plantations, mostly of Makino Bamboo (*Phyllostachys makinoi*) and Japanese Fir (*Cryptomeria japonica*), farmland, and human

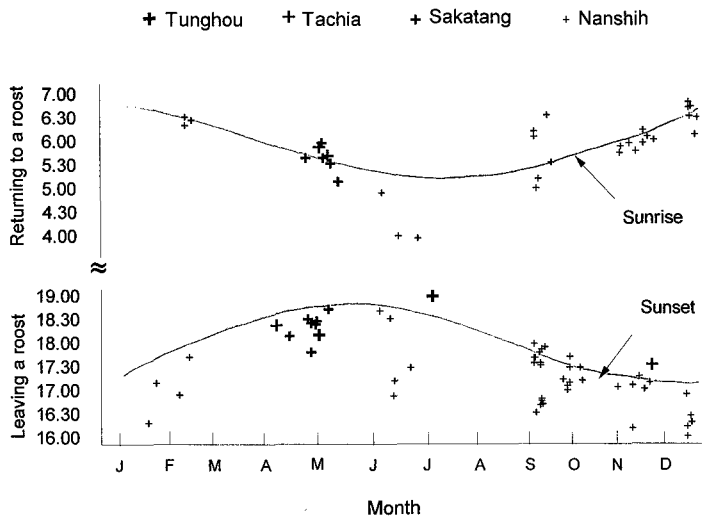

FIG. 1. Activity period of Tawny Fish Owls on the Nanshih, Tachia, Tunghou, and Sakatang streams, 1994–1996. Crosses indicate when activity began and ceased in relation to sunset and sunrise by stream location. Each point represents one record.

habitation occur mainly on the west bank. We recorded additional data with respect to the time when Tawny Fish Owls left and returned to their roosts at Tachia, Sakatang, and Tunghou streams.

From October 1994 through July 1996, we captured four Tawny Fish Owls using foot-snare traps on nighttime foraging perches or on pond banks of fish farms at the Nanshih Stream. Owls were leg-banded, and radio-tagged prior to release. Radio transmitters had activity sensors (MD-205; Telonics Inc., Mesa, Arizona), weighed 70–80 g (<4% of the owl's body mass, 2.1–2.6 kg) and had a lifespan of about two years. They were attached dorsally with a backpack harness of wire (1.5 mm in diameter) wrapped inside a tubular teflon ribbon. We recorded radio signals of the owls with a directional hand-held H-antenna with a TR-2 receiver (Telonics Inc., Mesa, Arizona).

To estimate the temporal activity pattern of the owls, we recorded radio signals of each owl for at least two 10-min periods each hour in one 24-h period approximately biweekly. The activity sensor of the transmitter generated two pulse rates on the basis of whether the bird was active (e.g., preening, walking, flying, and foraging) or inactive. It produced 37 pulses per minute (PPM) during owl inactivity and 54 PPM during owl activity. Over each hour period, two types of activities were recognized and measured: (1) all activity (sum of active pulses/[54 × 60]) × 100% and (2) moving activity (sum of active pulses with movement/[54 × 60]) × 100%. Owl movement could be detected from the fluctuations in radio signal strength, which we used as the index of foraging activity. Based on direct observation of a captive Tawny Fish Owl, non-movement activities such as head-turning (N = 93), body-turning (5), and preening (7) did not change the radio signal strength. We used the Mann-Whitney and Kruskal-Wallis test (Conover 1980) to compare between two or more independent sample populations, respectively.

Results and discussion.—Activity periods of Tawny Fish Owls coincided with diel pattern (Fig. 1). The time the owls went to their day roosts averaged 8.18 ± 31.59 min (range =

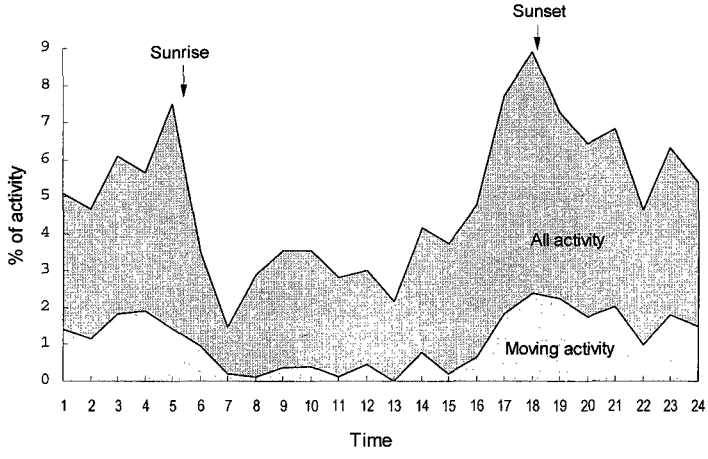

FIG. 2. Temporal variation in the percentages of all activity and movement of four radio-tagged Tawny Fish Owls at Nanshih Stream during 1993–1996.

