Day Versus Night Electrofishing Catches from Near-Shore Waters of the Ohio and Muskingum Rivers[1]

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ABSTRACT. Day and night electrofishing catches were compared for sampling effectiveness and diel movements of fish to and from near-shore waters of the Ohio and Muskingum rivers. Standardized methods were used to collect same-day paired samples by sampling during the day, displacing the catch, and resampling after twilight. Night catches contained significantly higher numbers of species, individuals (excluding *Dorosoma cepedianum*), weight, and biological index scores (Modified Index of Well-Being [MIwb] and Index of Biotic Integrity [IBI]). Night versus day paired samples in the Ohio and Muskingum rivers showed, respectively, mean increases of 7.6 and 4.6 species, 229 and 417 fish per km (excluding *D. cepedianum*), 18.2 and 30.4 kg/km, 2.3 and 1.5 MIwb units, and 10.8 and 8.7 IBI units. Total night catches yielded, respectively, 43% and 15% more taxa, 62% and 160% greater numbers (excluding *D. cepedianum*), and 50% and 70% more weight than total day catches. Catch differences were primarily attributed to diel movements from off-shore to near-shore waters during the evening-twilight period. Taxa which increased the most at night in the Ohio River were: *Alosa chrysochloris, Notropis wickliffi, Ictiobus bubalus, Moxostoma anisurum, M. duquesnei, Ictalurus punctatus, Morone saxatilis x M. chrysops, Ambloplites rupestris, Stizostedion canadense,* and *Aplodinotus grunniens*; and in the Muskingum River: *Ictiobus bubalus, Moxostoma anisurum,* and *Morone chrysops.* Standardized night electrofishing is an effective sampling technique for many mainstem species and provides a better, more complete biological assessment than day electrofishing. Therefore, it should be incorporated into long-term monitoring programs for these large, deep rivers. The findings of this study may also be applicable to other large, deep bodies of water elsewhere.

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INTRODUCTION

Day versus night electrofishing studies have shown night sampling, particularly in large bodies of water, can yield more species, greater numbers, and larger individuals than day sampling because of a variety of reasons including: diel movements, reduced gear avoidance, behavioral changes, and increased visibility resulting from calmer waters (Loeb 1957, Witt and Campbell 1959, Sanderson 1960, Frankenberger 1960, Kirkland 1962, Baumann and Kitchell 1974, Sonski 1982, Gilliland 1985, Graham 1986, Geo-Marine 1986, Paragamian 1989). Night sampling, however, can also produce undue fatigue, possible safety risks, or require overtime (Graham 1986), and is preferably avoided if satisfactory results can be obtained through day sampling.

Day electrofishing has been effectively used by Ohio Environmental Protection Agency (OEPA) personnel to monitor and assess shallow (<3 m) inland rivers and streams. Day catches from near-shore waters of the larger, deeper Ohio and Muskingum rivers, however, have been disappointing and are characterized by lower than expected values for species richness, catch per unit effort (CPUE) for most species, and two biological indices (Modified Index of Well-Being [MIwb] and Index of Biotic Integrity [IBI]).

The need for the present study was identified on 26 September 1986 when day and night electrofishing results from the Ohio River suggested that the composition of near-shore fish assemblages had markedly changed during the evening-twilight period with movement from deeper off-shore waters (Sanders and Yoder 1989). The difference was not surprising, given the results reported in earlier studies. However, such studies have primarily compared catches of sport species (i.e., *Micropterus* spp. and *Lepomis macrochirus*) and have been conducted in lakes and reservoirs for management purposes. Except for a report of a similar investigation on the Ohio River (Geo-Marine 1986), few studies have been conducted in large, deep, navigable rivers and have compared catches of all species for the purpose of biological assessment or diel movements of nongame species.

The objectives of the present study were to answer the following questions about day versus night electrofishing and diel movements in the Ohio and Muskingum rivers:

1. Does night sampling consistently catch more species, individuals, and weight than day sampling?
2. Do night catches provide a different biological assessment than day catches?
3. Do fish consistently move to shallow near-shore waters from deeper off-shore waters during the evening-twilight period? If so, which species move the most?

Study Area

The study area was located in the Western Allegheny Plateau and Interior Plateau ecoregions (Omernik 1987) and spanned a total distance of 760 river kilometers of the Ohio and Muskingum rivers (Fig. 1). Samples were collected at six sites on the Muskingum and seven sites on the Ohio. Sites were 430-650 m long and contained a

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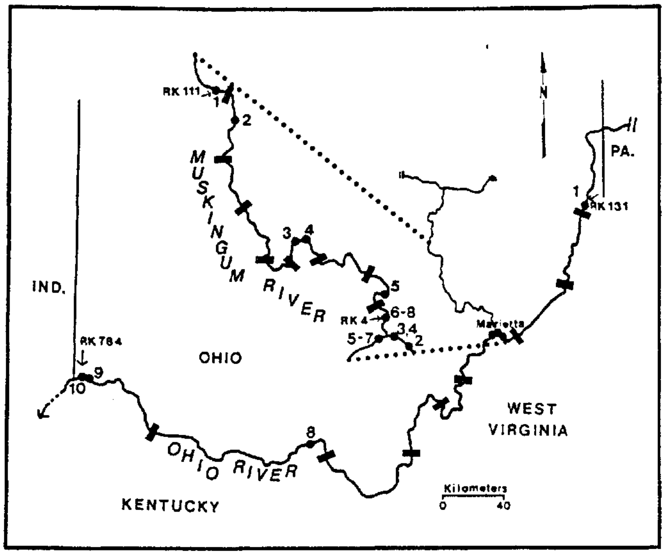

