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DISTRIBUTION AND ECOLOGY OF MUSSELS IN THE TURTLE RIVER, NORTH DAKOTA

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INTRODUCTION

During the late summer of 1964, an investigation was made of the mussel fauna of the Turtle River in Grand Forks County, North Dakota. Twenty stations on the Turtle River and one station at its mouth on the Red River were sampled for mussels. The purpose of this paper is to report on the species of mussels in the Turtle River and discuss certain ecologic factors which may affect their distribution.

Mussels of the Turtle River have not been studied previously. In fact, very little is known of the mussels of the entire state. Coker

and Southall (1915, p. 15) reportec
at Fargo, and four species from the
low (1921, p. 15) listed five species
and the Sheyenne River. In 1947, D
for the Red River. Tuthill (1962)
mollusks and included the mussel

Field work for this study was
National Science Foundation Facu
the University of North Dakota. M
bers of the Surface Water Branch
at Grand Forks aided in water v
R. A. Tubb of the biology departm
Dakota critically read the manuscri

METHO

Mussels were hand picked with
an aluminum alloy cylinder with a
long and six inches in diameter. Che
alkalinity and dissolved oxygen, were
erally following the manual of the A
ation and others (1960). Chloride c
Mohr method, titrating with silver ni
chromate indicator. Alkalinity was me
sulfuric acid, using phenolphthalein
The test for dissolved oxygen was ma
azide) modification of the Winkler
sodium thiosulfate solution and a st
oxygen measurements were made du

Approximate values of pH were
the nearest 0.5 pH. Turbidity was anal
lyzer, a pre-calibrated photoelectric c
was measured in the field by a home
diameter) mounted on a rod with 0.1 to
type was estimated in the field by visu
standard particle size. Bottom samples
of mussel specimens; they were analyze
bination of wet sieving and pipette me
Water velocity was measured in fps by

GEOLOGIC SET

The Turtle River, originating in w
flows eastward and northeastward and
North about 17 miles north of Grand Fo
ward reaches near Niagara, the Turtle
ground moraine of glacial till. The river
about 50 feet below the upland surface,
through the till into underlying Cretace

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ECOLOGY OF MUSSELS IN THE VER, NORTH DAKOTA

ra and Samuel S. Harrison
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TRODUCTION

of 1964, an investigation was made of tle River in Grand Forks County, North the Turtle River and one station at its re sampled for mussels. The purpose of e species of mussels in the Turtle River factors which may affect their distri-

iver have not been studied previously. of the mussels of the entire state. Coker

and Southall (1915, p. 15) reported six species from the Red River at Fargo, and four species from the Sheyenne River at Lisbon. Winslow (1921, p. 15) listed five species from two localities, Gravel Lake and the Sheyenne River. In 1947, Dawley listed 11 species of mussels for the Red River. Tuthill (1962) compiled a list of North Dakota mollusks and included the mussel species from previous literature.

Field work for this study was accomplished with the aid of National Science Foundation Faculty Research Grant 4263-43 of the University of North Dakota. Mr. George Pike and other members of the Surface Water Branch of the U. S. Geological Survey at Grand Forks aided in water velocity measurements. Professor R. A. Tubb of the biology department at the University of North Dakota critically read the manuscript.

METHODS

Mussels were hand picked with the aid of a Turtox Fishscope, an aluminum alloy cylinder with a glass plate measuring 24 inches long and six inches in diameter. Chemical factors, chloride content, alkalinity and dissolved oxygen, were determined by titration, generally following the manual of the American Public Health Association and others (1960). Chloride content was determined by the Mohr method, titrating with silver nitrate solution and a potassium chromate indicator. Alkalinity was measured by titrating with 0.02N sulfuric acid, using phenolphthalein and methyl purple indicators. The test for dissolved oxygen was made by the Alsterberg (sodium azide) modification of the Winkler method, titrating with 0.025N sodium thiosulfate solution and a starch indicator. All dissolved oxygen measurements were made during daylight hours.

Approximate values of pH were determined by test papers to the nearest 0.5 pH. Turbidity was analyzed by a Hellige Aqua Analyzer, a pre-calibrated photoelectric colorimeter. Light penetration was measured in the field by a homemade Secchi disk (20 cm in diameter) mounted on a rod with 0.1 foot divisions. General sediment type was estimated in the field by visual comparison with a chart of standard particle size. Bottom samples were collected at specific sites of mussel specimens; they were analyzed for particle size by a combination of wet sieving and pipette methods (Folk, 1961, p. 33-37). Water velocity was measured in fps by a Price Pygmy current meter.

GEOLOGIC SETTING

The Turtle River, originating in western Grand Forks County, flows eastward and northeastward and joins the Red River of the North about 17 miles north of Grand Forks (figure 1). At the headward reaches near Niagara, the Turtle River flows through rolling ground moraine of glacial till. The river valley in this area is incised about 50 feet below the upland surface. In places the river has cut through the till into underlying Cretaceous shale.

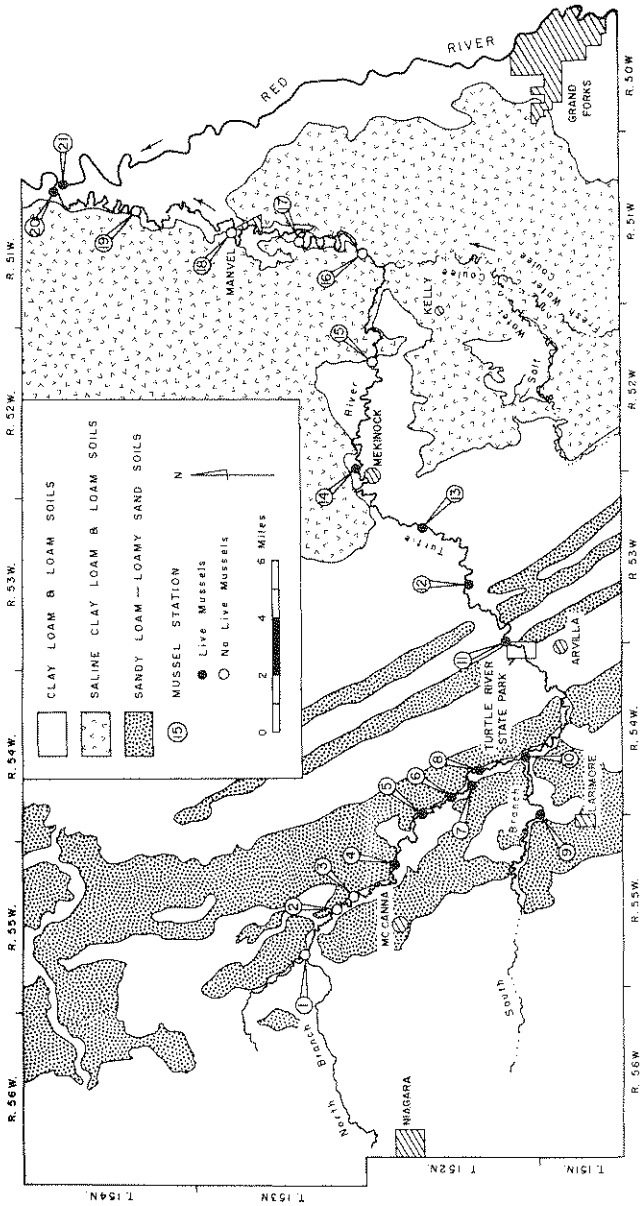


FIGURE 1.—Location map showing mussel stations on the Turtle River and the distribution of general soil types (soils generalized from soils map of North Dakota State University, Department of Soils, 1964).

About six miles east of Niagar
of former glacial Lake Agassiz,
slopes eastward toward the Red Ri
the western margin of the lake pla
the Elk Valley "Delta," a 5-mile-w
ment. Farther eastward, in the vic
(figure 1), the river transects sever
Here, the river has incised a valley
ing till. Both the "Delta" and ridge
loamy sand soils (figure 1).

The surface of the lake bed i
washed till, except for the sandy an
ta" and "beach" ridges. Toward the
however, till is overlain by lacustri
fine-grained sediment predominates
from the general area of Mekinock
of the Turtle River is noticeably sl
and is only a few to several feet b
plain.

