

Faits divers

Morphological and chronological tables of embryonic development in fish*

J. DEPECHE** and R. BILLARD***

This is a brief presentation of some references in embryonic development of fish including some species of agnatha. Numerous papers describe some morphological aspects of embryogenesis and the list below give several of them to show the variety of species studied and the long history of this discipline. Some works from the last century are very detailed, accurate and sometimes the drawings are colored by hand. Most of the recent papers give informations on chronology and

details on the incubation conditions (temperature and sometimes dissolved oxygene and other compounds).

Several works were conducted in a prospective of ecological and evolutionary embryology and some were recently edited by BALON (1985). A significant contribution came from Japanese scientists in the framework of trials to breed fish in sea ranching programmes.

Table 1. Some references of morphological and sometimes chronological tables of embryonic development

<i>Abramis brama</i> (hybrids)	RYABOV, 1973
<i>Acipenser transmontanus</i>	BEER, 1980
<i>Adinia xenica</i>	CUNNINGHAM, 1982
<i>Amia calva</i>	DEAN, 1895; BALLARD, 1986
<i>Anguilla japonica</i>	YAMAMOTO 1981-1982, YAMAMOTO <i>et al.</i> , 1975
<i>Aphyosemion calliurum</i>	PETERS, 1963
<i>Aptocyclus ventricosus</i>	KYÛSTIN, 1975
<i>Barbus barbus</i>	PENAZ, 1973
<i>Brachydanio rerio</i>	HISAOKA and BATTLE, 1958; LAALE, 1984
<i>Carassius auratus</i>	KAJISHIMA, 1960
<i>Chondrostoma nasus nasus</i>	DEDUAL, 1990
<i>Dicentrarchus labrax</i>	BARNABÉ, 1976
<i>Dorosoma petenense</i>	SHELTON and STEPHENS, 1980
<i>Dorosoma cepedianum</i>	"
<i>Eopsetta qriqorjewi</i>	FUJITA, 1965
<i>Ernogrammus hexagrammus</i>	FUJITA and USHITA, 1959
<i>Esox lucius</i>	LINDROTH, 1946; GIHR, 1957
<i>Fugu poecilonotus</i>	FUJITA, 1956a
<i>Fugu rubripes</i>	FUJITA and UENO, 1956a
<i>Fugu stitonotus</i>	FUJITA, 1956b
<i>Fundulus heteroclitus</i>	OPPENHEIMER, 1937; ARMSTRONG and CHILD, 1965
<i>Gobius niger jozo</i>	BALLARD, 1969
<i>Heterandria formosa</i>	FRASER and RENTON, 1940
<i>Hypophthalmichthys molitrix</i> (hybrids)	RYABOV, 1973
<i>Ictalurus nebulosus</i>	ARMSTRONG and CHILD, 1962
<i>Inimicus japonicus</i>	FUJITA and NAKAHARA, 1955
<i>Labeotropheus</i>	BALON, 1977
<i>Lampetra lamotteni</i> and others	SMITH <i>et al.</i> , 1968

*Recieved November 26, 1990

**Laboratoire de Physiologie de la Reproduction. Univ. P. and M. CURIE F. 75005 Paris. (Deceased)

***Laboratoire d'Ichtyologie, Muséum National d'Histoire Naturelle, 43, rue Cuvier F. 75231 Paris Cedex 05. To whom correspondence should be addressed.

Lepomis macrochirus and hybrids
Micromesistius poutassou
Nibea argentata
Nothobranchius guntheri
Nothobranchius korthausae
Oncorhynchus keta
Oncorhynchus mykiss (*S. gairdneri*)

Oncorhynchus nerka
Ophiocephalus striatus
Oryzias latipes

Percina caprodes semifasciata
Platypoecilus and *Xiphophorus*
Platypoecilus indicus
Platypoecilus maculatus
Poecilia reticulata
Polyodon spatula
Pseudoblennius percoides
Salmo trutta fario
Salmo salar

Scyliorhinus canicula
Sebastes oblongus
Sillago sihama
Sphyrna pinguis
Tanakuis kitaharai
Thymallus thymallus
Tinca tinca
Trichogaster trichopterus