FIGURE 1. Map of the Ohio and Muskingum rivers showing sampling sites (black circles), paired sample number(s), upstream and downstream river kilometers (RK), and dam locations (black rectangles).

variety of habitats including narrow, steep-sloped margins with rocky or hardpan substrates and wide, gentle-sloped margins with silt, sand, or gravel substrates. A general description of the Ohio River has been reported by Pearson and Krumholz (1984).

MATERIALS AND METHODS

Standardized field, laboratory, and data processing methods and procedures were used in this study (OEPA 1987, 1989). Field collections were made using OEPA's boat method between 19 July and 27 September 1988. A total of 18 same-day paired samples (Fig. 1) were collected by sampling first during the day (1115-1749 h), displacing the catch, and resampling no sooner than 40 min after sunset (2012-0037 h). Multiple samples were collected from three Marietta, OH, sites at monthly intervals. Cumulative shoreline distances of 5.9 and 4.1 km, respectively, in the Ohio and Muskingum rivers were electrofished during the day and resampled at night.

Samples were collected using a 4.9 m flat-bottom aluminum boat equipped with a straight electrode configuration consisting of four anodes suspended 2.6 m in front of the bow on a retractable boom, and four cathodes suspended from the bow. Smith-Root Type VI-A and GPP-3.5 electrofishers and 3500-watt gasoline generators were used to produce pulsed direct current. Pulse width was set at 60 or 120 pulses per second and voltage was varied between 500-1000 VDC to produce an output of 8-9 amperes. Two pairs of 75-watt floodlamps (powered by a separate gasoline generator) mounted on the bow railing and six-volt headlamps provided light for night collections. The boat was operated by the same individual during all samples and the same electrofishing gear and principal netter were used for each paired sample. Sites were fished consistently and time fished averaged 40.5 and 45.7 min, respectively, for day and night samples. All representative habitats with depths shallower than 3 m were thoroughly fished in a downstream direction. Visual observations were also made on the relative effectiveness of the gear and netters (primary and assist). Turbidity levels were determined using a secchi disk.

The MIwb and IBI, two indices which measure environmental disturbances (higher scores usually reflect less impairment), were used to quantify day and night catches for the purpose of biological assessment. The MIwb (modified version of the Index of Well-Being [Gammon 1976]) is a measure of the fish community based on a calculation using relative number, biomass, and the Shannon Diversity Index (based on numbers and weight) from which highly tolerant and exotic fishes are removed from numbers and biomass calculations. The IBI (first introduced by Karr [1981]) consists of 12 metrics which assess fish assemblages based on species richness and composition, trophic composition, abundance, and health. The boat method IBI metrics and scoring of the OEPA were used in the present study as an interim assessment tool until specific modifications for large, navigable rivers are developed.

Statistical significance in the present study was set at $P \leq 0.05$ and determined only for differences between paired samples (Wilcoxon signed-ranks test) and turbidity scatter plots (simple curve fit).

Study Design Considerations

Captured fish were released in good physical condition immediately after data collection ≥100 m from the site (release locations included the same shore, opposite shore, and middle of the river). The mean time between release and the beginning of a night sample was 6.8 h (range 3.5-11.0 h). It is unknown how many of the previously captured fish may have returned to the sampling sites prior to night sampling or what affect the disruption of local territories might have had on night catches.

RESULTS

Throughout the survey, the total composite catch (day and night) combined from both rivers weighed 1038.4 kg and consisted of 17,495 fish comprised of 59 species and three hybrids (Table 1). The total composite catch from the Ohio River weighed 547.6 kg and consisted of 10,337 fish comprised of 48 species and two hybrids. The total composite catch from the Muskingum River weighed 490.8 kg and consisted of 7,158 fish comprised of 42 species and one hybrid.

Species Richness and Frequency of Occurrence

Despite thorough day sampling and the displacement of catches, the numbers of species collected in night samples were significantly greater than all corresponding day samples from both rivers (Fig. 2a). Night samples showed mean increases of 7.6 species (range 1 - 12) in the Ohio River and 4.6 species (1 - 9) in the Muskingum River.

Night electrofishing in the Ohio River yielded all 50 taxa collected, while only 35 taxa were captured during the day (Table 1). Thirty-four of the 50 total taxa were captured more frequently at night (15 exclusively), five taxa more often during the day, and 11 taxa equally during day and night samples.

Of the 43 total taxa collected in the Muskingum River, night sampling yielded 38 taxa, and day sampling 34.

TABLE 1

Summary of day and night electrofishing catches from the Ohio River (N = 10) and Muskingum River (N = 8). List of species [1] and hybrids collected showing: the total number of individuals collected (number of samples captured in) and mean weight in grams.