STREAM CHARA

The Turtle River drainage basin
mately 640 square miles, most of whic
Agassiz. The gradient of the river, fi
(figure 1), is 6.6 feet per mile. Do
gradient is apparently somewhat less
appearance of the river and its gener

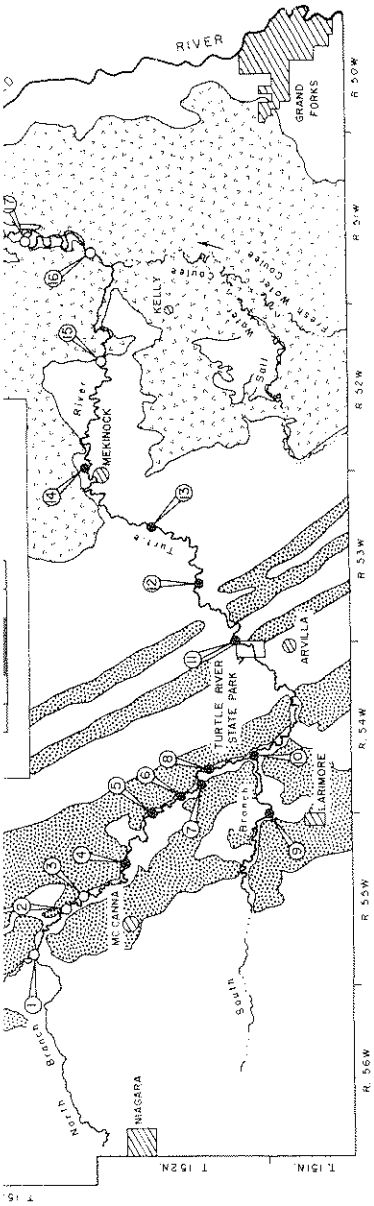
The mean annual rainfall in the
and more than three-fourths of this a
September (U. S. Weather Bureau, 19
mum of 3.85 inches falls during Ju
less than one inch per year (Miller, a

Data from a gaging station near
average discharge for the Turtle Rive
cfs or 32,580 acre-ft per year. These sa
peirods in late summer and midwinter
Mean velocities (at 0.6 of the total dep
sels at several stations in August and
0.17 to 0.78 fps or about ⅛ to ½ mph
typically occurs in April and is usual
which may cause severe high water c

DESCRIPTION OF S

University of North Dakota accession
bers; mussel species for each station ar

Station 1.—North Branch Turtle R
to secs. 20 and 21, T. 153 N., R. 55 W., ab



lowing mussel stations on the Turtl
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orth Dakota State University, Depart-

About six miles east of Niagara the Turtle River enters the bed of former glacial Lake Agassiz, a nearly featureless plain which slopes eastward toward the Red River at about 10 feet per mile. At the western margin of the lake plain the Turtle River cuts through the Elk Valley "Delta," a 5-mile-wide lobe of sandy alluvial sediment. Farther eastward, in the vicinity of Turtle River State Park (figure 1), the river transects several low ridges of sand and gravel. Here, the river has incised a valley about 30 feet into the underlying till. Both the "Delta" and ridges are reflected by sandy loam to loamy sand soils (figure 1).

The surface of the lake bed is composed primarily of wave-washed till, except for the sandy and gravelly sediment of the "Delta" and "beach" ridges. Toward the center of the former lake basin, however, till is overlain by lacustrine silt and laminated clay. This fine-grained sediment predominates on the surface of the lake bed from the general area of Mekinock eastward (figure 1). The valley of the Turtle River is noticeably shallower in this finer sediment, and is only a few to several feet beneath the surface of the lake plain.

STREAM CHARACTERISTICS

The Turtle River drainage basin encompasses an area of approximately 640 square miles, most of which lies on the bed of glacial Lake Agassiz. The gradient of the river, from about station 13 headward (figure 1), is 6.6 feet per mile. Downstream from this point, the gradient is apparently somewhat less, as evidenced by the sluggish appearance of the river and its general lack of riffles.

The mean annual rainfall in the Grand Forks area is 19.8 inches and more than three-fourths of this amount falls between April and September (U. S. Weather Bureau, 1961). An average monthly maximum of 3.85 inches falls during June. Runoff is extremely low, less than one inch per year (Miller, and others, 1962, pl. 10).

Data from a gaging station near Manvel (figure 1) shows the average discharge for the Turtle River for an 18 year period as 45 cfs or 32,580 acre-ft per year. These same records indicate occasional peirods in late summer and midwinter when the river does not flow. Mean velocities (at 0.6 of the total depth) taken at the sites of mussels at several stations in August and September, 1964, ranged from 0.17 to 0.78 fps or about ⅛ to ½ mph. The maximum annual flood typically occurs in April and is usually accompanied by ice jams, which may cause severe high water conditions.

DESCRIPTION OF STATIONS

(University of North Dakota accession numbers follow station numbers; mussel species for each station are given in Table I).

Station 1.—North Branch Turtle River, on section line common to secs. 20 and 21, T. 153 N., R. 55 W., about 3½ miles north-northwest

of McCanna, Grand Forks Co., N. Dak., September 6, 1964. Bottom mainly silty, medium to very coarse-grained sand; along banks sediment finer, of dark gray to black mud. About 210 yds above bridge is a beaver dam; below bridge is presumably another dam as water is ponded, 6 to 7 ft. deep. Water flowing slightly. Bottom examined from about 210 yds above bridge to 120 yds below it for 1½ hours. Banks mainly open, with few scattered trees. Live *Physa* and sphaeriids abundant.

Station 2.—North Branch Turtle River, on section line common to secs. 27 and 34, T. 153 N., R. 55 W., about 2¼ miles north-northeast of McCanna, Grand Forks Co., N. Dak., September 6, 1964. Bottom mainly dark gray to black mud (upper ½ inch light grayish brown), with medium to coarse-grained sand; generally soft to the step with much growing vegetation. Water flowing slightly. Bottom examined from about 94 yds above bridge to 128 yds below it for one hour. Banks open, with only grassy vegetation. Live *Physa* abundant, *Lymnaea* and *Helisoma* common; no other mollusks found alive.

Station 3.—North Branch Turtle River, on section line common to sec. 34 and 35, T. 153 N., R. 55 W., about 2 miles north-northeast of McCanna, Grand Forks Co., N. Dak., September 6, 1964. Bottom mainly silty, medium to coarse-grained sand, but in quiet water and along banks, dark gray to black, sandy, mud; generally soft to the step and with much growing vegetation. Where not ponded, stream 1 to 2 ft wide and few inches deep; where ponded, stream several yards wide and up to about 5 ft deep. Water flowing slightly. Bottom examined from about 132 yds above bridge to 128 yds below it for 1½ hours. Banks mainly open, with grassy vegetation and few bushes. Live *Physa* abundant and sphaerids common.

Station 4 (UND A15).—North Branch Turtle River, on section line common to secs. 2 and 11, T. 152 N., R. 55 W., about 2 miles east of McCanna, Grand Forks Co., N. Dak., September 7, 1964. Bottom mainly medium to coarse-grained sand with particles up to fine gravel. Ninety-three yards above bridge stream is 13½ ft wide; here, maximum depth is 0.9 ft, and mean velocity (at 0.6 depth) and velocity 0.1 ft off bottom is 0.17 fps (depth and velocity measured 7 ft from left bank). *Andodonta grandis* taken in immediate vicinity where depth and velocity measured. Bottom examined from about 112 yds above bridge to 211 yds below it for two hours. Banks largely shaded by trees. Live *Physa* abundant, *Helisoma* and sphaeriids uncommon.

Station 5 (UND A3).—North Branch Turtle River, on section line common to secs. 7 and 12, T. 152 N., R. 55 W., about 3¾ miles east-southeast of McCanna, Grand Forks Co., N. Dak., August 23, 1964. Bottom mainly muddy sand, with sandy mud near banks. About 5½ yds above bridge, stream is 29½ ft wide; here, about 12 ft from left bank, maximum depth is 1.7 ft and velocity at 0.2 ft depth

is 0.25 fps. Bottom examined from 139 ; below it for 2½ hours. Live mussels four side of bridge. Banks open, covered o Live sphaeriids abundant.

Station 6 (UND A4).—North Bran line common to secs. 18 and 19, T. 152 I north-northeast of Larimore, Grand For 1964. Bottom mainly muddy sand with boulders. Thirty-one yards above bridge near right bank, maximum depth is 2.4 depth) is 0.14 fps. *Lampsilis siliquoid* velocity measured. Bottom examined fro 79 yds below it for 3½ hours. Banks par sphaeriids abundant, small operculids co

Station 7 (UND A5).—North Branc line common to secs. 19 and 20, T. 152 N north-northeast of Larimore, Grand Fork 1964. Bottom mainly medium to coarse- and particles range up to boulders. Eight just below upstream end of "riffle pool," maximum depth, at about middle of strea (at 0.6 depth) is 0.47 fps and velocity 0. All species of live mussels taken in imme and velocity measured. Most mussels in " bridge. Bottom examined from 94 yds abo it for 3 hours. Banks largely shaded by t mon.

Station 8 (UND A6).—North Barnch T common to secs. 20 and 29, T. 152 N., R. 5 northeast of Larimore, Grand Forks Co., Bottom mainly medium to very coarse-g gravel common, some particles up to bou flowing; in small backwater areas near b fine-grained sand. Here, *Anodonta grand* Bottom examined from 104 yds above br yds below it for 2 hours. Banks weli shade uncommon.

Station 9 (UND A7).—South Branch 1, T. 151 N., R. 55 W., 1 mile north of La N. Dak., August 26, 1964. Bottom mainly grained sand, but up to pebble size; gener step. Generally, sediment black below dept ty-five yards below bridge stream is 5 ft mid-width. Here, three feet above small rif depth) is 0.29 fps and velocity 0.1 foot off bo *grandis* and *Anodontoides ferussacianus* cc

., N. Dak., September 6, 1964. Bottom coarse-grained sand; along banks sedi- lack mud. About 210 yds above bridge e is presumably another dam as water ater flowing slightly. Bottom examined idge to 120 yds below it for 1½ hours. scattered trees. Live *Physa* and sphaeri-

Turtle River, on section line common . 55 W., about 2¼ miles north-northeast ., N. Dak., September 6, 1964. Bottom id (upper ½ inch light grayish brown), ed sand; generally soft to the step with ater flowing slightly. Bottom examined idge to 128 yds below it for one hour. ssy vegetation. Live *Physa* abundant, non; no other mollusks found alive.

