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Observations on anomalous conditions in some flatfishes (Pisces: Pleuronectiformes), with a new record of partial albinism

John V. Gartner, Jr.
Florida Department of Natural Resources, Bureau of Marine Research, 100 8th Ave. S.E., St. Petersburg, FL 33701, U.S.A.

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Synopsis

Abnormalities in five specimens of pleuronectiform flatfishes (one specimen from the family Soleidae, four from Bothidae) are described. The account of naturally occurring anomalies in the naked sole, *Gymnachirus melas*, is the first from the western Atlantic for a soleid other than *Trinectes maculatus*. Anomalies in *G. melas* include partial albinism and osteological deformities. A second account of pigment and morphological aberrations is provided for *Paralichthys albigutta* (total ambicoloration, incomplete eye rotation and hooked dorsal fin). Partial ambicoloration is reported for three specimens of *Paralichthys lethostigma*. Possible causes of abnormalities in flatfishes are reviewed. It is postulated that minimum depth of occurrence of species may be linked to frequency of abnormalities. Anomalies appear to be most frequent in species and families of flatfishes which inhabit shallow coastal or estuarine (<5 m depth) waters.

Introduction

A variety of abnormalities have been noted among the pleuronectiform flatfishes. Conditions reported include morphological deformities, especially involving the head and/or caudal regions (e.g. Dawson 1967, Templeman 1970, Houde 1971, Powell & Schwartz 1972, Moore & Posey 1974), and pigmentation anomalies. Aberrant color patterns include: ambicoloration (both ocular and blind side pigmented, Dawson 1962), which may be accompanied by morphological deformity when either the entire blind side or one-fourth to one-third of the head is pigmented (Gudger & Firth 1936), partial albinism (varying degrees of pigment lacking from both sides), which usually is accompanied by skeletal deformation (Dawson 1967), and inverse ambicoloration (both sides lacking pigment) with no osteological anomalies (Dawson 1969).

In the western Atlantic and eastern Gulf of Mexico, abnormalities appear to be most prevalent in the Bothidae (see Dawson 1962 and citations therein, also Dawson 1967, 1969, Moore 1969, Powell & Schwartz 1972, Dorfman & Lockwood 1975), but are known as well from the Pleuronectidae (Dawson 1962 and citations therein, also Dawson 1967), Cynoglossidae (Dawson 1962, Moe 1968, Dahlberg 1970a, b) and Soleidae (Dawson 1962 and citations therein, also Dawson 1969, Dahlberg 1970a, Moore & Posey 1972, 1974, Koski 1974). Reports on the soleids have been restricted to a single species, the hogchoker *Trinectes maculatus*.

In this paper, I present the first record of abnormalities in a naked sole, *Gymnachirus melas*. In addition, the second occurrence of ambicoloration in an adult bothid *Paralichthys albigutta* is reported. Data are also presented on ambicolored *P.*

lethostigma. Abnormalities have often been reported for this species (see previous citations for bothids) and the new information is intended to expand the data base on aberrant conditions in this species. Possible causes for the comparative rarity of anomalies in certain families and species of flatfishes are discussed.

Methods

Three of the five specimens dealt with in this study were discovered during the archiving of uncatalogued material in the vertebrate collection of the Florida Department of Natural Resources, Bureau of Marine Research, St. Petersburg, FL (FSBC), the remaining two being previously cataloged material.

All specimens were taken in Florida waters from both east and west coasts by a variety of methods. They include: *Gymnachirus melas* (121 mm SL, FSBC 12952) taken by scallop tumbler dredge in 25 fms of water at 29° 00′ N, 80° 15′ W on 24 April 1983; *Paralichthys albigutta* (276 mm SL, FSBC 12953), gigged in about two feet of water near the Sunshine Skyway Bridge, Tampa Bay, FL on 16 August 1983; three *P. lethostigma* (302 mm SL, FSBC 12954, 1958; 263 mm, FSBC 12631, 2 November 1982; 408 mm, FSBC 12243, 15 July 1981). The first specimen was taken by shrimp trawl in an unknown depth of water in the Atlantic Ocean off St. Augustine, FL, while the latter two were captured approximately one year apart by hook and line at Canaveral Inlet, Cape Canaveral, FL. Precise depths for these specimens are not known, but depths in the area are less than 10 m.

Each specimen was measured to the nearest 1 mm standard length (SL). Identification of *Gymnachirus melas* follows Dawson (1964a), while the bothids were identified using Gutherz' (1967) key.

All specimens were x-rayed to determine the presence and extent of osteological abnormalities. The tail of *Gymnachirus* was removed and cleared and stained according to the methods of Taylor (1967).