	OHIO RIVER		MUSKINGUM RIVER	
	Day	Night	Day	Night
Ichthyomyzon unicuspis	0(0)	1(1)20.0	-	-
Lepisosteus osseus	1(1)400.0	1(1)432.0	0(0)	9(4)424.7
Amia calva	-	-	0(0)	1(1)2025.0
Hiodon tergisus	0(0)	5(3)123.0	-	-
Alosa chrysochloris	0(0)	113(2)4.8	-	-
Dorosoma cepedianum	2699(10)55.4	1204(10)44.7	2796(8)11.9	563(8)31.4
Campostoma anomalum	1(1)4.0	1(1)22.0	0(0)	3(1)4.0
Cyprinella spiloptera	34(6)5.1	59(4)5.3	111(8)2.7	102(7)2.7
Cyprinella whipplei	0(0)	1(1)5.0	-	-
Cyprinus carpio	9(5)1055.8	31(5)1285.0	40(6)1453.2	51(6)969.8
C. carpio x Carassius auratus	0(0)	1(1)780.0	-	-
Luxilus chrysocephalus	-	-	2(1)2.0	2(2)2.0
Macrhybopsis storeriana	0(0)	2(2)9.5	-	-
Notemigonus crysoleucas	0(0)	1(1)3.0	-	-
Notropis atherinoides	1414(8)2.5	419(10)2.0	98(7)2.3	51(5)1.7
Notropis blennius	61(7)2.5	130(7)5.1	-	-
Notropis buchanani	-	-	0(0)	8(2)0.6
Notropis hudsonius	3(1)6.7	1(1)3.0	-	-
Notropis stramineus	-	-	19(1)1.4	15(1)1.1
Notropis wickliffi	4(3)1.5	366(7)1.8	4(1)1.0	16(2)1.3
Phenacobius mirabilis	-	-	1(1)1.0	0(0)
Pimephales notatus	-	-	106(3)0.8	48(5)1.4
Pimephales vigilax	-	-	2(1)1.0	19(3)1.0
Semotilus atromaculatus	-	-	1(1)2.0	0(0)
Carpiodes carpio	-	-	0(0)	2(1)765.0
Carpiodes cyprinus	29(3)34.0	78(6)38.5	15(4)11.4	114(6)21.4
Hypentelium nigricans	2(1)99.0	5(2)116.6	-	-
Ictiobus bubalus	3(2)35.3	36(6)810.1	4(4)548.0	53(6)193.5
Minytrema melanops	2(2)314.0	1(1)1.0	-	-
Moxostoma anisurum	1(1)415.0	12(4)336.2	1(1)2.0	17(2)266.4
Moxostoma carinatum	0(0)	9(4)794.7	1(1)810.0	0(0)
Moxostoma duquesnei	2(2)290.0	35(4)494.5	1(1)595.0	2(2)627.5
Moxostoma erythrurum	46(6)89.2	107(9)393.5	40(7)324.8	142(7)464.8
Moxostoma macrolepidotum	17(7)103.1	17(8)115.1	5(3)441.2	10(4)345.9
Ictalurus punctatus	1(1)890.0	79(7)142.2	7(3)505.0	44(8)125.1
Pylodictis olivaris	5(3)222.0	27(9)266.7	34(7)322.9	73(8)327.3
Labidesthes sicculus	0(0)	4(2)1.3	19(2)0.8	17(3)1.0

TABLE 1 (Continued)

	OHIO RIVER		MUSKINGUM RIVER	
	Day	Night	Day	Night
Morone chrysops	90(5)36.8	654(10)37.6	3(2)106.7	301(3)66.2
Morone saxatilis	11(1)11.3	40(3)32.5	-	-
M. saxatilis x M. chrysops	1(1)20.0	15(4)69.7	-	-
Ambloplites rupestris	1(1)2.0	16(3)89.5	3(1)52.7	9(3)39.9
Lepomis cyanellus	2(1)27.5	10(4)12.0	0(0)	1(1)31.0
Lepomis gibbosus	10(3)10.7	3(2)24.0	-	-
Lepomis gulosus	-	-	0(0)	1(1)44.0
Lepomis humilis	1(1)2.0	1(1)5.0	25(2)3.6	188(5)2.4
Lepomis macrochirus	320(10)9.8	455(10)21.0	207(7)32.1	851(8)31.4
Lepomis megalotis	32(6)7.6	25(6)24.1	0(0)	2(2)81.0
L. sp. x *L.* sp.	-	-	0(0)	1(1)20.0
Micropterus dolomieu	21(5)71.7	49(6)113.3	16(5)108.3	20(5)80.5
Micropterus punctulatus	126(10)92.1	178(10)59.5	239(8)114.7	456(8)123.8
Micropterus salmoides	53(7)253.4	79(5)242.4	12(4)180.1	18(4)80.7
Pomoxis annularis	-	-	1(1)387.0	1(1)1.0
Pomoxis nigromaculatus	0(0)	3(2)300.0	2(2)217.5	4(2)174.0
Etheostoma blennioides	0(0)	4(2)1.3	-	-
Etheostoma zonale	0(0)	1(1)1.0	-	-
Percina caprodes	69(8)5.7	30(7)5.9	4(1)5.0	1(1)2.0
Percina copelandi	0(0)	5(1)1.2	-	-
Percina phoxocephala	0(0)	1(1)2.0	1(1)2.0	0(0)
Percina shumardi	17(2)1.9	15(2)2.4	-	-
Stizostedion canadense	5(2)380.0	187(10)113.2	5(1)331.4	18(3)357.4
Stizostedion vitreum	0(0)	2(2)486.0	-	-
Aplodinotus grunniens	61(7)149.5	664(10)13.4	25(6)613.5	74(7)29.1
TOTALS:				
Individuals	5154	5183	3850	3308
Species	34	48	34	38
Hybrids	1	2	0	1
Weight (kg)	219.1	328.5	181.9	308.9