Turtle River, on section line common R. 55 W., about 2 miles north-northeast o., N. Dak., September 6, 1964. Bottom se-grained sand, but in quiet water and lack, sandy, mud; generally soft to the vegetation. Where not ponded, stream ies deep; where ponded, stream several 5 ft deep. Water flowing slightly. Bot- 32 yds above bridge to 128 yds below inly open, with grassy vegetation and ndant and sphaerids common.

-North Branch Turtle River, on section 11, T. 152 N., R. 55 W., about 2 miles ks Co., N. Dak., September 7, 1964. Bot- se-grained sand with particles up to fine above bridge stream is 13½ ft wide; 9 ft, and mean velocity (at 0.6 depth) m is 0.17 fps (depth and velocity mea- *Andodonta grandis* taken in immediate locity measured. Bottom examined from to 211 yds below it for two hours. Banks e *Physa* abundant, *Helisoma* and sphae-

-North Branch Turtle River, on section 12, T. 152 N., R. 55 W., about 3¾ miles Grand Forks Co., N. Dak., August 23, dy sand, with sandy mud near banks. , stream is 29½ ft wide; here, about 12 ft epth is 1.7 ft and velocity at 0.2 ft depth

is 0.25 fps. Bottom examined from 139 yds above bridge to 132 yds below it for 2½ hours. Live mussels found only just upstream (west) side of bridge. Banks open, covered only with grassy vegetation. Live sphaeriids abundant.

Station 6 (UND A4).—North Branch Turtle River, on section line common to secs. 18 and 19, T. 152 N., R. 54 W., about 3¾ miles north-northeast of Larimore, Grand Forks Co., N. Dak., August 24, 1964. Bottom mainly muddy sand with pebbly gravel; few scattered boulders. Thirty-one yards above bridge stream is 14½ ft wide; here, near right bank, maximum depth is 2.4 ft and mean velocity (at 0.6 depth) is 0.14 fps. *Lampsilis siliquoidea* taken where depth and velocity measured. Bottom examined from 217 yds above bridge to 79 yds below it for 3½ hours. Banks partially shaded by trees. Live sphaeriids abundant, small operculids common.

Station 7 (UND A5).—North Branch Turtle River, on section line common to secs. 19 and 20, T. 152 N., R. 54 W., about 3¼ miles north-northeast of Larimore, Grand Forks Co., N. Dak., August 24, 1964. Bottom mainly medium to coarse-grained sand but variable, and particles range up to boulders. Eighty-eight yards above bridge, just below upstream end of "riffle pool," stream is 22 ft wide. Here, maximum depth, at about middle of stream, is 1.5 ft; mean velocity (at 0.6 depth) is 0.47 fps and velocity 0.1 ft off bottom is 0.37 fps. All species of live mussels taken in immediate vicinity where depth and velocity measured. Most mussels in "riffle pool," 66 yards above bridge. Bottom examined from 94 yds above bridge to 138 yds below it for 3 hours. Banks largely shaded by trees. Live sphaeriids common.

Station 8 (UND A6).—North Barnch Turtle River, on section line common to secs. 20 and 29, T. 152 N., R. 54 W., about 3 miles north-northeast of Larimore, Grand Forks Co., N. Dak., August 26, 1964. Bottom mainly medium to very coarse-grained sand (also pebbly gravel common, some particles up to boulder size) where water is flowing; in small backwater areas near banks, sediment is mud to fine-grained sand. Here, *Anodonta grandis* most frequently found. Bottom examined from 104 yds above bridge (washed out) to 156 yds below it for 2 hours. Banks well shaded by trees. Live sphaeriids uncommon.

Station 9 (UND A7).—South Branch Turtle River, NE¼ sec. 1, T. 151 N., R. 55 W., 1 mile north of Larimore, Grand Forks Co., N. Dak., August 26, 1964. Bottom mainly muddy, fine to medium-grained sand, but up to pebble size; generally soft and sinks to the step. Generally, sediment black below depth of a few inches. Seventy-five yards below bridge stream is 5 ft wide and 0.7 ft deep at mid-width. Here, three feet above small riffle, mean velocity (at 0.6 depth) is 0.29 fps and velocity 0.1 foot off bottom is 0.28 fps. *Anodonta grandis* and *Anodontoides ferussacianus* collected 37 yards and 28

yards, respectively, above point where velocity and depth measured. Where *Anodonta grandis* was collected, stream is 13 ft wide with maximum depth of 1.3 feet. Bottom examined from 136 yds above bridge to 165 yds below it for 1½ hours. Banks mainly open with few bushes and small trees. Dead branches and roots of bushes and small trees numerous on bottom. Live sphaeriids uncommon.

Station 10 (UND A8).—Turtle River, just below confluence of North and South Branch, on section line common to secs. 32 and 33, T. 152 N., R. 54 W., about 2¼ miles northeast of Larimore, Grand Forks Co., N. Dak., August 27, 1964. Bottom mainly medium to very coarse-grained sand, pebbles and cobbles (few boulders) also common; some gray, sandy to pebbly mud. About 22 yards below bridge, stream is 18½ ft wide but main channel is 8½ ft wide; maximum depth (3 ft from right bank) is 1.2 ft. Here, mean velocity (at 0.6 depth) is 0.56 fps and velocity 0.1 foot above bottom is 0.44 fps. *Anodontoides ferussacianus* common where velocity and depth measured. Bottom examined from 123 yds above bridge to 183 yds below it for two hours. Banks largely open, with few scattered trees.

Station 11 (UND A1).—Turtle River, Turtle River State Park, NE¼ sec. 36, T. 152 N., R. 54 W., about 1½ miles north of Arvilla, Grand Forks Co., N. Dak., August 2 and 27, 1964. Bottom mainly medium to course-grained pebbly sand; cobbles and boulders common. Left bank of clay till, right bank is edge of river terrace and sandy. Bottom examined over 284 yds above bridge, for 2 hours. Banks well shaded by bushes and trees. Live sphaeriids uncommon.

Station 12 (UND A9).—Turtle River, on section line common to secs. 20 and 21, T. 152 N., R. 53 W., about 2½ miles northeast of Turtle River State Park or 5 miles southwest of Mekinock, Grand Forks Co., N. Dak., August 28, 1964. Besides species listed in Table I, collected empty shells of *Fusconaia flava* and *Strophitus rugosus* along the bottom. Bottom mainly medium to coarse-grained pebbly sand; with mud and gravel up to boulders, surfaced with thin film of silt; water becomes clouded quickly upon walking over bottom. About 100 yds below bridge stream is 23 ft wide with maximum depth of 2.2 ft at 5 ft from right bank; mean velocity (at 0.6 depth) here is 0.14 fps.*Anodonta grandis* and *Lampsilis siliquoidea* collected where depth and velocity measured. Bottom examined from 2[illegible] yds above bridge to 165 yds below it for 2½ hours. Banks generally well shaded by trees. Live sphaeriids common; where many specimens collected, about 125 yds below bridge, 6 yds below a boulder crossing and up to 4 feet from left bank, sediment is muddy, fine-grained sand. Four feet from left bank, depth is 0.7 feet and mean velocity (at 0.6 depth) is 0.30 fps.

Station 13 (UND A10).—Turtle River, on section line common to secs. 11 and 14, T. 152 N., R. 53 W., about 2½ miles southwest of Mekinock, Grand Forks Co., N. Dak., August 28, 1964. Mussels [illegible]

plentiful than at any other station. Bot[tom] coarse-grained, silty, pebbly sand; exa[mined] bridge for 1½ hours. Banks largely op[en] bushes. Live sphaeriids common.

Station 14 (UND A11).—Turtle Riv[er] to secs. 31 and 32, T. 153 N., R. 52 W., ab[out] east of Mekinock, Grand Forks Co., N. [Dak.] ment in main channel generally mediu[m] sand; and along banks, of sandy mud surfaced by about one-fourth inch of cl[ay] below bridge stream is 22½ ft wide with Here. six feet from left bank, depth is (at 0.6 depth) is 0.24 fps. Live *Anodon[ta]* depth and velocity measured; also many in living position, with posterior ends up *ata* taken nine yards upstream. Here, ma[in] 4½ ft from left bank. Mean velocity (at velocity 0.1 ft off bottom is 0.19 fps. Bott[om] above bridge to 110 yds below it for 2¼ scattered to numerous trees. Live sphaer[iids]

Station 15.—Turtle River, on section l[ine] 3, T. 152 N., R. 52 W., about 3 miles nor[th] 3¾ miles east of Mekinock), Grand Forks 1964. Bottom mainly soft, black or dark places, medium to coarse-grained pebbly to dark gray mud; surfaced with about clayey silt, making water very turbid whe[n] yards above bridge stream is 17 ft wide; al[so] maximum depth of 1.2 ft. Here, mean 0.46 fps and velocity 0.1 ft off bottom is 0 from 112 yds above bridge to 138 yds below small trees and bushes along banks. Live common.

Station 16 (UND A12).—Turtle River, [on] secs. 5 and 33, Tps. 152 and 153 N., R. 51 W[.] east of Kelly (or 4¼ miles south-southwest [of] N. Dak., September 3, 1964. Bottom m[ud] black mud, upper one-fourth inch light empty snail shells in sediment. Thirty-five y[ards] 15 ft wide with maximum depth of 1.5 Here. mean velocity (at 0.6 depth) is 0.78 f[ps] bottom is 0.60 fps (velocities probably hi[gh] downstream wind when measured). Bottom ove bridge to 119 yds below it for 1½ h[ours] grassy vegetation. Refuse is dumped a[long] bed. Live *Physa* and *Helisoma* uncommon.

