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RIVER STURGEONS OF THE AMERICAN GENUS SCAPHIRHYNCHUS: CHARACTERS, DISTRIBUTION, AND SYNONYMY

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AMONG the many endemic genera of North American freshwater fishes, one of the most distinctive and bizarre is Scaphirhynchus, which includes two species confined to the larger rivers of the interior lowlands, primarily in the Mississippi basin. S. platorynchus (Rafinesque) is the more common and widely distributed species and is the subject of considerable commercial exploitation. S. album (Forbes and Richardson) was not described until 1905 and remains one of the least known of our larger freshwater fishes. Originally taken near the mouth of the Illinois River, it has since been reported definitely only from the mouth of the Missouri River and from the Mississippi River at Keokuk, Iowa. The recent accumulation of new material of both forms enables us to verify their specific, though not generic, distinctness, present descriptive measurements and meristic counts, contrast the species in certain differential characters, list new records of specimens, and map the known geographic ranges.

METHODS

Except as noted below, the methods employed in taking measurements and counts are those currently used by most American ichthyologists (e.g., Hubbs and Lagler, 1947: 8-15). In the plate counts all clearly carinate scutes are included. In the series of dorsal plates the postoccipital is reckoned as the anteriormost (this is normally the first to bear a well-formed spine), but the predorsal plate is excluded. In the lateral series the first plate counted is just behind the shoulder girdle (the tabular and posttemporal, which bear spines, are excluded); at the posterior end small plates are counted if they

are carinate. A small plate at the anterior end of the ventrolateral row is tallied, even if it is not keeled, as long as it is clearly an element in this series. In the dorsal and anal fin-ray counts all anterior rudiments behind the predorsal and preanal plates are included. The last ray in those fins, as counted, is double at its base. The pectoral count includes the strong spine anteriorly and all posterior rudiments (these may be tiny, and an appreciable personal error is involved in counting unstained material). The pelvic count includes all rudiments anteriorly. In all fins the rays are closely spaced, and accurate counts require patience, good illumination, and considerable magnification; they usually entail preparatory removal of superficial tissue by scraping. Use of insect pins to mark out sectional counts helps to eliminate errors.

The standard length terminates at the posterior end of the last carinate plate of the lateral series (this point is treated as the base of the caudal fin). The origin of the dorsal and anal fins is taken as the posterior edge of the predorsal and preanal plates (the large, noncarinate plates lying just in front of these fins). Body width is measured at the shoulder girdle. Caudal-peduncle depth and width are taken at the plane of the least depth. Head length is measured to the posterior (bony) margin of the primary bone of the operculum, which in sturgeons is the subopercle (the opercular membrane is commonly curled under, and to include it introduces an avoidable error). Head depth is the vertical measurement from the top of the left parietal crest. Head width is the maximum breadth of the rostrum. Rostral length is taken from snout tip to the prominent angle of the suborbital. The orbital length is established visually. Nostril width is the greatest dimension of each nostril. Mouth width is the greatest overall extent of the lips. Measurements involving barbels are taken from the anterior edge of their bases; the lengths are taken on both barbels of a pair and the longer is recorded. The front of the mouth is that point on the mid-line that lies on the anterior, cartilaginous edge of the labial depression. Caudal-fin measurements are taken from the fin base (see definition of standard length above); the filament is included, but since this structure is commonly broken the measurement is minimal. The height of the tenth lateral plate is taken, and the distance from the lower edge of this scute to the closest plate in the ventrolateral series is used as the interspace between these rows of plates.

The following abbreviations are employed to designate the location of specimens: KU, Museum of Natural History, University of Kansas; SU, Natural History Museum, Stanford University; TU, Department of Zoology, Tulane University; UMMZ, Museum of Zoology, University of Michigan; USNM, United States National Museum.

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THE RECENT GENERA OF THE ACIPENSERIDAE

Scaphirhynchus is superficially similar to the Asiatic genus P*seudoscaphirhynchus* Nikolski (1900), as is evident from the figures and accounts of Berg (1904, 1911, 1932, and 1948) and Forbes and Richardson (1905). The two genera have been regarded by Berg as a subfamily Scaphirhynchini (properly Scaphirhynchinae) of the Acipenseridae; the remaining Recent genera of the family, Acipenser and

Huso, constitute the Acipenserinae. On the basis of the comparison given by Forbes and Richardson (1905: 41) we were uncertain whether the two genera of "shovelnose" sturgeons (Scaphirhynchus and *Pseudoscaphirhynchus*) owed their close resemblance to common ancestry or to convergence. Examination of three specimens of P. *kaufmanni*[1] and perusal of a translation of the acipenserid section of Berg's freshwater fishes of Russia (1932: 42-70) leads us to believe that Berg's arrangement is correct, namely, that the genera of the Scaphirhynchinae are directly related. However, it is perhaps premature to deny categorically that the striking agreement in several features may be due to parallel modifications in animals that inhabit the channels of large silty rivers. Scaphirhynchus is much more highly specialized from the ancestral stock, exemplified presumably by Acipenser, than is Pseudoscaphirhynchus.

The apparent relationships and chief differential characters may be expressed in the following key to the Recent genera of the family:

KEY TO SUBFAMILIES AND GENERA

1a. ACIPENSERINAE. Spiracle and pseudobranchium present. Snout variously blunt or sharp, more or less conical, never extremely depressed and shovel-like. Upper lobe of caudal not prolonged into a filament.

2a. Gill membranes fused to isthmus, not forming a free fold below it. Mouth transverse, of moderate size, much narrower than rostrum. Barbels subcircular in cross section. North America and Eurasia. Approximately fourteen species. ..... Acipenser

2b. Gill membranes conjoined, forming a free fold below the isthmus. Mouth crescentic, large, nearly as wide as rostrum. Barbels flattened. Eurasia: drainage of the Amur River, eastern Siberia, and basins of the *Caspian*, Black, and Adriatic seas. Two species. ..... Huso

1b. SCAPHIRHYNCHINAE. No spiracle or pseudobranchium. Snout extremely depressed, broad and shovel-like. Upper lobe of caudal often very long, but the filament said to be wanting in Pseudoscaphirhynchus hermanni, and may be lost through mutilation.

3a. Caudal peduncle incompletely armored, little depressed, and short—tip of anal fin reaching almost to caudal base; caudal-peduncle length about 9 per cent of standard length. Barbels entire. Gill openings with their lower ends (where they join the isthmus) separated by a space of about one third the rostral width. Pectoral spine very stout. Each clavicle with a deep ventral keel that has from 2 to 5 strong,

[1] USNM 37242, 123 mm., Amu Darya River, Siberia; USNM 102346, 143 mm., Tchardjuy, U.S.S.R., June 12, 1916; USNM 102347, 337 mm., mouth of Amu Darya River, Siberia, September 2, 1925.

backward-projecting serrations (present in *Pseudoscaphirhynchus kaufmanni;* condition unknown to us in other species). Retrorse spines near end of snout wanting *(P. fedtschenkoi),* absent or poorly developed *(P. hermanni), or* few (2 to 7) and long and strong *(P. kaufmanni).* Caudal filament rather heavy and whiplike, or absent. *Basin of the Aral Sea, Siberia: drainages of the Amu Darya and the Syr Darya, not found in the Aral Sea itself.* Three species. *Pseudoscaphirhynchus*

3b. Caudal peduncle completely armored, notably depressed, and long—tip of anal fin remote from caudal base; caudal-peduncle length 15 to 26 per cent of standard length. Barbels fringed. Gill openings with their lower ends only narrowly separated. Pectoral spine well developed but not notably stout. Clavicles not keeled. Retrorse spines near end of snout numerous, short and slender (obliterated with growth). Caudal filament slender, short in adults. *United States: basins of the Mississippi River and the Rio Grande.* Two species. *Scaphirhynchus*

In the striking elongation and armature of the caudal peduncle, surely interpretable as specializations, Scaphirhynchus is unique among living sturgeons. That these features are not of recent acquisition is evident from their presence in a shovelnose sturgeon from the Upper Cretaceous, twenty-four miles southeast of Fort Peck, Montana, that was referred to by MacAlpin (1947: 168). This specimen, Museum of Paleontology, University of Michigan, No. 22210, has been studied by Norman J. Wilimovsky, who will soon report on it. Thus *Scaphirhynchus* (or its ancestral stock) had assumed its most distinctive structural features by the Cretaceous. The zoogeographic pattern of the Scaphirhynchinae may well have been established by that time, since the more highly modified group then occurred in an area within the present range of Scaphirhynchus.

THE GENUS SCAPHIRHYNCHUS

In establishing the name Parascaphirhynchus albus, Forbes and Richardson (1905: 38) commented: "Recognizing, as we are disposed to do, the generic criteria proposed for the scaphirhynchoids by Berg ('04), we regard this form as generically distinct from species hitherto described." They forthwith proposed Parascaphirhynchus as a new genus. Berg (1911: 138, 308-309, and 1948: 104), however, did not support this decision, and placed *albus* in *Scaphirhynchus,* an action

Since *Scaphirhynchus is* neuter, the adjectival specific name should properly be written *album,* as pointed out by Hubbs (1951: 14) and by Riggs and Moore (1951). We regard *platorynchus* as a substantive and therefore do not place it in agreement with the generic name.

that has been overlooked or disagreed with by American workers until recently.

Although *album* and *platorynchus* are readily separable and are well-marked species, it is clear that they are closely related and share several fundamental distinctions from the other Recent acipenserids. To separate the two generically obscures their close alliance, and we therefore follow Berg in treating them as congeneric.

Scaphirhynchus Heckel

Accipenser (in part).—Rafinesque, 1820: 80.

Acipenser (in part).—Gray, 1834: 122.

Scaphirhynchus.—Heckel, 1836: 71 (original description). Günther, 1870: 345. Duméril, 1870: 268-269. Kirsch and Fordice, 1890: 246-247. Jordan and Evermann, 1896b: 107. Berg, 1904: 667. Forbes and Richardson, 1905: 40. Giltay, 1929: 28. Holly, 1936: 40-41. Type species, by monotypy, *Scaphirhynchus rafinesquii* Heckel, 1836, a synonym of *Accipenser platorynchus* Rafinesque, 1820.

Scaphorhynchus (variant of *Scaphirhynchus* Heckel).—Agassiz, 1846: 332 (employed merely to show similarity to *Scaphorhynchus* Wied, 1831, a genus of birds).

Scaphirrhynchus (variant of *Scaphirhynchus* Heckel).—O'Shaughnessy, 1879: 8.