Results

The specimen of *Gymnachirus melas* displays a nearly complete lack of pigment on the ocular surface (Fig. 1a). Rather than the usual dorso-ventral bars on the eyed side, this specimen only has pigment between the eyes and around the mouth and median fins and a scattering of spots ranging from <1 to 3 mm in diameter. The blind surface shows a pigment pattern typical for the species (Fig. 1b).

Meristics and location of capture are in the ranges given by Dawson (1964a) for this species: dorsal rays 67; anal rays 48; precaudal vertebrae 9; caudal vertebrae 27. The only known species of *Gymnachirus* occurring off the east coast of Florida is *G. melas* (Dawson 1964a).

Examination of radiographs reveals anomalies associated with the caudal vertebrae and hypural plate (Fig. 2). Interpretation of this aberration was made after clearing and staining the caudal portion of the specimen.

The last five vertebral centra are involved. In the following analysis, rather than use conventional osteological terminology, I refer to these components as caudal centra 1, 2, 3, 4 and 5, counting anteriorly from the caudal fin.

Caudal centra 1, 2 and 3 are compressed antero-posteriorly and displaced towards the dorsal fin. Hypurals 2, 3, 4 and 5 and the epural are also displaced dorsally and anteriorly such that the epural and the neural spines on caudal centra 2 and 3 are jammed together. The neural spines of centra 4 and 5 are normally configured.

On the ventral side, the haemal spines of centra 4 and 5 are arched posteriorwards and are also displaced towards the blind side. Hypural 1 has been pushed anteriorly and fused to caudal centrum 3 on the ocular side of the centrum. There is a bony mass fused to the front of the hypural and also to the centrum, but it is unclear whether this is the remains of one or both of the haemal spines from caudal centra 2 and 3 or the parahypural or some combination of these, because all three of these elements are missing. The anterior shifting of the first hypural has left the seven ventralmost caudal rays unsupported in the fin. No cranial or dorsal fin anomalies were noted.

