Atelier international sur les bases biologiques de l'aquaculture des siluriformes

C. Albiges

BASIL 94

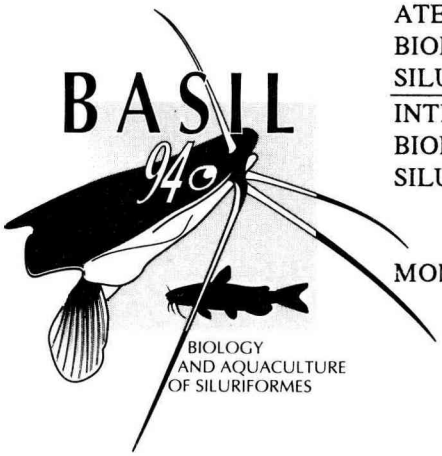
BIOLOGY AND AQUACULTURE OF SILURIFORMES

Atelier international sur les bases biologiques de l'aquaculture des Siluriformes

International workshop on the biological bases for aquaculture of Siluriformes

RESUMES

Montpellier 24-27 mai 1994



ATELIER INTERNATIONAL SUR LES BASES BIOLOGIQUES DE L'AQUACULTURE DES SILURIFORMES

INTERNATIONAL WORKSHOP ON THE BIOLOGICAL BASES FOR AQUACULTURE OF SILURIFORMES

MONTPELLIER : 24-27 MAI 1994

RESUMES

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Basil '94

SOMMAIRE

Les articles sont classés par session et dans chaque session par ordre alphabétique sur le nom du premier auteur

Communications are filed by session and according to first author's last name in alphabetical order

SESSION

DIVERSITE BIOLOGIQUE

BIOLOGICAL DIVERSITY

Communication affichée / Poster

VARIABILITE BIO-ECOLOGIQUE CHEZ *CHRYSICHTYS AURATUS*. ETUDE DE CERTAINS PARAMETRES DE SA REPRODUCTION DANS DIFFERENTES SITUATIONS HYDROCLIMATIQES DU FLEUVE NIGER

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Une variation intraspécifique importante a été remarquée par Risch (1986) au plan morphologique et méristique chez *Chrysichthys auratus*, espèce à très faible variabilité génétique (Agnèse 1991). Nous analysons ici la variation intra-spécifique au plan bio-écologique. Différents paramètres de la reproduction de *Chrysichthys auratus* (saisonnalité de la maturation ovarienne, fécondité et taille des ovocytes, taille de maturité sexuelle) sont étudiés dans des stations d'échantillonnage réparties dans la zone soudano-sahélienne, sur le cours du Niger. Trois stations (Kankan, Mopti et Niamey) intègrent un gradient latitudinal (pluviométrique) et amont-aval. *C. auratus* présente une reproduction très étalée dans l'année. La population de Niamey module peu son effort de reproduction; par contre, deux périodes de ponte privilégiées s'individualisent dans le haut Niger et le delta central ; la première correspond au début de la saison des pluies, la seconde au début de la période des hautes eaux. Dans le haut Niger les femelles présentent une fécondité relative moindre mais des ovocytes de diamètre plus élevé que dans le moyen Niger. Le même type de variation se retrouve au niveau saisonnier dans le haut Niger où l'on constate en outre l'existence parmi les reproducteurs de deux groupes de taille qui pourraient avoir des tactiques de reproduction différentes: en début d'année il existe une proportion de femelles matures plus importante chez les petites que chez les grandes et c'est l'inverse pour la deuxième saison de reproduction.

C. auratus apparait très polymorphe dans ses caractéristiques bio-écologiques relatives à la reproduction. Cette souplesse adaptative lui permet d'exploiter les différentes opportunités saisonnières du milieu pour sa progéniture, notamment les ressources liées d'une part à l'arrivée des pluies et d'autre part à l'arrivée de la crue.

Synthèse / Review Lecture

LIFE HISTORY STYLES OF SILURIFORM CATFISHES

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Siluriform catfishes are a diverse and widespread group of temperate and tropical freshwater and marine fishes. Although they are restricted in their ecological roles by morphology and other factors, the siluriforms are highly diverse in terms of ecomorphology and have adopted a wide variety of life-history styles. They range from small to very large bottom-feeding predators and scavengers and often form a major competitive element in their ecosystems. Siluriforms have representatives in all major breeding guild groups (non-guarders, guarders and bearers) and exhibit a wide range of altricial to precocial life-history styles. Parental investment in each young and parental care vary widely. They include generalists and specialists and are characterised by high levels of sensory development. The evolutionary success of the siluriforms can be ascribed, inter alia, to their domination of benthic habitats resulting from their adaptable feeding and breeding styles.

Communication affichée / Poster

FOOD NICHE OVERLAP AND PARTITIONING IN CLARIID CATFISHES (OSTEICHTHYES: CLARIIDAE) OF THE ANAMBRA FLOODRIVER SYSTEM

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The food relationships of *Clarias gariepinus, C. anguillaris, C. ebriensis, C. agboyiensis, C. macromystax, C. buthupogon* and *Heterobranchus longifilis* showed trophic niche overlap in all species. Surface, midwater and bottom fish food organisms were well represented in their diets. The overlap between adult *C. ebriensis, C. agboyiensis, C. macromystax* and *C. buthupogon*, and juvenile *C. gariepinus, C. anguillaris* and *H. longifilis* was predominant, reflecting their spatial overlap in littoral habitats. Intra-specific food niche overlap was more pronounced in *C. ebriensis, C. agboyiensis, C. macromytax* and *C. buthupogon* than in *C. gariepinus, C. anguillaris* and *H. longifilis*. Loose, season-independent food partitioning was established in the Clariids; *C. ebriensis, C. agboyiensis, C. macromystax* and *C. buthupogon* selected fish fries, while the other Clariids fed on larger-sized fish. In extensive fish culture systems in the fadama of the Anambra basin, the Clariids exploit all trophic niches and show great flexibility in feeding.

Communication affichée / Poster

THE PHYLOGENY AND BIOGEOGRAPHY OF THE GLYPTOSTERNOID FISHES (THE FRESHWATER CATFISH FAMILY : SISORIDAE)

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The glyptosternoid fishes are fresh water catfishes belonging to the family Sisoridae. This group can be identified from other sisorid fishes by the following main characters : 1. the last unbranched pectoral fin ray pinnate and soft, giving off soft point cartilaginous rays along the anterior margin which are enveloped in the membrane of the fin ; 2. the lack of an adhesive organ on the breast ; and 3. the horizontal insertion of the pectoral and ventral fins. These characters appear to be adaptations to the fast running brooks at high altitudes or at the base of the hills, where most of these catfish are found. There are nine genera containing 28 species in glyptosternoid fishes.

The matrix of 60 characters based on the osteology is sent to the computer and run by the Hennig 86 program; there is only one cladogram produced; based on this, following relationship of glyptosternoid fishes are hypothesized.

(1) The glyptosternoid fishes is a monophyletic group defined by 13 apomorphies, they differ from any other sisorid fishes especially in having the pectoral fin ray giving off point cartilaginous rays.

(2) The *glyptosternum* is the most primitive genus, which bears many plesiomorphy. All the other sisorid fishes are descended from it.

(3) Some external characters are the adaptive characters, so they are based on the ecological reason, result, they are incongruence with the evolutionary polarity stemmed from the osteology. Such as the posterior labia fold, mouth sucker, but these had been treated as the systematic character and used to produce evolutionary tree (Chu, 1979).

(4) Many of the conflicting characters occur in a group of taxa including *Exostoma*, *Glaridoglanis*, *Pseudexostoma* and *Oreoglanis* which appear to have gained a number of derived features by convergence. But my character analysis indicated that some specialized characters of the *Exostoma* and *Glaridoglanis* are derived directly from the primitive status, they have not systematic relationships with the *Pseudoexostoma* and *Oreoglanis* (having the mouth sucker, continuous labial fold).

(5) The genus *Pareuchiloglanis* is not a monophyletic group, they form a monophyly only when add the *Pseudexostoma* and *Oreoglanis* in.

The biogeographical analysis indicated that glyptosternoid fishes developed from the *Glyptothorax* -like ancestor by the strong stress of fast running water environment due to the interval uplift of the Qinghai/Tibet Plateau. Because of there existed widely distributed ancestor and the nature environment, a vicariance explanation for the distribution of glyptosternoid fishes is accepted.

Communication orale

SPECIES OF SILURIFORMES IN SOUTH VIETNAM

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The identification of Siluriformes order in South Vietnam (the Mekong delta and the Southeast of South Vietnam) has been carried out from 1981 to 1983. The study was continued in some coastal provinces such as Kien Giang, Minh Hai and Ba Ria-Vung Tau in 1989 and finished in 1991.

There were 51 species, 18 genus, 7 families including Siluridae (5 genus, 11 species), Clariidae (1 genus, 2 species), Plotosidae (1 genus, 2 species), Pangasiidae (4 genus, 13 species), Bagridae (3 genus, 11 species), Sisoridae (1 genus, 1 species) and Ariidae (3 genus, 11 species).There were two main ecological groups of fish existing in the studied area. The first group is freshwater fish including Siluridae, Pangasiidae, Clariidae, Bagridae, Sisoridae and the second one is marine and coastal fish migrating to freshwater bodies for feeding and breeding for a short time such as Plotosidae and Ariidae. Many species of *Pangasius* genus (Pangasiidae) only habitat in the Mekong river. In the other hand, some species of Siluridae e.g. *Wallagonia miostoma, Kryptopterus bleekeri, Mystus rhegma...*, only exist in the Southeast of South Vietnam but not in the Mekong River. Some species and genus are distributed all over the water bodies of South Vietnam, (*Wallagonia attu, Leiocassis siamensis, Mystus nemurus, Clarias* spp.,...).

There are 18 species among the total of studied fish having high commercial value. Some species are cultivated in ponds, lakes and rivers such as *Clarias macrocephalus* and their hybrids (Clariidae) and especially *Pangasius* spp. in ponds and in cages in the Mekong River. The two main cultivated species of *Pangasius* are *P. hypophthalmus* (formerly known as *P. micronemus*) in ponds and *P. bocourti* (formerly known as *P.pangasius*) in cages.

Some species are aquarium fish such as *Ompok bimaculatus* and *Pangasius sutchi*. Other fish could also be of aquariophilic interest : *Kryptoterus bicirrhis, Mystus vittatus, Leiocassis siamensis*. These fish live in school in rivers at high biomass. But some species now are highly valuable and some races are prone to be extinct (Red data Book of Vietnam, 1992). Two species, *Bagarius bagarius* (Sisoridae) and *Wallogonia miostoma* (Siluridae) are threatened in vulnerable level (V. level). In spite of large distribution, *Clarias batrachus* (Clariidae) has limited life area and are threatened in Threatened level (T. level). *Pangasius gigas* are listed in Rase level (R. level).

Communication orale

BIODIVERSITY OF CATFISHES IN THE HIMALAYAN WATER OF NEPAL AND THEIR CONSERVATION AND MANAGEMENT

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Diverse groups of Siluriformes occur in Himalayan waters of Nepal and offer an opportunity of development of aquaculture of these groups in this country. The important families found in the water courses of Himalayan foot-hills are Siluridae, Heteropneustidae, Clariidae, Bagridae, Amblycipitidae, Sisoridae, Schilbeidae, Pangasiidae, Chacidae. Among these families Bagridae, Amblycipitidae, Sisoridae, Pangasiidae are least studied. In the present paper kind, occurrence, distribution and reproductive potential of various species in the inland waters of Nepal are discussed. Breeding, management strategies and economically important cold water species living in snowfed water such as *Glyptothorax pectinopterus*, *Pseudecheneis sulcatus*, *Amblyceps mangois* are discussed. Besides these management of migratory catfish such as *Bagarius bagarius*, *Clupisoma gaura*, *Pseudeutropius antherinoides* in tail water of dams and reservoirs are discussed. The possibility of ranching economical species of catfishes are highlighted. Future areas of research, innovation conservation and management are identified.

Communication affichée / Poster

ZOOTECHNICAL PATTERN OF SURUBIM *PSEUDOPLATYSTOMA CORUSCANS* (AGASSIZ, 1829) (SILURIFORMES, PIMELODIDAE)

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Due to the high commercial promising of cultivated surubim (*Pseudoplatystoma coruscans*), some of its zootechnical patterns were established. Linear standard length, head length, height, width, largest perimeter, peduncular perimeter, dorsal thickness and wide thickness and mass (total and head weights) measurements were obtained. Head length/standard length, height/standard length, width/stantard length, largest perimeter/ standard length and height/width have shown linear relationship whereas total weight/standard length was expressed by $TW = 0.0019\ SL^{3.523}$.

TAXONOMY, PHYLOGENY AND BIOGEOGRAPHY OF SILURIFORMES : AN OVERVIEW

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Siluriformes, commonly known as catfishes, are one of the economically important groups of fresh and brackish fishes in the world: in many countries they form an important part of inland fisheries; several species have been introduced in fishculture; finally numerous species are of interest to the aquarium industry where they represent an important part of the world trade.

Nelson (1984) mentioned 31 familles with about 400 genera and about 2211 species of Siluriformes. However, the systematics of this order are still rather poorly known both on the taxonomic and the phylogenetic level. New species, new genera and even new families are still being described and disagreement exists on the interrelationships of the families.

Siluriformes have a wide geographical distribution and are found in North, Central and South America, Africa, south-east Asia, Eurasia, Japan and Australia. Except for two families with essentially marine species, Siluriformes are merely freshwater fishes.

In the following overview the position of the Siluriformes in the ichthyological classification is documented and a definition of the order is given. Recent data on numbers of families, genera and species of Siluriformes are presented and followed by a taxonomic review per continent. Finally the origin and the zoogeography of the Siluriformes are discussed and a summary of our present knowledge on their phylogeny is given.

Communication affichée / Poster

SILURIFORMES OF THE ARAL SEA BASIN

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The Siluriformes are represented in the Aral sea basin by two species : the european catfish *Silurus glanis*, and the turkestan catfish *Glyptosternum reticulatum*. In the middle of the 1980's the channel catfish *Ictalurus punctatus* was brought to Uzbekistan from U.S.A. Experimental fish culture is made by 2 fish-farms. The annual production is not large yet : about 10 t.

Turkestan catfish, the smallest species (about 25 cm) inhabits only upper reaches of the Aral basin rivers - Amudarya and Syrdarya - , lives in fast streams and has no gameness.

European catfish *Silurus glanis* is widely spread in the Aral basin, where specimens of 200 kg are known. Fishery was based on the anadromous populations. 4 % of the total catch consisted of catfish.

The ecological crisis which began in the Aral basin in 1961 has led to drastical changes in biota. The impact on the biology of fishes was especially strong because all anadromous and semi-anadromous species could no more reach the sea, as main feeding reservoir, and its large seashore as egg-laying area. This has led to a stop in the reproduction and a decrease of the number of fish. Especially, such late maturing species as catfishes have suffered. The age composition is reduced significantly, but there is no decrease of growh rate and fecundity.

Under present conditions, the Aral catfish species need to be protected and their populations should be supported. In Uzbekistan, it is suggested to organize fish-rearing of the local species for reintroduction into the natural population.

SESSION

REPRODUCTION

REPRODUCTION

SPAWNING AND MANAGEMENT OF GAMETES AND EGGS IN THE SILURIFORMES

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The structure of gonads and gametes is highly diversified in Siluriforme fish; in some groups the testis are composite with an anterior part formed of spermatogenetic tissues and the posterior part of seminal vesicles which may store or not spermatozoa. For catfish species of aquaculture interest, ovaries present the same general morphology as in other teleosts with oviducts. Spermatozoa are biflagellated in the Channel catfish (*Ictalurus punctatus*) and monoflagellated in the European catfish (*Silurus glanis*) and African catfishes (*Clarias gariepinus, Heterobranchus longifilis*). The egg size shows considerable intergroup differences, from 1.1-1.5 mm in Pangasiids and Clariids up to 15-20 mm in Ariids. In most cases, the eggs are adhesive and develop either a surrounding sticky layer (*Ictalurus, Chrysichthys, Silurus*) or an adhesive disk (*Clarias, Heterobranchus*) after oviposition.
Fertilization is in general external but internal fertilization is reported in some species. The annual sperm production was measured in European catfish and Channel catfish as 1.7×10^{11} and 1.8×10^{10} spermatozoa/kg body weight, respectively. In females, the relative fecundity ranges from about 50 eggs/kg body weight in Ariids up to more than 100,000 eggs/kg body weight, e.g. in Pangasiids.
A large variety of controlled reproduction systems are found in the Siluriformes. In some cases (*Ictalurus, Chrysichthys, Hoplosternum*), spawning occurs naturally in ponds or tanks providing that adequat spawning substrates are available; fertilized eggs are collected immediately after spawning and placed into incubators until hatching. But for most species, although natural or semi-natural spawning could be achieved in captivity, the tendency at the present time is to develop techniques using hormonal-induced ovulation and artificial insemination in order to control the various steps of reproduction and to allow gamete preservation and manipulation. Oocyte maturation and ovulation or spermiation can be induced in many species by a large variety of hormones (GnRHs, fish gonadotropins, HCG, various steroids...).
Some informations are available on gamete biology and preservation. Sperm motility is short, not exceeding 40-60 sec of forward movement as in most other freshwater teleosts. A peculiarity of the European catfish sperm is the activation by urine during sampling which could be prevented by direct collection in an immobilizing solution (NaCl 280 mOsm/kg). Spermatozoa cryopreservation was successfully attempted in several species (*S. glanis, C. gariepinus, I. punctatus*). Ova generally survive only a few hours after ovulation and fertilization must be carried out soon after.
Techniques for gamete collection, insemination and incubation of eggs are detailed for the most widely cultured Siluriforme species.

Communication affichée / Poster

SUMMARY OF THE EMBRYONIC DEVELOPMENT OF THE BRAZILIAN SILURIFORME *PSEUDOPLATYSTOMA CORUSCANS*

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Due to its importance as a future cultivated siluriform fish, *Pseudoplatystoma coruscans* has aroused the interest of various southeastern Brazilian hatchery stations which are now engaged in developing technologies regarding its artificial propagation. In this paper we present a pictorial view of the normal pattern of its embryonic development in order to give support to the work routine at the station .

The eggs were obtained through hypophysation and incubated at 25-26°C and observed under the microscope. They measured 1.3 ± 0.1 mm in diameter after hydration.

The following stages were then registered. Stage 1 - Blastodisc formation: the fertilized eggs formed a homogeneous mass. The separation of the blastodisc from the vegetal (yolk) pole began 0.5 h after fertilization (AF), followed by blastodisc cleavage. Stage 2 - High blastula: after successive cleavages, the blastomeres reached this stage 2.5 h AF and became noticeable in the animal pole. Stage 3 - Flat blastula: half hour AF the blastomeres flattened over the yolk. Stage 4 Gastrulation: epiboly began and at 5.5 h AF epiblast (the epidermic stratum), hypoblast (notochord-meso-endoderm), and periblast (perivitellinic syncitium) were easily seen. Stage 5 - Closure of blastopore: the enlargement of the periblast and epiblast over the yolk ended with the closure of the blastopore at 6.6 h AF. Stage 6 - Optic vesicles: lateral outpockets from the brain - the optic vesicles, and the first five somites appeared at 10 h AF. Stage 7 - Kuppfer's vesicle: This structure was registered 12 h AF. Stage 8 - Otoliths: the otoliths appeared at 15 h AF and at this stage the tail started moving slowly and the heart beat. Stage 9 - Hatching: at 19 h AF almost all embryos were hatching.