Scaphyrhynchus (variant of *Scaphirhynchus* Heckel).—Meek, 1895: 89-92.

Scaphyrhinchus (misprint for *Scaphirhynchus* Heckel).—Zograf, 1896: 199.

Scaphirynchus (misprint for *Scaphirhynchus* Heckel).—Cross and Moore, 1952: 400.

Scaphyrhynchops.—Gill, in Hayden, 1863: 178 (substitute for *Scaphirhynchus* Heckel, 1836, apparently regarded as preoccupied by *Scaphorhynchus* Wied, 1831, a genus of birds). Type species, by original designation, *Scaphyrhynchus (sic) rafinesquii* Heckel.

Scaphirhynchops (also spelled *Scaphirhychops)* (variant of *Scaphyrhynchops* Gill).—Jordan and Copeland, 1876: 161.

Scaphirynchops (variant of *Scaphyrhynchops* Gill).—Jordan, 1878c: 33.

Scaphirrhynchops (variant of *Scaphyrhynchops* Gill).—Jordan, 1879: 768. Jordan and Gilbert, 1883: 88.

Scaphirhyncops (probable misprint for *Scaphyrhynchops* Gill).—Scudder, 1882: 285.

Parascaphirhynchus.—Forbes and Richardson, 1905: 38. Type species, by monotypy, *Parascaphirhynchus albus* Forbes and Richardson, 1905.

Parascaphirynchus (probable misprint for *Parascaphirhynchus* Forbes and Richardson).—Sollas, 1906: 50.

Parascaphyrhynchus (variant of *Parascaphirhynchus* Forbes and Richardson).—Fowler, 1911: 604.

Diagnosis.—Species of Acipenseridae with caudal peduncle greatly elongate, notably depressed, and fully armored; rostrum much flat-

tened, expansive, with a sharp marginal carina and a median dorsal cluster of small retrorse spines near tip (these commonly obsolete in adults); no spiracle and no pseudobranchium; an accessory opercular gill that is poorly developed, consisting of only 20 to 25 short filaments; gillrakers short, fan-shaped, each provided with several soft points; gill openings closely approximated, the branchiostegal membrane attached to isthmus near mid-line; upper caudal lobe in young with an elongate filament that becomes relatively shorter with age; nostrils enlarged; eyes tiny; 4 fringed barbels; 4 heavily papillose lobes on upper lip and 4 fringed lobes on lower lip, of which 2 are located at angles of mouth; clavicles not keeled; plates mostly sharply pointed, of moderate to small size, numbering 14 to 19 in dorsal series, 38 to 48 in lateral row, and 9 to 14 in ventrolateral file; 30 to 43 dorsal-fin rays, 18 to 28 anal rays, 44 to 56 pectoral rays (the first a moderately strong spine), and 28 to 34 pelvic rays; 6 (rarely 7) pectoral radials; 8 pelvic radials; cartilaginous pleural ribs.

THE SPECIES OF SCAPHIRHYNCHUS

Careful study of the original characterization of *Parascaphirhynchus albus* (Forbes and Richardson, 1905), especially scrutiny of the illustrations, makes it apparent that the authors had a new species as well as *Scaphirhynchus platorynchus* before them. Nevertheless, a number of circumstances have led some contemporary ichthyologists to doubt, at least privately, the validity of *S. album.* Our specimens confirm the bulk of the original characterization and provide proof of the specific distinctness of *S. album.*

Plate and Fin-Ray Counts

Since the five lengthwise series of dermal plates are such a striking characteristic of sturgeons, and since counts may be taken with facility, all authors have dutifully recorded their numbers. These prove to be of high diagnostic value for certain species of *Acipenser* and *Pseudoscaphirhynchus.* In *Scaphirhynchus,* however, although there is considerable individual variation in plate counts (Table I), differences between the species are so slight as to have no value in identification and, probably, no significance. Fin-ray counts, though difficult to make and disregarded by most students of the group, furnish excellent differential characters (Table I). For each fin, *album has* a higher mean count than does *platorynchus.* In dorsal

TABLE I

FREQUENCY DISTRIBUTIONS OF PLATE AND FIN-RAY COUNTS IN THE SPECIES OF SCAPHIRHYNCHUS

Species	Dorsal plates 14 15 16 17 18 19	No. of spec.	Mean
platorynchus 	3 12 22 12 1 1 2 6 6 0 1	51 15	15.98 15.47
	Lateral plates 38 39 40 41 42 43 44 45 46 47 48		
platorynchus 	2 1 4 3 7 13 9 6 5 1 1 1 0 3 3 3 2 1 1	51 15	43.06 44.27
	V plates 9 10 11 12 13 14		
 	5 19 19 7 1 1 1 8 4 1	51 15	11.61 11.20
	Dorsal-fin rays 30 31 32 33 34 35 36 37 38 39 40 41 42 43		
platorynchus 	1 1 4 6 4 3 1 1 3 2 3 1 2 1	20 13	33.20 39.77
	Anal-fin rays 18 19 20 21 22 23 24 25 26 27 28		
 	1 0 2 8 6 3 3 0 6 3 1	20 13	21.35 25.92
	Pectoral-fin rays (left side) 44 45 46 47 48 49 50 51 52 53 54 55 56		
 	1 3 4 0 7 2 1 2 2 0 1 2 2 3 2 0 0 0 1	20 13	47.45 50.08
	Pelvic-fin rays (left side) 28 29 30 31 32 33 34		
 	1 11 2 5 1 1 1 4 5 2	20 13	29.70 32.46

and anal counts there is no recorded overlap between the species; in the paired fins the differences, though significant, are subject to enough overlap to limit their value for identification.

Morphometry

The 35 measurements taken on 16 individuals of *Scaphirhynchus platorynchus* and on all but two (15) of the available specimens of *S. album* are expressed as thousandths of the standard length in Tables II and III. Fork lengths are recorded to permit conversion of the data to that base measurement. For 21 measurements, differences between the species either are nonexistent or are so slight as to lack value in identification. That the species differ significantly in the other 14 measurements is obvious not only from the data but, with few exceptions, from direct visual comparison of the fish. Some differences apply only to specimens of like size, and others are in part obscured by overlap resulting from individual variation. No geographic variation is apparent. Study of geographic variation, however, has not been a prime function of this inquiry, and except for two specimens of *S. album* from Louisiana and for single examples of *S. platorynchus* from the Ohio and Mississippi rivers, all measured fish came from the Missouri River drainage. Future comparison of adequate material may reveal geographic variation.

In order to appraise ontogenetic changes and individual variation while making interspecific comparisons, graphs of proportional measurements against body length were made for each of 14 characters. This procedure indicated the desirability of more data, so 11 measurements were made on each of 38 additional specimens of *Scaphirhynchus platorynchus.*

Head length.—In small specimens the head is proportionately large, and its length is probably not sufficiently distinctive to permit reliable specific identification until a standard length of about 200 mm is attained. In larger fish the head length of 92 per cent (11 of 12) of the specimens of *album is* at least 30.5 per cent of the standard length; the head length of 96 per cent (45 of 47) of *platorynchus* specimens is shorter (Fig. *1).*

Snout length and rostral length.—Rostral length is essentially an alternative expression of snout length, and since both measurements show the same growth history and specific differences only snout length is discussed here. The snout in *album* is more pointed (Fig. 2)

TABLE II

PROPORTIONAL MEASUREMENTS OF SCAPHIRHYNCHUS PLATORYNCHUS, EXPRESSED AS THOUSANDTHS OF THE STANDARD LENGTH (TO END OF LAST LATERAL PLATE)

Ranges of variation and means include measurements of specimens not tabulated here. Specimens are as follows: 1, UMMZ 94424, near mouth of Powder River, Prairie Co., Montana; 2, UMMZ 103305, Ohio River, Stout, Adams Co., Ohio; 3, KU 2169,5, KU 2350,6, KU 2167, and 7, KU 2342, Kansas River, Lawrence, Kansas; 4, UMMZ 111542, Mississippi River, just above mouth of Ohio River, Alexander Co., Illinois; 8-10, UMMZ 167113, Missouri River, Yankton, South Dakota.

Measurement	1	2	3	4	5	6	7	8	9	10	No. of spec.	Range	Mean
Standard length (mm.)	730	600	524	466	386	340	286	207	136	56	54	50–730	300*
Snout to caudal fork (mm.)	784	636	563	503	414	367	309	225	150		15	150-784	411
Snout to dorsal origin	774	742	714	682	706	700	690	726	679	718	16	679-774	706
Snout to pelvic insertion	630	600	584	561	588	575	571	595	557	619	16	557-630	584
Pelvic insertion to anal origin	171	172	172	165	175	177	156	156	154	147	16	147-177	167
Anal origin to caudal base	195	228	235	278	255	263	280	251	299	255	16	195-299	260
Body, greatest depth		136	129	144	118	119	112	104	99	117	15	99-144	118
Body, greatest width	125	115	110	118	111	111	110	122	113	126	16	108-126	115
Caudal-peduncle length	157	188	195	236	214	212	242	212	257	212	16	157-257	218
Caudal-peduncle depth	17	16	12	16	15	16	15	15	16	23	16	12- 23	16
Caudal-peduncle width	27	24	26	27	26	27	24	25	25	23	16	22- 27	25
Head length	295	286	276	263	284	289	302	303	315	350	54	254-350	289
Head depth	79	76	77	74	79	72	70	87	81	95	16	67- 95	76
Head width	133	133	128	132	135	147	155	174	183	223	16	128-223	151
Interorbital width	90	86	83	84	89	87	86	96	92	110	16	83-110	89
Rostral length	191	204	202	197	218	214	237	240	249	255	16	191-255	219
Snout length	155	158	159	152	168	168	179	171	178	192	54	140-192	164
Drbit length	13	14	11	9	13	16	15	17	23	32	16	9- 32	16
Anterior-nostril width	12	10	14	10	11	14	12	16	17	25	16	10- 25	13
Posterior-nostril width	20	20	26	23	26	27	27	32	36	45	16	20- 45	28
Mouth width	85	84	77	78	73	77	76	84	92	106	54	71-108	83
Snout to outer barbel	95	109	101	104	112	109	122	107	114	115	54	86-131	105
Snout to inner barbel	88	106	95	94	102	104	115	97	106	122	54	80-122	95
Mouth to inner barbel	68	59	62	56	65	71	63	71	73	95	54	56- 95	67
Outer-barbel length	90	68	86	87	82	79	62	82	89	108	54	62-108	86
Inner-barbel length	73	54	64	66	63	63	53	64	65	72	54	53- 82	65
Dorsal-fin base	89	73	64	82	75	79	69	68	69	83	16	64- 89	74
Dorsal-fin height		78	80	98	85	86	65	82	79	92	15	65- 98	81
Anal-fin base	51	42	39	44	45	49	42	43	44	45	16	39- 51	44
Anal-fin height	114	88	91	102	96	101	87	93	94	108	16	86-114	95
Daudal-fin length			. . .		. . .	312	631	480	612	652	9	312-652	494+
Caudal fin, lower lobe	115	108	115	118	.	109	95	114	112	133	15	90-133	110
Pectoral-fin length	156	138	134	147	144	141	145	164	164	167	16	123-167	146
Pelvic-fin length	115	91	92	104	104	100	88	104	100	111	16	88-115	99
Tenth lateral plate, height	40	43	43	46	38	41	35	39	37	31	54	25- 46	37
Interspace lateral and ventrolateral plates	24	20	19	25	21	21	20	18	14	18	54	6- 26	17
Air bladder length			162	143	187	175	142	145	84	.	50	75-187	143