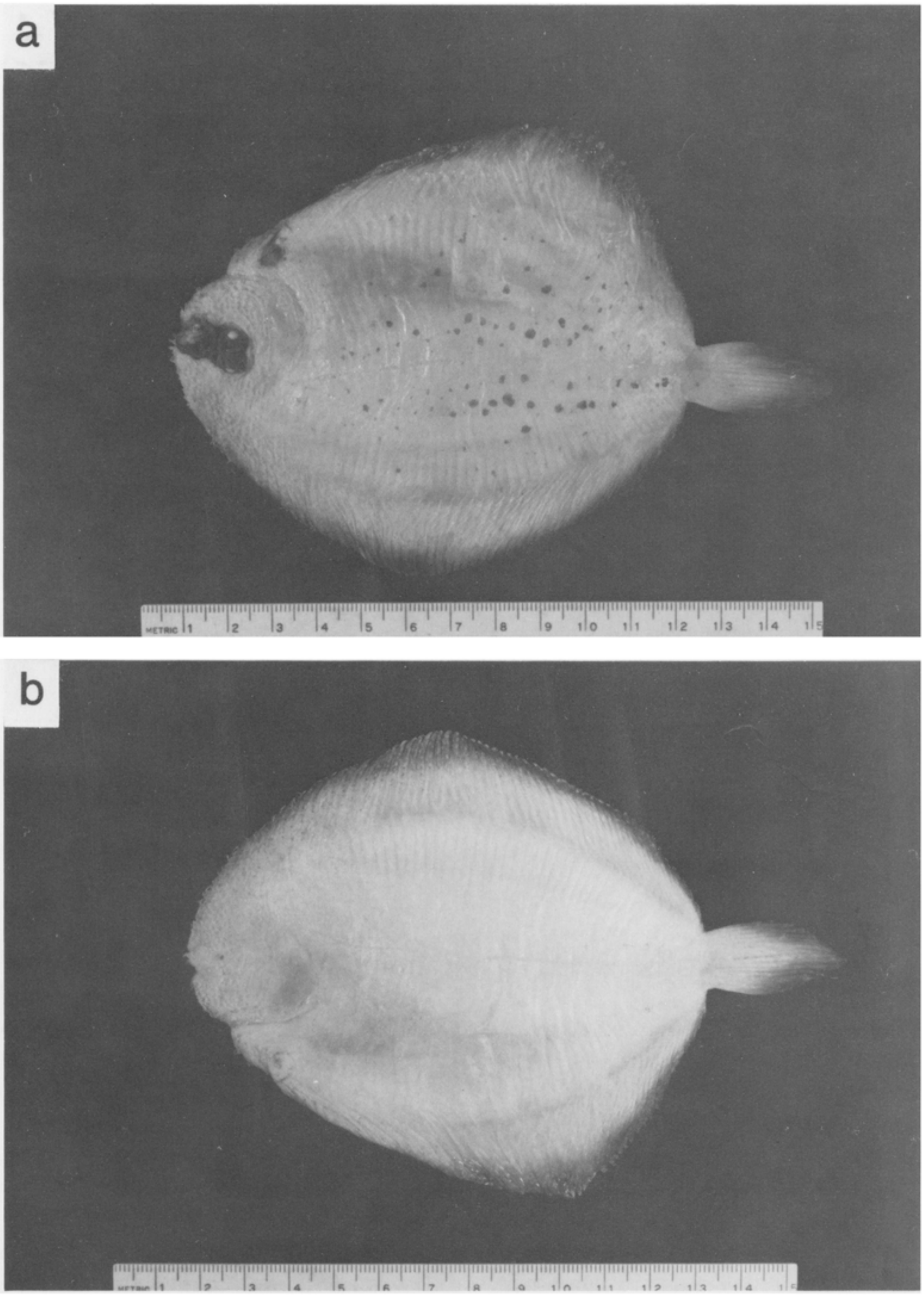

Fig. 1. Specimen of *Gymnachirus melas* showing pigmentation anomalies: *a* – ocular surface; *b* – blind surface.

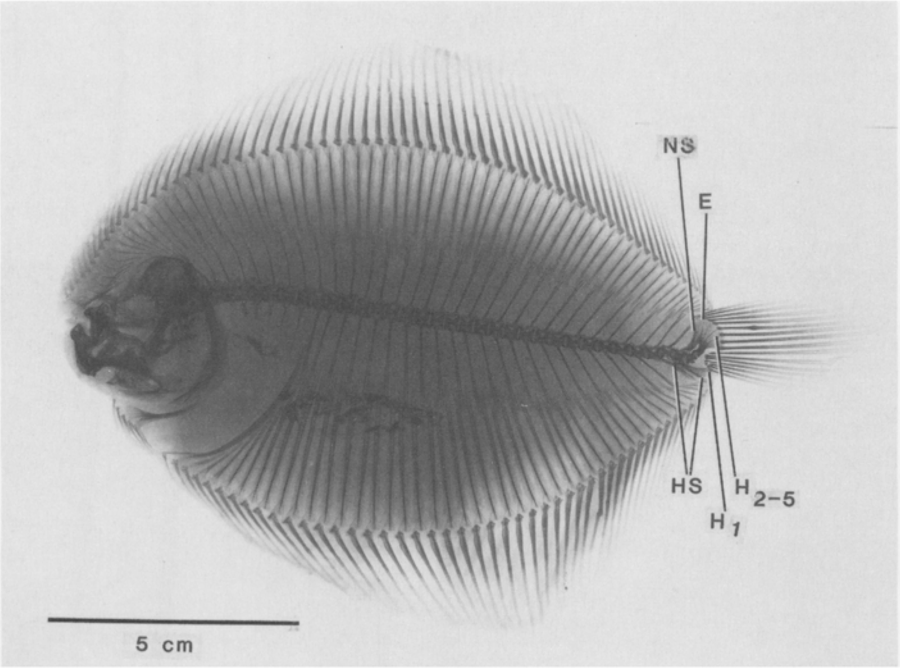

Fig. 2. Radiograph of *Gymnachirus melas* showing caudal deformities. (HS – Haemal spine; NS – Neural spine; E – Epural; H_1, $H_{2\text{-}5}$ – Hypurals).

Virtually complete ambicoloration is seen in the specimen of *Paralichthys albigutta* (Fig. 3a, b). The only unpigmented portion on the blind side is the distal half of the pectoral fin (Fig. 3b). The blind side is somewhat lighter in shade than the ocular side, but the three ocelli typical of *P. albigutta* are clearly seen on both sides and located in identical positions.

Incomplete eye rotation is obvious in this specimen. Hooking of the dorsal fin is pronounced as well, and radiographs (Fig. 4) show the incomplete development of the dorsal fin over the skull. Skull formation and caudal osteology appear to be normal when compared to x-rays of normally colored specimens.

In *Paralichthys lethostigma*, the specimens are almost totally ambicolored (Fig. 5a, b). Dark pigmentation occurs everywhere on the blind side but the head, distal portion of the pectoral fin and in the cases of the two smaller specimens, the posteriormost one-third of the caudal fin. The largest of the three specimens (FSBC 12243) was also lacking pigment over about one-half of the eyed surface. The x-rays of both specimens revealed no osteological anomalies.

Discussion

Teratological specimens have often been reported from among the pleuronectiform flatfishes although the actual incidence is usually low per species examined (see Dawson 1962 for review, Dahlberg 1970a, Moore & Posey 1974). Abnormal characteristics seem to be exhibited most often among species of the families Bothidae and Pleuronectidae (Dawson 1964b, 1966, 1971, 1976), only rarely in the Cynoglossidae and Soleidae. The present report of naturally occurring anomalies in *Gymnachirus melas* is the first for this species and is also the first western Atlantic account for a soleid other than *Trinectes maculatus*.