)oint where velocity and depth measured.
vas collected, stream is 13 ft wide with
t. Bottom examined from 136 yds above
or 1½ hours. Banks mainly open with few
d branches and roots of bushes and small
Live sphaeriids uncommon.

—Turtle River, just below confluence of
1 section line common to secs. 32 and 33,
2¼ miles northeast of Larimore, Grand
27, 1964. Bottom mainly medium to very
s and cobbles (few boulders) also com-
ebbly mud. About 22 yards below bridge,
main channel is 8½ ft wide; maximum
x) is 1.2 ft. Here, mean velocity (at 0.6
)city 0.1 foot above bottom is 0.44 fps.
ommon where velocity and depth mea-
n 123 yds above bridge to 183 yds below
ely open, with few scattered trees.

Turtle River, Turtle River State Park,
4 W., about 1½ miles north of Arvilla,
August 2 and 27, 1964. Bottom mainly
ebbly sand; cobbles and boulders com-
right bank is edge of river terrace and
er 284 yds above bridge, for 2 hours.
s and trees. Live sphaeriids uncommon.

Turtle River, on section line common
., R. 53 W., about 2½ miles northeast
5 miles southwest of Mekinock, Grand
8, 1964. Besides species listed in Table
usconaia flava and *Strophitus rugosus*
inly medium to coarse-grained pebbly
p to boulders, surfaced with thin film
d quickly upon walking over bottom.
stream is 23 ft wide with maximum
ht bank; mean velocity (at 0.6 depth)
dis and *Lampsilis siliquoidea* collected
easured. Bottom examined from 231
elow it for 2½ hours. Banks generally
haeriids common; where many speci-
below bridge, 6 yds below a boulder
1 left bank, sediment is muddy, fine-
left bank, depth is 0.7 feet and mean
fps.

Turtle River, on section line common
. 53 W., about 2½ miles southwest of
Dak., August 28, 1964. Mussels more

plentiful than at any other station. Bottom firm, mainly medium to coarse-grained, silty, pebbly sand; examined over 123 yds below bridge for 1½ hours. Banks largely open with scattered trees and bushes. Live sphaeriids common.

Station 14 (UND A11).—Turtle River, on section line common to secs. 31 and 32, T. 153 N., R. 52 W., about half a mile north-northeast of Mekinock, Grand Forks Co., N. Dak., August 28, 1964. Sediment in main channel generally medium to coarse-grained pebbly sand; and along banks, of sandy mud to muddy sand; commonly, surfaced by about one-fourth inch of clayey silt. Sixty-eight yards below bridge stream is 22½ ft wide with maximum depth of 2.3 feet. Here. six feet from left bank, depth is 1.9 ft and mean velocity (at 0.6 depth) is 0.24 fps. Live *Anodonta grandis* common where depth and velocity measured; also many double-valved empty shells in living position, with posterior ends upward. *Lasmigona complanata* taken nine yards upstream. Here, maximum depth is 1.6 feet at 4½ ft from left bank. Mean velocity (at 0.6 depth) is 0.26 fps and velocity 0.1 ft off bottom is 0.19 fps. Bottom examined from 156 yds above bridge to 110 yds below it for 2¼ hours. Banks covered with scattered to numerous trees. Live sphaeriids common.

Station 15.—Turtle River, on section line common to secs. 2 and 3, T. 152 N., R. 52 W., about 3 miles northwest of Kelly (or about 3¾ miles east of Mekinock), Grand Forks Co., N. Dak., September 2, 1964. Bottom mainly soft, black or dark gray sandy mud; and in places, medium to coarse-grained pebbly sand underlain by black to dark gray mud; surfaced with about one-fourth inch of loose clayey silt, making water very turbid when disturbed. Thirty-seven yards above bridge stream is 17 ft wide; about 7½ ft from left bank is maximum depth of 1.2 ft. Here, mean velocity (at 0.6 depth) is 0.46 fps and velocity 0.1 ft off bottom is 0.36 fps. Bottom examined from 112 yds above bridge to 138 yds below it for 1½ hours. Scattered small trees and bushes along banks. Live sphaeriids and *Physa* uncommon.

Station 16 (UND A12).—Turtle River, on section line common to secs. 5 and 33, Tps. 152 and 153 N., R. 51 W., about 3¼ miles northeast of Kelly (or 4¼ miles south-southwest of Manvel), Grand Forks C., N. Dak., September 3, 1964. Bottom mainly firm, dark gray to black mud, upper one-fourth inch light brown; high content of empty snail shells in sediment. Thirty-five yards above bridge stream is 15 ft wide with maximum depth of 1.5 ft, 5 ft from left bank. Here, mean velocity (at 0.6 depth) is 0.78 fps and velocity 0.1 ft off bottom is 0.60 fps (velocities probably high because of moderate downstream wind when measured). Bottom examined from 154 yds above bridge to 119 yds below it for 1½ hours. Banks open except for grassy vegetation. Refuse is dumped at bridge. No sphaeriids noted. Live *Physa* and *Helisoma* uncommon.

Station 17 (UND A13).—Turtle River, on section line common to secs. 21 and 22, T. 153 N., R. 51 W., about 2 miles south-southwest of Manvel, Grand Forks Co., N. Dak., September 3, 1964. Bottom mainly soft (one can sink in up to two feet), dark gray to black mud, surfaced with up to one inch of loose, light brownish gray, clayey silt; black sediment has odor of H_2S gas. Empty shells of aquatic snails very common to abundant in sediment. Bottom examined from 80 yds above bridge to 165 yds below it for 1½ hours. Banks with scattered to many trees. Live, small operculids common, *Physa* uncommon.

Station 18.—Turtle River, NW¼ sec. 10. T. 153 N., R. 51 W., about half a mile north-northwest of Manvel, Grand Forks Co., N. Dak., September 4, 1964. Bottom mainly soft (one can sink in up to two feet), dark gray to black mud, surfaced with up to one inch of loose, light brownish gray clayey silt; black sediment generally with odor of H_2S gas. Twenty-four yards above bridge stream is 20½ ft wide with maximum depth of 1.7 ft, 5½ ft from left bank. Here, mean velocity (at 0.6 depth) is 0.38 fps and velocity 0.1 ft off bottom is 0.29 fps. Bottom examined from 183 yds above bridge to 128 yds below it for 1½ hours. Banks mainly open with few trees. Live *Lymnaea* and *Physa* uncommon; small operculids common. No sphaeriids noted.

Station 19.—Turtle River, on section line common to secs. 23 and 26, T. 154 N., R. 51 W., about 4 miles north-northeast of Manvel, Grand Forks Co., N. Dak., September 4, 1964. Bottom mainly irregular and soft (one can sink in to about 1½ ft), dark gray to black mud, surfaced with up to half an inch of loose, light brownish gray to light grayish brown clayey silt; black sediment generally with odor of H_2S gas. Clay pellets mainly medium to coarse sand size, common. Bottom examined from 92 yds above bridge to 156 yds below it for 1¼ hours. Banks mainly well shaded by trees, lack other vegetation. Much wood debris in stream. Live, small operculids common. Empty shells of other aquatic snails abundant, sphaeriids common in sediment.

Station 20 (UND A20).—Turtle River at confluence with Red River, on section line common to secs. 11 and 12, T. 154 N., R. 51 W., about 7 miles north-northeast of Manvel, Grand Forks Co., N. Dak. (about 1½ miles south-southwest of Oslo, Minnesota), September 5, 1964. Bottom mainly dark gray to black silty clay, surfaced by 1/16 to 1 inch of loose, light grayish brown to brownish gray clayey silt; soft above bridge, one can sink in to two feet. Black sediment with slight odor of H_2S gas. Clay pellets, mainly of coarse sand to very fine pebble size, common. Twenty-six yards above bridge, stream is 18½ ft wide with maximum depth of 1.3 ft at 6½ ft from left bank. Here, mean velocity (at 0.6 depth) is 0.59 fps and velocity at 0.1 ft off bottom is 0.32 fps. Stream velocity faster on down stream side of bridge, because of constriction of channel. Bottom

examined from 145 yds above br
yds below bridge) for 1¾ hours.
Physa uncommon; empty shells
sediment.

Station 21 (UND A14).—Red
NW¼ sec. 12, T. 154 N., R. 51 W.
Manvel (or about 1½ miles south
Forks Co., N. Dak., September 5,
light tan-gray mud. Eighty-eight y
8½ ft from left bank, depth is 1.9
and velocity 0.1 ft off bottom is 0.
where velocity and depth measure
above mouth of Turtle River to 138
not collected below 2½ ft depth. Ba
is along undercut bank of Red Ri
tached to mussel shells) uncommon

ECOLOGIC

Selected possible ecologic factor
chloride content, total alkalinity, di
bidity and bottom sediment. Chemi
with station, are shown in figure 2.
16 to 2110 ppm throughout the Tur
three miles northwest of Kelly, the
three times as high as it is elsewhe
than six miles downstream, choride c
60 times as high as it is upstream fro
able increase in chloride content do
responds to an apparent total absence
2), which continues to the mouth of
limit of live mussels agrees closely wit
clay loam and loam soils where it cross
Land is generally poor for crop grow
near Kelly. It has been speculated that
the subsurface, perhaps from Cretaceou
may be responsible for these saline soil

Total alkalinity varies from 184 t
creases downstream (figure 2). It dec
responding increase in the chloride c
phenolphthalein indicate all alkalinity
ion.