Communication affichée / Poster

SPERM MOTILITY CHARACTERISTICS IN EUROPEAN CATFISH *(SILURUS GLANIS)*

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Several aspects of sperm biology of the European catfish (*Silurus glanis*) are presented: the knowledge of some of these aspects is certainly usefull for application to artificial reproduction of the European catfish in many respects. The potentiality of the European catfish spermatozoa to move was investigated using microscopic observation combined with stroboscopic illumination and video recording and analysis. Following incubation of hormonally induced freshly collected sperm in various pH buffered mediums, the main informations were obtained concerning : 1) the activability of sperm cells (percentage of motile cells), 2) the distance covered per unit time (speed), 3) the shape of the head tracks (linear or circular), 4) the beat frequency of the individual flagella, as well as the average frequency vs time 5) the wave shape along the flagellum .

Present results show that: a-at stripping, urine can easily contaminate sperm and lead to sperm samples with poor motility parameters; b-triggering of motility is mainly prevented by the high osmolality of the surrounding medium independantly of molecular nature of the solute (for instance ions such as Na Cl or non ionic solutions such as sucrose above 250 mOsm/Kg) which offers a good situation for short term preservation, c-motility is triggered in nearly 100% cells within 1-2 sec following transfert of cells in a low osmolality medium, d-all the motility parameters abovementionned decrease rapidly during the forward motility phase of spermatozoa which lasts mostly 40 seconds. The % of motile cells stays close to 100% for 40-50 sec and then drops to lower values; the beat frequency decreases during this period from 50 Hz down to 10-15 Hz. Initial waveform, observed on still images corresponding to spermatozoa at 4-5 sec post activation, shows quasi sinusoidal patterns with 3-4 bent regions along the lengths of the flagellum and 4-5 mm amplitude. At 40-50 sec post activation, flagella beating at low frequency present a dampened non sinusoidal oscillation with 6-7 bends of lower amplitude close to the head and very flattened waves in the distal region, leading to very low forward displacement efficiency. The tracks followed by head traces are slightly curved . e-some irreversible dammages such as curling of the distal part of the flagella appear in nearly 100% cells during early (5-10 sec.) exposure to fresh water: these dammages are prevented by use of an osmolality protective medium (such as 50 mM NaCl), in which case a slow motility period follows the 40 sec fast period and may lasts several minutes.

It is concluded from the present results on the European catfish that the ability of its spermatozoa to reach optimal motile properties shows large differences according to their environmental conditions or the time post-activation.

Communication orale

SEASONALITY OF THE REPRODUCTIVE CYCLE OF FEMALE *HETEROBRANCHUS LONGIFILIS* IN TROPICAL PONDS

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The aim of this study was to monitor the reproductive cycle of female *Heterobranchus longifilis* in its natural environment and under hatchery conditions in order to optimize controlled spawning in this species. Four experimental groups were set up :
The first group (I) was formed by adult females that were brought from their natural habitat, the Cross River Delta in Southern Nigeria, into ponds (Fish Farm Complex, University of Calabar, Nigeria). A second experimental group (II) consisted of broodfish that had been adjusted to husbandry conditions for at least one year. The third set of females (group III) was hatched under artificial conditions and reached sexual maturity in captivity. Females of the natural population in the Cross River served as controls (group IV).
Over a one year period blood samples were taken from individually marked females of groups I-III on a biweekly basis. At the same time females were weighed and checked for their gravidity. If ripe eggs were found, females were stripped, the eggs were fertilized and hatched artificially. Egg yield, fertilization and hatching rate were recorded.
None of the feral breeders that were transferred into ponds during their natural breeding season, could be stripped again the same year. The breeding season of both group II and III started in January. Seasonal changes in fecundity showed a peak between April and June. Fecundity of group III was generally higher. The average time intervall between two strippings of every single female was 6-8 weeks. Viable eggs were obtained from the adjusted feral breeders until August, whereas the breeding season of the hatchery-bred females was terminated in October. Two thirds of the latter females were stripped four or more consecutive times. Throughout the season high percentages of normal larvae ($74 \pm 9\%$) were obtained.
An enzymeimmunoassay for determination of plasma levels of testosterone and estradiol in catfish was used to monitor the corresponding seasonal patterns of sexual hormones.

Communication affichée / Poster

SOME METHODS OF ELIMINATION OF STICKINESS OF EUROPEAN CATFISH (*SILURUS GLANIS L.*) EGGS

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The European catfish is a typical plant spawner. After contact with the water its eggs develop a thick, gelatinous outer layer, which is very sticky. It is absolutely essential to get rid of this stickiness, in order to incubate the eggs in flasks. It is possible to achieve a high survival rate of eggs or embryos only if they float singly, not clumped together, in the water.
In these experiments three methods for reducing stickiness were compared:
- the well-known and frequently practised method according to Horvath (1979). After fertilization the eggs are put untreated into the flasks. They attach themselves onto the inside wall of the flask and form a big clump. About 12 hours after being put into the flasks, the eggs are treated for 5 minutes with alkalin protease. They then lose their stickiness.
- the eggs are fertilized and immediately afterwards, treated for 15 minutes in a clay suspension.
- after fertilization the eggs are treated with a tannic acid solution for 3 minutes.
A comparison of the experiments showed that all three methods are suitable for preparation of eggs for incubation in flasks. The survival rate of the eggs or embryos was almost identical. However the eggs which were treated with enzymes started to hatch about 6 hours earlier.
Electron microscope investigations of the surface of the eggs were carried out further, It was possible to show how these structures change through the use of the enzyme.

Communication orale

THE VITELLOGENIC OOCYTE OF TWO BRAZILIAN SILURIFORMES, *PSEUDOPLATYSTOMA CORUSCANS* AND *LOPHIOSILURUS ALEXANDRI*

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The zona pellucida and follicular cells play an important role in, respectively, the fertilization process, and in the vitellogenesis and final maturation of the oocyte. In order to understand the morphological basis of these structures in two important Brazilian Siluriformes - *Pseudoplatystoma coruscans* and *Lophiosilurus alexandri* - a comparative analysis of the histochemical components of their vitellogenic oocyte was performed.

Ovary fragments of *Pseudoplatystoma coruscans* and *Lophiosilurus alexandri* were fixed in Bouin's fluid, embedded in paraffin, and cut into sections (4-7 μm. thick) for histological study and for histochemical demonstration of carbohydrates and proteins; other fragments, fixed in either in formalin or calcium-formol, and cut on cryostat (10-12 μm thick), were used for lipid demonstration.

In vitellogenic oocytes (VO) of *P. coruscans* and *L. alexandri* which measured, respectively, 512 $\pm$ 63 μm and 1,506 $\pm$ 197 μm in diameter, distinct cortical vesicles (CV) and vitellinic (yolk) globules (VG) were observed. The CV appeared as non stained or slightly basophilic vacuolated structures. They were arranged as the cortical alveoli (CA) in the form of a continuous layer (in *L. alexandri*) and of non-continuous multilayer (in *P. coruscans*) of small peripheral vesicles containing neutral glycoproteins. Variations in the morphology and contents of the CA may indicate different mechanisms of polyspermy blockage. Neutral lipids, besides neutral glycoproteins, were detected in the VG of both species.

The zona pellucida of vitellogenic oocytes of *P. coruscans* and *L. alexandri* was arranged in one layer which contained neutral glycoproteins and was, respectively, 1.2 $\pm$ 0.4 μm and 1.5 $\pm$ 0.4 μm thick. The follicular cells (FC) of same vitellogenic oocytes were columnar in both species. In *P. coruscans*, they contained neutral glycoproteins associated to sulfated acid glycoconjugates and was 18.8 $\pm$ 1.9 μm in height. In *L. alexandri*, they contained neutral glycoproteins associated to carboxylated acid glycoconjugates and measured 35.4 $\pm$ 4.3 μm in height. Interpretations about the meaning of these histochemical differences could not be expanded at the present paper.

Synthèse / Review lecture

INTERNAL AND EXTERNAL FACTORS CONTROLLING REPRODUCTION IN THE AFRICAN CATFISH, *CLARIAS GARIEPINUS*

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The African catfish, *Clarias gariepinus*, is a highly appreciated species for aquaculture, because of its favourable food conversion, its resistance to diseases, its relatively low requirements for water quality, the possibility for high stocking density and the excellent meat quality. For those reasons even in the Netherlands, there is a modest but expanding catfish farming activity.

Although this species grows and matures in captivity, there is no spontaneous reproduction. We could demonstrate that the failure to reproduce resides in the brain-pituitary-gonad axis. Hormones required for oogenesis and spermatogenesis are being produced in sufficient quantities. However, final oocyte maturation, ovulation, spermiation and spawning behaviour do not occur, due to the lack of a gonadotropin surge.

In nature, the prespawning gonadotropin surge is induced by environmental factors such as the water level in the spawning area. Under farming conditions the environmental cues are hard to identify and to mimic. In combination with unavoidable stress this causes a blockade on the release of gonadotropin releasing hormone (GnRH). Consequently, gonadotropin surge release fails to occur, which is enforced by an effective hypothalamic dopaminergic inhibition. The gonadotropin surge induces the conversion of 17αOH-progesterone into 17α-hydroxy-20ß dihydroprogesterone, the final maturation inducing substance.

Based on these data, several protocols for artificial propagation could be developed. They include either a treatment with a GnRH analogue in combination with a dopamine receptor antagonist, a treatment with homologous gonadotropin or HCG, or a treatment with 17αOH progesterone. Since a number of years we use the African catfish as a model for fundamental research on fish reproductive endocrinology. GnRHs and gonadotropins were fully characterized (a specific catfish-GnRH and chicken-GnRH II) and the cDNAs encoding these hormones were cloned. The importance of the two GnRH forms for gonadotropin release was studied. Chicken-GnRH II appears to be 10 to 100 times more potent than catfish GnRH. Steroid hormone synthesis by ovaries, testis and seminal vesicles was analyzed. The sex steroids that play a role in the negative feedback control of gonadotropin release were identified (11-O-testosterone and testosterone) and their interaction with hypothalamic dopamine metabolism was demonstrated as one of the possible mechanisms of action. Several steroid conjugates from the seminal vescicles were shown to have pheromonal activities, involved in reproductive behaviour.

Recently, attention has been focussed on pubertal development. First data have shown that the sensitivity of the hypophysial gonadotropic cells for GnRH and the testis for gonadotropin do not develop synchronously, suggesting that in prepubertal stages not all parts of the brain pituitary-gonad axis are fully effective.

Communication affichée / Poster

CARACTERISATION DE LA MATURATION SEXUELLE ET APPROCHE PEU ONEREUSE DE PRODUCTION D'ALEVINS CHEZ *CHRYSICHTHYS NIGRODIGITATUS* (TELEOSTEI ; BAGRIDAE)

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Près d'une centaine de géniteurs (mâles et femelles) ont été suivis pendant deux périodes de reproduction. Un ensemble de caractères morphologiques et biométriques permettant la sélection des meilleurs spécimens à mettre à nid ainsi que le suivi de leur état sexuel après la formation des couples a été proposé.

Une nouvelle technologie, de conception simple et très peu onéreuse de production d'alevins de *Chrysichthys nigrodigitatus* a été mise au point en lagune Ebrié. Cette technique utilise, pour seule source d'énergie, les mouvements des vagues de la lagune. Elle a permis pour la première fois, en ce qui concerne l'espèce indiquée, de réaliser l'incubation, l'éclosion des oeufs et l'alevinage directement en lagune. Les calculs économiques donnent pour l'alevin de 15 - 20 g, un coût de production (30 F CFA) 5 à 6 fois inférieur à celui obtenu actuellement dans les autres structures existantes.

Communication orale

OVARIAN MATURATION OF A CATFISH, *CLARIAS BATRACHUS* BY PURIFIED MURREL HYPOTHALAMIC GONADOTROPIN RELEASING HORMONE

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Ovarian maturation is essential for induced breeding of a catfish. In India one of the major problems to induce ovarian maturation in a catfish is the shortage of good quality pituitary glands. To overcome this problem it is now necessary to use an alternative source of hormone which will have less problem for storing, with potentiality for induced maturation of catfish equally or higher than pituitary extract. The objective of this experiment was to determine the effectiveness of purified murrel (*Channa punctatus*) hypothalamic Gonadotropin releasing hormone (cGnRH) on the induced ovarian maturation of a catfish (*Clarias batrachus*). We have purified cGnRH by acetone fractionation, gel filtration (Sephadex G-25), ion exchange chromatography (FPLC, Mono-Q) and reverse phase chromatography (FPLC, Pep-RPC). At each step of purification cGnRH activity was examined by adding fraction into the enzymatically dispersed murrel pituitary cell culture and then determined the amount of gonadotropin released into the medium by Radioimmunoassay. During induced ovarian maturation experiment, female catfish were injected with cGnRH by utilizing modified Linpe method. Oocyte diameter measured at 16h, 20h, and 24h in treated catfish showed an increase of about 45% (maximum) at 20h from the initial diameter, while in control fish mean oocyte diameter remained unaltered. In treated fish 85% (considering total number of oocyte) Germinal vesicle breakdown (GVBD) was observed at 24h, whereas GVBD did not occur in control fish. These findings indicate that cGnRH has great potentiality for inducing final ovarian maturation of an Indian catfish.

Communication affichée / Poster

OOCYTE DEVELOPMENT IN FEMALE RIVER CATFISH, *MYSTUS NEMURUS* (CUVIER & VALENCIENNES) FOLLOWING TREATMENT WITH GONADOTROPIN RELEASING HORMONE ANALOG

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The influence of exogenous administration of [D-Ala6, Pro9-NHEt] LHRH (GnRH-A) on oocyte development in sexually maturing female catfish, *Mystus nemurus* was investigated over a period of five weeks. Females were divided into five groups (n=6 per group) and treated as follows: 1) intact (untreated) fish; 2) sham hormone cholesterol pellet implant control (SHAM IMP); 3) 100 µg GnRH-A cholesterol pellet implant (GnRH-A IMP); 4) a single saline injection/wk (SAL INJ); 5) a single 20 µg/kg GnRH-A injection/wk (GnRH A INJ). The criteria for the effectiveness of the hormone treatment includes oocyte maturation and ovulation, oocyte frequency distribution, oocyte diameter (OCDM) and germinal vesicle (GV) migration. GV position was staged as follows: 1) GV in the central position; 2) GV migrated midway to animal pole; 3) GV in peripheral position against egg membranes; 4) germinal vesicle breakdown (GVBD), and 5) ovulation (GV disappeared). At the beginning of the experiment, ovaries were biopsied for determination of the initial OCDM and GV position. At the initial stage of the study, OCDM and mean GV position of all the experimental females ranged from 1.01± 0.01 to 1.13 ± 0.02 mm and 1.02 ± 0.01 to 1.41 ± 0.06, respectively. Only a single female receiving GnRH-A cholesterol pellet ovulated 7 days after hormone implantation. In contrast, none of the controls responded to the hormone treatment. Upon termination of the experiment, OCDM and mean GV position ranged from 0.98 ± 0.01 to 1.20 ± 0.01 mm and 1.00 ± 0.00 to 1.49 ± 0.06, respectively. An analysis of oocyte frequency distribution and GV migration have shown that females receiving hormone treatment have advanced oocyte development. However, to reduce stress due to handling it is suggested that GnRH-A incorporated in a cholesterol pellet be used to accelerate oocyte development in river catfish compared to injection of hormone.

Communication affichée / Poster

DEVELOPPEMENT EMBRYONNAIRE CHEZ *CHRYSICHTHYS NIGRODIGITATUS* (BAGRIDAE)

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L'étude du développement embryonnaire de *Chrysichthys nigrodigitatus* a été effectuée. Les différentes étapes chronologiques relatives à la segmentation, à la gastrulation et à l'organogenèse ont été décrites. L'acquisition de ces connaissances nous a permis de caractériser avec précision les stades embryonnaires chez cette espèce. Elle permet donc de prévoir le moment de l'éclosion. L'utilité pratique est d'abord de permettre de distinguer relativement tôt des oeufs non fécondés et de mieux gérer l'incubation. Les oeufs de *Chrysichthys nigrodigitatus* sont du type télolécithe, très riches en vitellus. La segmentation est du type partielle qui n'intéresse que le pôle supérieur de l'oeuf. La plus grande partie (partie inférieure) restera insegmentée. C'est une segmentation discoïdale dont le clivage forme le blastodisque au niveau de la partie supérieure de l'oeuf sur lequel se formera l'embryon. Le blastodisque se développe, s'étale et couvre la masse vitelline. Parallèlement l'organogénèse de l'embryon (neurulation, bourgeon caudal) se poursuit jusqu'à l'éclosion (au bout de 80 à 90 heures à 29°C). Nos observations se sont poursuivies au cours du développement larvaire, jusqu'à la résorption complète des réserves vitellines (de l'éclosion jusqu'au 15ème jour). Une table chronologique fondée sur 10 stades de développement a été établie. Chaque description est accompagnée d'un croquis aidant ainsi à l'identification des différents stades. Quelques recommandations sont suggérées pour les observations ultérieures telles que relations vitesse de développement-température, les conditions létales aux différents stades, études comparées avec d'autres espèces proches comme *Chrysichthys maurus* et *Chrysichthys auratus*.

Communication orale

SYNTHESE DES OBSERVATIONS REALISEES EN GUYANE SUR LA BIOLOGIE DE LA REPRODUCTION DE L'ATIPA *HOPLOSTERNUM LITTORALE* (SILURIFORME, CALLICHTHYIDAE) : CYCLE ANNUEL, ROLE DU NID ET INFLUENCE DES CONDITIONS THERMIQUES D'INCUBATION SUR LE DETERMINISME DU SEXE

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Cette synthèse présente les acquis sur la Biologie de la Reproduction de l'Atipa, depuis 1986 en Guyane Française. Elle rassemble les travaux réalisés en milieu naturel et en pisciculture expérimentale.

Le cycle annuel de reproduction, étudié à partir de l'observation des gonades (évolution des valeurs du RGS, examen histologique des gonades et évaluation de la fréquence relative des diamètres folliculaires) et de l'enregistrement des nids construits sur les bassins de la pisciculture, met en évidence :

- Un synchronisme entre l'avènement des pluies et le début des pontes
- Une activité reproductrice importante (pour la construction et la garde du nid chez les mâles & dans les pontes successives, jusqu'à 14, qui peuvent représenter 170 % du poids vif chez les femelles) durant 3 mois de la petite saison des pluies (décembre à février), suivie d'un déclin progressif à partir du "petit été de mars"
- L'existence d'une période réfractaire aux pontes, nécessaire à la reconstitution des réserves, durant la grande saison des pluies (Mai à Juillet).

La construction par l'Atipa d'un nid d'écume et d'herbe amène à examiner l'intérêt de cette stratégie au regard des conditions du milieu naturel et des conditions d'élevage.

Les rôles joués par le nid dans la reproduction de l'espèce sont présentés dans un schéma de synthèse qui souligne :

- que centre du territoire défendu par un mâle, il joue un rôle de protection mécanique contre les intempéries et les prédateurs
- qu'il pallie la pauvreté en oxygène des eaux marécageuses en permettant aux oeufs de bénéficier d'une interface avec l'air ambiant
- qu' il offre un environnement thermique plus constant et plus chaud que ne le ferait le milieu aquatique environnant.