−83 to 55 min, N = 34) prior to sunrise, and they left their roosts for foraging about 5.77 ± 35.59 min (range = −105 to 35 min, N = 44) prior to sunset. Activity levels of owls with radios showed that owls spent <10% of their time in all activity levels (Fig. 2), with <3% in moving activity, mostly involved in foraging. Owls became most active 1 h before and after dark, slightly active shortly prior to dawn, and less active during the day, especially in the morning. Comparisons of daytime versus nighttime activity ratios showed that the daytime proportion of all activities in a 24-h period was higher (45%), a result of other non-moving activities such as preening by day, than that of moving activity (28%). Ali and Ripley (1969) reported Tawny Fish Owls as crepuscular and partially diurnal in habit. In our study, the owls became most active shortly before dark and engaged in intensive foraging until about 1 h after dark. Martin (1990) considered this twilight foraging activity to be more appropriately regarded as nocturnal in habit. The previous proposed circadian rhythm of Tawny Fish owls may reflect a lack of nighttime observations by earlier workers.

The owls' movement varied seasonally (Table 1). Generally, owl movement seemed to peak both in winter for all four birds and in summer for a pair of breeding birds (male—W503; female—W513) (Kruskal-Wallis test, $\chi^2 = 6.74$, $P = 0.08$) and became less active both in fall and winter for all four birds and in summer for the remaining two non-breeding birds (W508 and W494). Seemingly, the percent of daytime movement during a 24-h period seem to be higher for the breeding birds in summer, whereas it was lowest for non-breeding birds in summer ($P = 0.51$). Tawny Fish Owls moved more frequently in winter, probably due to scare natural food sources at Nanshih Stream (Sun 1996). Further, owls may require higher energy to overcome colder weather conditions. Hamilton (1985) and Stalmaster and Gessaman (1982) indicated that Barn Owls (*Tyto alba*) and Bald Eagles (*Haliaeetus leucocephalus*), respectively, consumed greater amounts of food when air temperature declined. Likewise, increased food needs of breeding birds may account for higher movement of the breeding pair (W503 and W513) in the summer of 1995. Laymon (1988) and Sovern et al. (1994) both found that Spotted Owls (*Strix occidentalis*) regularly hunted during the day when feeding fledged young and were more active at night than non-nesting birds. Additionally, at Sakatang Stream, a foraging male Tawny Fish Owl was often seen by day

TABLE 1

SEASONAL MOVING ACTIVITIES (% OF TOTAL ACTIVITY) AND DAYTIME MOVING ACTIVITIES (% OF TOTAL MOVING ACTIVITY) DURING A 24-H PERIOD OF FOUR RADIO-TAGGED TAWNY FISH OWLS AT NANSHIH STREAM DURING OCTOBER 1994–JULY 1996

Season	Moving activity (%)		Percent daytime activity during a 24-h period		Number of days tracked
	Mean	SE	Mean	SE	
Fall (1994–1995)	0.62	0.51	25.74	4.26	8
Winter (1994–1995)	1.43	0.80	26.88	12.93	12
Summer (non-breeding)[a]	0.67	0.30	19.94	15.60	8
Summer (breeding)[b]	1.34	0.62	30.29	9.86	6

[a] Based on activity of W494 and W508, 1995, and a pair of owls (W503 and W513) and W494, 1996.
[b] Based on activity of a pair of owls (W503 and W513) with two fledged nestlings from late May to August 1995.

flushing from a stream near the nest site while the female incubated. Again, on two occasions, the male was seen foraging in the morning after the female had permanently abandoned the nest with an owlet of about seven weeks of age. Because male owls feed incubating females (Mikkola 1983), it may be difficult for the male Tawny Fish Owl to provide enough food for itself, its mate, and young with only nighttime hunting. The increased energetic costs of foraging may explain why the male had to leave the nest and hunt by day to compensate for its hunger.

When foraging at night, Tawny Fish Owls could move up to 1800 m in one hour, with a mean daily moving distance of 275.1 ± 255.6 m/h (range = 3.3 ± 950.0 m, N = 41). When owls visited fish farms at Nanshih Stream at night, the distance moved was shorter (162.1 ± 203.0 m per hour, range = 3.3 ± 870.0 m, N = 17) than when owls foraged exclusively at the stream, $\bar{X}$ = 342.2 ± 270.0 m per hour (range = 92.8 ± 950.0 m, N = 24) (Mann-Whitney test, $P = 0.02$). On occasion, owls would just remain close by fish farms for the entire night, giving hungry calls-"whe-". Owls moved less at night when visiting fish farms, suggesting an easily available food resource. Basically, Tawny Fish Owls consume <300 g daily (<12% of its body mass), based on total prey biomass per owl pellet (Sun 1996); hence, foraging on fish farms with large fish, such as California rainbow trout (*Salmo mykiss*), definitely satisfied daily requirements more easily than taking natural prey exclusively. Owls sometimes flew directly to fish farms shortly after dark and became inactive during that night, perhaps because they had enough food to be satisfied.

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Food habits of nesting Ferruginous Pygmy-Owls in southern Texas.—Although Ferruginous Pygmy-Owls (*Glaucidium brasilianum*, hereafter referred to as FEPO) are listed as endangered in Arizona and threatened in Texas, only anecdotal accounts exist regarding their food habits (Bendire 1888, Bent 1938, U.S. Fish and Wildlife Service 1994). In conjunction with natural history studies on FEPOs of southern Texas (Proudfoot 1996), we collected data to profile the food habits of this species. We incorporated prey remain analysis, visual observation, and information obtained from video recordings to address several aspects of FEPO food habits (i.e., behavior and diet). However, because of the extreme vari-