Dissolved oxygen varies from 5.3 to
to change markedly in any part of the s
of values suggests that no serious organ

Approximate values of pH from 5.
the same selected stations as given in
be no marked trend of pH values in the

.—Turtle River, on section line common
. R. 51 W., about 2 miles south-southwest
o., N. Dak., September 3, 1964. Bottom
in up to two feet), dark gray to black
one inch of loose, light brownish gray
as odor of H_2S gas. Empty shells of aqua-
abundant in sediment. Bottom examined
o 165 yds below it for 1½ hours. Banks
s. Live, small operculids common, *Physa*

er, NW¼ sec. 10. T. 153 N., R. 51 W.,
thwest of Manvel, Grand Forks Co., N.
ttom mainly soft (one can sink in up to
ick mud, surfaced with up to one inch
ay clayey silt; black sediment generally
enty-four yards above bridge stream is
depth of 1.7 ft, 5½ ft from left bank.
depth) is 0.38 fps and velocity 0.1 ft
examined from 183 yds above bridge to
urs. Banks mainly open with few trees.
ncommon; small operculids common. No

er, on section line common to secs. 23
about 4 miles north-northeast of Manvel,
eptember 4, 1964. Bottom mainly irregu-
n to about 1½ ft), dark gray to black
lf an inch of loose, light brownish gray
ey silt; black sediment generally with
ts mainly medium to coarse sand size,
from 92 yds above bridge to 156 yds
ks mainly well shaded by trees, lack
debris in stream. Live, small operculids
her aquatic snails abundant, sphaeriids

—Turtle River at confluence with Red
n to secs. 11 and 12, T. 154 N., R. 51 W.,
t of Manvel, Grand Forks Co., N. Dak.
west of Oslo, Minnesota), September 5,
ay to black silty clay, surfaced by 1/16
ayish brown to brownish gray clayey
an sink in to two feet. Black sediment
Clay pellets, mainly of coarse sand to
mon. Twenty-six yards above bridge,
naximum depth of 1.3 ft at 6½ ft from
(at 0.6 depth) is 0.59 fps and velocity
fps. Stream velocity faster on down
se of constriction of channel. Bottom

examined from 145 yds above bridge to mouth of Turtle River (97 yds below bridge) for 1¾ hours. Banks well shaded by trees. Live *Physa* uncommon; empty shells of other aquatic snails common in sediment.

Station 21 (UND A14).—Red River, at mouth of Turtle River, NW¼ sec. 12, T. 154 N., R. 51 W., about 7 miles north-northeast of Manvel (or about 1½ miles south-southwest of Oslo, Minn.), Grand Forks Co., N. Dak., September 5, 1964. Bottom firm, light gray to light tan-gray mud. Eighty-eight yards above mouth of Turtle River, 3½ ft from left bank, depth is 1.9 ft. Here, mean velocity is 0.28 fps and velocity 0.1 ft off bottom is 0.18 fps. *Lampsilis siliquoidea* taken where velocity and depth measured. Bottom examined from 158 yds above mouth of Turtle River to 138 yds below it for 2 hours. Mussels not collected below 2½ ft depth. Banks well-shaded by trees. Station is along undercut bank of Red River. Live limpets (observed attached to mussel shells) uncommon.

ECOLOGIC FACTORS

Selected possible ecologic factors which were analyzed included chloride content, total alkalinity, dissolved oxygen, pH, water turbidity and bottom sediment. Chemical factors, and their variation with station, are shown in figure 2. The chloride content varies from 16 to 2110 ppm throughout the Turtle River. At station 15, about three miles northwest of Kelly, the chloride content (87 ppm) is three times as high as it is elsewhere upstream. At station 16, less than six miles downstream, choride content (2000 ppm) is more than 60 times as high as it is upstream from station 15. The first appreciable increase in chloride content downstream (at station 15) corresponds to an apparent total absence of live mussels (figures 1 and 2), which continues to the mouth of the Turtle River. This eastern limit of live mussels agrees closely with the western margin of saline clay loam and loam soils where it crosses the Turtle River (figure 1). Land is generally poor for crop growing in this belt of saline soils near Kelly. It has been speculated that seepage of saline water from the subsurface, perhaps from Cretaceous rocks of the Dakota Group, may be responsible for these saline soils (Laird, 1944, p. 6).

Total alkalinity varies from 184 to 328 ppm and generally decreases downstream (figure 2). It decreases markedly with a corresponding increase in the chloride content. Negative results with phenolphthalein indicate all alkalinity is present as the bicarbonate ion.

Dissolved oxygen varies from 5.3 to 8.9 ppm. It does not appear to change markedly in any part of the stream (figure 2). The range of values suggests that no serious organic pollution is present.

Approximate values of pH from 5.5 to 6.5 were obtained for the same selected stations as given in figure 2. There appears to be no marked trend of pH values in the river.

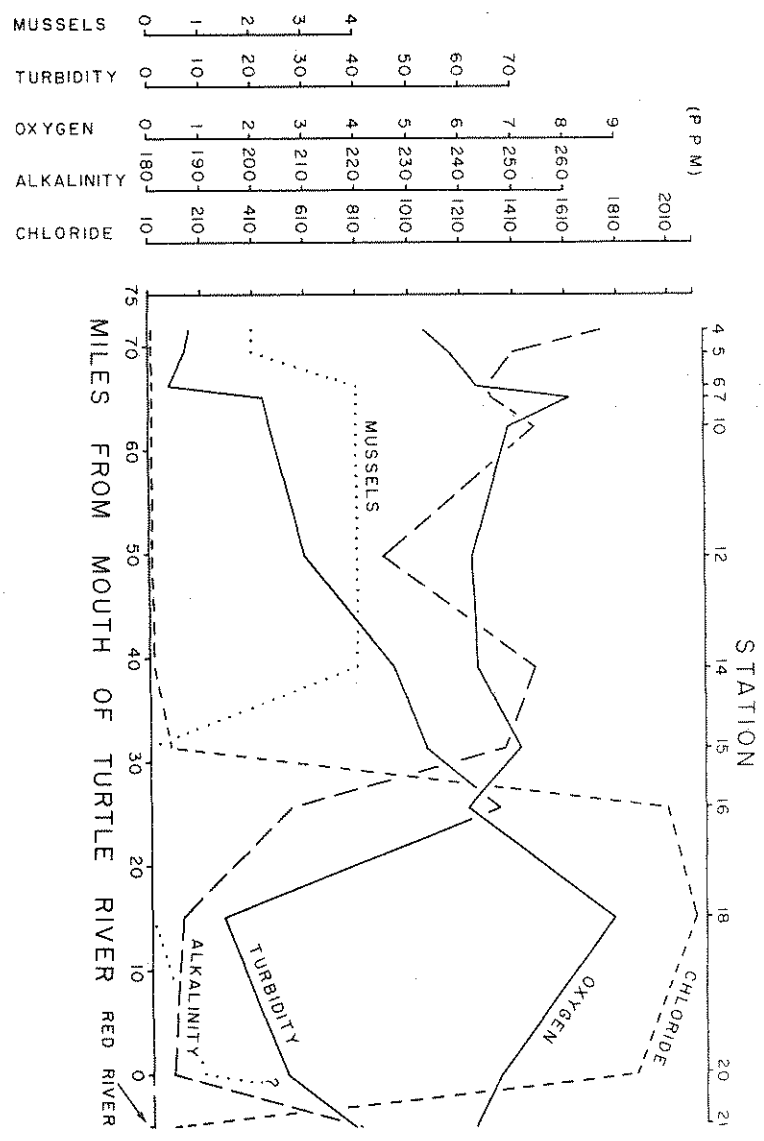


FIGURE 2.—Graph showing the variation of number of muss species, turbidity, dissolved oxygen, chloride content and tot alkalinity with station on the Turtle River.

These pH values are presumably l Model T-O, Hydrogen-Ion Slide Compa 27, 1965, were 8.1, 8.0, 7.9, 8.3 and 8.7 at respectively.

Water turbidity, expressed as ppm shows a general increase to station 16, downstream (figure 2). It is highest whe very markedly (station 16). Secchi disk to 1.2 ft in the Turtle River, generally turbidity values and show a similar tren

Bottom sediment is generally sandy reaches of the river and muddy in its partially reflected in figure 4, as lower a indicate the upstream and downstream pa ly.

The writers are well aware that per tors are more, or as, important ecologicall here. A few of these might be aquatic ve particular, food supply (Matteson, 1955, p.