Les expériences réalisées en milieu contrôlé font également apparaître une influence des conditions thermiques des incubations sur les variations du sexe ratio. La durée de l'incubation limitée à une cinquantaine d'heures (36 heures à 34 °C à 67 heures à 24 °C) indique une période thermosensible précoce au cours de l'ontogénèse. Ces observations ouvrent des perspectives d'applications chez une espèce où les mâles ont une croissance plus rapide que celle des femelles.

Communication affichée / Poster

REPRODUCTIVE CYCLE OF *SILURUS GLANIS L.* REARED IN WARM WATER

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The natural reproduction of *S. glanis* occurs during the period of May to June. The production of fry is done using different methods. The rearing of the fry takes place either in ponds, natural waters or increasingly in recent years in warm water, too. The time of reproduction determines the growth of the fry. Therefore, marketable fish and stocking material of a certain size are only available during a short time of the year. The data presented are based on investigations conducted with sheat-fish bred in warm water (20 - 25°) of the lignite plant in Jänschwalde (United energy plants corp.). It could be noticed that from a certain weight per fish (3 kg) within the stocks of marketable fish a certain percentage of mature males (≈10 %) and females (≈10 %) occurred. Between February and September 1993 some mature fish were selected and produced successfully. These investigations indicate that it is possible to produce fry of *S. glanis* at any time of the whole year. This would also lower the costs of production. The paper contains the most important biotechnological figures of the controlled reproduction.

Communication affichée / Poster

ASPECTS OF THE REPRODUCTIVE BIOLOGY OF *HYPOSTOMUS AFFINIS* LACEPEDE, 1803 (OSTEICHTHYES, LORICARIIDAE) SPAWNING SEASON, OVARIAN DEVELOPMENT AND FECUNDITY

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Hypostomus (=*Plecostomus*) comprises the species of armoured catfishes and it belongs to the Loricariidae family which distribution is limited to South and Central America continental waters. *H. affinis* (Lacépède, 1803) is the most abundant species of this genus that occurs in the lower sections of Paraiba do Sul river in the East Brazilian basin. Due to the extensive interest ot this species as a fishery resource in natural waters it is surprising that so little information is available concerning its life-history. The present work presents some aspects of the reproductive biology of this species. Bimestral trends in gonadosomatic indices and stages of ovarian development show that spawning season extended from September to February. The histological and oocyte size-frequency analysis indicated a fractional spawning and an asynchronous mode of ovarian development. Five phases of oocyte development were recorded. A maturity scale of six stages of gonadal development is proposed on basis of gonadal macroscopic morphology and oocyte composition. Fecundity was determined from the number of vitellogenic oocytes in mature ovaries and indicated that the reproductive strategy of *H. affinis* is characterized by a high absolute fecundity (1295-2310) when compared with other Loricariidae species.

Communication affichée / Poster

CARACTERISTIQUES HISTOLOGIQUES DU DIMORPHISME SEXUEL DES EPINES PECTORALES DE L'ATIPA *HOPLOSTERNUM LITTORALE* (PISCES, TELEOSTEI, SILURIFORMES).

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Il existe une nette différence de taille des épines pectorales entre mâle et femelle adultes chez l'atipa. Celles du premier sont plus longues et surtout plus épaisses que celles de la seconde. Ces caractéristiques morphologiques apparaissent avec la première maturation génitale. Chez le mâle il existe une nette dissymétrie de l'épine par suite d'une accélération de l'ostéogenèse sur son bord de fuite. L'os formé est très vascularisé, signe d'une très forte activité ostéogénitrice. Le marquage vital confirme ce résultat et montre que la vitesse moyenne des dépots osseux est voisine de 23 µm/j, soit une vitesse instantanée qui pourrait dépasser les 50 µm/j. Dans les secteurs équivalents de l'épine pectorale des femelles, le tissu osseux est peu ou pas vascularisé et la vitesse d'ostéogenèse ne dépasse pas 1 µm/j.

Il semble que chaque période de maturation génitale s'accompagne, chez le mâle, d'un nouveau dépôt d'os hypervascularisé. Il est donc possible de connaître le nombre de reproductions effectuées par les atipas mâles dans la nature à partir de l'étude histologique de leurs épines pectorales.

Communication affichée / Poster

PURIFICATION AND ASSAY OF VITELLOGENIN FOR TWO AFRICAN CATFISH SPECIES *CHRYSICHTHYS NIGRODIGITATUS* (BAGRIDAE) AND *HETEROBRANCHUS LONGIFILIS* (CLARIIDAE)

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Two specific Enzyme Linked Immunosorbent Assays (ELISA) for Vitellogenin (VTG) were developed using two different antisera anti-plasma VTG purified by Electrophoresis and electro-elution. Vitellogenin was purified from plasma of 17 β-Estradiol treated fish (cumulated dose of 5 mg/kg over a 15 days period, 1 mg/kg/injection) containing 1 mM of the protease inhibitor phenylmethylsulfonyl fluoride (PMSF). The electrophoresis was performed on 7.5 % gels under SDS non reducing conditions. Electro-elution was performed at 1 mA/cm^2 for 3 hours using an SDS-Tris-Glycine buffer. In these conditions from 20 µl of plasma, 600 µg of VTG were eluted from the VTG band. Both vitellogenins migrated as single bands of an apparent molecular weight of 146 kDa and 152 kDa for *C. nigrodigitatus* and *H. longifilis* respectively.

The VTG antibodies were raised in rabbits by injecting 100 µg of the VTG preparations in 500 µl of 8 $g.l^{-1}$ NaCl with 500 µl of complete Freund's adjuvent (4 injections spaced by 7 days). After a resting period of 10 days the rabbits received 2 boosting injections of 100 µg of VTG plus 500 µl of incomplete Freund's adjuvent spaced by 15 days. The serum was collected 7 days after the second boosting injection.

The ELISA was performed on 96 well microtiter plates using the peroxidase anti-peroxidase technique. The whole procedure was performed in less than 24 hours with the following assay characteristics : VTG coating (100 ng/ml) ; VTG antibody diluted 1 : 70 000 ; a sensitivity of 5 to 700 ng/ml in the range 90 %-10 % of binding with intra- and inter-assay variations of 6.5 % (n = 20) and 8.5 % (n = 15) respectively at 50 % of binding.

Parallel displacement curves were obtained between electrophoresis purified VTG and female plasma as well as plasma from treated fish. Both antibodies cross-reacted with the heterologous VTG but there was no parallelism of the curves obtained with the heterologous VTG and the homologous VTG, indicating different antigenic structures of the two catfish species VTG molecules. The reliability and the specificity of these assays allowed us to quantify VTG in plasma samples during vitellogenesis and other experimental conditions.

Communication orale

COMPARATIVE STUDY OF VITELLOGENESIS IN TWO CATFISH SPECIES *CHRYSICHTHYS NIGRODIGITATUS* (BAGRIDAE) AND *HETEROBRANCHUS LONGIFILIS* (CLARIIDAE)

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Chrysichthys nigrodigitatus and *Heterobranchus longifilis* are two commercially important African catfish that have been studied for their reproduction and breeding possibilities under fish farming conditions in the coastal lagoon waters of Ivory Coast.

C. nigrodigitatus is characterised by an annual reproductive cycle with a vitellogenesis period lasting from March to June. The reproductive season coincides with the small rainy season (from September to November) which is characterised by lower water temperature and salinity levels at the beginning (September) and by a progressive rise of these parameters at the end of the season (November). The previtellogenic oocytes enter vitellogenesis at an average diameter of 250 μm. This initial oocyte stock is reconstituted as soon as the spawning is achieved and lasts for a period of approximately 3 months (from December to March). Fully vitellogenic oocytes reach an average diameter of 2.8 mm by the end of June. The maturation is possible only if a male and a female are confined in artificial nests. Maturation and spawning generally occur within the following 3 to 5 weeks for 30 to 80 % of the females. When the non-spawning females are kept in the nests they maintain fully vitellogenic oocytes for 3 months with a continuous atresia of the larger oocytes, while the ovaries of the non-spawning females placed in the breeding tanks out of the nests undergo a complete atresia of all the vitellogenic oocytes.

After an induced spawning the reproductive cycle of *H. longifilis* can be achieved in less than a month in the brackish waters of the Ebrié lagoon. The previtellogenic oocytes enter vitellogenesis at an oocyte diameter of about 200 μm and become fully vitellogenic after 15 days (0.7 mm in diameter). If maturation is not artificially stimulated the females remain at the same stage of vitellogenesis while larger oocytes undergo atresia and are continuously replaced by fully vitellogenic oocytes. This oocyte turn over allows the artificial stimulation of maturation at any time of the year. Furthermore we showed that multiple vitellogenesis-maturation cycles can be achieved successfully with the same female with minor variations of fecundity and egg quality.

From these observations we conclude that the mobilisation of the materials and the energy necessary to the synthesis of vitellogenin and to its incorporation within the oocytes leading to the formation of the egg yolk, takes the place in a very short period of time in *H. longifilis* compared to the time required in *C. nigrodigitatus*. These two species present two different strategies in terms of vitellogenesis and reproductive cycles.

Communication affichée / Poster

TESTICULAR STRUCTURE AND SPERM CRYOPRESERVATION OF THE AFRICAN CATFISH *HETEROBRANCHUS LONGIFILIS* (CLARIIDAE)

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The morphological and physiological characteristics of the testes and spermatozoa of the catfish *Heterobranchus longifilis* are described. Aspects of the spermatogenesis are presented using histological and ultrastructural observations of the gonad. The coexistence in the lobules of spermatozoa and all the spermatogenetic stages indicates that this species is able to perform continuous reproduction.

The sperm of five males *Heterobranchus longifilis* was collected by dissecting the anterior lobes of the testes and pooled.

Different cryopreservation trials were conducted using several extenders and cryoprotective agents in order to evaluate their suitability as cryodiluents : 10 % Glycerol (E1), 10 % DMSO (E2). Mounib's medium to which were added 10 % DMSO and 10 % egg yolk (E3), and Mounib's medium with 5 % DMSO, 5 % Glycerol and 10 % egg yolk (E4). These different diluents were mixed with the sperm at a ratio of 1 : 3, placed in 5 ml straws and allowed to freeze above liquid nitrogen for 20 min. The straws were then stored in the liquid nitrogen for 24 hours.

The sperm motility and fertilizing ability were measured before and after cryopreservation. No motility was observed after thawing in the sperm treated with E1 and E2. The semen extended with E3 and E4 was not altered by the freezing-thawing process and exhibited sperm motility. However, the highest motility scores were produced with E4 extender.

Ovules of one female *H. longifilis* were inseminated with the Mounib's media E3 and E4. An insemination ratio of 0.2 ml of milt for 0.4 g (about 300) ovules was used. It appeared that cryopreserved milt was effective in fertilization and hatching trials. Hatching rates using fresh and cryoprotected milt, percentages of normal and deformed larvae are presented.

Communication orale

INFLUENCE DE LA TEMPERATURE SUR LA MATURATION GONADIQUE FINALE DU SILURE GLANE (*SILURUS GLANIS* L.) : APPLICATION A LA REPRODUCTION HORS SAISON NATURELLE

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Les techniques actuelles de production d'alevins de silure glane en écloserie et les conditions climatiques en France ne permettent d'obtenir, en fin de seconde saison d'élevage intensif, que 10 à 30% de poissons commercialisables (poids > 1,5 kg). Pour maintenir un cycle de production court (en 2 saisons) et réduire l'immobilisation des structures d'élevage, nous avons expérimenté à l'échelle de semi-production, une technique de ponte induite hors saison naturelle.

Chez le silure glane, la maturation gonadique finale de la femelle est influencée principalement par la température. La somme des températures moyennes quotidiennes dépassant 15 °C peut servir de repère pour évaluer en pisciculture le moment le plus opportun pour induire l'ovulation. Le suivi d'écloseries commerciales en France nous a permis d'évaluer cette quantité de chaleur pour un cycle complet à 3 400 - 3 500 degrés-jours. Après la période hivernale, 900 à 1 000 degrés-jours (T > 15 °C) au minimum sont nécessaires pour aboutir à la fin de la maturation gonadique et à la ponte.

Transférés avant la fin de l'hiver (T: 8-10°C) en écloserie où la température de l'eau est progressivement augmentée jusqu'à 24-25°C, les géniteurs sont prêts à se reproduire après avoir accumulé plus de 950 degrés-jours. Il est ainsi possible d'anticiper la ponte de deux à trois mois par rapport à la période naturelle. Les expérimentations réalisées montrent que :

- le diamètre modal des ovocytes augmente progressivement jusqu'à un pallier (1,8 - 2,2 mm) qui correspond à la fin de la maturation gonadique ;
- les meilleurs résultats d'induction de ponte sont obtenus entre 1 100 et 1 300 degrés-jours avec injection de LH-RH-a + Pimozide (0.1 mg et 5 mg par kg de poids vif), suivie éventuellement par une injection complémentaire d'extraits hypophysaires de carpe (5 mg/kg de Poids Vif), si l'ovulation n'a pas été obtenue 40 heures après la première injection ;
- les taux d'éclosion et de malformation des larves sont comparables à ceux que l'on obtient lors d'une reproduction en saison normale.

Après un prégrossissement en écloserie-nourricerie pendant environ deux mois, les juvéniles sont transférés en bassins extérieurs pour grossissement intensif afin de répondre à l'objectif de poids.

Communication orale

PRODUCTION ET GESTION DES SPERMATOZOIDES CHEZ LE SILURE EUROPEEN *SILURUS GLANIS*

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La production spermatogénétique annuelle, a été mesurée sur un lot de cinq silures glanes mâles, âgés de 3 ans, élevés à 20°C et sacrifiés à la fin de leur premier cycle de reproduction. Les mâles ont été alimentés pendant les 18 premiers mois *ad libitum* puis ensuite à 1,5 % du poids corporel/j de granulé pour truite. Les animaux ont été transférés à l'écloserie Heymann (Moselle, France), 48h avant l'expérience et ont été mis à jeun dès leur entrée en écloserie. Les femelles dont les ovules ont été utilisés pour les tests de fécondation, ont été élevées en étang et nourries essentiellement de poissons fourrages. Un prélèvement de un gramme a été effectué dans trois régions différentes du testicule (antérieure, médiane, postérieure), et broyé à l'aide d'un broyeur "Turax" dans 9 ml de solution saline 120 mM NaCl, pendant 1/2 à 1 mn, puis la dilution est portée à 1/2000 et la quantité de spermatozoïdes est déterminée par dénombrement des têtes spermatiques sur cellule de Thoma. Afin de déterminer la proportion de spermatozoïdes produits dans les testicules et utilisables lors de la reproduction artificielle, cinq mâles ont recu des injections de préparations hypophysaires de carpe, à raison de 4 mg /kg du poids vif, dissoute dans une solution saline (125 mM NaCl). Pour prévenir l'activation des spermatozoïdes par l'urine lors du prélèvement plusieurs solutions à base de NaCl, KCl ont été utilisées à différentes concentrations (de 110 à 310 milliOsmoles/kg) et pH 7; tampon Tris-HCl 30 mM. La réactivation des spermatozoïdes a été faite dans l'eau de l'écloserie et dans une solution saline (NaCl 30 mM, Tris HCl 30 mM, pH 7) et l'évolution du pourcentage de spermatozoïdes mobiles a été suivie après activation.

La production spermatogénétique annuelle du silure glane (*Silurus glanis*) s'est élevée à $1,7 \pm 0,3.10^{11}$ spermatozoïdes par kg de poids vif ce qui correspond à un RGS de $1,41 \pm 0,20\%$; il s'agit donc d'une espèce oligospermique. Il n'y a pas de spermiation spontanée et l'injection de préparation hypophysaire de carpe permet d'obtenir, dans les 24 h qui suivent, $1,49 \pm 0,7$ ml de sperme par mâle soit 0,5 ml par kg de poids vif. Cela correspond à $3,6 \times 10^9$ spermatozoïdes/kg soit 2% environ de la production spermatogénétique annuelle. Les spermatozoïdes spontanément activés par l'urine lors du prélèvement doivent être prélevés dans une solution d'immobilisation dont la pression osmotique est d'au moins 300 mOsmoles/kg. La solution d'activation servant de diluer pour les spermatozoïdes immobilisés doit avoir une pression osmotique finale de l'ordre 100 mOsmoles/kg et un pH de 7.

Communication affichée / Poster

EXPERIMENTAL INDUCED SPAWNING OF *PSEUDOPLATYSTOMA CORUSCANS*, THE MOST IMPORTANT COMMERCIAL FRESHWATER BRAZILIAN SILURIFORME FISH

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Pseudoplatystoma, with its two main species *P. coruscans* and *P. fasciatum*, is the most important freshwater siluriforme in the Brazilian commercial fisheries, being its most expensive table fish. *P. coruscans*, the largest species of the genus, reaches over 100 kg of body weight (BW). It is piscivore and performs long reproductive migration. Last years have seen a steady decline in its fishing yields and apparently it is in extinction in various Brazilian regions.

Twelve females (13.2±3.1 kg BW) and 12 males (5.1±1.5 kg BW), kept in ponds, were hypophysed using crude carp pituitary extract (CPE). The females were selected by their reddish genital papilla and the males by oozing semen at handling. The females were injected with 0.8±0.1 mg of CPE/kg BW and after 13.1±0.4 h with 6.1±0.2 mg of CPE/kg BW. The males received 2.3±0.2 mg of CPE/kg BW at the time of the injection of the 2nd dose in the females. Seven of the females released eggs under extrusion 225.7±4.5 degree-hours after the second dose, at the temperature of 24.3±0.7°C. The eggs were free, demersal, opaque and yellow. They measured 0.8±0.1 mm in diameter at stripping and 1.3±0.1 mm after hydration. The ova weight:body weight ratio (%) = 4.8±1.0, the number of eggs/g of ova = 2,554±121 and the fertilization rate (estimated at blastopore closure, in %) = 70.4±14.9. Initial fertility (indicated as the number of stripped eggs x 106) = 1.63±0.61 whereas the final fertility (the number of viable eggs at blastopore closure x 106) = 1.24±0.66. The relationship between body weight and initial (IF) and final fertility (FF) were expressed, respectively by : IF = -890137 + 191.1 BW (r = 0.95; n = 7) and FF = -12566 + 188.9 BW (r = 0.87; n = 7). Five females died within 1 week after treatment.

These results indicate that *P. coruscans* broodstock can be maintained in captivity. Although they do not naturally propagate in such conditions, they are susceptible to hypophysation procedures, which opens a major perspective for its cultivation.

Communication affichée / Poster

STUDIES ON BREEDING OF AIR-BREATHING SILURIFORMES CLARIAS BATRACHUS (LINN.) AND *HETEROPNEUSTES FOSSILIS* (BLOCH) IN AGROCLIMATIC CONDITIONS OF INDIA

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The main constraints of adoption for aquaculture of *Clarias batrachus* (Linn.) and *Heteropneustes fossilis* (Bloch) in India are availability of stockable size of seed and extension support, although a number of aquaculture demonstration trials given under All India Co-ordinated Project on Air-breathing Fishes of Indian Council of Agricultural Research proved the viability of this group of fishes for aquaculture.

The natural breeding takes place in low-lying areas and rice fields, where fishes migrate with the onset of monsoon and nursed, reared and caught before winter. In control breeding, environmental conditions are very important. To produce mass scale seed, it should be done in specially prepared rice fields, which imitates the natural conditions with appreciable success. For *C. batrachus* effective dose of pituitary gland of Indian major carps was 10-14mg/100g of recipient with egg drop rate of 75 - 100% while in *H. fossilis* effective dose was 8-10mg/100g of recipient with the breeding rate of 100%. The fertilization and hatching rate of eggs of *C.batrachus* was 94.35% and 86.15% respectively and for *H. fossilis* it was 76.6 - 97.3% and 73.3% respectively. Larvae production ranged between 800 - 840 per 100g of female body weight, whereas, for *H. fossilis* it was 6500 per 100g female body weight. Different methods of breeding described are natural breeding, stripping method, breeding in plastic pools, breeding in dry bunds (flooding dry ponds) etc.