HECKERMAN, 1969
 COOMBS and HIBY, 1979
 FUJITA, 1956c
 PETERS, 1963
 WOURMS, 1972
 MAHON and HOAR, 1956
 PASTEELS, 1936; BALLARD, 1973,
 WITSCHI, 1956-1962; VERNIER, 1969,
 KNIGHT, 1963
 VELSEN, 1980
 YAPCHIONGCO and DEMONTEVERDE, 1965
 GAMÔ and TERAJIMA, 1963
 HISAOKO and BATTLE, 1958
 PAINE and BALON, 1984
 TAVOLGA, 1949
 FUJITA and UENO, 1956
 TAVOLGA and RUGH, 1947
 BUI, 1963 in CHAMBOLLE, 1963
 BALLARD and NEEDHAM, 1964
 FUJITA, 1957
 HENNEGUY, 1888; KORPSCH, 1898
 TRIFONA *et al.*, 1959; KLINKHARDT, *et al.*, 1987;
 BATTLE, 1944
 BALFOUR, 1978; MELLINGER *et al.*, 1986;
 FUJITA, 1958
 UNENO and FUJITA, 1954
 SHOJIMA *et al.*, 1957
 FUJITA, 1965
 BIELEK, 1974; ZAYTSEV, 1986
 PENAZ *et al.*, 1981
 HISAOKA and FIRLIT, 1962

References

- ARMSTRONG, P. B. and J. S. CHILD (1962): Stages in the developmet of *Ictalurus nebulosus*. Syracuse University Press.
- ARMSTRONG, P. B. and J. S. CHILD (1965): Stages in the normal development of *Fundulus heteroclitus*. Biol. Bul., **128**: 143-168.
- BALFOUR, F. M. (1876): On the development of Elasmobranch Fishes. J. Anat. Physiol., **10**: 317-411, 517-570, 672-688.
- BALLARD, W. W. (1969): Normal embryonic stages of *Gobius niger joza*. Publ. Ataz. Zool. Napoli, **37**: 1-17.
- BALLARD, W. W. (1973): A new fate map for *Salmo gairdneri*. J. Exp. Zool., **184**, 49-71.
- BALLARD, W. W. (1973): Normal embryonic stages of *Gobius niger joza* Publ. Stat. Zool. Napoli, **37**, 1-17.
- BALLARD, W. W. (1986): Stages and rates of normal development in the Holostean fish *Amia calva*. J. Exp. Zool., **238**, 337-354.
- BALLARD, W. W. and R. G. Needham(1964): Normal embryogenic stage of *Polyodon spatula* (Walbaum). J. Morphol., **114**, 465-478.
- BALON, E. K. (1977): Early ontogeny of *Labeotropheus* Ahl, 1927 (Mbuna, Cichlidae, Lake Malawi), with a discuccion on advanced protective styles in fish reproduction and development. Env. Biol. Fish., **2**, 147-176.
- BALON, E. K. (1985): Early life histories of fishes. New developmental, ecological and evolutionary prospectives. Developments in environmental Biology of fish. 5, 280pp. Dr. W. Junk Publ.
- BARNABE, G. (1976): Contribution à l'étude de la biologie du loup *Dicentrachus labrax* L. (Poisson Serranidae). Thèse Doct. Etat USTL Montpellier F., 426p.
- BATTLE, H. I. (1944): The embryology of the Atlantic salmon (*Salmo salar*). Canad J. Res., D. **22**, 105-125.
- BEER, K. E. (1980): Embryonic and larval development of *Acipenser transmontanus*. M.Sc thesis Univ. California Davis, 93pp.