[1]Nomenclature follows Robins et al. (1991).

Twenty-seven taxa were collected more frequently at night (nine exclusively), five taxa more often during the day (four exclusively), and 11 species equally frequent during day and night.

CPUE (Number/Km)

The total relative number of fish collected per km in day and night samples were not significantly different in either the Ohio or Muskingum rivers (Fig. 2b). Including all taxa, night samples showed a mean decrease of 131 and 99 fish per km in the Ohio and Muskingum rivers, respectively. Results in both rivers, however, were skewed by large September day catches of *Dorosoma cepedianum*. With *D. cepedianum* excluded, total numbers per kilometer were significantly greater at night in the Ohio and Muskingum rivers and showed mean increases of 229 and 417 fish per km, respectively, over day catches (Fig. 2c).

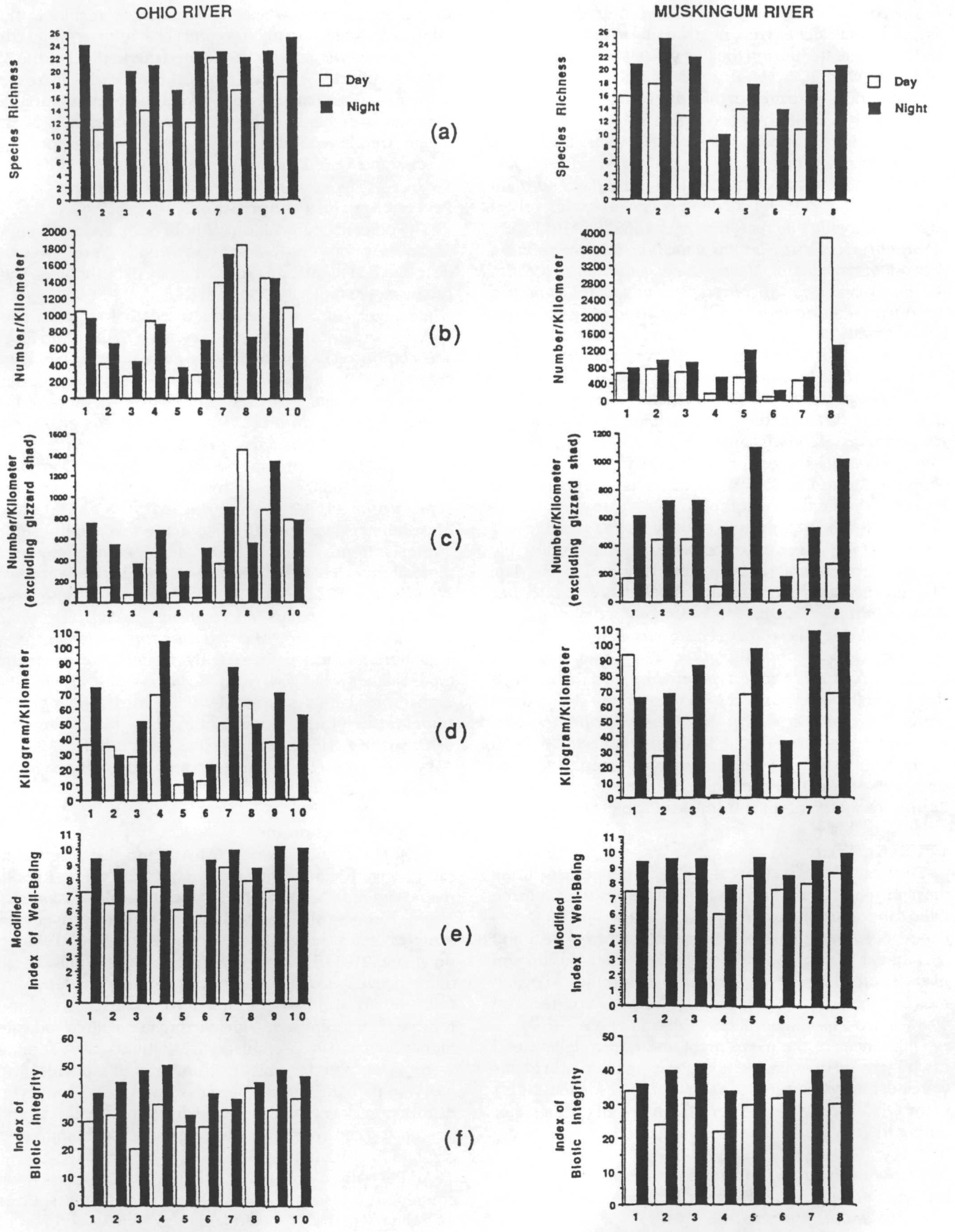

FIGURE 2. Day versus night electrofishing results (paired samples) from the Ohio and Muskingum rivers for: a) species richness; b) number/kilometer (all species); c) number/kilometer (excluding *Dorosoma cepedianum*); d) kilogram/kilometer; e) Modified Index of Well-Being scores; and f) Index of Biotic Integrity scores.