Communication affichée / Poster

MILT-EGG RATIO IN ARTIFICIAL FERTILIZATION OF THE ASIAN CATFISH, *CLARIAS MACROCEPHALUS* (GUNTHER), INJECTED SALMON GONADOTROPIN-RELEASING HORMONE ANALOGUE AND DOMPERIDONE

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The optimum milt-egg insemination ratio was investigated in the freshwater Asian catfish, *Clarias macrocephalus* using milt extracted from Ovaprim, which contains 0.02 µg salmon gonadotropin-releasing hormone analogue (sGnRHa) + 10 µg domperidone (DOM)/µl. Milt production was measured 12, 24, and 48 h after a single intramusclar injection of 0, 0.5, 1, and 2 µl Ovaprim/g BW (Experiment 1). Mean milt production (5.84 µl/g BW) peaked at 24 h after injection of 2 µl Ovaprim/g (0.04 µg sGnRHa + 20 µg DOM/g BW), while mean sperm density significantly decreased to 2.55 x 10^6 spermatozoa/µl. Fertilization, hatching, and larval survival rates were not significantly different when milt from treated and untreated males was used. Various aliquots (2.5, 5, 10 g) of eggs were also inseminated by different volumes (2, 5, 10, 25, 50, 100, 200 µl) of diluted milt (1:3.5 in 0.9 % NaCl) extrated 24 h after injection of 2 µl Ovaprim/g BW (Experiment 2). Fertilization was significantly influenced by the volume of milt used, but not by the quantity of eggs inseminated. Hatching rates (13-50 %) were variable, although more eggs hatched when inseminated by more milt. Survival of larvae (60-79 %) did not significantly differ when 2.5, 5, and 10 g egg aliquots were fertilized by various volumes of milt. Fertilization (70 %) and hatching (41-46 %) rates (data pooled from 2, 2.5, and 10 g aliquot egg samples) were consistenly high when inseminated by 25 and 50 µl milt, indicating that an insemination ratio of 25-50 µl milt to 10 g egg, or approximately 4-8 x 10^3 spermatozoa/egg is required. A 100 g male catfish injected 2 µl Ovaprim/g BW can therefore produce 5.84 µl milt/g BW, which is capable of fertilizing 286-572 g eggs from 13-26 females. This study demonstrated an effective means of stimulating milt production in *C. macrocephalus* by Ovaprim treatment, which maximized the use of limited quantities of extracted milt.

Communication orale

SPAWNING CATFISH *CLARIAS MACROCEPHALUS* (GUNTHER) AT DIFFERENT TIMES DURING AN ANNUAL REPRODUCTIVE CYCLE

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The Asian catfish *Clarias macrocephalus*, is becoming scarce in the Philippines after the introduction of *C. batrachus* from Thailand. The artificial propagation of *C. macrocephalus* was initiated by SEAFDEC/AQD to prevent its permanent loss in natural waters. Studies that determined the appropriate egg size, proper time of stripping females, effective dose combination of luteinizing hormone-releasing hormone analogue (LHRHa) and pimozide (PIM) and their effects on egg quality, led to the development of induced breeding protocol *of C. macrocephalus*. However, most of these studies were done within the natural breeding season. To test the responsiveness of captive catfish, induced spawning experiments were done during the off season (February), before (May), during (August) and end (November) of the natural breeding period. Intramuscular injections were given to five fish in each treatment consisting of 0.05 μg LHRHa + 1 μg PIM/g body weight (BW), 0.05 μg LHRHa, 1 μg PIM, LHRHa vehicle (0.9% NaCl) and PIM vehicle (1 dimethylsulfoxide : 9 propylene glycol). Results showed that only fish injected with the combination of LHRHa and PIM spawned at different times during the annual reproductive cycle, although initial egg size was similar among fish within a season. However, initial egg size was largest in fish induced to spawn in May (1.59 mm), followed by fish induced in August and November (1.54 mm), and smallest in fish induced in February (1.49 mm). Ovulation rate was 100% when fish were induced to spawn before and during the natural breeding season, but decreased to 80% and 60% when the fish were injected during the end of the season and off-season, respectively. Fertilization, hatching and survival rate of the larvae upon resorption were similarly higher in fish induced in May, September and November, than in February. These results indicate that although captive catfish contain vitellogenic eggs the whole-year round, initial egg size, ovulation rate, egg production, fertilization, hatching and survival rates are higher in fish induced to spawn before, during and at end of the natural breeding period than during the off season.

Communication orale

SOME BIOLOGICAL CHARACTERISTICS AND THE ARTIFICIAL REPRODUCTION OF RIVER CATFISH (*PANGASIUS MICRONEMUS* BLEEKER) IN THE SOUTH VIETNAM.

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River catfish (*Pangasius micronemus* Bleeker) is commonly cultured in small ponds in the Mekong Delta. Its yield is from 10 to 15 tons/ha per year. The induced spawning of this species has been achieved since 1981. In nature, *Pangasius micronemus* is a carno-omnivorous species, but in pond, they can be adaptable to food supplied by farmers. Fish can reach the weight of 0.7 - 1.5 kg/fish after a year of culture. This species has a good tolerance of unsuitable water conditions, e.g. critical concentration of dissolved Oxygen: 0.213 mg/l, demand of Oxygen expenditure: 104.42 mg O_2/kg of fish per hour. Fish gets mature at the age of 3^+ - 4 years. The relative fecundity varies from 139,000 to 150,000 eggs/kg of female. The eggs are sticky. The mature coefficient is from 3 to 12.57% in natural conditions. The spawning season lasts from May to July. In spawning period, most parent fishes migrate upstream to river sections belonging to Kratie and further for their spawning.

For induced reproduction, annually, from January the broodstocks are reared on special diet with the density of 20 - 30 kg of fish per 100 square meter. The food with protein component of 30 - 35% includes rice bran and fish meal which are boiled and mixed with vitamin - premix. The daily diet is 4 - 5% of the weight of fish . The maturation ratios are 90 - 95% in female and 100% in male. For the female, the Primary dosage of 1 - 2 mg of pituitary and the secondary dosage of 5 - 6 mg of pituitary plus 1,500 - 2,000 IU HCG per kg of fish are used, the interval between two injections is 8 - 12 hours, for the male, the single dosage of 1 - 2 mg of pituitary per kg of fish is used. The artificial fertilization is applied. The spawning rate is 80 - 90%, the fertilization rate is 70% in average. The incubation lasts 18 - 20 hours and the hatching rate is 70 - 85%.

After the depletion of yolk, fry is nursed in earthen pond. The survival rate is 8 - 10% (at the length of 8 - 10cm). The survival rate can attain 30%, if fry is reared in concrete tank for two weeks before released in earthen pond.

Communication affichée / Poster

BIOLOGICAL NOTES ON *LEIOCASSIS CRASSILABRIS* (GUNTHER, BAGRIDAE)

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During October, 1991 to July, 1992, 211 specimens of *Leiocassis crassilabris* were collected from the Jialing River. Their biometric characteristics were described. The cross-sections of the decalcified pectoral spines were used for age determination. The body length and the spine "radius" was shown to be linear corelated. 80% of the catches consist of 2 and 3 age groups. The weight, as well as the condition factor for females were higher than that for males of corresponding lengths. The females were confirmed to spawn once in spawning season from May to July. Sex ratio was a little in favor of female. Age and size at first maturation of female was 2 years old with a body length of 10.6 cm. Absolute fecundity of the female was from 583 to 2792 (mean 1372) eggs, and greatly related to body length, body weight, age and G.S.I.. The fertilized eggs, with a diameter of 2.0-2.2 mm, were very sticky. Under the water temperature of 26.5-30.5°C, 50 hr and 42 min was required from fertilized egg to the hatching out of the larva. Total length of the newly hatched larvae were 5.2-5.8 mm.

Communication orale

STUDIES ON THE REPRODUCTIVE HABITS OF THE SOUTHERN CATFISH *(SILURUS MERIDIONALIS* CHEN)

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The southern catfish (*Silurus meridionalis* Chen) is a species endemic to China and widely distributed in the Yangtz and Zhujiang Rivers and their larger tributaries. As a piscivore it occupies the highest trophic level in the freshwater ecosystem. It has highly commercial fishery value for its quick growth, large size, and delicious meat. In recent years this fish is becoming an important species for aquaculture in China. In order to study the reproductive habits of this species, monthly samples were collected in the Jialing River from January, 1983 to February 1985 and from January, 1990 to June, 1992. The age at first sexual maturity of *Silurus meridionalis* is 2 or 3 years old in the male and 3 or 4 in the female. In the two age groups the average values of body length, weight, condition coefficient and gonadosomatic index of adult individuals are higher than those of juvenile ones in the same age group for either male or female. The dominant distributions in the age composition of the reproductive population are 3-5 year groups (75.01 %) in the male and 4-6 year ones in the female. The dominant distributions of body length in the reproductive population range from 65 cm to 85 cm in the male (57.90 %) and 75 cm to 95 cm in the female (58.42 %), respectively ; and those of body weight range from 2000 g to 6000 g in the male (67.10 %) and 4000 g to 8000 g in the female (61.80 %), respectively. The spawning season in the Jialing River lasts from the middle of March to the middle of May, when the water temperature ranges from 15°C to 24°C. From June to August the gonad of stage VI in the spawned female degenerates into stage II. From September to November the gonad develops into stage III, and changes gradually into stage IV. It remains at the stage IV to pass through winter (from December to February). Only one peak value occurs on the annual cycle of the gonadosomatic index in either male or female, which suggests that this fish spawns only once a year. The spawning grounds locate at pebbly shoals with the water depth of 0.4-1.5 m and the current velocity of about 0.7 m/s. During courtship the parental fishes pursue and snap fiercely each other.

SESSION

GENETIQUE

GENETICS

Communication affichée / Poster

ANDROGENESIS IN THE AFRICAN CATFISH, *CLARIAS GARIEPINUS*

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Haploid androgenetic offspring (max. 81.0 %) were obtained after UV-irradiating eggs using dosages of 125 mJ/cm² (duration : 114 seconds at an intensity of 1.1 mW/cm²). During irradiation, eggs were stirred in a synthetic ovarian fluid. Absence of normal larvae in the offspring confirmed inactivation of the female genome. Diploidy could be restored by heat shocks (41.0°C, 1 min). The optimum shock onset (10.5 % androgenetic diploids) was located at 33 minutes postfertilization. Homozygous catfish will be used to generate isogenic strains.

Communication affichée / Poster

A STUDY ON THE POPULATION GENETICS OF THE AFRICAN CATFISH, *CLARIAS GARIEPINUS*

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The African catfish is an economically important aquaculture species which is cultivated extensively in Africa and intensively in Western Europe. Untill now the genetic aspects have hardly been studied. Two aspects in the population genetics of this species will be studied: the effect of domestication and the natural genetic variability.

Domestication may cause the loss of genetic variability through selection, inbreeding and bottlenecks. The increase in homozygosity may result in a decrease in fitness (such as survival, growth, fertility and resistance to disease). Loss of genetic variability reduces as well the options for selection in breeding programs. To obtain an idea about how much and which genetic variability is actualy lost, we are investigating the effect of domestication on the population genetics of the African catfish. In order to study this effect, the natural as well as the domesticated populations have to be genetically characterized so that their genetic variability can be compared. The catfish population under investigation came originaly from the Central African Republic. The domesticated populations in our laboratory and in commercial hatcheries in Belgium and the Netherlands are mostly derived from this population. A comparison among nuclear (DNA microsatellites) and phenotypic (allozymes) variation will give an idea about exactly which variability in the genome is lost, coding or non-coding information.

One method, the microsatellite markers, will be used as well to analyse five different population of African catfish dispersed all over its natural distribution range from Israel to South Africa. The aim is to obtain an idea about overall natural genetic variability.

In the long term it is important to maintain sufficient genetic variability but in the short term it is vital for aquaculture purposes to obtain an optimal, fast growing strain. These fish are ideally genetically identical such as is the case with clones. We are producing such a clone in our lab for experimental goals. The production will be done through mitogynogenesis which represents a very fast way of inbreeding. The optimal conditions to induce homozygous diploids will be checked with the microsatellite markers.

Communication affichée / Poster

GENOMIC DIVERSITY AND KARYOEVOLUTIONARY TRENDS IN SILURIFORMES: AN OVERVIEW

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Cytogenetical data available on over 110 species distributed over some 16 families (including some 20 species under 8 families from India), DNA data on 30 odd species distributed over 13 families and location of constitutive heterochromatin and Nucleolar Organizer Regions reported only in a few species have been critically analyzed to evaluate the cytogenetical status and karyoevolutionary trends in different families of the order Siluriformes. The families Ictaluridae, Bagridae, Siluridae, Loricaridae and Callichthyidae are represented by relatively more number of species cytogenetically studied than in others. Cytogenetical characterization is difficult in most of the families in view of the occurrence of greater range of chromosomal variability, both at inter-specific and inter-generic levels. However, a careful analysis reveals a definite karyoevolutionary trend in certain families, demonstrating pericentric inversions to have played the key role in species differentiation in many instances, followed by the role of fission/fusion of chromosomes in the derivation of related karyotypes. In the family Callichthyidae, cytogenetical evidence of certain species having a polyploid origin exists. Interestingly enough, all the reported karyotypes comprise many biarmed chromosomes and none with exclusively acrocentric ones, a fact which may be significant in revealing the possible time of origin of this group from the ancestral stock.

Communication affichée / Poster

STUDIES ON THE ARTIFICIAL HYBRID CATFISH (FEMALE *CLARIAS MACROCEPHALUS* GUNTHER x MALE *C. GARIEPINUS* BURCHELL) AND THE RECIPROCAL HYBRID

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The hybrid catfish, pla duk big-oui (female *C. macrocephalus* Günther x male *Clarias gariepinus* Burchell) is of considerable commercial importance in Thailand (over 80,000 tonnes each year since 1990). Artificial hybridization, using in vitro fertilization, was first achieved in 1988 by the National Inland Fisheries Institute, Thailand. This hybrid performs better in intensive culture than the native *species (C. macrocephalus* and *C. batrachus*) and has become the most popular *Clarias* stock for aquaculture in Thailand and some of the neighbouring countries.

In this study, experiments were carried out to obtain a better understanding of this hybridization. Fertilization and hatching rates and survival to yolk-sac resorption were compared in the hybrid, reciprocal hybrid and parental pure species, using milt from the same male and eggs from the same female. The big-oui hybrid had fertilisation, hatching and yolk sac resorption rates not significantly different from those of the pure species, while the reciprocal cross showed very low hatching rates, deformations among the hatched embryos and zero survival to yolk-sac resorption at three days post-hatch.

Karyotyping of the pure species and hybrids was performed. C. macrocephalus has a karyotype of 2n = 54, while C. gariepinus has 2n = 56. Both the big-oui and the reciprocal hybrid have 2n = 55. This shows that both hybrids have one haploid genome from each parent species. Allozyme studies resolved 20 protein loci in pure species and the big-oui hybrid. Three loci (PGI-2, LDH-1 * and MDH-2*) show fixed differences between the parental species, while the big-oui hybrid was always heterozygous. The big oui was shown to be morphologically intermediate between the parent species for several characteristics. The reason for the failure of the reciprocal hybrid to survive is not clear.

Communication affichée / Poster

BREEDING PROGRAMME AND GENOME MANIPULATION OF EUROPEAN CATFISH (*SILURUS GLANIS* L.) : FIRST PERFORMANCE DATA

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The traditional way of fish selection for weight gain, utilizing the effect of heterosis, genome manipulations and sex reversal will be applied. The first complete diallele crossing (2 x 2) of European catfish was performed. Two populations of European catfish, *Silurus glanis L.* South Bohemian (Czech, Vodnany) and West France (Morannes) were chosen, using 3 to 4 females and 4-5 males. The eggs obtained from the females of the same line were divided into two parts and inseminated with the sperm from two populations. The diallele crossing tests were conducted first year 1993 two times in 2 "communal" stocks. The results, particularly those concerning the breeding stock fish, will be analyzed in detail and can be excepted to be used in further breeding schedule. The results will be completed at March 1994.

Triploidisation by heat shock at 40.5°C, starting 7-9 min after gamete activation and lasting 1 min was successfully induced in European catfish. Yield of triploid fry was determined by quantification of Ag-stained nucleoli in interphase cells on a representative sample of hatched fry. This yield reached 84.2 - 100 %, when expressed from the absolute number of viable fry. Triploidy of the fishes was assessed by erythrocyte DNA content measurement by flow cytometry and peripheric blood leucocyte chromosome counts. The results indicated that cells from diploid fishes had DNA content of 1.9 pg/cell and a diploid number of 2n=60. Manipulated fishes showed cell DNA content of 2.8 pg/cell and a chromosome number of 90, which indicated that they have a third haploid set of chromosomes.

Communication orale

COMPARISON OF COLD AND HEAT SHOCKS TO INDUCE DIPLOID GYNOGENESIS IN THAI WALKING CATFISH (*CLARIAS MACROCEPHALUS*) AND POTENTIAL USE OF THE MEIOTIC GYNOGENS FOR AQUACULTURE

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In Thai walking catfish (*Clarias macrocephalus*) female fish are more desirable for many reasons. Firstly, they seem to grow faster than male although scientific comparison has not been made. Secondly, their ovaries filled with eggs are one of the most popular food among Thai consumers. Finally, large number of female broodstocks are required each year to produce hybrid catfish which combines both the maternal meet quality of Thai walking catfish and the paternal fast growing and disease resistance traits of African catfish (*Clarias gariepinus*). Therefore, diploid meiotic gynogens were induced in Thai walking catfish aiming at creating all female stocks and evaluating their potential use for aquaculture. Induction was performed using UV-irradiated sperm of striped catfish (*Pangasius sutchi*) followed by either cold or heat shock at 4.5 minutes after activation. Results showed that heat shock at 42°C lasting 1 minute was the best condition among various heat shock regimes. When comparison was made in 11 females, cold shock (7°C lasting 14 minutes) gave significant higher percentage of meiotic diploid fry (26.4-40.7 %) than that of the heat shock (11.7-25.7 %). Six months old meiotic gynogens were all female and showed slightly inferior growth to male and female control ($P>0.05$). Sizes of the six months old gynogens were 39.5 ± 15.2 g ; 16.1 ± 1.8 cm, while those of the control were 45.4 ± 7.0 g ; 17.5 ± 0.9 cm and 40.3 ± 8.6 g ; 17.1 ± 1.1 cm in female and male respectively. Survival of the gynogens (73.0 ± 8.3 %) were slightly inferior to the mixed sex control (87.3 ± 10.1 %) ($P>0.05$). GSI of gynogens at 1 year of age (5.66 %) was slightly inferior to that of the control female (8.82 %). Therefore, the attempts to use all female meiotic gynogens to enhance production of Thai walking catfish or to use them as a source of female broodstock may be doubtful.