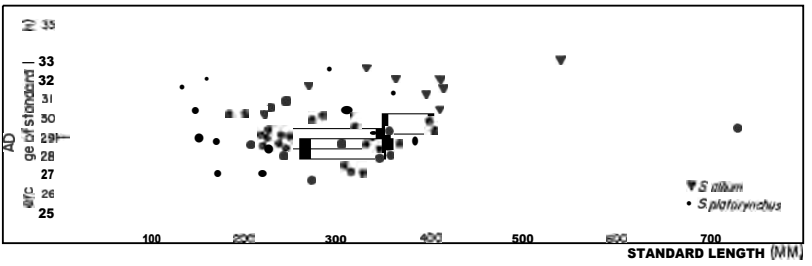
* The mean standard length of the 16 specimens that were measured for all characters is 360 mm.

TABLE III

PROPORTIONAL MEASUREMENTS OF SCAPHIRHYNCHUS ALBUM, EXPRESSED AS THOUSANDTHS OF THE STANDARD LENGTH (TO END OF LAST LATERAL PLATE)

Ranges of variation and means include specimens not tabulated here. Specimens are as follows (see text for provenance): 1, UMMZ 167110; 2, UMMZ 144742; 3, KU 2337; 4 and 6, UMMZ 144743; 5, KU 2079; 7, KU 2161; 8, UMMZ 167111; 9, Illinois Natural History Survey; and 10, UMMZ 167112.

Measurement	1	2	3	4	5	6	7	8	9	10	No. of spec.	Range	Mean
Standard length (mm.)	622	540	415	395	366	328	294	274	226	167	15	167-637	399
Snout to caudal fork (mm.)	671	576	443	430	404	352	322	299	244	183	15	183-677	431
Snout to dorsal origin	736	726	688	706	696	688	684	686	670	664	13	664-736	692
Snout to pelvic insertion	617	593	565	577	572	588	580	570	569	550	13	550-617	575
Pelvic insertion to anal origin	162	165	158	155	161	160	152	157	149	144	13	144-177	160
Anal origin to caudal base	232	242	283	263	277	270	283	276	288	302	13	232-302	272
Body, greatest depth	114	114	116	124	127	132	116	107	108	98	12	98-132	117
Body, greatest width	132	115	119	124	115	123	119	117	116	126	13	115-132	120
Caudal-peduncle length	184	196	233	211	223	224	233	228	243	258	13	184-258	224
Caudal-peduncle depth	16	16	15	14	15	13	14	15	16	16	13	13- 16	15
Caudal-peduncle width	30	27	24	24	26	23	23	26	25	24	13	23- 30	25
Head length	354	331	316	313	321	327	325	318	302	323	13	302-354	322
Head depth	76	86	74	76	75	76	77	77	79	82	13	74- 86	78
Head width	133	134	133	146	141	147	152	150	153	168	13	129-168	143
Interorbital width	95	92	86	95	86	92	87	91	90	94	13	86- 95	90
Rostral length	239	235	227	224	228	233	239	222	221	241	13	210-241	229
Snout length	198	191	185	178	180	190	191	169	173	180	15	167-198	182
Orbit length	9	11	10	9	11	11	12	14	11	16	15	9- 16	11
Anterior-nostril width	12	13	11	11	13	11	12	16	13	15	15	11- 16	12
Posterior-nostril width	26	24	27	29	29	26	30	33	26	39	13	24- 39	28
Mouth width	96	94	86	94	92	91	92	95	90	100	13	84-100	92
Snout to outer barbel	159	154	147	139	147	151	150	131	136	138	13	131-159	145
Snout to inner barbel	142	138	130	119	128	135	141	114	124	120	13	114-142	130
Mouth to inner barbel	53	47	53	56	49	53	48	57	48	58	13	47- 58	52
Outer-barbel length	114	94	79	80	85	93	77	86	77	82	15	74-114	87
Inner-barbel length	47	45	40	41	47	48	44	50	42	50	15	37- 50	45
Dorsal-fin base	81	77	80	86	87	79	77	81	81	79	13	77- 87	81
Dorsal-fin height	84	85	84	90	91	82	77	89	86	92	13	77- 92	85
Anal-fin base	51	47	48	52	55	47	54	48	49	47	13	47- 55	50
Anal-fin height	107	100	100	109	102	101	94	101	92	103	13	90-109	99
Caudal-fin length			419	142	433	382	539	312	389	610	9	?-610	391+
Caudal-fin, lower lobe	121	110	108	120	113	115	111	114	94	108	15	92-121	108
Pectoral-fin length	161	144	140	149	153	141	143	153	138	150	13	127-161	145
Pelvic-fin length	108	98	101	105	103	102	92	99	95	100	13	92-108	100
Tenth lateral plate, height	35	29	34	33	33	32	32	31	31	26	15	26- 35	32
Interspace, lateral and ventro-lateral plates	31	34	28	39	31	30	28	22	24	22	14	22- 39	29
Air-bladder length	102	111	114	110	123	136	95	108	81	71	13	71-143	III



Fm. 1. Scatter diagram showing proportional length of head in the species of Scaphirhynchus

and longer than it is in platorynchus. Although few large adults of either species have been measured, the difference seems to increase with age. In fish less than 300 mm. long the snout lengths are sufficiently alike to preclude positive identification, and in a few specimens of platorynchus between 300 mm. and 400 mm. long the snout is quite as sharp and as long as in some examples of album. But above 300 mm., the snout of 10 (91 per cent) of 11 specimens of Scaphirhynchus album is at least 17.4 per cent of the standard length,

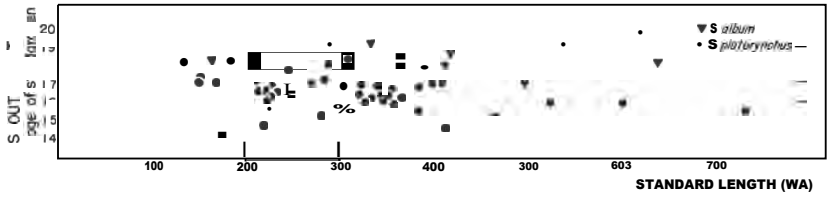


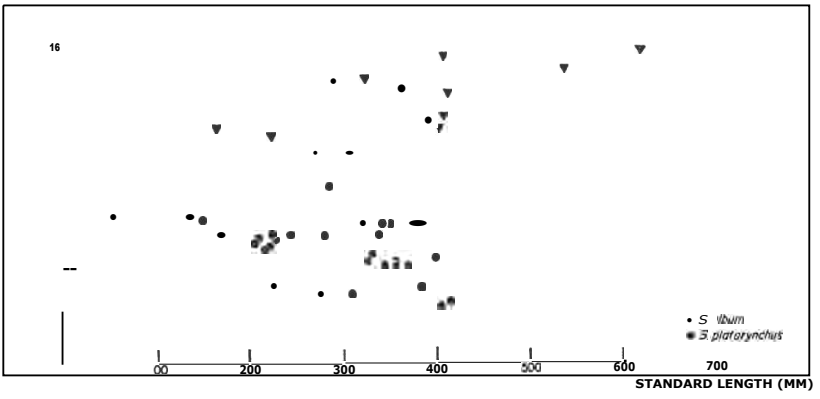
FIG. 2. Scatter diagram showing proportional length of snout in the species of *Scaphirhynchus*

and the snout of 25 (93 per cent) of 27 examples of S. platorynchus is no more than 16.9 per cent of the length.

Orbit length.—In both species the eye is minute, but it is relatively larger in young fish, becoming smaller with age until a length of about 250 mm. is attained. As a corollary of the high turbidity of the waters to which album is restricted, the eye in this species is smaller (usually 0.9 to 1.2 per cent of standard length) than in platorynchus (typically 1.2 to 1.5 per cent), which often occurs in waters of moderate turbidity. Individual variation, however, is considerable (Tables II and III), and this character by itself is not trustworthy for identification.

Mouth width.—The mouth is wider in young fish than in old fish, but there appears to be little change in relative breadth after a body length of about 250 mm. is reached. Beyond that size the mouth is usually wider in *album* than in *platorynchus.* In *album* the variation is from 8.4 to 9.6 per cent of body length, and the width is more than 8.9 per cent in 9 (82 per cent) of 11 specimens; in *platorynchus* the comparable values are 7.1 to 9.1 per cent, less than 8.7 per cent in 28 (93 per cent) of 30 examples. Although a reliable character for well-preserved specimens, this measurement is subject to modification from shrinkage.