The combined total number of fish captured during the day and night catches were nearly equal in the Ohio River, and 16.4% greater during the day in the Muskingum River (Table 1). With *D. cepedianum* excluded, combined total night numbers were greater than day by 62.1% in the Ohio River and 160.4% in the Muskingum River.

By taxa, total numbers collected in the Ohio River were greater during the night for 38 (76.0%) taxa, during the day for 8 (16.0%) taxa, and equally during the day and night for 4 (8%) taxa. Fifteen taxa were collected exclusively at night. Taxa which increased most markedly (≥10x) were *Alosa chrysochloris, Notropis wickliffi, Ictiobus bubalus, Moxostoma anisurum, M. duquesnei, Ictalurus punctatus, Morone saxatilis x M. chrysops, Ambloplites rupestris, Stizostedion canadense,* and *Aplodinotus grunniens*. Species with substantially greater night numbers (≥5x <10x) were *Hiodon tergisus, Moxostoma carinatum, Pylodictis olivaris, Morone chrysops, Lepomis cyanellus,* and *Percina copelandi*. Taxa which decreased the most at night (>2x greater day abundance) were *Notropis atherinoides, Lepomis gibbosus, Notropis hudsonius, Percina caprodes,* and *Dorosoma cepedianum*.

In the Muskingum River, greater total numbers were collected during the night for 30 (69.8%) taxa, during the day for 11 (25.6%) taxa, and equally during the day and night for 2 (4.6%) taxa. Nine taxa were collected exclusively during the night and 4 taxa exclusively during the day. Marked increases were recorded for *Ictiobus bubalus, Moxostoma anisurum,* and *Morone chrysops*, and substantial increases for *Lepisosteus osseus, Notropis buchanani, Pimephales vigilax, Carpiodes cyprinus, Ictalurus punctatus,* and *Lepomis humilis*. Taxa which decreased the most at night (>2x greater day abundance) were *Dorosoma cepedianum, Percina caprodes,* and *Pimephales notatus*. For the 31 species collected in both rivers, numerical day to night abundance trends (increase, decrease, or equal) between the rivers were the same for 22 species and varied for 9 species (Table 1).

CPUE (Kg/Km)

The total relative weights of fish collected per km during the night were significantly greater than during the day in the Ohio and Muskingum rivers (Fig. 2d). Night catches experienced mean increases over day catches of 18.2 and 30.4 kg per km, respectively, in the Ohio and Muskingum rivers. The total weight of combined night samples exceeded the combined day weight by 49.9% in the Ohio River and 69.8% in the Muskingum River (Table 1).

Differences in the mean night and day weights (total catch by river) of collected taxa show heavier individuals were not always captured at night (Table 1). Mean weights in the Ohio River were greater at night for 24 taxa, greater during the day for 11 taxa, and similar (≤10% difference) for 5 taxa. Mean night weights were substantially greater for *Ictiobus bubalus, Moxostoma duquesnei,* and *M. erythrurum*, but markedly lower for *Ictalurus punctatus* and *Aplodinotus grunniens*.

In the Muskingum River, mean weights were greater at night for 12 species, greater during the day for 15 species, and similar (≤10% difference) for 8 taxa. *Moxostoma erythrurum* was the only species with a substantially greater mean night weight and similar to results in the Ohio River, the mean night weights of *Ictalurus punctatus* and *Aplodinotus grunniens* declined markedly. For the 31 species collected in both rivers, taxa trends (increase, decrease, or similar) between rivers were more variable for mean weights than for numerical abundance. Mean weight trends were the same in both rivers for only 13 species and varied for 18 species (Table 1).

Percent Species Composition

The percent composition (of both numbers and weight of species captured) was consistently more evenly distributed at night than during the day in both rivers. Day catches were typically dominated by one or two species, while night catches contained three to four dominant species. Numerically, the total day catch in the Ohio River was composed of predominantly *Dorosoma cepedianum* (52.4%) and *Notropis atherinoides* (27.4%) as apposed to the total night catch, which was more evenly composed of *Dorosoma cepedianum* (22.9%), *Aplodinotus grunniens* (12.9%), and *Morone chrysops* (12.3%). By weight in the Ohio River, dominant species changed from *Dorosoma cepedianum* (68.2%) in the total day catch to *Dorosoma cepedianum* (16.6%), *Cyprinus carpio* (12.1%), and *Moxostoma erythrurum* (13.1%) in the total night catch.