Communication affichée / Poster

RESPONSE TO MASS SELECTION FOR DISEASE RESISTANCE IN *CLARIAS MACROCEPHALUS*

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Among 3 species of *Clarias* being cultured in Thailand, Thai walking catfish (*Clarias macrocephalus*) demands higher price because of its desirable meat quality. However, production of this species comprises less than 10 % of Thailand total production of *Clarias*. The reasons are their highly susceptibility to disease caused by *Aeromonas hydrophila* as well as their slow growth rate. Therefore, attempt was made to increase resistance to disease by means of selective breeding. Two genetically different base populations were created and their F_2 generations were subjected to mass selection for resistance to *A. hydrophila*. The 104 days and 112 days fish from respective population A and B were injected intraperitoneally with suspension of *A. hydrophila* (1×10^7 cells/ml). Prior to injection, random sample of fish from each population were kept as controls without injection. Survivors were kept to be used as broodstocks. In the next generation, offsprings from each selected and control groups were tested for disease resistance by injecting them a solution of 1×10^6 cells/ml *A. hydrophila*. Results revealed that there were no differences in survival rate after disease challenge even when 50 % mortality occurred. Differences in mean liability were 0.19 σ p and 0.11 σ p in population A and B respectively. Heritability of liability values were 0.17 and 0.10 based on population A and B respectively. Short duration of selection, low heritability of disease resistant traits and inappropriate disease challenging technique were main factors responsible for the results.

Communication orale

EFFETS DE LA DOMESTICATION SUR LA VARIABILITE GENETIQUE, LA FERTILITE, LA SURVIE ET LA CROISSANCE D'UN SILURIFORME TROPICAL : *HETEROBRANCHUS LONGIFILIS* VALENCIENNES, 1840

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La fertilité, le taux de survie, la croissance larvaire ainsi que la variabilité génétique à 23 locus, ont été analysés dans deux populations représentant les générations F1 et F4 du Siluriforme africain *Heterobranchus longifilis* Valenciennes, 1840. Une perte de variabilité génétique a été observée dans la génération F4 par rapport à la génération F1 et dans la génération F1 par rapport à la population sauvage étudiée antérieurement (Teugels et al., 1992). Ainsi, pour 23 locus étudiés, on observe un seul locus polymorphe avec deux allèles pour la génération F4, deux locus polymorphes avec deux allèles pour la génération F1. La souche F1 est caractérisée par un plus faible taux de larves déformées et une plus forte survie au 14ème jour. Cette différence dans les taux de survie n'a pas permis d'interpréter sans ambiguïtés les différences observées pour les vitesses de croissances. Une étude mesurant l'effet de la densité d'élevage sur la vitesse de croissance a permis de constater la corrélation négative entre densité d'élevage et taux de croissance. Ces résultats montrent que *H. longifilis* est une espèce pour laquelle la perte de variabilité génétique entraine rapidement des baisses de performances sensibles.

Synthèse / Review lecture

SELECTION, HYBRIDIZATION AND GENOME MANIPULATION IN THE SILURIFORMES

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The majority of genetics research on siluriformes has focused on ictalurids. Large differences in performance are found among species as well as strains within species of Ictaluridae. Domestic channel catfish, *Ictalurus punctatus* grow faster than wild strains. Selection has increased growth rate by 30 % in channel catfish. Correlated responses include greater carcass yield and reduced tolerance of low dissolved oxygen. Heritabilities have been estimated that indicate channel catfish should respond to selection for tolerance of sublethal oxygen, ammonia and nitrite levels, and various pathogens. Direct selection for feed conversion efficiency and dress-out percentage will likely be unsuccessful but genetic correlations indicate the potential for indirect selection. Combining abilities vary among strains of channel catfish, but some intraspecific crosses show heterosis for growth rate, reproductive performance, tolerance of pathogens and stress and angling vulnerability. Domestic x domestic crosses are more likely to exhibit heterotic growth than domestic x wild crosses. Interspecific hybridization rarely results in a catfish exhibiting potential for commercial culture. However, when reproductive isolating mechanisms are overcome, the hybrid between the female channel catfish and the male blue catfish, *I. furcatus*, may become the genotype of choice for culture of ictalurids. This hybrid has superior growth, disease resistance, tolerance of poor water quality, carcass yield, seinability, and angling vulnerability compared to channel catfish. Triploid induction did not improve growth or carcass yield, and decreased tolerance of low dissolved oxygen in channel and hybrid catfish. Sex reversal and breeding can allow the production of 100 % male channel catfish with the genotype XY, a desirable result since males grow about 20 % faster than females in most strains. Growth hormone genes from salmonids have been transferred to channel catfish. The GH genes are expressed and inherited, resulting in F_1 transgenic fish that grow 20-40 % faster than controls. Genotype-environment interactions are rare when comparing strains, select lines and transgenics, but are common for crossbreeds, hybrids, species and polyploids which have greater genetic distance. Research efforts are just beginning for genetic improvement of other siluriformes with most of the effort on Clariidae. Gynogenesis, sex reversal, and breeding research has been initiated for *Clarias macrocephalus*, to produce faster growing, all-female populations. Commercialization of the interspecific hybrid between *C. macrocephalus* and *C. gariepinus* by the private sector in Thailand is one of the few large-scale applications of hybridization in aquaculture. The hybrid exhibits growth rate intermediate to that of the parents, and has the desired yellow flesh of the traditionally-grown *C. macrocephalus*.

Communication orale

PROSPECTS OF USING CATFISH HYBRIDS FOR AQUACULTURE IN INDONESIA

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Four families of Siluriformes are represented in the open waters of Indonesia: Bagridae (17 species), Clariidae (5 species), Pangasiidae (11 species) and Siluridae (19 species). Among them only four species are actually domesticated and cultured: two Clariids (*Clarias batrachus* and *C. melanoderma*), one Bagrid (*Mystus nemurus*) and one Pangasiid (*Pangasius pangasius*). *C. batrachus* is easy to breed naturally in pond and recent success have been obtained in the induced breeding of *C. melanoderma* and *M. nemurus*. By contrast, the culture of *P. pangasius* is still based on the capture of juveniles from the wild. Beside those autochtonous species, two other catfishes of aquaculture interest were introduced in Indonesia, the African catfish *Clarias gariepinus* (from Taiwan in 1985) and the Thai catfish *Pangasius sutchi* (from Thailand in 1973).

Since 1992 different investigations were carried out at RIFF in order to improve the quality or performance of the local species through interspecific hybridization or induction of polyploidy.

The hybridization between *C. melanoderma* (female) and *C. gariepinus* (male) proved to be successful. Compared to the *C. melanoderma* brood, survival and growth rates of the F1 hybrids were higher. In the hybrids, the survival rate reached about 80 % while it was 60 % only in their female parent. Their growth rate was also 20 -30% faster compare to the female parent. However, fertility of hybrid was lower than that of *C. melanoderma*. the hybrids produced around 2000 - 3000 fry per female, weighing 300 g and 18 months old, while their female parent for a same weight/age produced 5000 - 6000 fry. Other investigations on F1 hybrids show that they are more resistant to disease, *Aeromonas hydrophila*, compared to their both parents. Conversely, attempts to hybridize *C. batrachus* with *C. melanoderma* systematically failed (no hatching).

The perspective of using catfish hybrids in Indonesia is promising, since demand of fish farmers for hybrids is increasing due to their better survival, better growth and suitable market size.

Synthèse / Review Lecture

GENETIC DIVERSITY AND THE CHARACTERISATION OF NATURAL AND CULTURED POPULATIONS OF SILURIFORMES

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The genetic characterisation of Siluriformes by means of phenotypic markers, karyotyping, protein and DNA polymorphisms has been incorporated in systematics, population genetics, quantitative genetics, biochemistry, toxicology and aquaculture. Most papers take a pragmatic approach since the Siluriformes do not include model species for fundamental genetic research. The Clariidae and the Ictaluridae have been the most frequently studied families. The systematic status of a number of species and families has been either elucidated or confirmed by genetics. Several studies looked at biochemical properties of allelic polymorphisms. Population structure of natural populations does not seem a popular topic, while the evaluation of strains for aquaculture (especially Ictaluridae and Clariidae) is in progress at several research centers. The mapping of genetic markers has begun in *Ictalurus*. It appears that a more detailed knowledge of catfish populations is required from two perspectives. First, natural populations which are threatened by habitat loss and interfluvial or even intercontinental transfers are poorly characterised. Secondly, the selection of suitable strains for aquaculture should be speeded up. The implementation should pose no problems given the present powerful means, such as DNA characterisation combined with protein polymorphisms and phenotyping, to solve the above mentioned problems.

Communication affichée / Poster

THE STUDY OF THE REGULATION OF GENE EXPRESSION BY MEANS OF TRANSGENESIS IN AFRICAN CATFISH, *CLARIAS GARIEPINUS* (BURCHELL, 1822).

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African catfish represents an excellent model for the characterisation of genes which have been newly transferred in its genome. The good control of reproduction, the short hatching time, the transparence of the embryo, the relative short generation time and the excellent biological background make it a prime target. Aim of our research is the testing of various promoters/enhancers/silencers of fish genes to evaluate their time- and tissue-specificity, and to prepare all fish "cassettes" for efficient gene expression. To this purpose, upstream promoter/enhancer/silencer sequences of fish genes are cloned, linked to a (easy to detect) reporter gene and inserted in a plasmid vector. The transfer of foreign DNA in the embryo by means of microinjection results in the (1) transient and (2) stable presence of this DNA. (1). Transient replication occurs in catfish within the first 48 h after fertilisation and results in a massive increase, followed by an even spectacular decrease of fusion DNA. Most of the fusion DNA does not integrate in the genome, but remains extrachromosomal. The gene included in the fusion gene is expressed concomitantly with a strength corresponding to the promoter/enhancer/silencer system chosen. The cytomegalovirus promoter induces the highest levels of expression, various deletion mutants of the tilapia prolactin I promoter show lower levels of expression, while a promoterless construct doesn't show any expression at all (as expected). (2) Stable replication involves the integration of one or several copies of the fusion gene in the genome. Since integration in founder catfish is very patchy ("mosaic"), two consecutive backcrosses with wild type fish (which corresponds to two generations) are required before a truly stable family is founded. Moreover, expression of the fusion gene depends strongly on the site of integration (actively transcribing DNA or silent DNA) and the nature of the construct itself. We are in the process of characterising the tiPRLI3.4-Luc fusion gene by means of DNA (PCR and blotting) and protein (in toto luminometry) assays in cell culture and in vivo.

SESSION

NUTRITION, ALIMENTATION ET CROISSANCE

NUTRITION FEEDING AND GROWTH

Communication affichée / Poster

SOME BASIC REQUISITES FOR AQUACULTURAL PROSPECTS OF A CATFISH *MYSTUS VITTATUS* (BAGRIDAE) - A REVIEW

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Studies on aquacultural prospects of siluriforme species *Mystus vittatus* have been reviewed. On food and feeding habits : It was found that it can predate larvae of mosquito and chironomous and tubifex worms; consumes chopped tissues of earthworm, fish and freshwater mussel; and also accepts formulated diets made of silkworm pupae, oil-cake etc. The satiation time and satiation amount of food for this were 30 minutes and 8.7 % of its live body weight respectively and its stomach evacuation rate was found as 13.5 hrs.

On nutritional requirement : The Optimum protein requirement was found as 40-45% of its diet. The studies on optimum mineral requirement are in progress.

On growth as a function of biotic and abiotic factors : Studies on feeding energetics of *M. vittatus* revealed that the maximum feeding rate was 508 $Jg^{-1}.d^{-1}$, growth rate was 80 $Jg^{-1}.d^{-1}$ and net conversion efficiency was 21%. Rearing this fish on different rations of food, the growth was assessed. By means of geometric derivation of growth rate to feeding rate relations, the maintenance, optimum and maximum rations were estimated as 135, 400 and 500 $Jg^{-1}.d^{-1}$ respectively. From these studies, it was derived that 80% of the maximum ration will be the optimum level of food for economic culture. The growth studies with reference to temperatures indicated that 30°C was the optimum. The body weights of fish had negative correlation with growth. The number of meals required was two per day. Culture of this fish in different concentrations of NaCl indicated that soft water will be beneficial. Periodical renewal of rearing medium is a must because the excretory products affected the feeding energetics of fish inspite of artificial aeration. Polluted waters with pesticides, fertilizers and industrial wastes affected the growth and body composition. Photoperiods have no effect on growth of fish.

Communication affichée / Poster

CONSOMMATION VOLONTAIRE D'ALIMENT EN PERIODE D'ECLAIREMENT ET D'OBSCURITE CHEZ *HETEROBRANCHUS LONGIFILIS*

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La consommation volontaire d'aliment durant les périodes d'éclairement et d'obscurité a été étudiée chez *Heterobranchus longifilis* par la méthode du distributeur d'aliment à la demande.

Six lots de 27 à 38 poissons, maintenus en photopériode constante (12 J / 12 N), d'un poids initial moyen de 7,6 grammes ont été utilisés. L'auto-distribution de nourriture a été mesurée par pesée deux fois par jour : à 06:30 h lors de la mise en route et 18:30 h, lors de l'extinction de la lumière pendant 11 jours consécutifs.

Au cours de cette période les poissons ont doublé de poids, la croissance journalière variant de 0,6 à 0,9 g/jour, et l'indice de consommation de 0,86 à 1,21.

La consommation moyenne journalière d'aliment a éte de 5,4 % du poids vif moyen. La prise de nourriture intervient en période d'obscurité pour 70 % (66 à 82 %) de la consommation totale.

Il est ainsi confirmé que *Heterobranchus longifilis* a une activité trophique préférentiellement nocturne. Toutefois il apparait également que l'éclairement n'inhibe pas la prise de nourriture et donc que la prise de nourriture chez ce siluriforme n'est certainement pas sous la dépendance étroite d'un rythme endogène.

Communication affichée / Poster

BIOLOGICAL EVALUATION OF THE NUTRITIVE VALUE OF FISH/FEATHER MEAL CO-ENSILAGED BLENDS ON THE PERFORMANCE OF THE AFRICAN MUDCATFISH

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The replacement value of fishmeal with fish/feather meal co-ensilaged blends and the effects on the growth performance and nutrient utilization of Clarias gariepinus fingerlings were investigated. Fish discards and hydrolysed feather meal were co-ensiled together in various proportions (wt/wt) as follows: 100% fish discard, 80% fish + 20% feathermeal (FM), 60% fish + 40% FM, 40% fish + 60% FM and 20% fish + 80% FM. The co-ensiling procedure was carried out using sulphuric acid (2.0%) and formic acid (0.75%) until pasty products were obtained. The resulting pastes were thinly spread on cellophane sheets and dried in a solar-drier. Samples of dried products were taken for proximate analysis and amino acid analysis. The dried products were then used to formulate diets in which each product completely replaced fishmeal. In all, six diets including the fishmeal control diet were formulated each containing 35% protein. The biological assessment of growth performance and nutrient utilization were based on percentage weight gain, specific growth rate (SGR), protein intake, protein efficiency ratio (PER), feed gain ratio and carcass analysis.

All diets were found to support positive growth. Significant differences ($P < 0.05$) were obtained for % weight gain, specific growth rate (SGR), protein efficiency ratio and Net nitrogen retention in all groups of fish fed the fish/FM co-ensiled blends. However, in all respect, the diet in which fishmeal was completely replaced by 80% fish + 20% FM silage product gave a comparable performance to that of the control fishmeal diet. Product containing higher level of feathermeal elicited comparably poorer performance.

Economic analysis in terms of cost per kilogram of feed and cost per kilogram gain showed that the 80 % fish + 20 % feather meal silage product was significantly ($P < 0.05$) better than all other fish/feather meal silage products but not significanlty different from the control diet.

Communication affichée / Poster

PROTEIN AND AMINO ACID REQUIREMENT STUDIES OF THE AFRICAN MUDCADFISH (*CLARIAS GARIEPINUS*) USING PRACTICAL DIETS

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Protein and lysine requirements of the fingerlings and juveniles of the African mudcatfish were investigated using practical diets.

For protein requirement studies, five isocalaric diets with protein levels (DM basis) and protein energy ratios of 25 % and 79 mg protein/kcal, 30 % protein and 97 mg protein/kcal, 35 % and 116 mg protein/kcal, 40 % and 137 mg protein/kcal and 45 % and 159 mg protein/kcal were used respectively.

Fingerlings were tried on 25 %, 30 %, 35 %, 40 % and 45 % protein diets respectively while juveniles were tried on four graded levels of protein ranging from 25 % to 40 %.

Criteria for judgement were based on weight gain, SGR and feed gain ratio (FGR).

Results based on these parameters showed that the optimum performance was obtained with the 40 % protein diet as judged by SGR, % WG and FGR.

At juvenile stage, FGR was optimal at 35 % protein level while the SGR and % WG were best at between 30 % and 35 %. Studies on the lysine requirement of *Clarias gariepinus* were carried out using 10 isonitrogenus and isocaloric diets (5 - 37.5 % protein diets for fingerlings and 5 - 32.5 % protein diets for juveniles).

Result of lysine requirement with the essential parameters showed that a mean requirement of 2.04 % of diet was estimated at the fingerling phase and a lysine requirement of 2.80 % of the diet at the juvenile phase was obtained.

Communication affichée / Poster

GROWTH AND FEEDING OF WELS (*SILURUS GLANIS*) IN CLOSED SYSTEM WITH WATER RECIRCULATION

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European wels (Silurus glanis) is an excellent fish to grow in closed systems. Data recorded in a 75 tons p.a. capacity table size fish production plant show that growth is outstandingly good even in conditions of mass production. Though growth decreases by larger size it remains still high over the size of 1500 g.

Growth of wels at 23 °C, fed by pelleted feed: ALMA Welsfutter

Age (days)	SGR (%/day)	Body mass (g)	advised density (kg/m^3)
60		5	
	3.5		15
90		14	
	3.1		20
120		35	
	2.7		25
150		78	
	2.4		30
180		159	
	2.1		40
210		297	
	1.8		50
240		507	
	1.5		55
270		792	
	1.2		60
300		1133	
	1.1		60
330		1573	

Up to 600 g size less than 1 kg feed is needed for producing 1 kg fish. Wels tolerates NH_4 up to 1, NO_2 up to 2 and NO_3 up to 800 ppm without any visible sign in decrease of appetite. Year round propagation is easy when using adequate temperature regime. A complete technology for culture in closed system is presented.

Synthèse / Review Lecture

RYTHMES ALIMENTAIRES ET ALIMENTATION CHEZ LES SILURIFORMES

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Les silures sont réputés avoir, en milieu naturel, une activité trophique essentiellement nocturne. Ce trait comportemental a été confirmé par plusieurs auteurs et pour plusieurs espèces, au cours d'expérimentations réalisées en conditions d'accès constant à une source de nourriture, ou encore à l'aide de distributeurs d'aliments à la demande. Cependant, d'autres auteurs ont aussi montré qu'en conditions limitatives en température ou en oxygène, l'activité trophique de certains silures devient dépendante de ces deux facteurs, et n'est plus synchronisée par l'alternance jour/nuit. Au vu de ces travaux, il est permis de déduire que chez les espèces étudiées, le rythme nycthéméral d'activité trophique présente une acrophase préférentiellement nocturne, mais possède aussi une certaine plasticité. L'existence d'un contrôle d'origine endogène de ce rythme est aussi discuté.