Arrangement and position of barbels.—The most obvious differences between the species of *Scaphirhynchus* involve the barbels (Fig. 9). In *platorynchus* the bases of the four barbels typically lie in a straight line, or the outer pair originate slightly ahead of the inner pair, so that the line described is concave forward. In contrast, the outer barbels are placed behind the inner barbels in *album;* thus the line through their bases is convex forward. Of 13 examples of *album,* 11 have the outer barbels well behind the inner barbels, whereas 2 have them only slightly behind. Of 78 specimens of *platorynchus* examined for this character, 64 have the barbels in a straight line, 13 (mostly under 250 mm. long) have the outer barbels ahead of the inner, and 1 has the outer barbels slightly behind the inner barbels. (Forbes and Richardson's figure [1905: facing p. 44] of *album fails* to show the relationship accurately.) Furthermore, in *platorynchus* all of the barbels are farther forward on the lower surface of the snout than in *album.* This difference may be demonstrated by comparisons of the distances from the tip of the snout to the base of the outer barbel, which is greater in *album* (Fig. 3), or from the inner barbel to the mouth, which is greater in *platorynchus* (Fig. 4). Except for fish less than about 150 mm. long, in which the values for both measurements are high, these characters show no marked variation with size. As may be observed in Figures 3 and 4, there is little overlap between the species in either measurement. Except for a single unusual specimen of *platorynchus* (308 mm. long) in which the anterior portion of the snout is exceptionally sharp-pointed and lengthened, as in *album,* the measurement from snout to outer barbel is adequate for correct identification. The ratio "snout tip to outer barbel :mouth to inner barbel" provides an effective expression (Table IV), since it varies from 1.27 to 2.19 in *platorynchus,* from 2.29 to 3.26 in *album.*



Fm. 3. Scatter diagram showing proportional distance from tip of snout to base of outer barbel in the species of Scaphirhynchus

Length and structure of barbels.—The length of the inner barbel is the only measurement taken that shows no overlap between the species. In platorynchus it varies from 5.3 to 8.2 per cent of the standard length; in album, from 3.7 to 5.0 per cent (Fig. 5). The outer barbel, in contrast, shows no difference in length, with mean values of 8.6 and 8.7 in platorynchus and album. The relative lengths

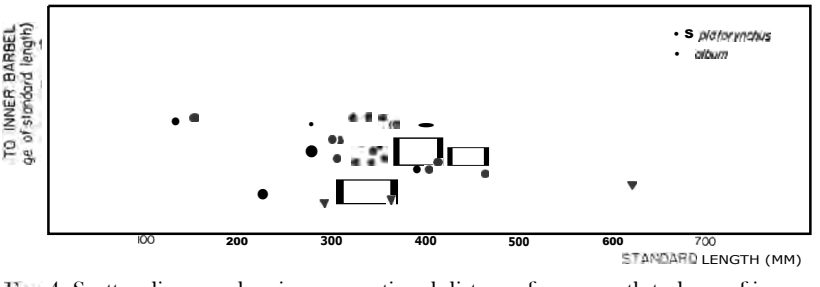


FIG. 4. Scatter diagram showing proportional distance from mouth to base of inner barbel in the species of Scaphirhynchus

of both pairs of barbels remain constant throughout life. Because of the more posterior origin of the outer barbel in album, the tip when extended lies farther back on the head, commonly reaching or exceeding the sharp angle of the suborbital; in platorynchus the tip always falls considerably short of this point. The ratio between the lengths

of the barbels provides one of the quickest and most reliable means for identification of these species: the inner barbel is contained in the outer 1.17 to 1.48 times in platorynchus, 1.64 to 2.41 times in album (Table IV).

The structure of the barbels, as well as their positions and lengths, is distinctive of the species. In platorynchus the inner barbel is relatively heavy, with a basal diameter about three fourths that of the longer barbel; in album the short inner barbel is slender, with a basal diameter about one half as great as that of the outer barbel. Probably more important are differences in the fringing, that in album being everywhere less well developed than that in platorynchus. In platorynchus there are three rows of prominent papillae subequal in size, one series on the ventral (anterior) edge and one projecting from each side of the dorsal (posterior) surface of each barbel. In album

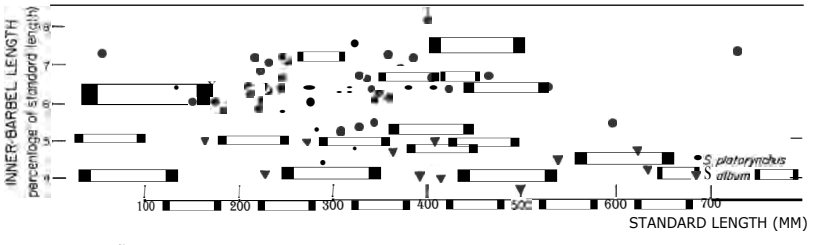


FIG. 5. Scatter diagram showing proportional length of inner barbel in the species of *Scaphirhynchus*

the two dorsal series of papillae are uniformly better developed than the ventral file, which is imperfectly developed or, frequently, entirely lacking. Also, the fringing on the longer barbel is usually stronger than that on the shorter one, in which even the dorsal ornamentation may be reduced to a few tiny projections. In the illustration by Forbes and Richardson (1905: facing p. 44), the barbels of platorynchus are rather well shown, but the papillae on the barbels of album are better developed in their figure than in our specimens.

Dorsal- and anal-fin bases.—The relative basal lengths of the median fins seem not to change with age. In each of these fins the average length is shorter in platorynchus than in album (Tables II and III), but there is some overlap in both measurements. For example, the anal-fin base varies from 3.9 to 5.1 per cent of the standard length in 16 examples of platorynchus (4.6 per cent or less in 88

per cent of the fish), from 4.7 to 5.5 per cent of the length in 13 specimens of *album.* The fin-ray counts provide another expression of fin length, and since our data for these show no overlap (Table **I)** the counts are more reliable than are the measurements.

Size and distribution of plates.—Although the numbers of plates in the longitudinal series do not differ between the species (p. 175), there is a pronounced difference in the height of these plates and consequently in the interspace between the rows. The measurement of the tenth lateral plate (Fig. 6) varies less than that of the space between this plate and the ventral row, probably because the interspace is in part dependent on the condition or fatness of the body. In an emaciated specimen of *album* that had been kept for a long time in an aquarium the interspace was unusually narrow, although

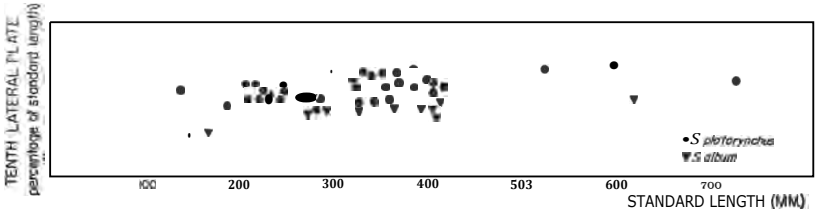


FIG. 6. Scatter diagram showing proportional height of tenth lateral plate in the species of *Scaphirhynchus*

the tenth plate was of normal size. At a body length of less than 200 mm. the tenth lateral plate is relatively small; but in fish longer than 250 mm. its height increases little if at all faster than body length. In the larger fish a plate height equal to 3.4 per cent of body length provides a convenient and usually reliable line of separation between the species: only 1 of 13 specimens (8 per cent) of *album* has a larger value (3.5 per cent) and only 2 of 30 (7 per cent) *platorynchus* specimens have a smaller one (minimum 3.2 per cent). The relative width of the interspace increases until a body length of at least 250 mm. is attained. The data suggest some relative increase with growth thereafter, but individual variation is great and the number of available specimens longer than 400 mm. is too small to furnish a conclusive test.

Like the plates in the primary rows, the lesser dermal ossifications in *platorynchus* are larger, more closely spaced, and more completely

distributed over the body than those in album, in which these structures are mostly mere spicules. The difference is of degree rather than of kind. Most of the belly is naked at all ages in album, though large specimens may have small scattered scutes laterally, near the pelvic fins, or on the breast. In young specimens of platorynchus, also, the belly is naked, but adults have an irregular mosaic of rather large, rhomboidal scutes covering the ventral surface. The presence of scutes is usually apparent in fish longer than 200 mm ; but a median naked strip may persist in fish up to and beyond 300 mm. long. In the interspaces above and below the lateral series of plates the ossifications are typically larger in platorynchus. In album the strip between the lateral plates and the midventral plating usually

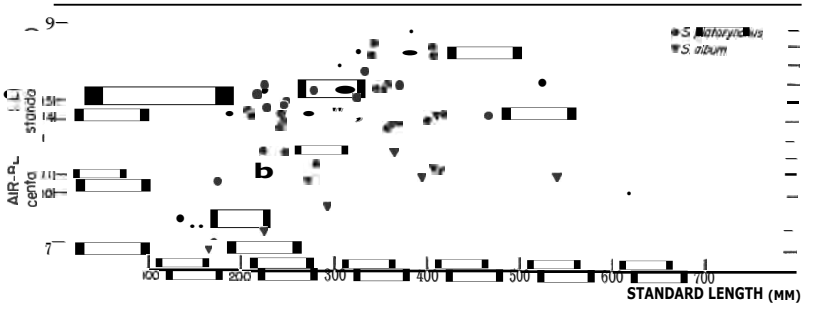


FIG. 7. S[illegible] *Scaphirhynchus*

extends back about as far as the origin of the anal fin; in platorynchus this strip terminates a short distance before or behind the origin of the dorsal fin (in both species the interspace contains many small ossifications).

Air bladder.—The air bladder is thick-walled and is connected to the pharynx by a large pneumatic duct. Forbes and Richardson (1905: 41) stated that the length of the air bladder is contained 5 times in the length of the head and body in platorynchus, 8 times in that of album. As shown in Tables II and III and in Figure 7, this is an oversimplification. Although the air bladder in platorynchus is notably larger than in album, this character shows marked ontogenetic change: the length of the air chamber in platorynchus increases from 8 or 9 per cent of the body length in fish of 150 mm. to approxi-

mately 16 per cent in specimens more than 300 mm. long. Conspicuous also is the gross variation in its size among fish of the same approximate length. If relative length of the air bladder is appraised in terms of body length (Fig. 7), the overlap between the species is slight.

Measurement ratios.—In the preceding discussion we have seen that there are a considerable number of measurements in which the species of Scaphirhynchus differ. With the exception of the length of the inner barbel, however, the differences are not so great as to be mutually exclusive. In other measurements some specimens fall in an overlapping area. In attempting identification on the basis of morphometric data alone, then, it is frequently necessary—and always a wise precaution—to check several measurements.

Judicious combination of two or more characters into a single expression often makes possible the elimination of overlap in comparing species. This has been readily accomplished in Scaphirhynchus through use of ratios so chosen as to combine proved differences (Table IV). In order to minimize the effect of pronounced allometric change the data are separated into two size classes. The ratios numbered 2 and 4 in Table IV have already been mentioned. Of the 9 ratios tabulated, there is no overlap (within a size class) in 7, and only a slight overlap occurs in 2 (numbers 7 and 9). Additional ratios could be used, but those given are adequate to provide a clear expression of the principal morphometric differences noted. By plotting ratio 6 against ratio 8 it has been possible to develop a visual expression of specific difference involving 4 of the most valuable contrasting measurements: head length, inner-barbel length, distance from snout tip to outer barbel, and height of the tenth lateral plate (Fig. 8).