Similar trends occurred in the Muskingum River where the total day catch was dominated numerically by *Dorosoma cepedianum* (72.6%) while total night catches were dominated by *Lepomis macrochirus* (26.1%), *Dorosoma cepedianum* (16.7%), *Micropterus punctulatus* (13.9%), and *Morone chrysops* (8.4%). By weight, the dominant total catches changed from *Cyprinus carpio* (32.8%), *Dorosoma cepedianum* (18.1%), and *Micropterus punctulatus* (15.1%) during the day, to *Moxostoma erythrurum* (21.3%), *Micropterus punctulatus* (18.6%), *Cyprinus carpio* (15.7%), and *Lepomis macrochirus* (8.8%) during the night.

Biological Assessment

Biological index values (MIwb and IBI) for night samples were significantly greater than day values in both rivers (Fig. 2c,f). Night samples in the Ohio and Muskingum rivers, respectively, showed mean increases over day samples of 2.3 (range 0.8 - 3.6) and 1.5 (0.9 - 2.0) MIwb units, and 10.8 (2 - 28) and 8.7 (2 - 16) IBI units. These differences exceed OEPA's range of insignificant departure (>0.5 MIwb and 4.0 IBI units) for both indices, and represent different assessments (greater values indicate higher quality fish assemblages). MIwb increases at night were attributed to greater numbers of species and individuals, additional biomass, and a more even distribution of species. Increases in species richness and percent top carnivores, and declines in percent omnivores resulted in IBI differences.

Additionally, two night catches from the Ohio River contained unusual associations of nongame species including fish listed as endangered, threatened, or of special interest in Ohio. During single night samples, five species of *Moxostoma* were captured on 27 September at RK 276.0 (sample 4), and four species of *Percina* (Fig. 3) were collected 12 September at RK 571.9 (sample 8).

These collections illustrate the effectiveness of night electrofishing for monitoring and assessing mainstem fishes, including darter species, which are not usually collected by boat-operated electrofishing crews.

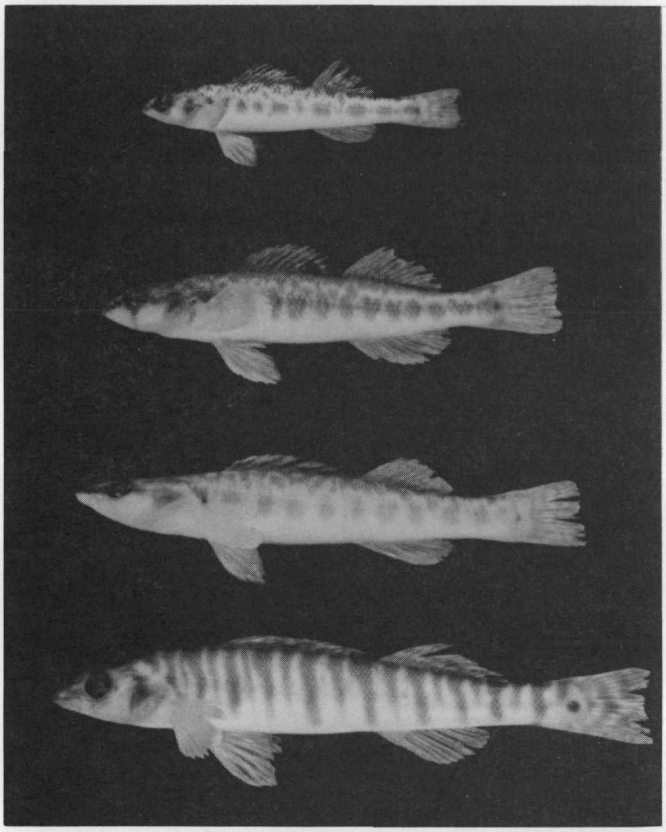

FIGURE 3. Four species of *Percina* collected from the Ohio River (RK 571.9, KY shore) on 12 September 1988 while night electrofishing. Top to bottom: *P. copelandi*, *P. shumardi*, *P. phoxocephala*, and *P. caprodes*.

DISCUSSION

Electrofishing Efficiency

Results from the present study show night sampling in both rivers was more effective than day sampling with regard to the consistent collection of more species, greater total numbers (excluding *Dorosoma cepedianum*) and weight of fish, and greater biological index scores. Although many factors (fish and habitat characteristics, and operating conditions) can influence electrofishing efficiency (Simpson 1978, Reynolds 1983), the greater night efficiency during the present study appeared to result primarily from diel movements by fishes during the evening-twilight hours from deeper off-shore waters to shallower near-shore waters for the night. Apparently, at least during the warmer months, two distinctly different fish assemblages inhabit near-shore waters of the Ohio and Muskingum rivers during the day and night, with transitional periods during dusk and dawn. Previous electrofishing studies which have included diel movements as a contributing factor to higher nighttime catches include those by Loeb (1957), Witt and Campbell (1959), and Baumann and Kitchell (1974). Observers using SCUBA gear have also found greater densities and species diversity of fish at night than during the day in shallow waters of Ontario lakes and have attributed this difference to an influx of offshore species (Emery 1973).