On sait qu'en conditions d'élevage, rares sont les Siluriformes qui refusent de s'alimenter lors de distributions diurnes d'aliments. Il convient cependant d'évaluer les conséquences que pourraient avoir sur la croissance, des horaires d'alimentation non synchronisés par rapport aux rythmes alimentaires. Les travaux concernant l'effet de l'heure des repas sur les performances de croissance montrent une tendance générale à une meilleure croissance chez les animaux nourris de nuit. Ces résultats sont cependant à prendre avec une certaine prudence, car la plupart des différences de croissance observées concernent des expérimentations où le taux de croissance est faible. De plus, certains auteurs observent que le mode de distribution choisi (en repas ou en continu) a plus d'influence sur les performances de croissance que n'en a l'heure de distribution. Il faut aussi rappeler que la quantité réelle d'aliments ingérés lors de ces expériences n'est jamais un paramètre mesuré avec précision. Il n'est dès lors pas possible de déterminer si les différences de croissance sont dues à un effet comportemental (ingéré volontaire différent), ou bien à un effet d'origine métabolique (utilisation différente des nutriments). Les résultats obtenus concernant la plus grande adiposité des animaux qui présentent les moins bonnes croissances, impliquent cependant un réel effet de l'heure de l'alimentation sur l'utilisation des nutriments.

Communication orale

EFFECTS OF DIETARY PROTEIN ON THE GROWTH RATE AND NITROGEN METABOLISM OF THE AFRICAN CATFISH, *CLARIAS GARIEPINUS* (BURCHELL, 1822)

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The rates of growth (live weight and length) and nitrogen (total nitrogen and ammonia) efflux of individual *C. gariepinus* fingerlings, kept under 4 feeding regimes following 48h imposed fast, were measured weekly. In phase 1 (45 d), groups A, B, and C were fed a 50%, 40% or 30% protein pelleted diet respectively at a ration of 0.5 % body weight (g/d). Group D was not fed. In phase 2 (21 d), all groups were fed the 40% protein diet at 0.5 % body weight per day.

During phase 1, growth rates in B (40%) and C (30%) were similar and approximately double those of A (50 % protein). Group D (unfed) lost weight at a constant rate for 21 days and at a much slower rate thereafter. Group A had a significantly higher mean ammonia efflux rate than the other groups ($P < 0.05$, ANOVA) and ammonia comprised 70-90% of the total nitrogen efflux in all groups. Group D showed a direct relationship between ammonia efflux rate and length of fast. In phase 2, refeeding with the 40% protein diet caused the ammonia efflux rates of groups C and D to converge within 3 days to values equivalent to those of group B but group A maintained a significantly higher mean value ($P < 0.05$, ANOVA) than those of the other groups until day 21. Results are discussed in relation to the physiological and cost implications of dietary acclimation, protein content and ration.

Communication orale

UTILISATION PAR *CHRYSICHTHYS NIGRODIGITATUS* D'ENSILAGE CHIMIQUE OU BIOLOGIQUE DE POISSONS.

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Deux expériences ont été réalisées pour tester la valeur alimentaire, pour le mâchoiron (*Chrysichthys nigrodigitatus*), de dérivés de poissons de mer conservés par la méthode de l'ensilage.

Le premier essai a concerné des déchets de conserveries de thons conservés par la méthode de l'ensilage acide (3 % d'acide formique). L'hydrolysat, renfermant 66,7 % de Nx6,25 (MS) a été incorporé dans un aliment expérimental en substitution à la farine de poisson sur une base isoprotéique. Les aliments ont été distribués à 6 lots de 50 mâchoirons, d'un poids initial de 34 g, pendant 56 jours à raison de 3% (sec) du poids vif. Les performances zootechniques procurées par cet aliment sont meilleures, pour ce qui concerne le gain de poids (0,86 g/j) et l'indice de consommation (1,79) et le coefficient d'efficacité protéique (CEP: 1,46), par rapport à celles obtenues avec l'aliment témoin (pas de différence significative).

Lors du deuxième essai il a été réalisé un complexe hydrocarbonné à base de maïs pour conserver des sardinelles broyées par fermentation lactique. Ce mélange (coensilage), à pH stabilisé à 4,18, et renfermant 35,65 % de Nx6,25 (MS), a également été testé contre un témoin farine de poisson dans des conditions expérimentales identiques à celles décrites plus haut. L'aliment à base de coensilage a procuré de meilleurs gains de poids (0,94 g/j), indice de consommation (1,77) et CEP (1,61) que l'aliment témoin.

Les produits de la pêche ou leurs dérivés conservés par la méthode de l'ensilage acide ou du coensilage biologique apparaissent ainsi constituer une bonne source azotée pour l'alimentation du mâchoiron.

Communication orale

NUTRITIVE VALUE OF LACTIC ACID FERMENTED FISH SILAGE AND SOYBEAN MEAL IN DRY DIETS FOR JUVENILE CATFISH, *CLARIAS GARIEPINUS* (BURCHELL, 1822)

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Dry diets containing either fish meal (C-FM) or dried fermented fish silage and soybean meal blend (1:1,w/w)(C-FS) as the sole protein source were fed to triplicate groups of juvenile *Clarias gariepinus* (10.8 $\pm$ 0.3g) at 5% body weight/day for 70 days. Catfish fed the C-FS diet showed reduced ($p<0.05$) growth rate, feed conversion, protein efficiency and digestibility. Lower amounts of available amino acids in C-FS diet resulted in the inferior nutritive value for catfish growth, than C-FM diet. Postprandial changes in plasma amino acids showed similar patterns in both diet treatments, but the maximal mean levels attained for the C-FS diet were correspondingly lower and occurred earlier than with the C-FM diet. There were no effects of feeding C-FS diet on the hepatosomatic index but carcass analysis showed that body protein deposition was lower ($p<0.05$). Differences in haematocrit, haemoglobin content and liver histology were demonstrated but were not pathological. Lower digestible energy of C-FS diet also contributed to the poor performance of catfish in this treatment. Results of this study indicate that *C. gariepinus* cannot metabolize protein from fish silage : soybean blend efficiently as fish meal protein when used as the sole dietary protein source.

Communication affichée / Poster

COMPARAISON DE QUATRE ALIMENTS EN AQUACULTURE INTENSIVE DU SILURE GLANE

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L'incidence de 4 aliments différents (A: 49,0/9,5[1]; B: 50,0/9,0 ; C: 32,4/3,7 ; D: 41,7/8,3) sur les performances de croissance a été étudiée en élevage intensif de silure *Silurus glanis* de juin à octobre 1993. Les tests ont été effectués en bassins en terre, équipés d'aérateurs programmables, à une densité initiale de 5000 poissons de 1 été (masse moyenne individuelle: 46,2g) par hectare, avec un rationnement journalier de 1 à 3,5% de la biomasse selon la température. Chaque traitement a fait l'objet de 3 répétitions.

Les températures mensuelles moyennes au cours de la saison de croissance sont les suivantes; juin: 23,1°C, juillet: 23,9°C, août: 23,7°C, septembre: 17,8°C, octobre: 14,5°C. La masse finale individuelle est significativement différente selon les aliments (A: 676g, B: 757g, C: 302g, D: 332g), avec une variabilité intra-aliment d'autant plus faible que la croissance est forte. Signalons toutefois que le type de rationnement utilisé (en % de la biomasse) tend à amplifier les différences de croissance. Le taux d'accroissement journalier distingue les aliments riches en protéines animales (A & B) des aliments moins riches (C & D) et présente des variations importantes au cours de la saison en fonction de la température mais aussi de l'aliment. Les taux de survie sont respectivement 84,9%, 82,8%, 71,9% et 83,6%. Les indices de conversion de l'aliment, calculés en tenant compte de la mortalité sont les suivants: aliment A: 1,12, aliment B: 0,99, aliment C: 1,67, aliment D: 1,46. Leur variation au cours du temps montre des différences de performances entre les aliments selon les conditions thermiques.

(1) : Protéines (%)/Lipides (%)

Communication affichée / Poster

FEEDING OF EARLY FRY OF EUROPEAN CATFISH (*SILURUS GLANIS* L.) WITH FOUR STARTER FEEDS AND ZOOPLANKTON

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Four starter feeds and zooplankton were tested in early European Catfish fry under conditions of controlled environment at water temperature 24 - 26°C for period of 25 days. Following starter feeds were tested: trout starters Trouvit and Taco, European catfish starter Alma Welsfutter and the universal starter feed Inra. Apart from zooplankton, the best results were reached with Alma feed. The highest final individual weight (420.7 $mg.ind^{-1}$) was reached with Alma feed followed by zooplankton (384.9 $mg.ind^{-1}$) but the cumulated survival rate was lower (36 % and 59 %, respectively). The specific growth rates of fish fed with Alma starter and zooplankton were 10.7 - 26.2 and 10.2 - 21.6, respectively, and feed conversion ratio 0.8 - 2.7 and 5.4 - 14.3, respectively. It can be concluded, that the Alma Welsfutter starter feed is suitable for feeding of young catfish under conditions of controlled environment just from the beginning of food acceptance.

Synthèse / Review Lecture

NUTRITION AND FEEDING OF SILURIFORM LARVAE AND EARLY JUVENILES

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Successful commercial production of most cultured fish species has been facilitated by the intensification of larval rearing techniques. Siluriform species are no exception and early attempts at larval rearing in ponds were soon superseded by intensive hatchery production, at least for those species that are farmed on a commercial scale. The review focuses on larval and early juvenile nutrition of the most important siluriform species currently cultured on a commercial and subsistence level, as well as on the development and efficacy of practical feeds and feed application. The paper highlights several commonalities in terms of the nutritional requirements of the larvae of the various species for which data are available, particularly the requirements for protein and lipids. The requirement for live feed appears to be of short duration and all species can be successfully weaned onto dry feed at a relatively early stage. This, coupled with the relatively high tolerance level towards nitrogenous metabolites, is considered to be one of the reasons why the intensification of larval rearing of siluriform fishes has, in general, been highly successful. The review clearly revealed that our knowledge of siluriform larval nutrition and feeding is sorely lacking for many species, in comparison to other groups of fish. This emphasises the need for a concerted research effort.

Communication affichée / Poster

NUTRIENT DIGESTIBILITY COEFFICIENTS OF SOME PLANT AND ANIMAL PROTEINS FOR CATFISH (*HETEROPNEUSTES FOSSILIS*)

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Apparent protein digestibility (APD), apparent lipid digestibility (ALD) and true protein digestibility (TPD) coefficients of some plant and animal proteins were determined for fingerlings of *H. fossilis*. Diets were formulated to be isonitrogenous (32% protein). A protein-free diet was used to study the true protein digestion coefficient. Of the animal proteins tested, fish meal produced significantly ($P<0.05$) the highest APD (88.52%) and TPD (92.58%) values and blood meal the lowest APD (78.92%) and TPD (82.78%). There was no significant differences ($P>0.05$) between the APD and TPD values of silkworm pupae and fish silage and the values ranged between 84.66 to 85.26% and 88.78 to 89.46% respectively. Among the plant proteins tested, soybean meal produced significantly ($P<0.05$) the highest APD (84.10%) and TPD (88.44%) and sesame and cotton seed meal the lowest APD and TPD values. There was no significant differences ($P>0.05$) between the APD and TPD values of mustard and linseed diets respectively. ALD values for all the diets tested were higher than those of APD values and ranged between 90.05 to 94.66%. The results of the study indicated that *H. fossilis* may be able to utilize the above mentioned ingredients efficiently.

Communication affichée / Poster

EFFECT OF PHOSPHORUS SUPPLEMENTATION TO FISH DIET ON GROWTH AND BODY COMPOSITION OF *MYSTUS VITTATUS* (BAGRIDAE)

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Mystus vittatus was reared on different diets containing different levels of phosphorus to assess the optimum requirement of phosphorus for this fish in the laboratory condition. The basal diet was formulated using silkworm pupae (50%), fish meal (20%), oilcake (19%), mydha (10%) and Vitamin premix (1%). The protein content of the diet was 45.3 $\pm$ 0.32% . The phosphorus content was 0.714%. To increase the phosphorus content of the diets to 0.913, 1.112, 1.511, 1.908 and 2.306% a proportionate amount of NaH_2PO_4 was added. The fish was reared as groups (10 individuals) for 60 days. The cumulative growth of fish at an regular interval of 15 days, total growth and growth rate were estimated. The results revealed that the growth rate of *M. vittatus* which was 7.704 mg live weight.g live fish^{-1} day^{-1} when received the basal diet, increased gradually to 9.149 mg live weight.g live fish^{-1} day^{-1} in the fish which received the diet with 1.112% phosphorus. As the phosphorus content increased in the diet the growth rate was gradually reduced. The growth rate of *M. vittatus* was expressed in terms of energy value and the trend of growth was similar to that of live weight. The results were statistically analysed and discussed. The growth of fish on diet with optimum level of phosphorus in the laboratory was compared to that of the fish reared on the same diet in the field. It was found that the fish reared in the field exhibited less growth. The protein content of the fish which received the diet with optimum level of phosphorus was higher when compared to that of fish receiving other diets. Correspondingly, fat content was decreased. The water content was negatively correlated with fat. The ash content did not show any significant variation. The activity of enzymes GOT and GPT was less when the protein level was high and vice versa. The activity of lipase exhibited negative trend to the fat content.

Communication orale

BIOLOGICAL AND NUTRITIONAL BASES FOR THE CULTURE OF TROPICAL FRESHWATER CATFISH, *MYSTUS NEMURUS* C. & V.

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Tropical freshwater catfish, *Mystus nemurus* C. & V, though little known few years ago has now become a popular and cultured species in Malaysia. Because of the exotic nature and lower acceptance by local consumers of the African catfish, *Clarias gariepinus*, *M. nemurus* offers relatively better scope for further development due to its high dress-out percentage, indigenous origin and popularity among the Malaysians.

In line with intensification of its culture, baseline biological and nutritional works have been done since late 1980s and the information gathered over the years has started to disseminate among the subsistence farmers and entrepreneurial levels. The results have indicated that most of the feed ingredients were farely well digested except maize and chicken viscera. Digestibility coefficients for protein, dry matter and energy for fish meal, soybean meal, rice bran and copra meal were found to be satisfactory and they ranged between 68.9 and 97.8 %. Selected ingredients from the study were used to formulate the practical diets of varying protein levels and their effect on the growth, food conversion, protein utilization and body composition of *M. nemurus* cultured in static pond water system was studied. The species was found to be moderately growing compared to the Channel catfish. The weight gain, food conversion ratio (FCR), protein efficiency ratio (PER) and specific growth rate (SGR) indicated that a 42 % protein diet with digestible protein to energy ratio (D/E) of 113.82 mg/kcal produced the maximum growth under the static pond water system.

Communication affichée / Poster

REARING OF EARLY FRY OF EUROPEAN CATFISH (*SILURUS GLANIS* L.): INTRODUCTION OF BATHING IN SOLUTIONS OF DALARGIN AND ITS ANALOGUES AND PREVENTIVE APPLICATION OF THE DRUGS DUON AND IMEQUYL IN FEEDS

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A short-term bath of the early fry in solutions of some oligopeptides increased the survival of larvae in the following period of life. In our experiments, we tested the effect of 5 synthetically prepared oligopeptides. Catfish larvae in the stage preceding active feeding were subjected to a single bath in a peptide solution (concentration 1 $\mu g.l^{-1}$; duration of treatment 1 hour). The larvae were then reared in flow-through aquaria at a temperature of 24 - 26 °C. In the first experiment lasting for 14 days, the effect of the peptide dalargin was tested on larvae fed with live zooplankton (in duplicate). In the second experiment lasting 20 days (in one replicate), the effect of 4 dalargin analogues was tested on larvae fed either with live zooplankton or with starter feed. The effect of the drugs Duon and Imequyl on the starter-fed larvae was also investigated in this experiment. The larvae treated with dalargin had 1.79 times better survival rate (67.3 %) than controls (significance level 0.05). The larvae treated with the analogues of dalargin showed improved survival only in some cases. Treatment with dalargin or its analogues did not influence the individual weight reached. The survival rate was improved remarkably (29.7 %) as compared with controls when the larvae were given starter feed containing 0.125 $mg.g^{-1}$ Duon (1.54 times) or 0.12 $mg.g^{-1}$ Imequyl (1.47 times). In this case a slight increase was also observed in the specific growth rate and the individual weight ; the feed conversion ratio was lower.

Communication affichée / Poster

REGIME ALIMENTAIRE ET CROISSANCE DE *CHRYSICHTHYS NIGRODIGITATUS* ET *C. AURATUS* DANS LE COMPLEXE LAGUNAIRE DU LAC NOKOUE ET LA LAGUNE DE PORTO NOVO AU BENIN

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L'étude du régime alimentaire et de la croissance de *Chrysichthys nigrodigitatus* et de *C. auratus* a porté sur des individus (Lt 6-69 cm) capturés en 1990-1991 dans le lac Nokoué et la lagune de Porto-Novo (180 km^2) au Bénin par pêche artisanale utilisant des filets, des lignes et des pièges. Sur la base d'indices alimentaires (occurrence, abondance et volume) des proies contenues dans 933 estomacs, le régime alimentaire des poissons est analysé. La croissance est étudiée grâce à l'analyse des marques saisonnières sur les épines dorsales de 194 poissons. Les deux espèces présentent un spectre alimentaire très varié et nettement dominé par les Crustacés Décapodes (Macroures et Brachyoures) et les Poissons. Toutefois, chez *C. auratus* l'importance relative assez élevée de la vase, des macrophytes et des insectes dans le régime rend les indices alimentaires des proies principales (Crustacés et Poissons) plus faibles que chez *C. nigrodigitatus*. Le régime alimentaire varie avec la taille des poissons, les saisons et les habitats. L'étude de l'âge et de la croissance révèle des différences importantes entre les deux espèces qui, de plus atteignent leur maturité sexuelle à des âges différents: 2-3 ans chez *C. auratus* et 4-7 ans chez *C. nigrodigitatus*. *C. nigrodigitatus* a une croissance pondérale meilleure que celle du *C. auratus* dont le poids par unité de taille tend à diminuer au fur et à mesure que sa longueur augmente. La taille maximale théorique calculée pour *C. auratus* est de 40 cm et de 93 cm pour *C. nigrodigitatus*. La plasticité des régimes alimentaires et la tendance carnivore des *Chrysichthys* constituent la similitude principale entre les deux espèces mais la prédominance des proies carnées (Crustacés Décapodes et Poissons) dans le régime de *C. nigrodigitatus* peut être mise en liaison avec la meilleure croissance observée chez cette espèce, par rapport à *C. auratus*.

Communication affichée / Poster

LARVAL REARING OF AN AFRICAN CATFISH, *HETEROBRANCHUS LONGIFILIS* VAL. (TELEOSTEI, CLARIIDAE) : EFFECTS OF DIETARY LIPID ON GROWTH RATE, SURVIVAL RATE AND BODY COMPOSITION

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Under hatchery conditions, *Artemia salina* nauplii proved to be highly suitable as a first feed for *Heterobranchus longifilis* larvae and generally led to high growth and survival rates of fry. However, *Artemia* may not be the most appropriate feed for large-scale rearing of larvae in many African countries due to practical and economical reasons. As an alternative, the use of artificial diets may present several advantages. Preliminary results demonstrated that a dry diet, efficient in coregone and common carp (Bergot et al., 1986, Charlon et al. 1986), leads in *H. longifilis* to survival rates as high as those obtained with *Artemia* but with a slower growth rate after the first two weeks of rearing (Kerdchuen and Legendre, in prep.). As fatty acids requirements may vary between temperate and tropical fishes, the present study was conducted to evaluate the effect of dietary lipid sources on growth, survival and fatty acid composition of *H. longifilis* fry from 2 days up to 17 days of age.