Most of the significant morphometric characters in Scaphirhynchus are discernible in a ventral view of the head. These are illustrated in Figure 9, in which the drawings are based on mean values from Tables II and III. The details of structure are from individual specimens. Comparison with these figures and use of the ratios should facilitate quick and accurate identification.

Other Characters

Ribs.—In their characterization of Parascaphirhynchus albus, Forbes and Richardson (1905) emphasized the number of ribs as a

difference between this species and *Scaphirhynchus platorynchus;* the former was said to have 20 or 21 ribs, the latter 10 or 11. No explanation of the method of counting is given. The ribs are wholly chondrified and X rays taken by us fail to show them. It is evident from dissection that the ribs are rather long anteriorly but become progressively shorter posteriorly, where they appear merely as transverse processes. It may be questioned whether even the anterior elements should be termed ribs. In *album* the myosepta appear to

TABLE IV

COMPARISON OF THE SPECIES OF SCAPHIRHYNCHUS IN CERTAIN MEASUREMENT RATIOS

All ratios were derived arithmetically from the original straight-line measurements.

Ratio	Standard length (mm.)	*platorynchus*			*album*		
		No. of spec.	Range	Mean	No. of spec.	Range	Mean
I. Mouth width:mouth to inner barbel	100-200	6	1.22- 1.36	1.28	1		1.74
	200+	47	1.07- 1.42	1.25	12	1.63- 2.00	1.80
2. Snout tip to outer barbel:mouth to inner barbel	100-200	6	1.32- 1.68	1.54	1		2.40
	200+	47	1.27- 2.10	1.60	12	2.29- 3.26	2.87
3. Head length: mouth to inner barbel	100-200	6	4.10- 4.55	4.29	1		5.59
	200+	47	4.00- 5.04	4.37	12	5.54- 7.00	6.31
4. Outer barbel length:inner barbel length	100-200	6	1.28- 1.47	1.36	1		1.64
	200+	47	1.17- 1.48	1.34	14	1.72- 2.41	1.98
5. Snout tip to outer barbel:inner barbel length	100-200	6	1.44- 1.92	1.73	1		2.77
	200+	47	1.26- 2.50	1.64	12	2.63- 3.73	3.26
6. Head length:inner barbel length	100-200	6	4.49- 5.19	4.80	1		6.47
	200+	47	3.65- 5.76	4.47	12	6.35- 8.00	7.17
7. Height of tenth lateral plate: interspace between lateral and ventrolateral series	100-200	6	1.90- 2.63	2.32	1		1.19
	200+	47	1.23- 3.20*	2.37	13	0.85- 1.51	1.11
8. Snout tip to outer barbel:height of tenth lateral plate	100-200	6	2.73- 4.45	3.47	1		5.23
	200+	47	2.23- 3.58	2.80	12	4.12- 5.26	4.55
9. Head length:height of tenth lateral plate	100-200	6	8.49-12.00	9.62	1		12.20
	200+	47	5.72- 9.33	7.69	12	9.12-11.30	10.02

* Except for one specimen all values are below 3 69.

be somewhat better chondrified; thus the ribs are longer, especially posteriorly, than in *platorynchus.* This seems to be a minor difference of degree, of far less importance than Forbes and Richardson's description suggests. Perhaps these authors counted cross sections of ribs revealed in longitudinal incisions of the body wall. If so, the longer ribs of *album* would result in a higher count. Emelianoff's (1926) observations on the ribs in *Acipenser* seem to be similar to ours on *Scaphirhynchus.*

P .—F R (1905) P
9 " ," S *platorynchus*
7. D 3

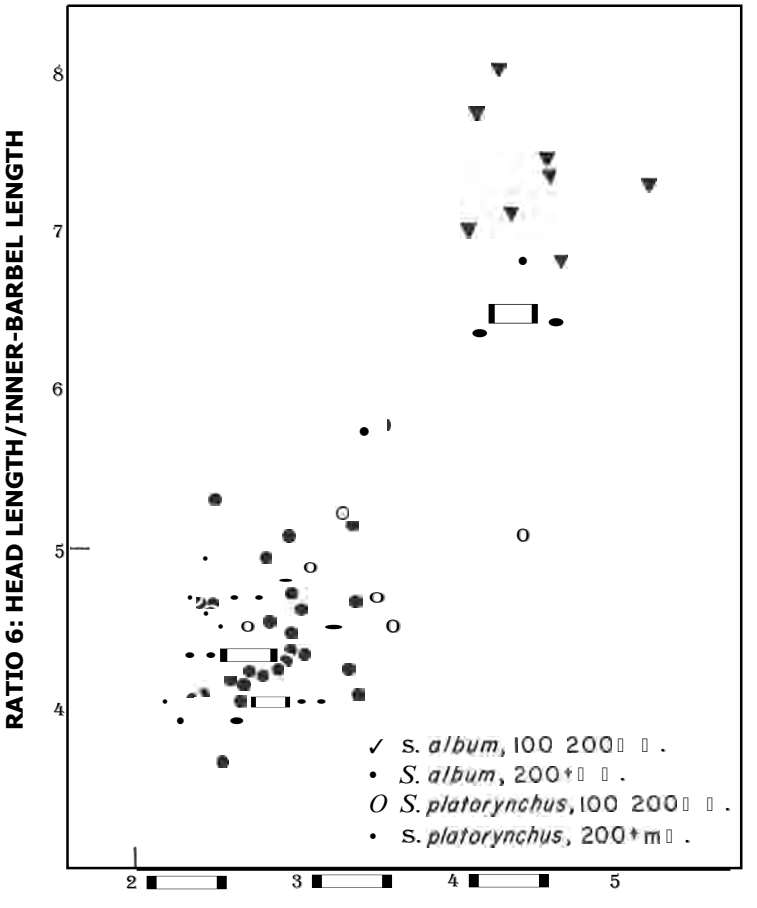


FIG. 8. S S

;
8 .

G .—S

fled gillrakers on the outer face of the lower half of the first branchial arch than does S. album, a difference correctly noted by Forbes and Richardson (1905). In album most of the rakers have a simple dichotomy, but usually one or two rakers on each arch have 3 blunt points. In platorynchus the rakers are more notably fanlike, and

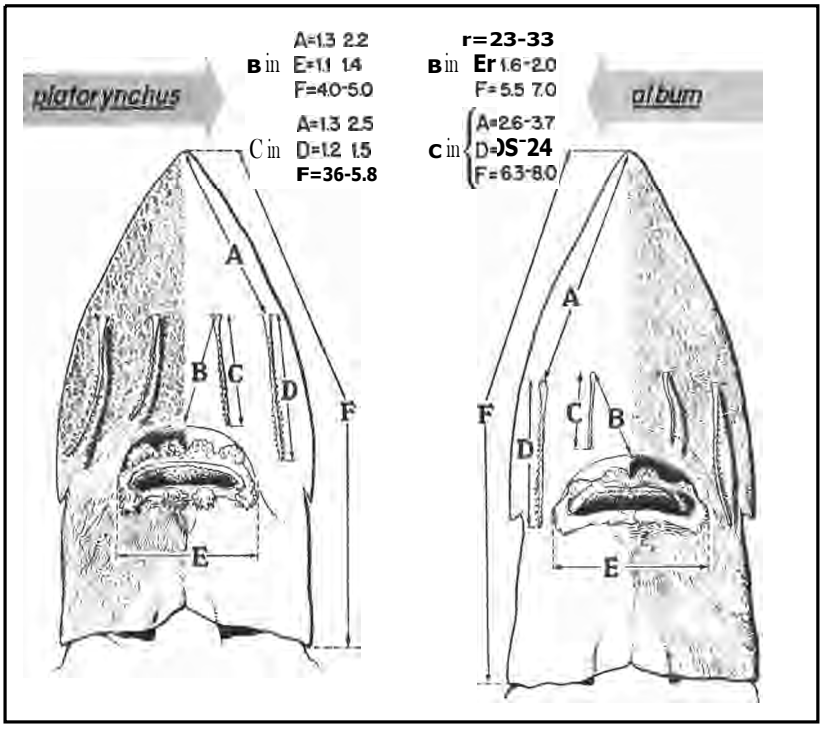


FIG. 9. Comparative diagrams of the ventral surface of the head in the species of Scaphirhynchus, showing several measurement ratios of value for identification

most have either 3 or 4 blunt tips. Often one or two rakers on each arch have 2 or 5 points.

In Huso and in most species of Acipenser the gillrakers are simple and rodlike, not short and fan-shaped as in Scaphirhynchus. In Pseudoscaphirhynchus kaufmanni (Bogdanow) the gillrakers are similar to those in Scaphirhynchus, though somewhat less strongly modified. In P. fedtschenkoi (Kessler) and in P. *hermanni* (Kessler), however, the gillrakers are described as lancet-shaped, and in A. baeri

Brandt, as fan-shaped, each with 2 or 3 points (Berg, 1932: 57, 69-70). It would appear, then, that modification from simple to dichotomous gillrakers has occurred along two or more independent lines in the Acipenseridae. *S. platorynchus* is interpreted as the most highly specialized species in the family in this character.

Color.—Neither species shows any noteworthy color pattern. The basic ground color in *platorynchus,* at least, is subject to considerable variation, determined in part by turbidity and probably by other environmental factors. It is doubtful whether dark individuals of *album* and light ones of *platorynchus* could be separated on the basis of color. Nevertheless, *album* is usually much lighter, a grayish white, and *platorynchus* varies from light to rather dark brown. When the species have been taken together we have each independently found that *album* is more pallid, as was reported by Forbes and Richardson (1905).

Scaphirhynchus platorynchus (Rafinesque)

Shovelnose Sturgeon

Accipenser platyrhincho.—Rafinesque, 1818: 354 (nomen nudum).

Accipenser platorynchus.—Rafinesque, 1820: 80 (original description; Ohio, Wabash, and Cumberland rivers, seldom reaching as high as Pittsburgh; also in Mississippi and Missouri rivers). Kirtland, 1838: 170, 196 (Ohio River).

Acipenser platorynchus.—*Storer,* 1846: 249 (characters; Ohio River). Kirtland, 1847: 25-26, pl. 8 (characters; length 1-8 feet; Ohio River, Cincinnati).

Scaphirhynchus platirhynchus.—Girard, 1858: 357 (characters; synonymy; Missouri River and near mouth of Poteau River).

Scaphyrhynchops platyrhynchus.—Hayden, 1863: 178 (upper Missouri River). Goode, 1879: 65 (Ohio River; Madison, Indiana). Hobbs, 1881: 125 (falls of Ohio River).