Greater daytime avoidance did not appear to be a primary factor during the present study because only *Dorosoma cepedianum* and *Notropis atherinoides* were observed swimming around the electrical current during the day (their numbers decreased at night), and the relative effectiveness of the gear appeared similar during day and night sampling (i.e., fish were equally susceptible to day and night electrofishing). Paragamian (1989) reported that *Micropterus dolomieu* capture rates in a smaller free-flowing river were significantly greater when electrofishing at night than during the day, primarily because of reduced gear avoidance. Behavioral changes of fishes at night, such as nocturnal torpidity and resting on the bottom (Witt and Campbell 1959, Emery 1973), may have also contributed to the higher night capture rates during the present study, but were not evident through field observations.

In addition to movement, Loeb (1957) also attributed greater night efficiency to increased visibility and calmer waters. In the present study, visibility was better during the day and night catches remained good despite rough water encountered during several stormy nights. The artificial lights used at night did not appear to be a predominant factor causing the higher capture rates. Good catches occurred immediately with the start of night sampling and more fish were captured from the shallower shoreline waters than from the deeper main channel side of the boat. Other factors which could contribute to greater night efficiency include the apparent greater penetration of artificial lights into the water, fewer distracting reflections, and a forced concentration of the netter on a smaller lit area.

Turbidity has also been stated as a factor which can influence differences between day and night electrofishing results. There is a general consensus in the literature that electrofishing in lakes should be conducted at night when the water is clear but, as clarity decreases, so do the differences between day and night sampling (Frankenberger 1962, Kirkland 1962, Graham 1986). During the present study, scatter plots of secchi depth readings versus the difference between night and day values for species richness, the MIwb, and the IBI showed no significant trends in either river. However, night sampling in the clearer Ohio River (mean secchi depth = 133 cm) yielded the greatest mean increase for species richness and biological index scores (MIwb, IBI), while night sampling in the more turbid Muskingum River (mean secchi depth = 52 cm) yielded greater mean increases in the numbers (excluding *D. cepedianum*) and weight of fish per km.

Catches

Night samples during the present study consistently yielded more species than day samples in both rivers. These results differ from those of previous studies. Frankenberger (1960) captured one additional species during the day, and Witt and Campbell (1959) captured an equal number of species during the day and night. Geo-Marine (1986) reported a greater number of species at night in 58%

of their Ohio River samples and concluded that night electrofishing yielded different, but not more, species.

Most previous electrofishing studies have reported greater catch rates during night sampling than day sampling for the total catch or for certain species (Loeb 1957, Witt and Campbell 1959, Sanderson 1960, Frankenberger 1960, Kirkland 1962, Sanders and Yoder 1989, Paragamian 1989). The Geo-Marine (1986) study found that night electrofishing did not always capture greater total numbers of fish. With *Dorosoma cepedianum* excluded, night electrofishing yielded greater numbers of fish in 50% of their samples.

A comparison, by taxa, of night versus day abundance trends found in the present and previous studies is presented (Appendix). Greater night abundance has been reported for 28 species and one hybrid, whereas greater day abundance has been reported for only six species. Contrasting results have been cited for 20 species while 16 species and two hybrids have not been previously reported. By showing the consistency or variability of results by taxa, this summary may help other investigators decide when (day or night) to sample shallow-water habitats for greater efficiency.

In addition to greater numbers, Sanderson (1960) reported that the average length and weight of fish captured while electrofishing in Maryland waters was greater at night than during the day. Kirkland (1962) reported a seasonal decline in the percent of harvestable-size *Micropterous punctulatus* and *M. salmoides* in night catches. Lengths were not recorded during the present study, but heavier fish did not predominate night catches because of increased numbers of young-of-the-year or juvenile fish. Mean weight differences (day versus night) of fish captured varied by taxa, and for some taxa, between rivers.

Previous comparison of day and night electrofishing catches has not been made for the purpose of biological community assessment. Results from the present study, however, show night sampling consistently provided a better, more complete mainstem assessment than day sampling by yielding significantly more species, greater numbers (of most species) and weight of fish, and greater MIwb and IBI values. No other collecting technique used in the Ohio River (to the author's knowledge) has collected all five species of *Moxostoma* verified to be found in the Ohio River (Pearson and Pearson 1989), or four species of *Percina*, from a single sampling. New or recent distributional records were also established for many of the species collected during the study (Trautman 1981, Pearson and Krumholz 1984, Burr and Warren 1986).

Primarily because of the diel movements by many species, night electrofishing in the near-shore waters is an effective sampling technique for large, deep rivers and should be incorporated into long-term monitoring programs. Trends observed during the present study are expected to continue during subsequent years and may be applicable in other large, deep bodies of water because the data were collected over a broad geographical area, from a variety of near-shore habitats, and throughout contrasting physical conditions (weather, flows, and turbidities).

Subsequent Studies

Since 1989, annual nongame and endangered species funding has been provided to OEPA by the Ohio Department of Natural Resources, Division of Wildlife for night electrofishing surveys in the Ohio River (Sanders 1990, 1991). These studies are not discussed here but are cited to provide additional information about nighttime fish assemblages of Ohio River near-shore waters. Additionally, nighttime electrofishing has recently been incorporated into several existing Ohio River monitoring programs (Ohio River Valley Water Sanitation Commission and the Ohio River Ecological Research Program [J. Schulte and R. Reash pers. comm.]).