- BIELEK VON, E. (1974): Die entwicklung der asche *Thymallus thymallus* L. Zool. Jb. Anat. Bd., **82**, 137-162.
- BUI, G. (1963): Table chronologique du développement embryonnaire de *Lebistes reticulatus* Dipl. Et. Sup. Biol. Anim. Bordeaux. In Chambolle thèse 3ème cycle Univers. Bordeaux, 94pp.
- COOMBS, S. H. and A. R. HIBY(1979): The development of the eggs and early larvae of blue whiting, *Micromesistius poutassou* and the effect of temperature on development. J. Fish Biol., **14**, 111-132.
- CUNNINGHAM, J. E. R. (1982): Early ontogenesis of *Ardinia xenica* (Cyprinodontiformes, Fundulidae): some patterns and progress of epigenesis M.Sc thesis University of Guelph Ontario, 198 pp.
- DEAN, B. (1895): The early development of *Amia*. Quart. J. Microsc. Sci., **38**, 413-444.
- DÉDUAL, M. (1990): Biologie et problème de dynamique de population du nase *Chondrostoma nasus nasus* dans la petite sarine. Thèse Dost. es. Sciences CH. Fribourg, 168pp.
- FRASER, E. A. and R. M. RENTON(1940): Observations on the breeding and development of the viviparous fish, *Heterandria formosa*. Quart. J. Microsc. Sci., **81**, 479-520.
- FUJITA, S. (1956a): On the development and prelarval stages of the puffer, *Fugu (Shosaifugu) poecilonotus* (Temminck et Schlegel)Bul. Faculty Agric. Kyushu Univ., **15**, 531-536.
- FUJITA, S. (1956b): On the development and prelarval stages of the puffer, *Fugu (Shosaifugu) stictonotus* (Temminck et Schlegel)Bul. Faculty Agric. Kyushu Univ., **15**, 525-530
- FUJITA, S. (1956c): On the development of egg and prelarval stages of *Nibea argenta* (Houttuyn) Bul. Faculty Agric. Kyushu Univ., **15**, 537-540.
- FUJITA, S. (1957): On the development of egg and prelarval stage of a marine sculpin *Pseudobleinnius percoides* Günther Bul. Faculty Agric. Kyushu Univ., **16**, 11-115.
- FUJITA, S. (1958): On the egg development and larval stages of a viviparous scorpaenid fish, *Sebastes oblongus* Günther. Bul. Japan. Soc. Scienc. Fish., **24**, 475-479
- FUJITA, S. (1965): Early development and rearing of two common flatfishes *Eopsetta gricorjewi* (Herzenstein) and *Tanakius kitaharai* (Jordan et Starks). Bul. Japan. Soc. Sci. Fish., **31**, 258-262.
- FUJITA, S. and K. NAKAHARA (1955): On the development of the egg and prelarval stages of a scorpaenid fish, *Inimicus japonicus* (Cuvier et Valenciennes). Bul. Faculty Agric. Kyushu Univ., **15**, 223-228.
- FUJITA, S. and K. UCHIDA(1959): Breeding habits and rearing of larvae of a blennioid fish *Ernogrammus hexagrammus* (Temminck et Schlegel). Bul. Faculty Agric. Kyushu Univ., **17**, 283-289.
- FUJITA, S. and M. UENO(1956a): On the development and prelarval stages of Fugu (*Torafugu*) *Rubripes rubripes* (Temminck et Schlegel). Bul. Faculty Agric. Kyushu Univ., **15**, 519-524
- FUJITA, S. and M. UENO(1956b): On the development of egg and prelarval stages of *Platycephalus indicus* (Linné). Bul. Faculty Agric. Kyushu Univ., **15**, 513-518.
- GAMO, H. and I. TERAJIMA(1963): The normal stages of embryonic development of the Medaka, *Oryzias latipes*. Japan. J. Ichtyol., **2**(6), 31-38.
- GIHR, M. (1957): Zur Entwicklung des Hechtes. Rev. Suisse Zool., **64**, 355-474.
- HECKMAN, J. R. (1969): Embryological comparaison of *Lepomis macrochirus* X *macrochirus* and *Lepomis macrochirus* X *gibbosus*. Trans. Amer. Fish. Soc., **98**, 669-675.
- HENNEGUY, F. (1888): Embryogènese de la truite. J. Anat. Physiol., **24**, 413-502, 525-617.
- HISAOKA, C. K. and H. I. BATTLE(1958): The normal developmental stages of the zebrafish *Brachydanio rerio*. J. Morphol., **102**, 311-328.
- HISAOKA, K. K. and C. F. FIRLIT(1962): The embryology of the blue gourami, *Trichogaster trichopterus* (Pallas). J. Morph., **111**, 239-254.
- KAJISHIMA, T. (1960): The normal developmental stages of the goldfish *Carassius auratus*. Jap. J. Ichtyol., **8**, 20-28.
- KLINKHARDT, M., A. ANDREJ STRAGANOV and A. DIMA Pavlov (1987): Motricity of Atlantic salmo embryos *Salmo salar* L. at different temperature. Aquaculture, **64**, 219-236.
- KNIGHT, A. E. (1963): Embryonic and larval development of the rainbow trout *Salmo gairdneri*. Trans. Amer. Fish. Soc., **92**, 344-355.
- KOPSH, F. (1898): Die Entwicklung der äusseren Form des forellen embryo. Arch. mikr. Anat., **51**, 181-213.
- KYÛSHIN K. (1975): The embryonic and larval de-