Scaphirhynchus platyrhynchus.—Duméril, 1870: 268-271 (characters; synonymy; distribution). Meek, 1889: 164 (characters; larger streams in Iowa). Kirsch and Fordice, 1890: 246-247 (characters; synonymy; distribution). Meek, 1892: 221, 231 (Iowa records: Mississippi River; Cedar River [presumably at Cedar Rapids]; Missouri River, Sioux City). Bean, 1892: 5-6 (characters; distribution; common in western Pennsylvania). Evermann and Kendall, 1894: 96, pl. 10 (compiled records). Eigenmann and Beeson, 1894: 98 (Indiana records compiled: Ohio River; Wabash River, Terre Haute). Eigenmann, 1894: 119 (presumptive record for Winnipeg—probably erroneous). Berg, 1904: 67 (characters; monotypic). Jordan, 1905: 256 (compiled).

Scaphirhynchops platyrhynchus.—*Cope* and Yarrow, 1875: 639 (Rio Grande near Albuquerque—specimens reëxamined by us). Nelson, 1876: 51 (Ohio and Mississippi rivers). Jordan and Copeland, 1876: 161 *(Scaphirhynchops* Gill

explained as substitute name for Scaphirhynchus). Jordan, 1877: 45 (nomenclature). Jordan, 1878a: 409, 413 (distribution). Jordan, 1878b: 778 (synonymy; Missouri River, Ft. Buford, [North] Dakota). Jordan, 1878c: 346 (characters; distribution). Bean, 1881: 114 (records: Cincinnati, Ohio; Republican River, Kansas; Yellowstone River; Madison, Indiana; Mt. Carmel, Illinois). Jordan, 1885: 13 (listed). Jordan and Gilbert, 1886: 14 (Red River, Fulton, Arkansas). Jenkins, 1887: 93 (Wabash River, Vigo Co., Indiana). Henshall, 1888: 77 (Ohio River, Hamilton Co., Ohio).

Scaphirynchops platyrhynchus.—Jordan, 1878d: 33 (Illinois records: Ohio River, Cairo; Illinois River, Peoria).

Scaphirrhynchops platyrhynchus.—Jordan, 1879: 768–769 (characters; synonymy; distribution).

Scaphirrhynchops platyrrhynchus.—Jordan and Gilbert, 1883: 88 (characters; *synonymy;* distribution). Cragin, 1885: 106 (Kansas River, Topeka and Lawrence, Kansas). Graham, 1885: 70 (common throughout Kansas).

Scaphirhynchus platorhynchus.—Evermann and Jenkins, 1888: 44 (Wabash River near Delphi, Indiana). Cox, 1896: 608 (Minnesota River, Mankato, Minnesota). Jordan and Evermann, 1896a: 227 (distribution). Evermann, 1902: 285–286 (size; Ohio River, Louisville). Forbes and Richardson, 1905: 40, pls. 4–7 (comparisons). Forbes and Richardson, 1909: 27–28, figs. (characters; natural history). Berg, 1911: 138, 308, 319 (measurements; Mississippi basin). Evermann, 1918: 333 (falls of Ohio River, Louisville, Kentucky). Potter and Jones, 1928: 34 (Iowa records compiled). Jordan, 1929: 33 (compiled). Hankinson, 1929: 445 (compiled). Giltay, 1929: 30–32, fig. 3 (comparisons). Coker, 1930: 152–155, figs. 3–4 (natural history; fishery; Mississippi River, Keokuk, Iowa). Gudger, 1932: 3 3 (Arkansas River near Scott, Pulaski Co., Arkansas). Gowanloch, 1933: 414–416, 418, fig. (compiled). Thompson, 1933: 31 (Mississippi River, Grand Tower, Illinois). O'Donnell, 1935: 475 (compiled). Holly, 1936: 41, fig. 40 (synonymy; characters; distribution). Kuhne, 1939: 17 (characters). Simon and Simon, 1942: 48 (North Platte and Big Horn rivers, Wyoming). Jennings, 1942: 364 (Kansas records: Blue and Kansas rivers, Riley Co.). Rostlund, 1952: 248–249, map 3 (records compiled; distribution).

Scaphirhynchus platyrrhynchus.—Meek, 1893: 107 (Cedar River, Iowa).

Scaphyrhynchus platyrhynchus.—Meek, 1895: 89–92 (Arkansas records compiled).

Scaphirhynchus platorynchus.—Jordan and Evermann, 1896b: 107 (characters; synonyms). Evermann and Cox, 1896: 385 (Missouri River records compiled; also North Platte River at Casper [reexamined by us] and Douglas [Wyoming] and Grand Island [Nebraska]; Bazile Creek, 15 miles from Creighton [Nebraska]). Osburn, 1901: 19 (characters; Ohio records compiled). Hay, 1902: 65 (distribution; size). Jordan and Evermann, 1902: 13–14, fig. (characters; distribution; size; importance). Fowler, 1919: 53 (occurrence in Pennsylvania). Fowler, 1921: 398 (Fox Creek, tributary to Meramec River, 26 miles from St. Louis [Missouri]). Jordan, Evermann, and Clark, 1930: 35 (listed). Greene, 1935: 25 (Wisconsin records listed [reexamined by us]; distribution). Blatchley, 1938: 19–20 (compiled; in part based on Acipenser fulvescens). Welter, 1938: 65 (formerly in Licking River,

Farmers, Kentucky). Schrenkeisen, 1938: 15 (compiled). Driver, 1942: 251 (compiled). Eddy and Surber, 1943: 57, 61-62, fig. 4 (description; natural history; Minnesota records). Fowler, 1945: 21 (compiled). Gerking, 1945: 29 (Indiana records compiled; also West Fork White River, Spencer, Owen Co., and Wabash River, New Harmony, Posey Co.). Simon, 1946: 26, fig. 6 (characters; abundance; Wyoming records). Baughman, 1950: 124 (record from Eagle Mountain Lake near Dallas, Texas). Barnickol and Starrett, 1951: 288-290 (abundance; size; utilization; Mississippi River localities). Riggs and Moore, 1951: 16-18 (Oklahoma records: Arkansas River, Spiro, Le Flore Co.; Red River, west of Roosevelt; North Fork of Red River, west of Cooperton; Red River, below Denison Dam—identification verified in letter from Riggs). Harlan and Speaker, 1951: 36, pl. 4 (compiled; Iowa). Bailey, 1951: 190, 207 (comparisons). Bonn and Kemp, 1952: 204 (Texas records: Wichita River, near mouth in Red River, Clay Co.; Shawnee Creek, below Denison Dam, Grayson Co.).

Scaphirhynchus platorhychus.—Eigenmann and Beeson, 1905: 116 (Indiana records compiled).

Scaphyrhynchops platorynchus.—Fowler, 1911: 604 (generalized records).

Scaphirynchus platorynchus.—Cross and Moore, 1952: 400 (compiled).

Acipenser cataphractus.—Gray, 1834: 122-123 (original description; Mississippi River).

Scaphirhynchus cataphractes.—Gray, 1851: 18 (synonymy; distribution).

Scaphirhynchus cataphractus.—Gtinther, 1870: 345 (synonymy; description; New Orleans and generalized localities).

Scaphirhynchus rafinesquii.—Heckel, 1836: 72-78, pl. 8 (original description; Ohio, Wabash, Cumberland, Mississippi, and Missouri rivers—after Rafinesque, 1820).

Scaphirhynchus mexicanus.—Gilbay, 1929: 28-32, figs. 1-2 (original description; " . . du Mexique [sans localité precise], acheté en 1859 a Parzudaky . . . . Peut-être le Texas, avant 1848"; comparisons). Holly, 1936: 42, fig. 41 (characters; distribution; photographs of type specimen).

Nomenclature.—It is obvious from Rafinesque's (1820) original description that *Accipenser platorynchus is* a species of *Scaphirhynchus.* Although the structural characterization does not engender confidence, the fin-ray counts, though too low for either species, agree better with those of the shovelnose sturgeon than with those of the pallid sturgeon *(S. album),* as does the statement, "dorsal scales brownish." Since Rafinesque described this species as very common in the Ohio, Wabash, and Cumberland rivers, it is clear that he was dealing with the present form.

In reply to a query regarding the type specimen of *Acipenser cataphractus* Gray, 1834, Dr. Ethelwynn Trewavas, of the British Museum of Natural History, informs us that it must be a small

stuffed skin without a label, probably specimen e (Günther, 1870: 345). She reports that this specimen agrees exactly with Gray's description in plate counts and other details. The fish reported from New Orleans (Günther, ibid., spirit specimen c, number 1852.8.16.26) was also examined by Dr. Trewavas, who has provided the following measurements, taken by the methods employed in this paper:

Measurement	Type specimen of *Acipenser* cataphractus (in mm.)	New Orleans specimen (in mm.)
Standard length	ca. 484	420
Head length	122.5	110.5
Snout tip to inner barbel	48.5	40
Inner barbel to front of mouth	91.5	81
Inner barbel	ca. 25	23.5
Mouth width	ca. 32	30
Depth of tenth lateral plate	19.5	12.5

Translated into ratios listed in Table IV, these measurements yield the following values: ratio 1, 1.09 and 0.97; ratio 3, 4.15 and 3.56; ratio 6, 4.90 and 4.70; ratio 9, 6.28 and 8.84. Reference to Table IV makes it obvious that both specimens are Scaphirhynchus platorynchus. This verifies the allocation of Acipenser cataphractus to the synonymy of that species and provides the only acceptable record of platorynchus from the lower Mississippi River.

Heckel's (1836) Scaphirhynchus rafinesquii, without specific locality, is referable to the synonymy of the more common species (S. platorynchus), as is evident from the careful original description and the excellent drawings that clearly portray such diagnostic features as the barbels and the midventral plates.

Giltay (1929) proposed the name Scaphirhynchus mexicanus on the basis of a single mounted specimen from Mexico, or perhaps Texas. His characterization depends on the supposed intermediacy in size of the ventral scutes; but there is much variation in these structures in platorynchus. The short inner barbels attributed to mexicanus agree in length better with those of S. album, but in Giltay's mounted specimen, which had been caught at least seventy years before, their original length could not have been ascertained. Unfortunately, standard length was not recorded, so accurate interpretation of the other measurements is impossible. The photographs

of the type specimen (Holly, 1936: 41) show a dried specimen with shrunken snout. The head length seems to be between 29.8 and 30.0 per cent of the standard length—too small for album but well within the range of variation in platorynchus. If the counts are correct, the dorsal-fin rays (39) point to identification with album, the anal-fin rays (23) to platorynchus. As indicated above, fin-ray counts are difficult to obtain with accuracy. Until someone who has a first-hand acquaintance with the species can examine the type specimen, we see no reason why mexicanus should not be referred to the synonymy of platorynchus. Judging from the known distribution of the species, the type of mexicanus probably came from the Rio Grande.