Six feeding regime were tested: *Artemia nauplii* which served as reference, and 5 experimental dry diets differing only by the lipid source. The diet composition was the following: " Protibel " yeast powder (50 %), beef liver (30 %), vitamin mix (7.5 %), mineral mix (5 %) and oil (7.5 %). The different oils used for the different experimental diets were the following: cod liver oil, palm oil, copra oil, peanut oil and cotton oil. Each diet was tested on duplicate groups of 400 larvae placed in the 40 l tanks of a tapwater recirculating system (28 °C) and fed *ad libitum* six times per 24 h. Separation and identification of the fatty acids of diets and fish were carried out by gas-liquid chromatography.

After the 15-day feeding period, survival rates were high for all treatments (71 - 87 %) and did not differ significantly. By contrast, growth rates were largely influenced by the feeding regime. Fry fed with *Artemia* were significantly bigger (289 mg) than those fed artificial dry diets (79 - 115 mg). However, it was found that the specific growth rate of fry fed *Artemia* was superior to that of fry receiving dry diets only for fish of less than 50 mg body weight, indicating that *Artemia* presents a nutritional advantage only for fry at their youngest stages of development (first week). Among the artificial dry diets, the best results were obtained with diets containing palm or copra oil, the lowest growth rate being observed with the cod liver oil diet ($p < 0.05$). Peanut and cotton oil diets led to intermediate results.

The fatty acid composition of the whole fry reflected that of the experimental diets. All together, the results indicated the existence of an optimal ratio between n-3 and n-6 fatty acids for covering essential fatty acids requirement of the fry. Growth rates of fry tended to be reduced by an excess in n-3 fatty acids (cod liver oil) or by an excess in n-6 fatty acids (cotton oil) as well.

Communication orale

MISE EN EVIDENCE ET VALORISATION DE LA CROISSANCE COMPENSATRICE CHEZ *HETEROBRANCHUS LONGIFILIS*

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Trois expériences de manipulation des niveaux de rationnement alimentaire ont été réalisées chez le silure *Heterobranchus longifilis*.

Au cours d'un premier essai, effectué sur des poissons d'un poids initial de 60 grammes, les performances zootechniques de silures subissant un rationnement sévère (1 % du PV) pendant 3 semaines puis réalimentés pendant 3 semaines soit *ad libitum* soit à 3 % du poids vif, ont été comparées à celles de poissons témoins nourris en permanence soit en excès soit à raison de 3 % du poids vif. Le poids final des lots restreints est inférieur à celui de leurs homologues non restreints, mais les résultats indiquent que la restriction alimentaire induit ultérieurement une croissance spécifique significativement supérieure et un indice de consommation inférieur. Cette croissance compensatrice est due pendant la première semaine à la fois à une hyperphagie et à une amélioration du métabolisme. Un effet positif de l'hyperphagie est encore sensible pendant les 2 semaines suivantes.

Lors de la deuxième expérience, des silures d'un poids moyen initial de 141 grammes ont été nourris pendant 10 semaines soit à un taux constant de 4 % du poids vif, soit alternativement restreints pendant 1 semaine à 2 % du poids vif, et réalimentés pendant une semaine à raison de 4 ou 5 % du poids vif . Au terme de l'essai, les croissances (3,82 à 4,04 g/j) ne sont pas signifiquement différentes. Les indices de consommation les plus favorables (1,79) sont notés pour les poissons ayant subi une restriction de 50% du niveau alimentaire une semaine sur 2.

Lors d'une troisième expérience ont été comparees les performances zootechniques de silures d'un poids moyen initial de 340 grammes nourris pendant 5 mois soit à un taux constant de 3 % du poids vif, soit de façon alternée à 2 et 4 % du poids vif sur la base d'un pas de 15 jours en tenant compte des phases lunaires. Les meilleures croissances (6,5 g/j) et indices de consommation (2,12) sont notés, pour l'ensemble de la période expérimentale, chez les lots restreints en période de lune descendante.

Communication affichée / Poster

INFLUENCE DE L'ALIMENTATION LIPIDIQUE DES REPRODUCTEURS FEMELLES DE *HETEROBRANCHUS LONGIFILIS* SUR LES PERFORMANCES DE REPRODUCTION, LA SURVIE ET LA CROISSANCE LARVAIRES

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Trois groupes de femelles de *Heterobranchus longifilis*, agées de 3 ans, ont été constitués après induction d'une ponte. Ces poissons ont été ensuite nourris avec un aliment à base de tourteau de soja (renfermant 8 % de farine de poisson), supplémenté avec 3,5 % d'huile de foie de morue (HFM), de soja (PRIM) ou de Palme (DIN), afin de typer les apports en acides gras considérés comme essentiels.

Il a été procédé à l'induction et à la ponte de deux femelles de chaque lot trois fois, 76, 97, et 118 jours après le début du traitement. Les performances de reproduction : fécondité, diamètre et poids des oeufs, taux d'éclosion ont été relevés. Ont ensuite été suivis la survie et la croissance, jusqu'au 12 ème jour des larves nourries sur *Artemia salina*.

Les résultats obtenus pour ces différents critères ne permettent pas de différencier les traitements.

Il en est conclu que les géniteurs femelles de *Heterobranchus longifilis* sont peu sensibles à la nature de l'alimentation lipidique vis à vis de leurs performances reproductrices.

Communication affichée / Poster

RYTHME DE CROISSANCE DE L'ATIPA, *HOPLOSTERNUM LITTTORALE* (PISCES, TELEOSTEI, SILURIFORMES), DANS SON MILIEU NATUREL, EN GUYANE FRANÇAISE

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L'atipa présente des marques de croissance squelettiques (zones et annuli) sur ses épines pectorales. Il est donc possible d'envisager une analyse des cycles de croissance de cette espèce dans son milieu si l'on réussit à décrypter la signification physiologique des marques de croissance; éventuellement, on pourra alors obtenir une estimation de l'âge individuel.

Chez les femelles, le taux de croissance baisse fortement au bout de la première année de vie et le décryptage des marques de croissance qui se mettent en place les années suivantes devient alors très difficile en l'absence de techniques de validation correcte *in naturae* ; les annulis sont en effet très resserés. En revanche, chez les mâles, grâce à la formation d'épaisses couches d'os hypervascularisé au moment de chaque période de maturation génitale, un rythme de croissance annuel est plus facile à mettre en évidence et le décompte du nombre de cycles de croissance est relativement aisé.

L'étude squelettochronologique des épines pectorales (histologie osseuse ; microradiographie) de deux lots de poissons capturés dans les marécages de Guyane française (marécages de Kaw et de Macouria) montre que les atipas mâles semblent ne présenter qu'un seul cycle de croissance annuel contrairement à d'autres téléostéens guyanais qui ont deux périodes de croissance active correspondant aux deux saisons humides. Les atipas ont une croissance rapide au cours de la première année de vie et une longévité moyenne de 4 ans, voire de 5 ans; une telle longévité représenterait un potentiel de 3 à 4 reproductions pour les mâles.

Communication affichée / Poster

FLAVOUR ENHANCING EFFECT OF FRESH PALM NUT EXTRACT ON THE AFRICAN CATFISH (*CLARIAS GARIEPINUS* BURCHELL 1822) DIET

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Effect of fresh palm nut extract (FPNE) on acceptance of diets by *Clarias gariepinus* was determined by offering single pellets of a diet sprayed with the extract to fingerlings, determining the time (sec) to consume the pellets compared to the time to consume pellets sprayed with commercial palm oil and another untreated diet. Also, five groups of *C. gariepinus* larvae produced from induce-bred broodstock were reared in three replicates for 30 days in concrete tanks with static flow but for daily replacement of 20% water. The larvae were fed to satiation three times daily with bambara nut waste-based diet (BW), bambara nut waste-based diet with 5% of formula as FPNE sprayed to enhance flavour (BWP), bambara nut-based diet with inclusion of the 5% FPNE plus 1.5% *Spirulina* powder as additional flavour enhancer (BWPS), fish waste-based diet (FW) with 5% inclusion of FPNE, and freshly hatched *Artemia salina* as control. Fresh palm fruit extract improved acceptance of the fingerling's diet; they consumed the pellets sprayed with FPNE in significantly ($p < 0.01$) less time than untreated diet. The growth and survival of larvae fed BW was significantly less ($p < 0.05$) than that of fish fed *Artemia*, and FW ($p < 0.10$). The larvae fed *Artemia* had the best mean growth rate ($mm.d^{-1}$) (0.99 ± 0.07) though not significantly different ($p > 0.05$) from that of fish fed FW (0.93 ± 0.10) and BWP (0.83 ± 0.06). The inclusion of FPNE to BW formula as flavour enhancer significantly ($p > 0.05$) improved the survival *of C. gariepinus* larvae but additional inclusion of *Spirulina* did not have additional improvement on growth or survival. By day 30, the fish fed *Artemia* had the most uniform sized larvae (39.2 ± 1.03 mm) and the highest survival than larvae fed other diets. The rate of survival (%) was for *Artemia*, 66; FW, 50; BWP, 40; BWPS, 40, and BW, 20. More work is recommended in this rather promising *C. gariepinus* larval diet flavour enhancer.

Communication affichée / Poster

SOME FEEDING AND GROWTH SPECIFIC FEATURES OF JUVENILE EUROPEAN WELS (*SILURUS GLANIS*) UNDER DIFFERENT CONDITIONS

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A new shallow area appeared between the delta of Volga river and the Caspian Sea (outer delta) after dams had been built along the river. The main part of the wels population migrated into this area, that promoted an increasing in the population size due to a better nourishment for both juveniles and adults. The food supply was abundant in the outer delta, carp fish having an intermittent spawning.

Depending on food conditions the juvenile wels growth rate differs significantly in different regions and is related to the shift to fish prey. In the outer delta the length of first year welses averages from 4-7 cm in middle June to 6-9 cm in middle July when the food for a long while has consisted of invertebrates (Cladocera, Chironomidae, Gammaridae). The growth rate of juvenile welses accelerates rapidly when they shift to fish prey (length about 3 cm) and they reach a length of 11-23 cm (mean 18 cm) in late July.

The length of first year juvenile welses in upper Volga river is only 4-6 cm in late June when the food has been invertebrates. The length increases up to 6-10 cm by late July when a fish prey has been appended (10%). The juvenile welses reach a length of 11 cm since late August and fish prevail in the food (84%).

Dwelling the outer delta larger wels juveniles (1+, length 15-21 cm) feed in June on other fish juveniles (length 3-10 cm; 90%) and Gammaridae. In July the length of the welses is 18-26 cm. Two or more years old juveniles have a food spectrum that is similar to the adult welses' spectrum. The food consists of diverse fish juveniles and other organisms including mainly crayfish, frogs, and insect larvae.

Communication orale

ELEVAGE LARVAIRE DU SILURE *HETEROBANCHUS LONGIFILIS* : TAUX D'ALIMENTATION JOURNALIERS ET MISE AU POINT D'UNE GRILLE DE RATIONNEMENT

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Quatre manipulations successives destinées à produire des alevins de 10 jours (J10) ont été réalisées dans des auges de 240 l (200 x 40 x 30 cm) reliées à un circuit fermé, sur des larves de silure *Heterobranchus longifilis* âgées de 2 jours (J2) et dont le poids moyen varie entre 1,8 et 2,0 mg.

Plusieurs densités initiales de mise en charge (de 40 à 72 larves par litre) ont été testées de même que deux modes de distribution des nauplii de *Artemia salina*.

Cette étude a permis de préciser, dans des conditions d'élevage larvaire de masse, les besoins alimentaires quantitatifs pour l'utilisation exclusive des nauplii d'*Artemia*. Après une série d'ajustements, un tableau de rationnement modulé selon la densité initiale de mise en charge et l'évolution de l'âge des larves a été déterminé. Les quantités minimales d'*Artemia* nécessaires évoluent de 67 nauplii par larve à J2 (100% de la biomasse) à 800 nauplii par larve à J10 (65% de la biomasse). Une augmentation de ce taux de rationnement de 110% à J2 (soit 72 nauplii par larve) à 70% à J10 (soit 872 nauplii par larves) conduit à une amélioration sensible de la croissance des larves qui passe de 32 mg à 45 mg avec des indices de consommation comparables (2,5 et 2,7 respectivement).

Ce tableau permet d'établir des prévisions sur les quantités de cystes d'*Artemia* nécessaires à la production d'un nombre donné d'alevins et par conséquent sur les coûts liés à cette production. Son application a permis de déterminer un seuil de densité initiale de mise en charge (50 larves /litre) qui minimise l'hétérogénéité des tailles des larves tout en améliorant leur survie.

Communication affichée / Poster

EVOLUTION DES PERFORMANCES ZOOTECHNIQUES ET DU RENDEMENT EN MUSCLE AU COURS DE LA CROISSANCE CHEZ LE SILURE AFRICAIN *HETEROBRANCHUS LONGIFILIS*

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La croissance pondérale, l'évolution de la proportion de muscle au cours du temps ainsi que la composition corporelle ont été analysées sur un lot de silures africains *Heterobranchus longifilis*.

Des individus âgés de 3 mois et d'un poids moyen initial de 95,7 g, stabulés dans un étang à Layo et alimentés à 3 % de leur poids corporel par jour avec un aliment composé titrant 35 % de protéines totales, ont été suivis pendant une période de 9 mois

Pendant cette période expérimentale, le poids des poissons est passé de 95,7 g à 1490,1 g en 9 mois de suivi (soit 12 mois d'âge) avec une croissance moyenne journalière évoluant de 1,57 $g.j^{-1}$ à 7,97 $g.j^{-1}$.

L'indice de consommation inférieur à 2,0 jusqu'au poids moyen de 840 g a connu ensuite une nette augmentation pour atteindre 3,5 à partir de 1000 g et se maintenir autour de cette valeur (IC > 3,2).

La proportion de muscle total augmente progressivement avec le poids, passant de 38,5 % du poids vif à environ 46 % du poids total du poisson. Le muscle latéro-dorsal présente une croissance quasi isométrique (20,5 à 21,9 %) tandis que la proportion du muscle latéro-ventral augmente avec la taille, évoluant de 17,9 % à 23,3 % lorsque le poisson atteint un poids moyen de 600 g environ. Cette période correspond au début de l'accumulation de matières grasses dans le muscle et la cavité abdominale.

La présente étude ne permet pas toutefois de déterminer si cette augmentation des dépôts lipidiques associée à une augmentation de l'indice de consommation est due à un changement dans le métabolisme ou à un niveau d'alimentation inadapté.

Communication affichée / poster

INFLUENCE OF FEEDING AND STARVATION ON THE GROSS BIOCHEMICAL COMPOSITION AND THE LIPID METABOLISM OF AFRICAN CATFISH, *CLARIAS GARIEPINUS*

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Two experiments were conducted in order to study the effect of feeding and starvation on the proximate composition of the muscle and the fatty acid composition of muscle, liver and adipose fat tissue of *Clarias gariepinus*.
In both experiments one group of African catfish was fed a commercial diet, while the other group was starved (45 or 66 days).
In the fed fish the muscle protein and lipid content was significantly higher compared with the values at day 0. Successive significant decreases of the fat concentration together with a significantly higher moisture content were noticed in the starved group. At a later stage of starvation also the percentage of muscle protein significantly decreased in the latter group. An increase of the weight of liver, viscera, carcass and adipose fat was observed in the fed group, while the weight of these tissues gradually decreased in the starved fish. Patterns of fatty acid mobilization in liver, muscle and adipose fat tissue during starvation were also investigated. In liver, saturated fatty acids and monoenes were preferentially mobilized, resulting in a relative increase of n-3 fatty acids derived from 18:3n-3. In muscle, the percentage of monoenes declined, whereas the content of saturated fatty acids and n-3 fatty acids derived from 18:3n-3 increased. In the adipose fat tissue there was no real preferential utilization of specific fatty acids.

Communication affichée / Poster

CROISSANCE DU POISSON-CHAT AFRICAIN (*CLARIAS GARIEPINUS* B) NOURRI AU SON DE RIZ ET AU TOURTEAU D'ARACHIDE EN BACS METALLIQUES

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Dix lots de juvéniles de *Clarias gariepinus* (6g) ont été soumis en duplicats stochastiques, en bacs métalliques (185 l, eau renouvelée, 9 ind./bac), à des régimes à base de son de riz et de tourteau d'arachide. Les régimes expérimentaux étaient formulés pour contenir des teneurs croissantes en protéines brutes, comme ci-après : 0 % (lots non nourris), 14 % (son de riz exclusivement), 20 % (mélange de 80 % de son de riz et de 20 % de tourteau d'arachide), 40 % (mélange de 20 % de son de riz et de 80 % de tourteau d'arachide), et 46 % (tourteau d'arachide exclusivement). Les poissons étaient nourris à satiété, deux fois par jour et six jours par semaine. Des pêches de contrôle étaient réalisées tous les quinze jours. Au bout de 12 semaines, les meilleurs gains individuels journaliers sont restés inférieurs à 1 $g.j^{-1}$, traduisant un rendement médiocre des aliments testés par rapport au potentiel de croissance de *Clarias gariepinus*. Les taux de croissance spécifique des poissons recevant les régimes à 14 et 20 % de protéines d'une part (0,6 et 0,8 $\%.\ j^{-1}$) et ceux recevant les régimes à 40 et 46 % de protéines d'autre part (1,5 et 1,4 $\%.j^{-1}$, respectivement) étaient significativement différents ($p<0,05$). Les indices de consommation ont varié de 3 (mélange à 40 % de protéines) à 11 (son de riz), les différences étant significatives ($p<0,05$) entre les traitements. Les lots non nourris ont perdu du poids à un rythme de 0,81 % par jour, ce qui correspondrait à leurs besoins d'entretien. Ces resultats indiquent que la croissance de juvéniles du poisson-chat africain augmente avec la teneur en protéines végétales de l'aliment, l'optimum se situant au voisinage de 39 %.

Communication orale

OPTIMISATION DE L'ELEVAGE INTENSIF DES JEUNES STADES DE *SILURUS GLANIS*

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Pour mieux valoriser la technique de reproduction induite précoce du Silure glane (*Silurus glanis*) que nous avons mise au point nous avons cherché à optimiser la croissance des juvéniles jusqu'à J60 en conditions d'élevage intensif.
Des lots de 255 larves en fin de résorption vésiculaire ont reçu 3 régimes alimentaires différents :

- nauplii d'*Artemia* (de J0 à J14), puis micro-particules,
- nauplii et micro-particules (de J0 à J14), puis micro-particules seules,
- aliment artificiel seul.

Les distributions étaient *ad libitum* jusqu'à J39, puis la ration a été ajustée à 10% de la biomasse de chaque lot par jour. Chaque régime a été réalisé en triplicat. Toutes les larves étaient issues de la même femelle. L'installation d'élevage consistait en un circuit fermé, thermorégulé à 24-26°C.
La biométrie des alevins (taille, poids frais et sec) a été suivie chaque semaine sur 30 individus de chaque lot. Les mortalités et la qualité de l'eau ont été relevées chaque jour.
En fin d'expérimentation (J60), la croissance pondérale et la survie étaient d'autant plus élevées que les rations distribuées au début de la phase exotrophe contenaient une proportion importante d'*Artemia*. L'obtention d'individus âgés de 60 jours pesant en moyenne 10 g est réalisée sans difficulté majeure.
Par rapport à des alevins obtenus en saison normale (Mai-Juin), l'usage de ces alevins prégrossis issus de pontes précoces permet de raccourcir la durée du cycle de production intensive en étang et d'obtenir des individus de taille commerciale (1,5 - 2 kg) en 2 saisons au lieu de 3.