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APPENDIX

Night Versus Day Numerical Abundance: Comparison by Taxa

The following is a taxa comparison of day versus night near-shore abundance trends observed during the present study (Table 1) to those previously reported. Factors considered were: all collecting techniques, observations, diel movements, and activity patterns (diurnal, crepuscular, or nocturnal).

SIMILAR RESULTS

Greater night abundance: *Lepisosteus osseus* (Pearson and Froedge 1989, Scott and Crossman 1973); *Amia clava* (Pflieger 1975); *Alosa chrysochloris* (Becker 1983); *Cyprinella spiloptera* (Geo-Marine 1986); *Cyprinus carpio* (Loeb 1957); *Macrhybopsis storeriana* (Geo-Marine 1986, Clay 1975); *Notropis blennius* (Trautman 1981); *Pimephales vigilax* (Geo-Marine 1986); *Carpiodes carpio* (Geo-Marine 1986); *C. cyprinus* (Geo-Marine 1986); *Moxostoma duquesnei* (Carlander 1969); *M. erythrurum* (Geo-Marine 1986); *M. macrolepidotum* (Geo-Marine 1986); *Ictalurus punctatus* (Geo-Marine 1986, Pflieger 1975, Trautman 1981, Becker 1983); *Pylodictis olivaris* (Pflieger 1975, Trautman 1981, Becker 1983); *Labidesthes sicculus* (Becker 1983); *Morone chrysops* (Witt and Campbell 1959, Trautman 1981); *M. saxatilis x M. chrysops* (Geo-Marine 1986); *Ambloplites rupestris* (Frankenberger 1960, Geo-Marine 1986); *Lepomis cyanellus* (Frankenberger 1960, Geo-Marine 1986); *L. macrochirus* (Frankenberger 1960, Baumann and Kitchell 1974, Sonski 1982, Geo-Marine 1986); *Micropterus dolomieu* (Geo-Marine 1986, Paragamian 1989); *M. punctulatus* (Kirkland 1962); *M. salmoides* (Frankenberger 1960, Kirkland 1962, Sonski 1982, Gilliland 1985, Graham 1986, Geo-Marine 1986); *Pomoxis nigromaculatus* (Keast 1968, Sonski 1982, Geo-Marine 1986); *Percina copelandi* (Trautman 1981, Phinney 1988); *Stizostedion canadense* (Carlander and Cleary 1949, Geo-Marine 1986); *Stizostedion vitreum* (Carlander and Cleary 1949, Witt and Campbell 1959, Pflieger 1975); and *Aplodinotus grunniens* (Trautman 1981).

Greater day abundance: *Dorosoma cepedianum* (Geo-Marine 1986); *Notropis atherinoides* (Geo-Marine 1986); *N. stramineus* (Geo-Marine 1986); *Pimephales notatus* (Geo-Marine 1986); *Lepomis gibbosus* (Emery 1973, Geo-Marine 1986); and *Percina caprodes* (Emery 1973, Geo-Marine 1986).

CONTRASTING RESULTS

Dorosoma cepedianum (Emery 1973, Pearson and Froedge 1989); *Cyprinus carpio* (Carlander and Cleary 1949, Geo-Marine 1986, Pearson and Froedge 1989); *Notropis hudsonius* (Scott and Crossman 1973); *N. wickliffi* (Geo-Marine 1986); *Hypentelium nigricans* (Geo-Marine 1986); *Ictiobus bubalus* (Geo-Marine 1986); *Moxostoma carinatum* (Geo-Marine 1986); *M. duquesnei* (Geo-Marine 1986); *Ictalurus punctatus* (Pearson and Froedge 1989); *Pylodictis olivaris* (Geo-Marine 1986); *Morone chrysops* (Geo-Marine 1986); *M. saxatilis* (Geo-Marine 1986); *Lepomis gibbosus* (Frankenberger 1960); *L. gulosus* (Geo-Marine 1986); *L. megalotis* (Geo-Marine 1986); *Micropterus dolomieu* (Emery 1973); *M. punctulatus* (Geo-Marine 1986); *Percina shumardi* (Sanders and Yoder 1989); *Stizostedion canadense* (Pearson and Froedge 1989); and *Aplodinotus grunniens* (Geo-Marine 1986).

TAXA NOT PREVIOUSLY REPORTED

Greater night abundance: *Ichthyomyzon unicuspis, Hiodon tergisus, Campostoma anomalum, Cyprinella whipplei, Cyprinus carpio x Carassius auratus, Notemigonus crysoleucas, Notropis buchanani, Moxostoma anisurum, Lepomis humilis, L* sp. *x L.* sp., *Etheostoma blennioides, Etheostoma zonale,* and *Percina phoxocephala.*

Greater day abundance: *Phenacobius mirabilis, Semotilus atromaculatus, Minytrema melanops.*

Equal day and night abundance: *Campostoma anomalum, Luxilus chrysocephalus, Lepomis humilis, Pomoxis annularis,* and *Percina phoxocephala.*