MUSSELS

Species presently in the Tu

General.—Four species were found to Turtle River: *Anodonta grandis* Say, (Barnes), *Anodontoides ferussacianus* (L *quoidea* (Barnes) (Table I). The relative ab tion to station but, of the four species, *Ano silis siliquoidea* occur most commonly. In Turtle River, only two species are present *Anodontoides ferussacianus*. At stations 1 to are the only mussels. At the single station the Red River, only *Lampsilis siliquoidea*

Mussels in the Turtle River generally n riffle pools. The highest mussel density iffle pool (station 7) was 0.4 mussels per s

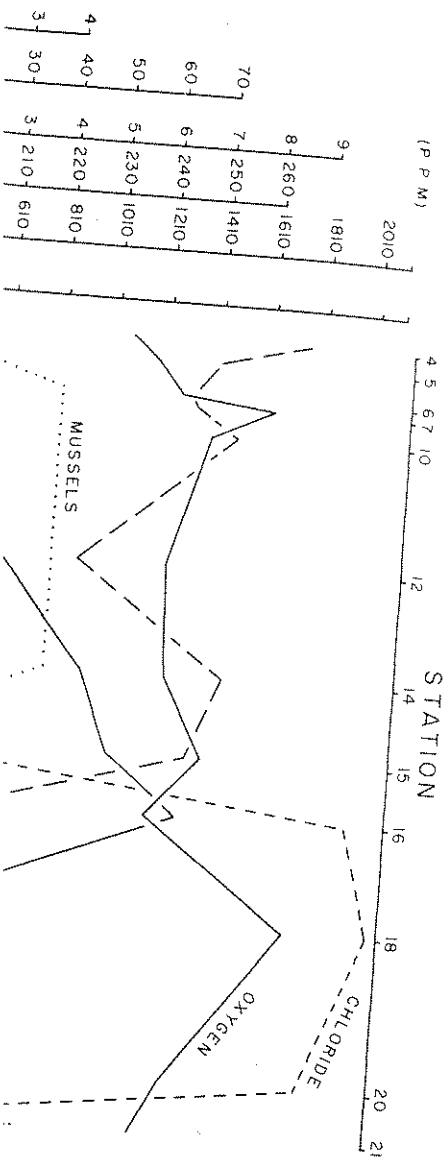
Family Unionidae

Subfamily Anodontina

Anodonta grandis Say "Flo

Diagnosis.—Shells of this species differ rtle River mussels in having the combina double-looped beak sculpture.

Remarks.—The color of the nacre varies fr to pale greenish yellow to moderate ora dard and others, 1948). Shell measurement width/length show no apparent trend do



he variation of number of mussel oxygen, chloride content and total he Turtle River.

These pH values are presumably low, however, using a Taylor T-O, Hydrogen-Ion Slide Comparator, pH values on August 1965, were 8.1, 8.0, 7.9, 8.3 and 8.7 at stations 10, 11, 13, 15 and 19, ectively.

Water turbidity, expressed as ppm SiO_2, varies from 4 to 67 and es a general increase to station 16, with lesser values farther nstream (figure 2). It is highest where chloride content increases y markedly (station 16). Secchi disk readings, varying from 4.3 ft 1.2 ft in the Turtle River, generally correspond inversely with bidity values and show a similar trend.

Bottom sediment is generally sandy and gravelly in the upper aches of the river and muddy in its lower reaches. This fact is rtially reflected in figure 4, as lower and higher station numbers dicate the upstream and downstream parts of the river respective-

The writers are well aware that perhaps numerous other fac- ors are more, or as, important ecologically as those briefly described ere. A few of these might be aquatic vegetation, fish host, and in particular, food supply (Matteson, 1955, p. 127).

MUSSELS

Species presently in the Turtle River

General.—Four species were found to presently occur in the Turtle River: *Anodonta grandis* Say, *Lasmigona complanata* (Barnes), *Anodontoides ferussacianus* (Lea), and *Lampsilis siliquoidea* (Barnes) (Table I). The relative abundance varies from station to station but, of the four species, *Anodonta grandis* and *Lampsilis siliquoidea* occur most commonly. In the headwaters of the Turtle River, only two species are present, *Anodonta grandis* and *Anodontoides ferussacianus*. At stations 1 to 4 and 9 (figure 1(, these are the only mussels. At the single station sampled for mussels in the Red River, only *Lampsilis siliquoidea* was found present.

Mussels in the Turtle River generally occur most commonly in riffle pools. The highest mussel density observed at one such riffle pool (station 7) was 0.4 mussels per square yard.

Family Unionidae

Subfamily Anodontinae

Anodonta grandis Say "Floater"

Diagnosis.—Shells of this species differ from those of other Turtle River mussels in having the combination of no hinge teeth and double-looped beak sculpture.

Remarks.—The color of the nacre varies from pale blue to bluish white to pale greenish yellow to moderate orange pink (colors after Goddard and others, 1948). Shell measurement ratios of height/length and width/length show no apparent trend downstream.

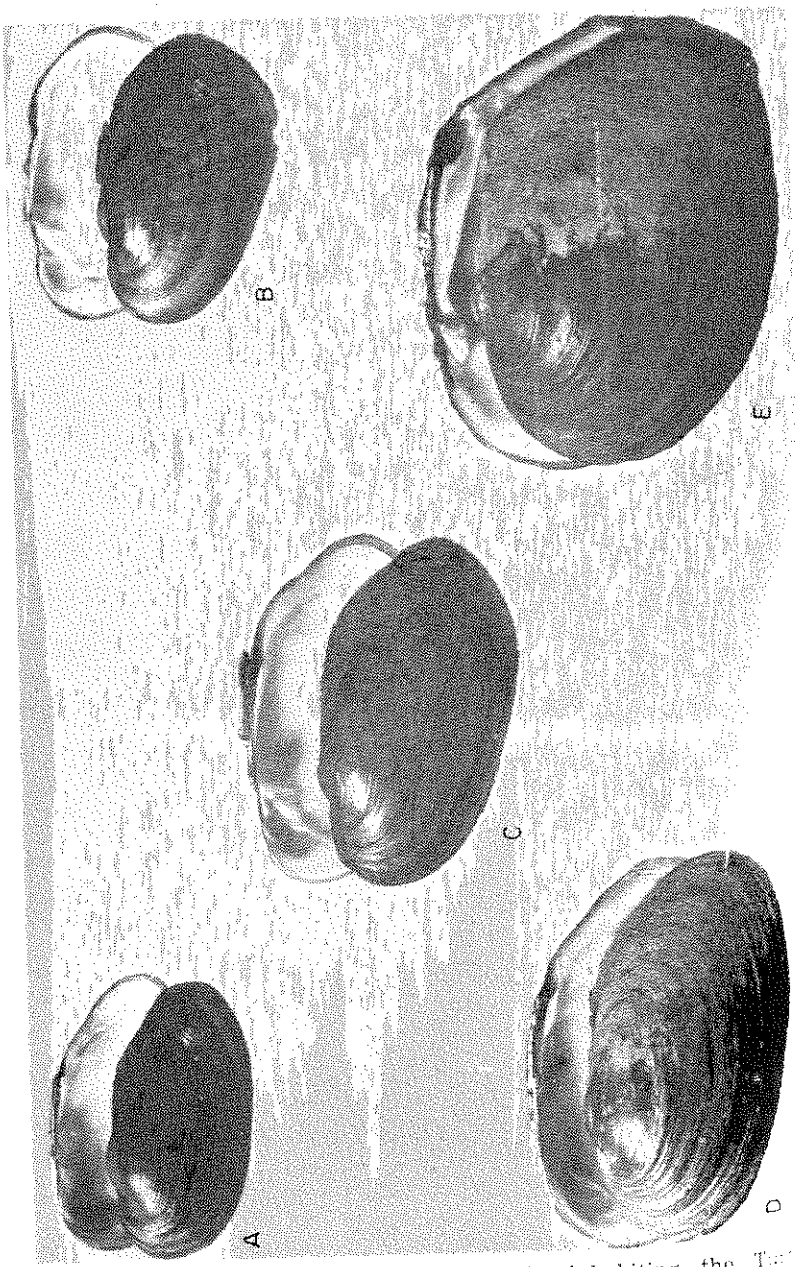


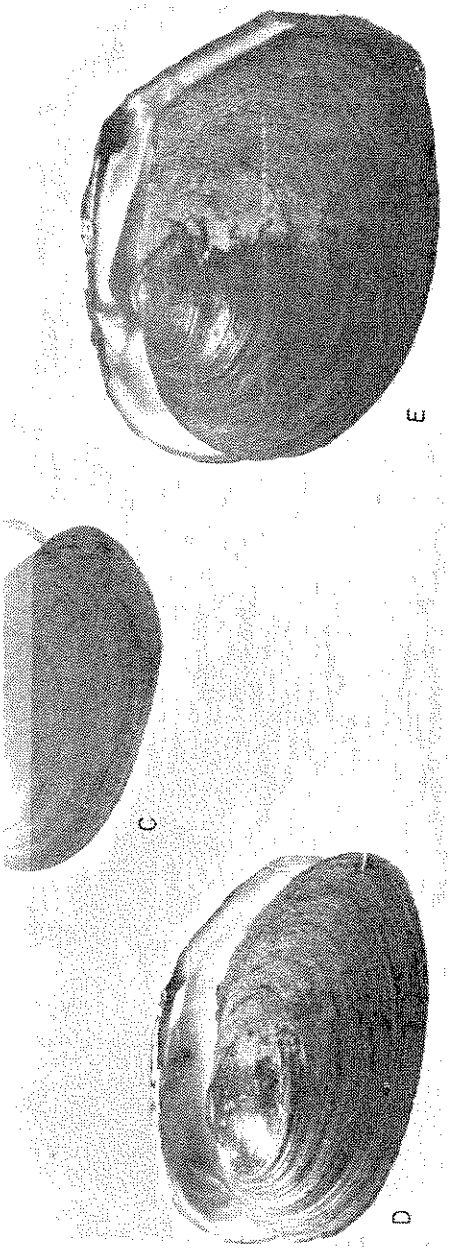
FIGURE 3.—Species of mussels presently inhabiting the T... River. All figures are X½. A, *Anodontoides ferussacianus* (L... UND Cat. No. 11041, A7. B, C, *Lampsilis siliquoidea* (Ba... female and male, respectively, UND Cat. Nos. 11048. A... 11049, A4. D, *Anodonta grandis* Say, UND Cat. No. 11039. A... *Lasmigona complanata* (Barnes), UND Cat. No. 11044. A...