- velopment, growth, survival and changes in body form, and the effect of temperature on these characteristics of the smooth lumpsucker *Aptocyclus ventricosus* (Pallas). Bul. Fac. Fish. Hokkaido Univ., **26**, 49-72.
- LAALE, H. W. (1983): Naturally occurring diablastodermic eggs in the zebrafish *Brachydanio rerio*. Can. J. Zool., **62**, 386-390.
- LINDROTH, I. (1946): Zur biologie der befruchtung und entwicklungs beim Hecht. Medd. Stat. Försökant, Sötvattens-fisket., **24**, 1-173.
- MAHON, F. F. and W. S. HOAR(1956): The early development of the chum Salmon *Oncorhynchus keta*. J. Morphol., **98**, 1-48.
- MELLINGER, J., F. WRISEZ and J. ALLUCHON-GÉRARD (1986): Developmental biology of an oviparous shark, *Scyliorhinus canicula*. pp 310-332 in Indo-Pacific Fish Biology (T. UYENO, R. ARAI, T. TANIUCHI and K. MATSUURA eds) Ichtyol. Soc. Japan, Tokyo.
- OPPENHEIMER, J. M. (1937): The normal stages of *Fundulus heteroclitus*. Anat. Rec., **68**, 1-15.
- PAINE, M. D. and E. K. BALON(1984): Early development of the northern log-perch *Percina caprodes semifasciata* according to the saltatory ontogeny. Env. Biol. Fish., **11**, 173-190.
- PASTEELS, J. (1936): Etudes sur la gastrulation des vertébrés méroblastiques. I-Téléostéens. Arch. Biol., **47**, 205-308.
- PENAZ, M. (1973): Embryonic development of the barb *Barbus barbatus* (Linnaeus 1958) Zool. Listy, **22**, 363-374.
- PENAZ, M., E. WOHLGEMUTH, J. HAMACKOVA and J. KOURIL (1981): Early ontogeny of the *Tinca tinca*, 1. Embryonic period. Folia Zoologica., **30**, 165-176.
- PETERS, N. (1963): Embryonale Anpassungen oviparer Zahnkarpfen aus periodisch austrocknenden Gewässern. Int. Rev. ges. Hydrobiol., **48**, 257-313.
- RYABDOV, I. N. (1973): Embryonic and larval development characteristics of hybrids of silver carp *Hypophthalmichthys molitrix* (Val.) and Eastern bream *Abramis brama orientalis* (Berg). J. Ichtyol., **13**, 701-714.
- SHELTON, W. L. and R. R. STEPHENS(1980): Comparative embryogeny and early development of threadfin and gizzard shad. Progr. Fish. Cult., **42**, 34-40.
- SHOJIMA, V., S. FUJITA and U. KEITARO(1957): On the egg development and prelarval stages of a kind of barracuda, *Sphyræna pinguis* Günther. Bul. faculty Agric. Kyushu Univ., **16**, 313-318.
- SMITH, A. J., J. H. HOWELL and G. W. PIAVIS(1968): Comparative embryology of five species of lampreys of the upper great lakes. Copeia, **3**, 461-469.
- TAVOLGA W. N. (1949): Embryonic development of the platy-fish *Platypoecilus*; the swordtail *Xiphophorus* and their hybrids. Bul. Am. Mus. Nat. Hist., **94**, 161-230.
- TAVOLGA W. N. and R. RUGH (1947): Development of the platyfish *Platypoecilus maculatus*. Zoologica. USA., **32**, 1-15.
- TRIFONA, A. N., M. F. VERNIDOUBE and N. D. PHILLIPOV (1939): Les périodes critiques dans le développement des salmonidés et leurs bases physiologiques. Acta Zool., **20**, 239-267.
- UENO, M. and S. FUJITA(1954): On the development of the egg of *Sillago sihama*. (Forsk.) Japan. J. Ichtyol., **3/4/5**, 118-120.
- VELSEN, F. P. J. (1980): Embryonic development in eggs of sockeye salmon, *Oncorhynchus nerka*. Can. Sp. Publ. Fish. Aquat. Sci., **49**, 18pp.
- WITSCHI, E. (1956): Development of vertebrates Saunders. Philadelphia.
- WITSCHI, E. (1962): Prenatal vertebrate development Characterization of developmental stages, Salmonid Fishes. Growth, 329-331.
- WOURMS, J. P. (1972): The developmental biology of annual fishes III. Preembryonic and embryonic diapause of variable duration in the eggs of annual fishes. J. Exp. Zool., **182**, 389-414.
- YAMAMOTO, K. (1981): Cleavage pattern and formation of the blastocoel in the egg of the eel, *Anguilla japonica*. Jap. J. Ichtyol., **27**, 301-308.
- YAMAMOTO, K. (1982): Periblast in egg of the eel, *Anguilla japonica*. Jap. J. Ichtyol., **28**, 423-430.
- YAMAMOTO, K., K. YAMAUCHI and S. KASUGA(1974): On the development of the Japanese eel *Anguilla japonica*. Bul. Japan. Soc. Sci. Fish., **41**, 21-28.
- YAPCHIONGCO, V. J. and L. C. DEMONTEVERDE (1965): The biology of dalag, *Ophicephalus striatus*. Nat. Applied Sci. Bul., **19**, 133-159.