Diagnosis.—A species of Scaphirhynchus with 30 to 36 dorsal rays and 18 to 23 anal rays; gillrakers on lower half of first arch mostly with 3 or 4 blunt tips; contrasting with S. album notably in smaller head, narrower mouth, longer inner barbels, shorter and usually blunter snout, more advanced position of barbels, with outer pair originating on a level with or anterior to inner pair, larger eye, and larger dermal plates, especially in lateral series, presence of small dermal scutes on belly in adults, and more brownish color (see Tables I and IV and compare Tables II and III; see text comparison, pp. 177-190, and Fig. 9).

New locality records.—On Figure 10 are plotted all records of the species known to us. Literature reports are cited in the synonymy; those verified by us are indicated there. Below are listed museum numbers and localities for specimens examined by us (indicated by asterisks) or on which information has been made available to us by colleagues (see Acknowledgments).

ALABAMA

*UMMZ 132704, Tennessee River at Wilson Dam.
USNM 143799, Wheeler Reservoir, Morgan Co.

ARKANSAS

Spring River at Imboden and at Black Rock, Lawrence Co.; Black River, Pocahontas, Randolph Co.; and Black River, Powhatan, Lawrence Co. (specimens caught by Byron C. Marshall, the records made available to us by Dr. John D. Black).

ILLINOIS

Illinois Natural History Survey, Mississippi River, Savanna, Carroll Co.
*UMMZ 101572, Mississippi River, Chester.
*UMMZ 111542, Mississippi River at Cairo bridge, [redacted] mile above confluence with Ohio River, Alexander Co.

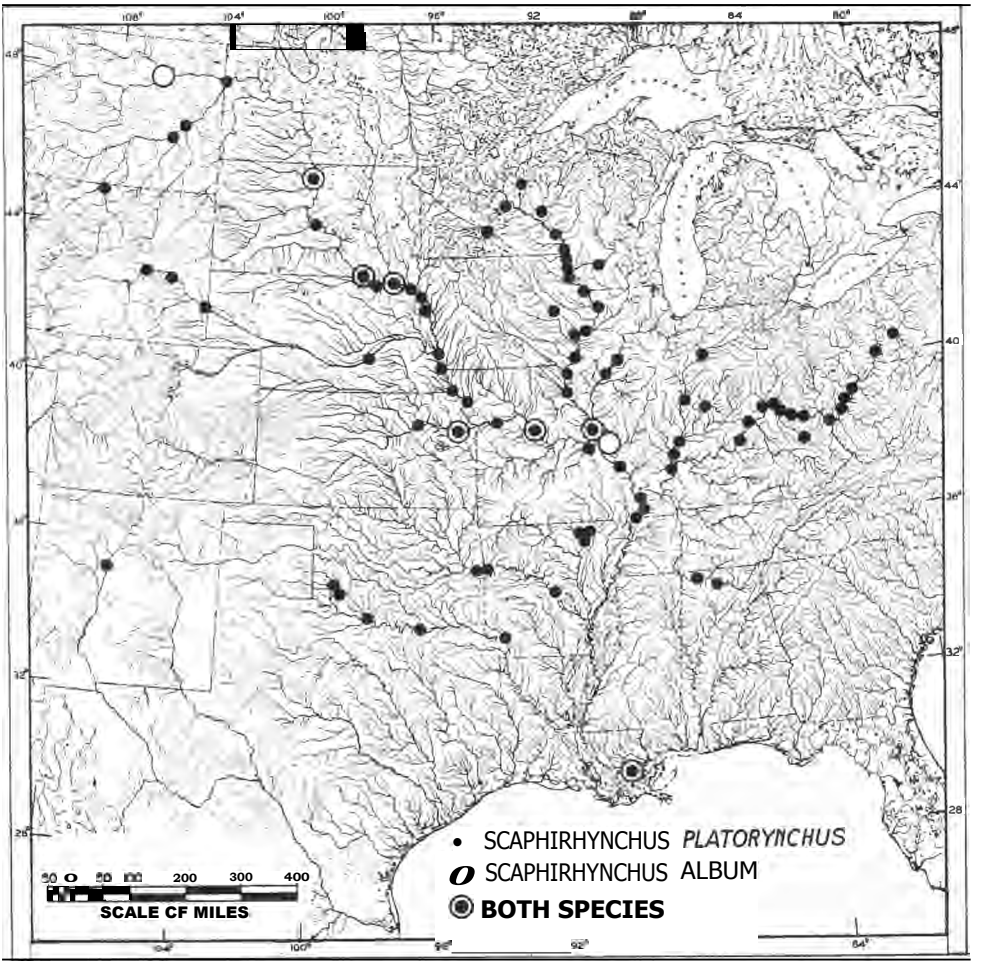


FIG. 10. The central United States, showing stations recorded for the species of *Scaphirhynchus* (dubious records omitted)

SU 13494, Cairo, Alexander Co.
Illinois Natural History Survey, Ohio River, Shawneetown, Gallatin Co.
USNM 22159, Wabash River, Mt. Carmel, Wabash Co.

IOWA

*UMMZ 146963 and 146966, Mississippi River, about 6 miles north of Lansing, Allamakee Co.
*Iowa State College, Missouri River, 3½ miles west of Pacific Junction, 1 mile below mouth of Platte River, Mills Co.

KANSAS

*UMMZ 63176–77 and KU (approximately 90 specimens), Kansas River, below dam at Lawrence.
*UMMZ 157199, Kansas River near Sand Digs, Riley Co.
USNM 3294, Republican River.

KENTUCKY

SU 17109, Clinton.

MISSOURI

*UMMZ 144738, Missouri River, St. Joseph, Buchanan Co.
*UMMZ 144739, Missouri River, Lexington, Lafayette Co.
*UMMZ 144740-41, Missouri River, Rocheport, Boone Co.

MONTANA

*UMMZ 94424, Powder River, near its mouth in Yellowstone River, Prairie Co.
*UMMZ 94425, Tongue River, Miles City, Custer Co.

NEBRASKA

*UMMZ 134561, Niobrara River near mouth, 1 mile west of Niobrara, Niobrara State Park, Knox Co.
*UMMZ 135336, Missouri River, 2 miles northeast of Niobrara, Knox Co.
*UMMZ 135810, Missouri River, 4 miles north and 1 mile west of Newcastle, Dixon Co.
*UMMZ 135816, Missouri River, 3 miles north and 2 miles east of Macy, Thurston Co.
*UMMZ 134825, Missouri River, due east of Minersville, Otoe Co.
*UMMZ 135372, Missouri River, 3 miles southeast of Rulo, Richardson Co.

NORTH DAKOTA

USNM 76584, mouth of Yellowstone River.

OHIO

*UMMZ 103305, Ohio River, southern Green Township, Stout, near Dam No. 32, Adams Co.

SU 10442 and 11739 and USNM 3255 and 3288, Ohio River near Cincinnati.
Ohio State University, Ohio River at various localities in Hamilton, Clermont, Brown, Adams, Lawrence, Gallia, Meigs, and Belmont counties (records furnished by Milton B. Trautman).

OKLAHOMA

Red River, just below Denison Dam, Bryan Co. (record provided by Carl D. Riggs).

SOUTH DAKOTA

*UMMZ 167114, Missouri River near mouth of Grand River, 2 miles northwest of Mobridge, Corson and Walworth counties.
*UMMZ 167116, Missouri River, 3 miles southeast of Pierre, Hughes Co.
*UMMZ 167115, Missouri River, 1 to 2 miles below Ft. Randall Dam, Charles Mix and Gregory counties.
*UMMZ 167113, Missouri River, Yankton, Yankton Co. (Cedar Co., Nebraska, also).

WISCONSIN

USNM 125820-21, Mississippi River, Lynxville (data labels read Illinois, probably a slip for Wisconsin).

Distribution.—Scaphirhynchus platorynchus is known from most of the larger rivers of the Mississippi basin and from the Rio Grande (Fig. 10). There is a questioned report from Lake Winnipeg by Eigenmann (1894: 119), but he did not see specimens. Greene (1935: 25) listed the species from lakes Winnipeg and Winnipegosis, but he informs us (in correspondence) that he is now unable to verify the source. We suspect that the records are an inadvertent transposition and really apply to the preceding species *(Acipenser fulvescens).* There is no reliable evidence to indicate that *S. platorynchus* ever used postglacial channels of dispersal to enter either the Hudson Bay or the St. Lawrence River drainage basin. We note with some skepticism, and therefore do not map, the reported occurrence of this species in Eagle Mountain Lake, near Dallas, Texas (Baughman, 1950: 124).

Habitat and abundance.—The shovelnose sturgeon is a fish of the river bottom, living by preference and in greatest numbers in the strong current of the channels. Although normally found over sand or gravel bottom, the fish may lie over a soft substratum near the head of a silt bed, provided that this is swept by a substantial current. The preference for current almost excludes the species from Lake Keokuk and Lake Pepin, man-made and natural-river lakes, respectively, in the Mississippi (Coker, 1930: 155).

Formerly Scaphirhynchus platorynchus was probably more widely distributed and was certainly more abundant than at present. The factors involved in its decline include the reduction in flow resulting from irrigation diversions (in the Rio Grande and the North Platte River), the impoundment of river waters behind dams, commercial fishing, and, locally, pollution (Coker, 1930; Barnickol and Starrett, 1951; Trautman, manuscript data). Increased turbidity, an important factor in the depletion of many species, is probably not directly deleterious to the species of Scaphirhynchus. But behind dams the combination of a reduction in current and the covering of a firm bottom with a heavy bed of flocculent silt has caused a marked decline in numbers of sturgeon. Dams may also be detrimental because they block spawning migrations (Eddy and Surber, 1943: 62). The shovelnose sturgeon remains abundant in the Missouri River, where natural conditions have been altered less than in the Ohio, Tennessee, Illinois, upper Mississippi, Rio Grande, and other streams. But dams now under construction in the Missouri will surely reduce the population there, too.