TABLE I

Distribution of Live Species of Mu...

STATION	
1.	N. Branch Turtle R., 3½ mi NNW McCanna
2.	N. Branch Turtle R., 2½ mi NNE McCanna
3.	N. Branch Turtle R., 2 mi NNE McCanna
4.	N. Branch Turtle R., 2 mi E McCanna
5.	N. Branch Turtle R., 3 3/4 mi ESE McCanna
6.	N. Branch Turtle R., 3 3/4 mi NNE Larimore
7.	N. Branch Turtle R., 3½ mi NNE Larimore
8.	N. Branch Turtle R., 3 mi NNE Larimore
9.	S. Branch Turtle R., 1 mi N Larimore
10.	Turtle R., 2½ mi NE Larimore
11.	Turtle R., Turtle R. State Park
12.	Turtle R., 2½ mi NE Turtle R. State Park
13.	Turtle R., 2½ mi SW Mekinock
14.	Turtle R., ½ mi NNE Mekinock
15.	Turtle R., 3 mi NW Kelly
16.	Turtle R., 3½ mi NE Kelly
17.	Turtle R., 2 mi SSW Manvel
18.	Turtle R., ½ mi NNW Manvel
19.	Turtle R., 4 mi NNE Manvel
20.	Turtle R., at mouth (confluence with Red R.)
21.	Red River, at mouth of Turtle R.

Relative abundance of each species is indicated by ... = uncommon, and R = rare. Letter symbols underl... presence only by empty shells.
... = Anodonta grandis Say; b = Lasmigona complanata ... ferussacianus (Lea); and d = Lampsilis siliquoidea



sels presently inhabiting the Turtle
A, *Anodontoides ferussacianus* (Lea),
B, C, *Lampsilis siliquoidea* (Barnes),
vely, UND Cat. Nos. 11048, A10 and
ndis Say, UND Cat. No. 11039, A5. E,
arnes), UND Cat. No. 11044, A8.

TABLE I

Distribution of Live Species of Mussels in the Turtle River*

STATION	MUSSEL SPECIES**			
	a.	b.	c.	d.
1. N. Branch Turtle R., 3½ mi NNW McCanna	U	...	U	...
2. N. Branch Turtle R., 2¾ mi NNE McCanna	C	...	C	...
3. N. Branch Turtle R., 2 mi NNE McCanna	C	...	C	...
4. N. Branch Turtle R., 2 mi E McCanna	C	...	U	...
5. N. Branch Turtle R., 3 3/4 mi ESE McCanna	C	R	U	U
6. N. Branch Turtle R., 3 3/4 mi NNE Larimore	U	R	U	C
7. N. Branch Turtle R., 3¾ mi NNE Larimore	C	R	U	A
8. N. Branch Turtle R., 3 mi NNE Larimore	A	U	R	U
9. S. Branch Turtle R., 1 mi N Larimore	U	...	R	...
10. Turtle R., 2¾ mi NE Larimore	C	R	U	C
11. Turtle R., Turtle R. State Park	U	C	R	A
12. Turtle R., 2½ mi NE Turtle R. State Park	C	R	R	R
13. Turtle R., 2½ mi SW Mekinock	A	U	U	C
14. Turtle R., ½ mi NNE Mekinock	C	U	U	R
15. Turtle R., 3 mi NW Kelly	R	...	...	R
16. Turtle R., 3¾ mi NE Kelly	...	...	R	R
17. Turtle R., 2 mi SSW Manvel	...	...	...	R
18. Turtle R., ½ mi NNW Manvel	...	...	...	...
19. Turtle R., 4 mi NNE Manvel	...	...	...	...
20. Turtle R., at mouth (confluence with Red R.)	...	...	...	R
21. Red River, at mouth of Turtle R.	...	...	...	C

* Relative abundance of each species is indicated by: A = abundant, C = common, U = uncommon, and R = rare. Letter symbols underlined indicate a species presence only by empty shells.

** a = Anodonta grandis Say; b = Lasmigona complanata (Barnes); c = Anodontoides ferussacianus (Lea); and d = Lampsilis siliquoidea (Barnes).

Figure 4 shows that *Anodonta grandis* can occur on a variety of bottom type in the Turtle River. However it seems to occur most commonly on a soft bottom of muddy sand in the slow backwater parts of the stream. This species rests relatively high on soft bottom, but on firm substrate its siphons are not uncommonly flush with the bottom.

Lasmigona complanata (Barnes)
"White Heel Splitter"
Figure 3E

Diagnosis.—This is the largest species in the Turtle River. Its shells are heavy, with strong pseudo-cardinal but no lateral teeth, and beak sculpture consists of strong double-looped ridges.

Remarks.—Shell measurement ratios of height/length and width/length show no apparent trend downstream. This species seems to prefer a bottom of muddy, very fine to fine-grained sand (figure 4), and occurs most commonly near banks. It commonly is resting partially on one side in the sediment and usually its siphons are directed upstream.

Anodontoides ferussacianus (Lea)
"Cylindrical Paper Shell"
Figure 3A

Diagnosis.—This species is the smallest of the Turtle River mussels. It has a thin shell which lacks hinge teeth and is characterized by a beak sculpture of low, concentric ridges.

Remarks.—Shell measurement ratios of height/length and width/length show no apparent trend downstream. This species seems to prefer a firm sand or gravelly sand bottom (figure 4) near the upstream end of riffle pools. However, it also occurs in finer sediment and quieter water. *Anodontoides ferussacianus* commonly occurs with its siphons flush with the bottom.

Subfamily Lampsilinae

Lampsilis siliquoidea (Barnes)
"Fat Mucket"
Figures 3B, C

Diagnosis.—Shells of this species are sexually dimorphic, and possess both pseudocardinal and lateral teeth. Beak sculpture consists of low, wavy chevron-like ridges.

Remarks.—Shell measurement ratios of height/length and width/length show no apparent trend downstream. This species occurs in a variety of bottom type (figure 4) and a preference is not apparent in the Turtle River. Not uncommonly, *Lampsilis siliquoidea* occurs with its siphons flush with the bottom. The modified mantle flaps of the female of this species were observed at two localities, stations 11 and 13.

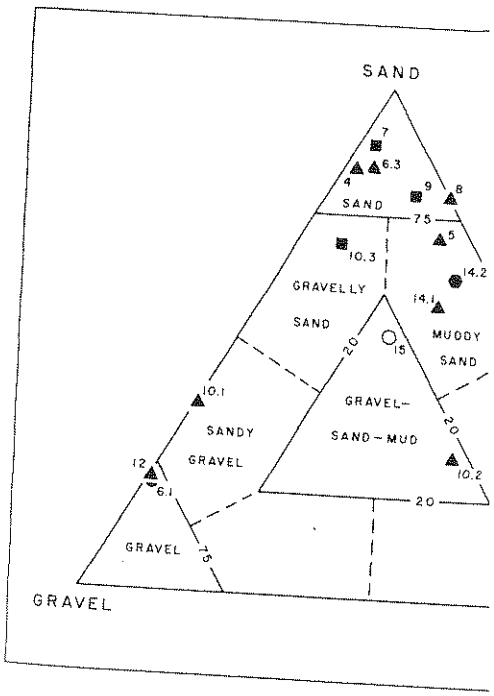


FIGURE 4.—Triangular diagram showing species to bottom sediment (percenta 1954). Numbers at plots correspond t on figure 1. 4 = UND Cat. No. 1103 6.1 = UND Cat. No. 11045; 6.2 = U = UND Cat. No. 11033; 7 = UND Ca Cat. No. 11034; 9 = UND Cat. No. No. 11035; 10.2 = UND Cat. No. 1103 11042; 12 = 11037; 14.1 = UND Cat Cat. No. 11043; 20 = UND Cat. No. 11 11047.