Despite the apparently greater frequency of atypical traits in the bothids, the description of anomalies in *Paralichthys albigutta* is only the second report in an adult of this species (White 1962

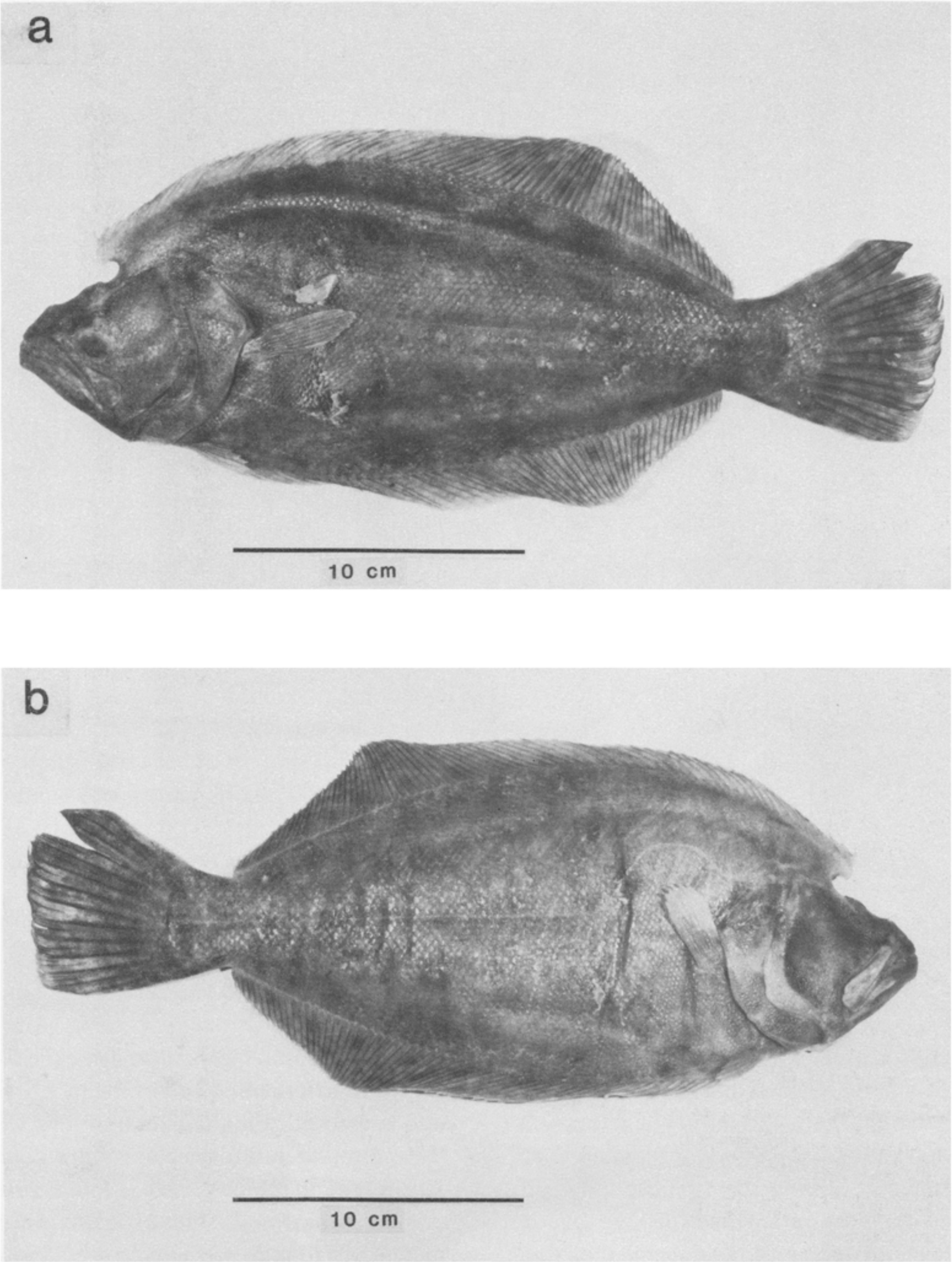

Fig. 3. Specimen of *Paralichthys albigutta* showing pigmentation and morphological anomalies: *a* – ocular surface; *b* – blind surface.

noted anomalies in a 10 mm specimen). In addition, only one other work (also on *P. albigutta*) provides information on aberrant flatfishes from the eastern central Gulf of Mexico region (Hoff 1969).