Many of the peripheral records for the species are based on specimens collected more than half a century ago, an indication that the adverse forces are reducing its range. No specimens are known to have been taken in the Rio Grande since 1874 (Cope and Yarrow, 1875), and the records from the Platte River are old. Rafinesque (1820) and Bean (1892) reported shovelnose sturgeon from as high in the Ohio as Pittsburgh. Trautman (manuscript) learned that until about 1910 it was still common in Washington County, on the Ohio River in eastern Ohio, but since impoundment began, about 1911, the species has declined and is now rarely taken upstream from Scioto County. Welter (1938) said that formerly the species was common in the Licking River at Farmers, Kentucky, but that it had not been taken there for a number of years. A decline in abundance and a restriction in range in Illinois was already evident in 1909 (Forbes and Richardson, 1909: 27–28).

Size.—Male shovelnose sturgeon in the Mississippi River reach maturity at a length (to base of caudal filament) of from 19.5 to 22 inches; the smallest adult female taken was 25 inches long (Barnickol and Starrett, 1951: 289). These authors determined the mean weight to be 1.3 pounds. In Ohio River fish Evermann (1902: 285-286) determined the average length (method of measurement not speci-

fled) and weight for females to be 25.4 inches and 3.24 pounds, for males, 21.7 inches and 1.89 pounds. The largest specimen, a female, measured 29.5 inches and weighed 4.75 pounds. Rafinesque (1820) said that the species attains a weight of 20 pounds, but because of his habitual inaccuracy, verification of this is needed. Since he indicated a length of from 2 to 3 feet, he may have intended 2.0 pounds. Forbes and Richardson (1909: 27) said of platorynchus: "...it seems probable that the species rarely reaches a length greater than 3 feet." Reports of shovelnose sturgeon attaining lengths of from five to eight feet (Kirtland, 1847; Bean, 1892; Hay, 1902) are believed to be erroneous, but confusion with Scaphirhynchus album and Acipenser fulvescens, which are larger species, may account for some records of especially large specimens.

Scaphirhynchus album (Forbes and Richardson)

Pallid Sturgeon

Scaphirhynchops platyrhynchus (not of Rafinesque).—Cope, 1879: 441 (dubious record; head of 47-pound specimen; Missouri River, Ft. Benton, Montana). Jordan, 1884: 318 (New Orleans; USNM 32475—reidentified by us).

Parascaphirhynchus albus.—Forbes and Richardson, 1905: 37-44, pls. 4-7 (original description; comparisons; Mississippi River, Grafton, Illinois, also in lower Missouri River). Forbes and Richardson, 1909: 28-29, 1 pl. (description; size; comparisons). Fowler, 1911: 603-612 (record from "North America," as *Parascaphyrhynchus albus).* Jordan, 1929: 32-33 (compiled). Coker, 1930: 154-155 (dubious record; food; Mississippi River, Keokuk, Iowa). Jordan, Evermann, and Clark, 1930: 35 (compiled). Gudger, 1932: 323 (compiled). Gowanloch, 1933: 417-418 (compiled). O'Donnell, 1935: 475 (compiled). Schrenkeisen, 1938: 15-16 (compiled). Kuhne, 1939: 17 (hypothetically in Tennessee). Driver, 1942: 251 (compiled).

Scaphirhynchus albus.—Berg, 1911: 138, 308-309, 319 (comparisons). Giltay, 1929: 30-32 (comparisons). Holly, 1936: 40-42, fig. 42 (compiled).

Parascaphirhynchus album.—Riggs and Moore, 1951: 17-18 (comparisons).

Scaphirhynchus album.—Hubbs, 1951: 9 (distribution). Harlan and Speaker, 1951: 36 (compiled). Bailey, 1951: 190, 207 (comparisons). Barnickol and Starrett, 1951: 290, 324-341 (abundance; mouth of Missouri River).

Nomenclature.—The original description leaves no room for doubt as to the proper assignment of Parascaphirhynchus albus to the present species. Mr. Philip W. Smith informs us that the Illinois Natural History Survey has five specimens (two as heads only) of the original series of nine. We suspect that the fish measured by Berg (1911:

319) may be another of these nine, that was sent to him by Forbes and Richardson.

Diagnosis.-A species of *Scaphirhynchus* with 37 to 43 dorsal rays and 24 to 28 anal rays; gillrakers on lower half of first arch mostly with 2 blunt tips; contrasting with *S. platorynchus* in larger head, wider mouth, shorter inner barbel, longer and sharper snout, more posterior placement of barbels with outer pair originating more posteriorly than inner pair, smaller eye, smaller dermal plates, absence of scutes on belly at all ages, and more pallid color (see Tables I and IV and compare Tables II and III; see pp. 177-190 and Fig. 9).

Material examined.-Seventeen specimens of *Scaphirhynchus album* have been studied, as follows:

MONTANA

UMMZ 167118, 1290 mm. in length to end of last lateral scute, Missouri River, Fort Peck Reservoir, North Fork of Rock Creek Bay, T. 23 N., R. 43 E., Sec. 18, McCone Co., June 12-13, 1949, H. W. Newman. (This fish was received too late for its measurements to be entered in Table III.)

SOUTH DAKOTA

UMMZ 167110, 622 mm. long, Missouri River about 200 yards below mouth of Grand River, T. 19 N., R. 30 E., Sec. 31, 2½ miles northwest of Mobridge, Corson Co., Aug. 24, 1952, Marvin O. Allum and R. M. Bailey.

UMMZ 167111, 274 mm. long, Missouri River, about 2 miles below Ft. Randall Dam, T. 95 N., R. 65 W., Sec. 22, Gregory Co., Aug. 29, 1952, Allum and Bailey.

UMMZ 167112, 167 mm. long, Missouri River, Yankton, Yankton Co., Aug. 30, 1952, Allum and Bailey.

KANSAS

KU 2079, 2113, 2160, 2161, and 2337 and UMMZ 167108, from 294 to 415 mm. long, Kansas River, Lawrence, T. 12 S., R. 20 E., Sec. 20 and 27, Douglas and Jefferson counties, March 29 to June 17, 1952, F. B. Cross.

MISSOURI

UMMZ 144742, 540 mm. long, Missouri River, Rocheport, Boone Co., Oct. 20-30, 1945, Lester M. Berner.

UMMZ 144743 (2), 328 and 395 mm. long, same locality, Feb. 24, 1946, Berner.

Illinois Natural History Survey, 226 mm. long, Missouri River, in chute along north bank 25 yards above confluence with Mississippi River, St. Charles Co., July 12, 1944, Upper Mississippi River Conservation Committee.

LOUISIANA

USNM 32475, 413 mm. long, vicinity of New Orleans (Orleans Parish), 1882, R. W. Shufeldt (reported by Jordan, 1885: 318).

TU 4526, 637 mm. long, Mississippi River, New Orleans, Orleans Parish, brought in during spring, 1952, by Paul K. Anderson, died in Audubon Park aquarium, April 21, 1952.

TU 4525, 500 mm. long, same locality, Nov. 17, 1950, Earl Dufresne and Lawrence Avant, for Audubon Park aquarium.

Distribution.—As indicated by the records above, Scaphirhynchus album ranges in the Missouri-Mississippi River proper from Fort Peck Reservoir, Montana, to New Orleans, Louisiana, and in the Kansas River upstream to Lawrence, Kansas (Fig. 10). The reported extension of range upstream in the Mississippi from the mouth of the Illinois River (the type locality) to Keokuk, Iowa (Coker, 1930), needs verification. This locality is omitted from the map, as is the record by Cope, 1879: 441, from the Missouri River at Fort Benton, Montana. Extensions of the known range are to be expected, however, probably into the lower courses of major, turbid tributaries to the Mississippi River.

Habitat and abundance.—Like *Scaphirhynchus* platorynchus, the pallid sturgeon is a bottom inhabitant of the channels of large rivers. It lives in a strong current over a firm sand bottom; of the specimens with data only the Fort Peck individual is from standing water or a sluggish current. The Missouri-Mississippi, to which this species is almost restricted, is probably the most turbid large stream on the continent. Moderately turbid streams, such as the Ohio, are apparently not entered, and the only pallid sturgeon reported in the Mississippi above the mouth of the Missouri and Illinois rivers is from Keokuk. If this record is well founded the species is certainly rare there (Coker, 1930; Barnickol and Starrett, 1951) and is probably represented only by stragglers from down river. Even at the mouth of the Illinois River Forbes and Richardson (1905) reported that S. album was outnumbered by S. platorynchus 500 to 1 (Forbes and Richardson, 1909, give a ratio of 300 to 1). The species was said to be more common in the lower Missouri. Our observations indicate that in the highly turbid Kansas River at Lawrence about 8 per cent of the specimens of Scaphirhynchus are album. In the Missouri River of South Dakota, among 62 sturgeon taken at random in August 1952, 3 (5 per cent) were album. Of 4 identified specimens from New Orleans, 3 are S. album. Thus, although nowhere common, the pallid sturgeon seems to be most frequent in waters of very high turbidity. Among other fishes, *Hybopsis* meeki Jordan and

Evermann seems most closely associated with album both in habitat and in distributional pattern.

Size.—The pallid sturgeon is shown by Forbes and Richardson (1909) to attain a standard length of 43½ inches and a weight of 9¾ pounds, and they have received reports of specimens 4½ feet in length estimated to weigh from 15 to 25 pounds. Mr. Joe Blazek, a commercial fisherman with many years' experience at Yankton, South Dakota, is familiar with two species of sturgeons at that locality. He described both species as having elongate caudal filaments; hence they are referable to Scaphirhynchus. He said the brown sturgeon (S. *platorynchus*) was small, usually not exceeding 2½ pounds, but the "white" species, known locally as rock sturgeon, he reported to reach a weight of 36 pounds. Although he was questioned closely, it seems certain that there was no confusion with Acipenser fulvescens (with which Mr. Blazek was unfamiliar). Cope's record **(1879: 441)** of Scaphirhynchops platyrhynchus from Fort Benton, Montana, was based on the head of a 47-pound fish. Because of the size, it is judged to be S. album. S. platorynchus is not known to approach this weight, and Cope would almost certainly not have misidentified A. *fulvescens* as a shovelnose sturgeon. Dr. Robert R. Harry has been unable to locate this specimen in the Academy of Natural Sciences of Philadelphia. By far the largest specimen examined by us, that from Fort Peck Reservoir, Montana, measured 58 inches in total length and weighed 31.5 pounds when captured. In formalin preservation four years later it is 1355 mm. in fork length and weighs 26.3 pounds.

Scaphirhynchus album obviously attains a much greater size than does S. platorynchus. If anadromous forms are excluded, only about a dozen species of North American freshwater fishes exceed S. album in maximum size.

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