Species formerly in the Turt

Mussels were also collected at three loc sediments of the Turtle River. These col tional species which presently do not inha ra (Rafinesque), *Lasmigona compressa* gosus (Swainson). All three localities, wi each are as follows (numbers in parenthese the University of North Dakota):

Anodonta grandis can occur on a vari-
tle River. However it seems to occur m
om of muddy sand in the slow backwa
species rests relatively high on soft botto
siphons are not uncommonly flush wi

na complanata (Barnes)
'hite Heel Splitter"
Figure 3E

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rent trend downstream. This species seems
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nly near banks. It commonly is resting
he sediment and usually its siphons are

des ferussacianus (Lea)
ndrical Paper Shell"
Figure 3A
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or gravelly sand bottom (figure 4) near
pools. However, it also occurs in finer
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siliquoidea (Barnes)
'Fat Mucket"
Figures 3B, C
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and lateral teeth. Beak sculpture con-
ike ridges.
ement ratios of height/length and width/
end downstream. This species occurs on
gure 4) and a preference is not apparent
commonly, *Lampsilis siliquoidea* occurs
the bottom. The modified mantle flaps
were observed at two localities, stations

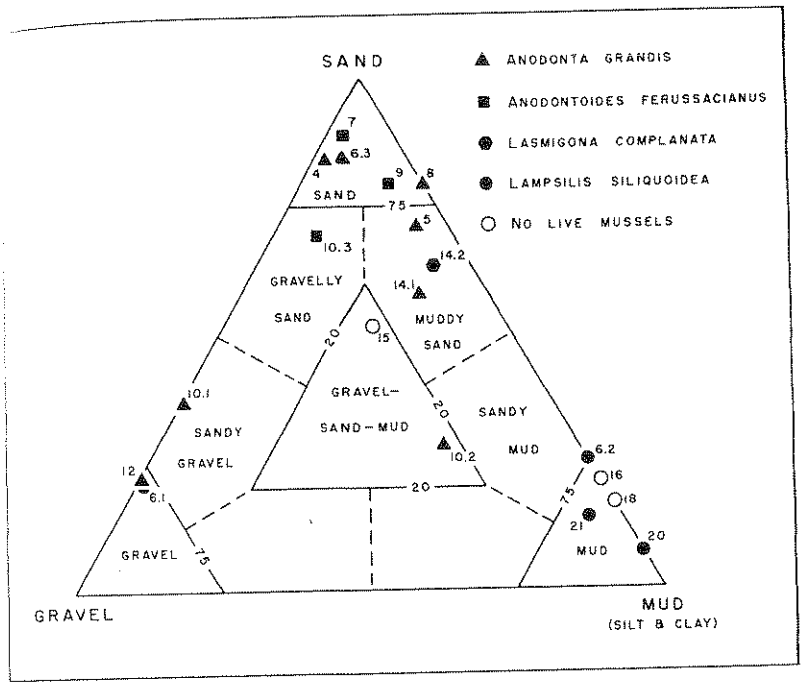

FIGURE 4.—Triangular diagram showing relationship of mussel species to bottom sediment (percentage limits after Shepard, 1954). Numbers at plots correspond to station numbers shown on figure 1. 4 = UND Cat. No. 11031; 5 = UND Cat. 11032; 6.1 = UND Cat. No. 11045; 6.2 = UND Cat. No. 11046; 6.3 = UND Cat. No. 11033; 7 = UND Cat. No. 11040; 8 = UND Cat. No. 11034; 9 = UND Cat. No. 11041; 10.1 = UND Cat. No. 11035; 10.2 = UND Cat. No. 11036; 10.3 = UND Cat. No. 11042; 12 = 11037; 14.1 = UND Cat. No. 11038; 14.2 = UND Cat. No. 11043; 20 = UND Cat. No. 11050; 21 = UND Cat. No. 11047.

Species formerly in the Turtle River

Mussels were also collected at three localities from the terrace-like sediments of the Turtle River. These collections reveal three additional species which presently do not inhabit the river: *Fusconaia flava* (Rafinesque), *Lasmigona compressa* (Lea), and *Strophitus rugosus* (Swainson). All three localities, with mussel species found at each are as follows (numbers in parentheses are accession numbers of the University of North Dakota):

1 (A19). Cutbank (12½ ft. high) in floodplain on west bank of Turtle River, north and south sides of bridge, SW¼ sec. 20, T. 152 N., R. 53 W., about 6 miles southwest of Mekinock, Grand Forks Co., North Dakota.

Anodonta grandis
Anodontoides ferussacianus
Lampsilis siliquoidea

2 (A18). Cutbank (14½ ft. high) on Turtle River, east edge of bridge, west boundary sec. 21, T. 152 N., R. 53 W., about 5 miles southwest of Mekinock, Grand Forks Co., N. Dak. (see Station 12).

Fusconaia flava
Anodonta grandis
Lasmigona compressa
Anodontoides ferussacianus
Lampsilis siliquoidea

3 (A17). Cutbank (11 ft. high) in floodplain of Turtle River, ¼ mile downstream from locality 2 (A18).

Fusconaia flava
Anodontoides ferussacianus
Strophitus rugosus

All species presently inhabiting the Turtle River were also collected from the terrace-like sediments, with the exception of *Lasmigona complanata*. This species will presumably be found upon further collecting.

Analysis of the mussel fauna

The Turtle River mussel fauna, past and present, constitutes a total of seven species. Six of these seven species have been taken from terrace-like sediments previously deposited by the river.

Of the seven species, four are common to both the Turtle and Red rivers: **Fusconaia flava, Anodonta grandis, *Strophitus rugosus* and *Lampsilis siliquoidea* (those marked with an asterisk do not presently inhabit the Turtle River). In addition, the following species of the Turtle River do not occur in the Red River (Dawley, 1947): *Lasmigona complanata, L. compressa* (does not presently inhabit the Turtle River) and *Anodontoides ferussacianus*. The latter two species are characteristic of creeks or small rivers (Baker, 1928, p. 141 and p. 177, and van der Schalie, 1938, p. 54 and 56). In addition to the four species common to both the Turtle and Red rivers, Dawley (1947) has listed seven other species for the Red River.

The living mussel fauna of the Turtle River is that found in other small rivers or creeks. The three additional species from terrace-like sediments of the present Turtle River also conform with the idea of a small river or creek fauna, and indicate no appreciable difference in the size of the Turtle River when the terrace-like sediments were deposited.

SUMMA

Four species of mussels presen
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are particularly characteristic.

Of the four living species, the r
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SUMMARY

Four species of mussels presently occur in the Turtle River: *Anodonta grandis* Say, *Lasmigona complanata* (Barnes), *Anodontoides ferussacianus* (Lea), and *Lampsilis siliquoidea* (Barnes). The shells of three other species have been taken from terrace-like sediments of the same river: *Fusconaia flava* (Rafinesque), *Lasmigona compressa* (Lea) and *Stophitus rugosus* (Swainson). This assemblage of seven species is suggestive of a small river or creek fauna, although only *Anodontoides ferussacianus* and *Lasmigona compressa* are particularly characteristic.

Of the four living species, the relative abundance varies from station to station; however, *Anodonta grandis* and *Lampsilis siliquoidea* occur most commonly. In the headwaters of the Turtle River, only two species are present, *Anodonta grandis* and *Anodontoides ferussacianus*.

The Turtle River is apparently barren of mussels from a point about three miles northwest of Kelly (about 12 miles northwest of Grand Forks) to its mouth. Of the ecologic factors analyzed, chloride content, turbidity and total alkalinity seem to be the most important in affecting mussel distribution. The downstream limit of mussels in the Turtle River agrees closely with the western margin of saline clay loam and loam soils where it crosses the river.

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BIOLOGY OF *ENDRIA INIMICA* (SAY), VECTOR OF WHEAT STRIATE MOSAIC

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ABSTRACT

The biology of *Endria inimica* (Say) was studied under greenhouse, environmental chamber, and field conditions. When the environmental chamber had day, interim, and night temperatures of 80°-75°-70°F, respectively, it was found that the females required an average of 12.8 days to oviposit eggs after they mated. Females ovipostited an average of 44 eggs in durum wheat, which required an average of 13.6 days to hatch.

E. inimica has five nymphal instars. The length of the nymphal stage and of each stadium were studied under varying temperature ranges. The nymphs survived best when the day, interim and night temperatures were between 80°-70°-65°F and 90°-80°-70°F. At these temperature ranges the length of the nymphal stage was from 27 - 31 days. Each instar required from 3 to 8 days to complete development. The nymphs could not survive in the environmental chamber when the day, interim and night temperatures were 65°-60°-55 F below.

In North Dakota E. *inimica* has two generations per year. The leafhoppers hatch from overwintering eggs from late June to mid-July and can be found until mid-October.

The eggs are oviposted under the under the epidermis of the leaf blade, a of the host plant.

In North Dakota smooth brome (*B* important host plant. Blue grass (*Poa p pyron repens*), and wheat are also com

There is some indication of a migra Dakota in the spring.

Parasites of *E. inimica* include spec pidae, Pipunculidae, and Dryinidae.

HABITAT DISTRIBUTION AN VARIATION OF THE DEER MC COMPLEX OF NORTHWESTSEI NORTHEASTERN NOR

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Department of Bi

University of North Dakota, Grand

ABSTRACT

Attempts by several authors to dis forms of Deer Mouse, *Peromyscus manicul gracilis* and *P. leucopus noveboracensis*, or and ecological variations have been unsuc of northeastern North Dakota and northw poses of the present study were to ana characters and to develop improved criter these three forms by using techniques of liminary analyses of variation of 11 morph strated overlap among the three forms so th ments could not be reliable for definite habitat preferences were not distinctive fo are in other parts of their geographical d specimen of each form was chosen on the characters published by others. All specim *P. m.* bairdii and 51 *P. l. noveboracensis*,) "typical" specimens by calculation of the slight modification of the coefficient of c

$$K = \sum_{i=1}^{12} \left(\frac{2w}{a +} \right.$$

which gave equal weight to each of the 12 comparison. The results indicated that mi specific intergrades were present in the ori the use of similiarity coefficients in ma