The specimen of *Gymnachirus melas* shows an almost totally albinistic pigment pattern. Norman (1934) indicated that areas of the body lacking normal pigmentation often followed an injury, especially to the vertebral column. Dawson (1967) reviewed cases of partial albinism and noted that

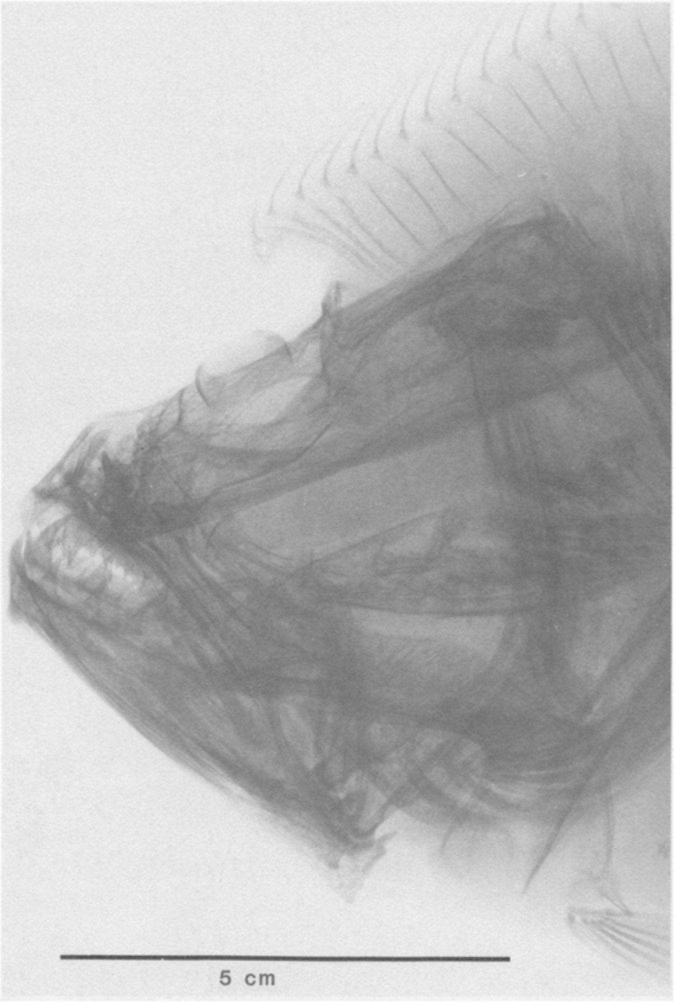

Fig. 4. Radiograph of head of *Paralichthys albigutta* showing incomplete formation of dorsal fin.

most were associated with osteological aberrations. He felt that these abnormalities were trauma induced, i.e. wounds inflicted during development which resulted in varying degrees of pigment loss.

The specimen of *Gymnachirus* clearly shows abnormal caudal osteology. However, the caudal structure does not appear to have reached its final conformation as a result of injury, but is more probably a developmental aberration. Since the defect involved the vertebral column, pigment formation may thus have been affected.

The specimens of *Paralichthys albigutta* and *P. lethostigma* show typical patterns of ambicoloration which are consistent with the conclusions of Gudger & Firth (1936). They found that when the blind side is completely colored like the ocular side, or one-fourth to one-third of the head on the blind side is colored, then the rotating eye will not migrate completely and the dorsal fin will be hooked. This is seen in the specimen of *P. albigutta* which is totally ambicolorate. In contrast, Hoff's (1969) specimen had little pigment on the blind side of the head, and dorsal fin hooking and incomplete eye rotation were much less pronounced. The two smaller specimens of *P. lethostigma* are pigmented except for the head on the blind side and show no other morphological anomalies. The largest specimen, however, also lacks pigment on the ocular side. The unpigmented area appears as a light gray in preservative, in sharp contrast to the normal

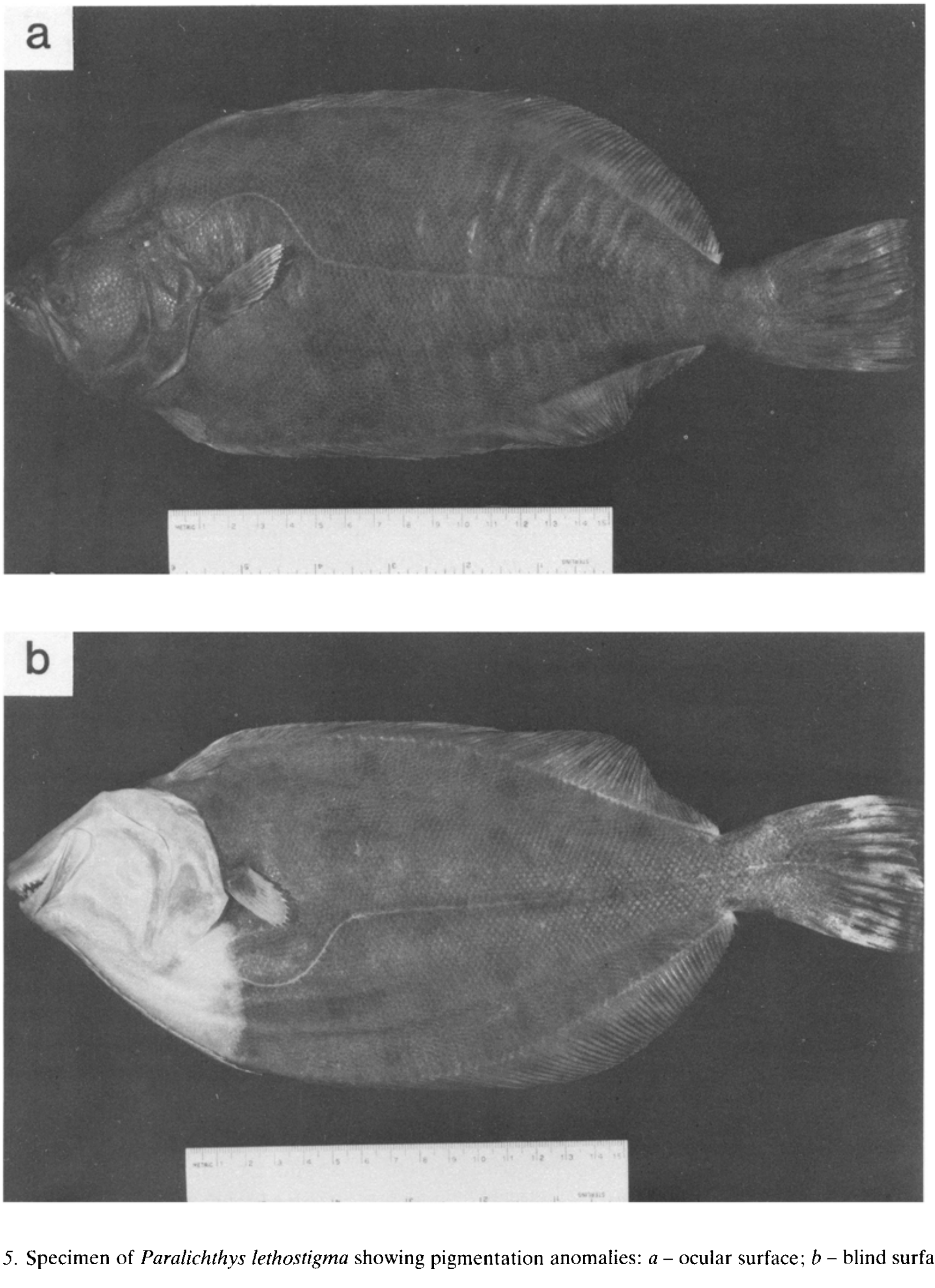

Fig. 5. Specimen of *Paralichthys lethostigma* showing pigmentation anomalies: *a* – ocular surface; *b* – blind surface.

dark olive brown color. Its shape follows that of the lateral line and covers the lateral line and an area about 3 cm to either side from the base of the head to the base of the caudal fin. No dorsal fin or eye anomalies are apparent in this specimen. Conformity to the rule of Gudger & Firth (1936) may be species dependent, since DeVeen (1969) and Houde (1971) did not find complete correlation in their studies of *Pleuronectes platessa* and *Achirus lineatus*, respectively.

The cause(s) of anomalous conditions in flatfishes remain uncertain but available evidence indicates that abnormalities are induced during larval development. The most significant causative factors seem to be light and temperature. Cunningham (1893, 1895) found that if the blind sides of young flounders were exposed to light, pigmentation would develop. Norman (1934), in addition to light, listed natural mutations or disruptive influences during embryonic transformation while DeVeen (1969) discussed the effects of light, population density, food levels and temperature on inducing anomalies in flatfish larvae. More recently, Houde (1971) conducted experiments on tank-reared larval *Achirus lineatus* and found a high incidence of abnormalities and postulated that lighting, contact with the sides of the rearing tanks or high metabolite concentration may have contributed to producing the observed anomalies. Houde (1971) also remarked on the occurrence of abnormalities in tank reared *Paralichthys albigutta* and *Gymnachirus melas* but gave no data for either species. Stickney & White (1975), working with *Paralichthys dentatus* in aquaria, found that after metamorphosis, if specimens could not find suitable substrate in which to bury, light reflecting from the bottom induced diffuse pigmentation of the blind side.

Temperature is also thought to be important in causing aberrations, especially with respect to pigmentation anomalies. Shelbourne (1964) suggested that the degree of pigmentation at metamorphosis may be linked to incubation temperature. Dawson (1962, 1967) suspected that temperature extremes during larval metamorphosis resulted in both pigmentation and morphological abnormalities. Lux (1973) found a higher percentage of white spotting in a year class of *Pseudopleuronectes americanus* that was subjected to abnormally low temperatures as larvae. Achmad (1973 cited in Moore & Posey 1974) found a high degree of color reversal in *Achirus lineatus* subjected to rearing temperatures outside the optimum range for the larvae. Moore & Posey (1974) suggested that thermal stress of larvae from the outfall of electric power plants was responsible for a higher than normal incidence of abnormalities in *Trinectes maculatus* captured in the region of power plants in the Potomac and Patuxent Rivers.

In the western Atlantic, the infrequency of reported anomalies in the Cynoglossidae and Soleidae suggests two possible causes. The first is simply fishing effort. Unlike species of the Bothidae and Pleuronectidae which are valued food fish subjected to intensive fishing, cynoglossids and soleids are economically unimportant and are usually not kept when caught. A second possibility is suggested, based on previously mentioned reports of light and temperature effects.

The species of flatfishes most often reported with abnormalities (see Dawson 1964b, 1966, 1971, 1976 for listings) are those whose distributions are generally shallow coastal to estuarine (most often <5 m bottom depth). Table 1 provides a complete listing of western Atlantic and eastern Gulf of Mexico flatfishes, minimum depth of capture for the species and reports of abnormalities. It is quite possible, in view of the apparent correlation of light and temperature to abnormalities that most occurrences of anomalies are in species subjected to the most variation of these factors. Shallow water species, especially those in estuaries, would receive the greatest extremes of light intensity and temperature fluctuations, which could result in atypical character formation during developmental stages. This theory is lent support by the fact that most reports of abnormalities are from more northern climates (North Carolina and above) where seasonal extremes of temperature are more pronounced. Fewer anomalous specimens are taken from the subtropical-tropical latitudes. In addition, Dawson (1962) noted that reports of abnormal flatfishes were much less frequent from the Gulf of Mexico than from the eastern seaboard. He believed that lower temperatures during larval development, which are more common on the east coast than in the Gulf of Mexico, were the most likely cause since extensive fishery operations exist along both coasts. The extent of fishery operations both inshore and offshore in the western Atlantic also makes it unlikely that the higher frequency of anomalies in inshore species is an artifact of sampling intensity.

The relative absence of abnormalities in deeper dwelling species must be explained since, in many cases, the eggs and larvae are pelagic and like

Table 1. List of western Atlantic and eastern Gulf of Mexico flatfishes, with summary of records of abnormalities.

Family/Species	Minimum depth of occurrence (m)	Anomalies/ Type	Source(s)
BOTHIDAE			
Ancylopsetta dilecta	>60	No	
Ancylopsetta quadrocellata	<5	Yes; PA	Wilkens & Lewis (1971)
Bothus robinsi	>15	No	
Bothus ocellatus	>20?	No	
Bothus lunatus	>20	No	
Chascanopsetta lugubris	>220	No	
Citharichthys arctifrons	>20 (usually >45)	No	
Citharichthys cornutus	>25	No	
Citharichthys dinoceros	>175	No	
Citharichthys gymnorhinus	>40	No	
Citharichthys macrops	>5	No	
Citharichthys spilopterus	>10	Yes; R	Wilkens & Lewis (1971)
Cyclopsetta chittendeni	>20	No	
Cyclopsetta fimbriata	>20	No	
Engyophrys senta	>35	No	
Etropus crossotus	<5	Yes; O, PA, R	Dahlberg (1970a) Taylor, Stickney & Heard (1973)
Etropus microstomus	>10?	No	
Etropus rimosus	<10	No	
Gastropsetta frontalis	>30	No	
Hippoglossina oblonga (= *Paralichthys oblongus*)	<10 in North to >250 in South	Yes; AL, D, E, PA	Gudger & Firth (1936) Lux (1959)
Monolene antillarum	>150	No	
Monolene sessilicauda	>100	No	
Paralichthys albigutta	<5	Yes; D, E, PA, R	White (1962); larvae Hoff (1969) Present study
Paralichthys dentatus	<5	Yes; A, D, E, PA	Dawson (1962 and citations therein) Dahlberg (1970a) Lux & Mahoney (1972) Powell & Schwartz (1972) Stickney and White (1975)
Paralichthys lethostigma	<5	Yes; A, AL, D, E, IA, O, PA, R	Dawson (1962 and citations therein) Dawson (1967, 1969) Dahlberg (1970a) Moore (1969) Powell & Schwartz (1972) Present study
Paralichthys oblongus (see *Hippoglossina oblonga*)	–	–	
Paralichthys squamilentus	>10	No	
Scophthalmus aquosus	<5	Yes; PA	Burgess & Schwartz (1975)
Syacium gunteri	>5	No	
Syacium micrurum	>10?	No	
Syacium papillosum	>5	No	
Trichopsetta ventralis	>30	No	
PLEURONECTIDAE			
Glyptocephalus cynoglossus	>20	Yes; PA? (extent uncertain)	Bigelow & Schroeder (1953)

Table 1. (Continued).

Family/Species	Minimum depth of occurrence (m)	Anomalies/ Type	Source(s)
Hippoglossoides platessoides	>20	Yes; PA	Bigelow & Schroeder (1953) Brunel (1971)
Hippoglossus hippoglossus	>50	Yes; D, E, PA, R	Gudger & Firth (1935, 1937) Bigelow & Schroeder (1953)
Limanda feruginea	>5 (usually >10)	Yes; AL, PA	Gudger (1935, 1946)
Liopsetta putnami	<5	No	
Pseudopleuronectes americanus	<5	Yes; A, O, PA, R	Dawson (1962 and citations therein) Bishop (1946) Medcof (1946) Pearcy (1962) Eisler (1963) Dawson (1967) Lux (1973) Munroe (pers. comm.)
Reinhardtius hippoglossoides	>70	Yes; O	Templeman (1970)
CYNOGLOSSIDAE			
Symphurus civitatus	>10	No	
Symphurus diomedianus	>5 (usually >20)	Yes; PA, R	Moe (1968)
Symphurus marginatus	>150	No	
Symphurus minor	>20	No	
Symphurus nebulosus	>250	No	
Symphurus parvus	>35	No	
Symphurus pelicanus	>25	No	
Symphurus piger	>100	No	
Symphurus plagiusa	<5	Yes; A, AL, O, PA, R	Dawson (1962) Dahlberg (1970a, b)
Symphurus pusillus	>150	No	
Symphurus urospilus	>5	No	
SOLEIDAE			
Achirus lineatus	<5	Yes*; A, AL, D, E, O, PA, R	Houde (1971); larvae Achmad (1973, cited in Moore & Posey 1974); larvae
Gymnachirus melas	<5 (usually <10)	Yes; AL	Present study
Gymnachirus texae	>20	No	
Trinectes maculatus	<5	Yes; A, AL, IA, PA, R	Dawson (1962 and citations therein) Dawson (1967, 1969) Dahlberg (1970a) Moore & Posey (1972, 1974) Munroe (pers. comm.)

* – Abnormalities in *A. lineatus* occurred in tank reared specimens, no natural occurrences yet reported.

Key

A – Total ambicoloration
AL – Albinism (any degree)
D – Hooked dorsal Fin
E – Incomplete eye rotation
IA – Inverse ambicoloration
O – Other condition
PA – Partial ambicoloration
R – Reversal

inshore species, subject to extremes of light and temperature in surface waters. At least two factors may counter these effects on such species. First, species may spawn while temperatures are relatively stable. Topp & Hoff (1972) estimated probable spawning periods for 17 species of flatfishes captured over the Florida shelf in the Gulf of Mexico. Of the six species they listed for which anomalies have been reported (*Etropus crossotus, Symphurus plagiusa, S. diomedianus, Gymnachirus melas, Ancylopsetta quadrocellata* and *Paralichthys albigutta*), all but *S. diomedianus* have spawning periods that span autumn to spring months when temperature changes are most severe in the Gulf (October–March). *Symphurus diomedianus* and five other species, only one of which has been reported with anomalies (again, *S. diomedianus*), spawn only during the months of April-August, when temperature fluctuations are much less pronounced. *Paralichthys lethostigma* is a winter spawner as well (Randall & Vergara 1978). In addition, temperature extremes may only occasionally impinge on the developing larvae. Lux (1973) correlated the increased incidence of a white spotting pigment anomaly in a specific year class of *Pseudopleuronectes americanus* (which spawns in deep water and has demersal, adhesive eggs) with unusually low temperatures in the deep waters of the spawning region during the year of larval development. These aperiodic low temperature extremes at depth in the northern latitudes may account for the occasional reports of anomalies in deep water species.

A second explanation accounting for few reports of abnormalities in deeper dwelling species is that the reversibility of anomalies after settling, especially of atypical pigment patterns, has been noted. Shelbourne (1964) reported the reversal of pigment deficiencies in a plaice larva. Stickney & White (1975) found in their experiments on *Paralichthys dentatus* that light induced ambicoloration could be reversed to varying degrees. The implications of this for deeper dwelling species of flatfishes is that when the pelagic larvae settle, the effects of anomaly inducing factors may be negated allowing normal pigment patterns to be reestablished whereas shallower water forms remain at depths where light intensities might prevent the reversal of anomalous pigmentation.

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