Communication affichée / Poster

FEEDING ECOLOGY OF CATFISH FROM A TROPICAL RIVER KSHIPRA (M.P.) INDIA

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The benthic invertebrate fauna and the stomach content of catfish in a stretch of 30 km in Kshipra river were sampled regularly from September 1987 to August 1988. Seventeen kinds of food group organisms were categorized with their frequency of occurrence in the stomach of catfish. The percentage of occurence of fish as food group items in *Mystus seenghala* were found dominant (18.5% to 78.1%) throughout the year out of nine food groups. *Ompok bimaculatus* feed on ten food groups and percentage of occurence of fish as food ranged from 18.36% to 73.2%. *Mystus bleekeri* and *Heteropneustes fossilis* feed on thirteen food groups and the dominant food group was Diptera. The variation in the food groups were correlated with fish size. It was observed that medium size fish feed on a large nutritional spectrum consuming seven food groups while the youngest and oldest fish had a comparatively smaller nutritional spectrum (2-4 food groups). The diet feeding patterns indicate that index of stomach fullness showed two peaks in the feeding cycle of catfish, one at the sunset and other shortly before sunrise. The ranges of food organisms utilized by the four catfish species were very smilar as were the proportions of the different food categories indicating food competition. Kendall rank correlation coefficient and Forage ratio concept indicated that the diet of the two fish species (*M. seenghala* and *O. bimaculatus*, *M. bleekeri* and *H. fossilis*) were similar on all but the June and July 88 sampling date. Due to apparent difference in habitat preferences, this similarity in diet may be regarded as giving rise to indirect food competition.

Communication affichée / Poster

DEVELOPMENT, STRUCTURE, SUPERFICIAL ORNAMENTATION AND GROWTH OF THE POST-CRANIAL BONY PLATES (SCUTES) IN SOME ARMOURED SILURIFORMES (LORICARIIDAE, CALLICHTHYIDAE, DORADIDAE)

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The development of the scutes was studied in a growth series of *Corydoras arcuatus* using light and transmission electron microscopy; their structure, mineralization and superficial ornamentations were compared in various species representative of three families (Callichthyidae, Loricariidae and Doradidae) using 1 μm-thick sections, ground sections, microradiography and SEM; and their growth was studied in *Hoplosternum littorale* using fluorescent labelling of calcified tissues in experimentally reared specimens.

Scute papillae form in the dermis, and appear first in the caudal peduncle. Collagen bundles of the dermis are colonized by the papilla cells, and are remodeled and incorporated in the papilla to form, in addition to newly synthesized woven-fibered bony material, the initium of the scute. Scutes grow owing to the deposit of parallel-fibered bone on both sides of the initium. A characteristic, highly -mineralized tissue and devoid of collagen fibrils is deposited on the scute surface. This non-osseous layer is called hyaloine. In Callichthyidae and Loricariidae, the scute surface shows numerous odontodes ("dermal teeth"), but they lack in Doradidae, the scutes of which are characterized by a large central osseous spine. The odontodes have various species specific shapes but they show the same structure and organization. Although the scutes have various shapes their structure is relatively homogeneous: an osseous cellular plate covered by a layer of hyaloine. Three fluorochromes were alternatively administered and their deposit on the calcified tissues of the scutes was observed through ultraviolet light. Scutes grew faster in width than in thickness, and the dry season period showed a slow down of the bone deposit in the scutes.

Communication affichée / Poster

FOOD STRUCTURE AND GROWTH OF EUROPEAN CATFISH (*SILURUS GLANIS*) FRY UNDER EXPERIMENTAL CONDITIONS

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Food structure of early European catfish (*Silurus glanis*) fry was studied from the beginning of its exogenous nutrition till the 30 th day of its age. Specific- and size different mixture of live plankton was submitted to catfish larvae under experimental conditions.
Zooplankton supply consisted of rotifers, cladocerans, copepods and their developmental stages. Phytoplankton supply consisted of coccal and filamentous forms of blue-green algae, conjugates and green flagellates.
The experiments with food selectivity of early fry were performed in aquaria at temperature of 24 ± 1°C. Fry was preserved after 2 h test and investigated. Consequently, the dissection of alimentary tract and determination of ingested food organisms were performed. The importance of individual taxonomic groups of plankton was studied in food structure dependently on size and age of fry. Food selectivity was characterized using preference coefficient.
There was found that the size of early fry is more important for the intake of individual items of supplied live food than its age. According to the size of young catfish (as compared to small larvae e.g. of carp and tench), copepods formed 15 % of gut content (*Paracyclops* 13 %, *Eucyclops* 2 %) already in the first day of food intake. The share of rotifers amounted 19 % of gut content (*Brachionus* 14 %, *Asplanchna* 5 %). Small cladocerans dominated in the food with 52 % (*Bosmina* + *Chydorus* 43 %, other cladocerans 9 %). Low share of coccal forms of phytoplankton (8 % of gut content) was registered at the beginning of exogenous nutrition. The preference for smaller cladocerans is of decreasing tendency with increasing size of fry during experiment. On the other side, bigger species of cladocerans and copepods are of continuously increasing importance.

Communication orale

CURRENT STATUS OF NUTRITION AND GROWTH OF THE AFRICAN CATFISH *CLARIAS GARIEPINUS*

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Research on nutrition and growth of the African catfish *Clarias gariepinus* gave rise to aquaculture enterprises of the species in Europe, Africa and Asia (Dijkema, 1992; Verreth and Eding, 1993; Viveen and Verreth, 1993) demonstrating its suitability both for high-tech intensive culture systems (Verreth and Eding, 1993) and for low-tech pond systems (Viveen *et al.*, 1985; Haylor, 1993).
The present paper gives an overview of research findings on nutrition and growth of African catfish, with emphasis on results obtained in our own laboratory over the last decade. Main fields covered in the overview relate to:
- basic growth studies and bioenergetics,
- research methodologies,
- growth simulation models,
- feed ingredients and feeding strategies,
- intensive system design and performance.

Research topics which have received less attention are indicated and suggestions for future research are made, with a view to deepen our physiological understanding of nutrition and growth in the species, but also in conjunction with the present need, notably in high-tech intensive systems, for sustainability of African catfish culture.

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Communication orale

USE OF SOYBEAN MEAL AS PARTIAL OR TOTAL REPLACEMENT OF FISH MEAL IN DIETS FOR BLUE CATFISH, *ICTALURUS FURCATUS*

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Two 12-week feeding experiments were conducted in aquaria with juvenile blue catfish, *Ictalurus furcatus*. In experiment 1, juvenile (6 g) blue catfish were fed one of four isonitrogenous (34% protein) and isocaloric (2.4 kcal of digestible energy/g) diets containing 13, 9, 4, and 0% menhaden fish meal. Soybean meal was added in increasing percentages (48, 55, 62, and 69%) to the respective diets. Fish were fed all they would consume in 40 minutes twice daily (08.00h and 16.00h). After 12 weeks, fish fed a diet with 13% fish meal had a significantly ($P<0.05$) higher individual body weight than fish fed any of the other diets. There was no significant difference ($P>0.05$) in body weights of fish fed the other four diets. No significant differences ($P>0.05$) were found in percentage survival, feed conversion ratio, and protein efficiency ratio among diets.

In experiment 2, blue catfish (9 g) were fed one of five isonitrogenous (35% protein) and isocaloric (2.5 kcal of digestible energy/g) diets. Diet 1 contained 15% menhaden fish meal and 42% soybean meal. Diets 2-5 contained 0% fish meal and 69% soybean meal with various (0.0, 0.3, 0.6, and 0.9%) percentages of L-methionine added. Fish were fed as in experiment 1. After 12 weeks, individual weight, weight gain, survival, specific growth rate, and feed conversion ratio were not significantly different ($P>0.05$) among treatments and averaged 36 g, 302%, 100%, 1.6%/day, and 2.4, respectively. Whole-body compositions of fish were not significantly different ($P>0.05$) among treatments and averaged 75, 61, and 27% for percentage moisture, protein, and fat, respectively.

These data indicate that soybean meal can totally replace fish meal in a diet for blue catfish without supplemental L methionine. This may allow producers to feed more economical diets without adverse effects on growth and survival.

Synthèse / Review lecture

NUTRIENT REQUIREMENTS OF SILURIFORMES

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The channel catfish (*Ictalurus punctatus*) is the most widely cultured foodfish in the U.S., thus most of the nutrient requirement data are available for this species. Qualitatively, about 40 nutrients have been identified as necessary for the normal metabolic function of the channel catfish with quantitative requirement values available for about 30 nutrients including amino acids, fatty acids, minerals and vitamins. Additional information is available on protein and energy requirements, digestible protein and energy coefficients as well as amino acid availability values. Thus adequate nutritional information is available to formulate high quality practical channel catfish feeds.

Only limited nutrient requirement data are available for the other Siluriforme species. Some requirement data have been reported for a few species from Africa (*Clarias gariepinus, C. anguillaris, C. isheriensis, Heterobranchus longifilis* and *H. bidorsalis*), Asia (*Clarias batrachus, C. macrocephalus, C. fuscus* and *Heteropneustes fossilis*) and Europe (*Silurus glanis*). The available requirement data will be summarized and compared with the requirement data for the channel catfish. Some variation does appear to exist in optimum dietary protein levels, essential fatty acid requirements, and lipid vs carbohydrate utilization.

Communication affichée / Poster

THE FAECAL PRODUCTION AND DIGESTIBILITY OF THE SOUTHERN CATFISH (*SILURUS MERIDIONALIS* CHEN), IN RELATION TO RATION LEVEL, BODY WEIGHT AND TEMPERATURE

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The digestibilities of the yearlings were estimated by measuring their faecal productions in laboratory from February, 1988 to February, 1989. The results showed that at 25°C the mean values of the digestibilities as percentages of food energy in the fish fed ration levels of 1%, 2%, 4% body weight per day and satiation were 80.3%, 84.9%, 88.4% and 87.3%, respectively. And in the fish with the mean initial weights of 8.72, 25.43, 45.16, 78.18 and 127.5g, the mean values were 86.6%, 81.5%, 90.4%, 86.9% and 81.1% respectively. The mean digestibilities in the fish with similar initial weight (43.84 - 47.19g) at 15, 20, 25 and 30°C were 78.1%, 82.0%, 85.2% and 90.0%, respectively. By regression analysis a model for prediction of the faecal production (F: J/day) with the food consumption (C: J/day), body weight (W: g) and temperature (T: °C) as independent variables was developed as following:

$$F = 0.868\ C^{(0.981 + 0.0346 \ln W - 0.100 \ln T)}$$

The discussion suggested that the positive effect of temperature on the efficiency in transforming food energy into net energy might occur on the basis of the relationship between the digestibility and temperature.

SESSION

PHYSIOLOGIE ET ADAPTATION

PHYSIOLOGY AND ADAPTATION

Synthèse / Review Lecture

PHYSIOLOGICAL ADAPTIVE MECHANISMS OF SILURIFORMES TO ENVIRONMENTAL CHANGES

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Although a lot of interesting data have been accumulated in the areas of respiratory (branchial and extra-branchial) physiology, neurobiology, sensory physiology (visual, olfactory and electroreceptors), haematology, osmoregulation and endocrines of siluriformes, the present review is restricted to organismal, cellular and molecular strategies employed by these teleosts for survival in the dynamic environment. (1) Only a limited number of siluroid species seem to have been used as poikilothermic models for assessing the effects of environmental thermal fluctuation on physiological processes and adaptive compensations of such rate processes to temperature. Seasonal enzymatic compensation (c-MDH, m-MDH and LDH) to low temperature of winter in the Indian air-breathing *Clarias batrachus*, adaptive alteration of molecular and structural composition of hepatic phospholipid membrane in *Clarias gariepinus*, temperature-mediated processes in immunities of *Ictalurus* sp. are a few recent-most demonstrations. (2) Although the current literature is flooded with reports on a variety of physiological and biochemical effects of xenobiotic stresses on teleosts including several siluroid genera like *Ictalurus*, *Plecostomus*, *Clarias*, *Heteropneustes* etc, apparently little attempt has been made in exploring the mechanisms of detoxication and elimination of these toxicants in the aforesaid fish, as has been exhibited by some other groups of teleosts or mammals. Only a few excellent investigations on the pharmacokinetics, tissue distribution and excretion of poisons and drugs have been conducted on the channel catfish in the USA. (3) That the fishes have been armed with various powerful natural humoral defence systems for their survival amidst different environmental pathogens, has been revealed by a few investigations on catfishes (besides trouts and carps) in Indian and American laboratories in the last five years or so. (4) Although the teleosts are ammonotelic (but ureogenic), some of the Indian freshwater air-breathing species exhibit a diurnal and seasonal variation (of adaptive significance) in the excretory ammonia-N/urea-N and an enhancement of ureogenesis (through activation of the enzymes of o-u cycle) during hyper-ammonia stress. While a complete hepatic o-u cycle has been demonstrated in four species including two siluroids (*Heteropneutes fossilis* and *Clarias batrachus*), a non siluroid *Channa sp.* lacking arginino-succinate synthetase, as well as the fingerlings of *Clarias* seem to be capable of channelizing the ammonia-N/urea-N into amino acid (and protein) under sublethal hyper-ammonia stress. (5) Crowding stress has now been recognized as one of the most important factors affecting growth rate, haematological characteristics, reproduction (spawning), immune responses, pituitary-adrenocortical axis and the sum total of homeostatic mechanisms of fish. Although most of the investigations have been conducted on carps, salmonids, blue gourami, blennies and trouts, only a few physiological parameters like the haematological picture and certain traits of carbohydrate metabolism have been shown to be influenced by loading density of the Indian air-breather, *Heteropneustes fossilis.*

Communication orale

RESPIRATORY ADAPTATIONS TO HYPOXIA IN *SILURUS GLANIS*

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In our laboratory we studied the mechanisms by which the sheat-fish *Silurus glanis* adapts to variations in water oxygenation ranging from Po_2 = 40 to 3 kPa. (Forgue et al., 1989, J.exp.Biol. 143: 305-319). All the experiments were performed in animals weighting either 90-180 or 600-900 g, at T=13°C and during the daytime. From Plo_2 = 40 to 3 kPa, the resting oxygen consumption (Mo_2) is kept constant at a low value (15.4 $mmol.min^{-1}.kg^{-1}$) close to that in the carp but lower than that in trout or salmon. We showed that Mo_2 maintenance is achieved only by an increase in the ventilation when Plo_2 decreases. It increases 7 fold between Plo_2 = 20 and 3 kPa, while the blood flow rate, blood pH and blood O2 affinity remain unchanged. The ventilatory flow rate is low in normoxia, so that 90 % O2 is extracted from the water entering the gill cavity. This leads to low Po_2's in the expired water and arterial blood. In spite of the large ventilatory increase in hypoxia, the ventilation is always set at its minimal level, just enough to ensure the strict maintenance of Pao_2 at 2 kPa. This oxygenation constancy in the internal medium is the sufficient condition to ensure the maintenance of the aerobic metabolism.

The ability of resting *Silurus* to live with a minimal ventilation and at low internal Po_2 can explain its particular resistance to hypoxia. It is known for years that most water breathers are able to maintain their oxygen consumption constant in spite of large variations of the water oxygenation, but the physiological adaptations used to achieve such a maintenance were still a matter of controversy. The efficacy of the ventilation in Silurus allowed us to demonstrate the key position of the ventilation in the adaptation of teleosts to hypoxia.

Communication orale

CONTROLLED HATCHERY PRODUCTION OF AFRICAN CATFISH, *CLARIAS GARIEPINUS* (BURCHELL) : THE INFLUENCE OF TEMPERATURE ON EARLY DEVELOPMENT

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Temperature is the major abiotic factor contolling the rate of morphogenesis in fish, however, few studies have investigated the effect of different constant temperatures on the time taken by African catfish to attain different development stages. The present work investigated hatching and the transition from endogenous to exogenous feeding at five constant temperatures over the range 15 - 35°C. *C. gariepinus* eggs can be successfully hatched where ambient water temperatures lie between 20 and 35°C, although at 30°C the % hatch rate is significantly improved. At 15°C embryos do not survive. The period of hatching is inversely related to temperature such that synchronous hatching is encouraged by high temperature within the species temperature range. The extent to which development rate and metabolic rate in *C. gariepinus* are accelerated by temperature is not the same. The duration between attaining feeding ability, yolksac absorption and the point-of-no-return is inversely related to temperature. The same threshold temperature, below which development is theoretically arrested can be estimated for *C. gariepinus* from the linear development rate-temperature relationship for the period up to hatching, first feeding and yolksac absorption. This closely approximates to the lower lethal temperature of 15°C estimated directly from embryo survival. The effect of temperature can be usefully modelled in *C. gariepinus* using the linear development rate-temperature relationship $V=a+bt$ to estimate t_0 and D^0_{eff} and the hyperbolic relationship $\tau=D^0_{eff}/(t-t_0)$ to determine development time. From the present work, t_0 is 14.5° C and D^0_{eff} is 13, 26.3 and 35.7 for hatching, first feeding and yolksac absorption respectively for *C. gariepinus*. Unlike day-degrees, effective day-degrees remain independent of temperature over the range 20 -35°C. An approximate guide to development time at different constant temperatures within this range is given.

Communication affichée / Poster

MARQUAGE INDIVIDUEL DES POISSONS-CHATS AU BLEU ALCIAN PAR INJECTION AU DERMOJET

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Une méthode de marquage utilisant le principe de l'injection sous-cutanée au dermojet a été pratiquée sur les géniteurs de poisson chat *Chrysichthys nigrodigitatus*. Le dermojet utilisé (type Dr Kranz) est initialement prévu pour la vaccination par injection sous-cutanée. Cette technique de marquage est peu coûteuse, rapide et très pratique sur le terrain. Le colorant utilisé est le bleu alcian 8 GX (R. A. L.) à une dose de 100 mg/ml en suspension dans l'eau distillée. Un millilitre de colorant permet de réaliser 10 points de marquage. Dans ces conditions les marques sont restées lisibles pendant plus de deux ans pour des individus adultes.

Une méthode de codage simple (4 points par poisson) et pratique pour le déchiffrage rapide a été établie en utilisant 10 zones (0 à 9) ventrales claires à proximité des nageoires. Le codage (1 point pour les unités, 2 points pour les dizaines) a permis, dans notre cas, de marquer individuellement 200 mâles et 200 femelles. L'application de ce principe de marquage a été pratiquée également avec succès sur une autre espèce de silure africain, *Heterobranchus longifilis*.

L'utilisation d'un colorant aussi durable mais d'une couleur différente ouvrirait une possibilité de marquer individuellement jusqu'à 1000 individus. Cette méthode pourrait être appliquée à d'autres espèces de poissons sans écailles.

Communication affichée / Poster

PURIFICATION OF A GROWTH HORMONE FROM THE PITUITARY GLAND OF THE AFRICAN CATFISH (*CLARIAS GARIEPINUS*) AND DEVELOPMENT OF A RADIOIMMUNOASSAY

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Growth hormone (GH) was purified from African catfish pituitary extracts, using immuno affinity chromatography. Therefore an anti-chicken GH monoclonal antibody, specifically cross-reacting with the catfish hypophyseal somatotropes, was used. The purity of the obtained GH preparation was demonstrated using rpHPLC and SDS-PAGE. Furthermore the amino terminal end of the protein was shown to be homogenous and the first 50 residues matched the proposed protein sequence for GH of the channel catfish (*Ictalurus punctatus*) with the exception of 1 substitution at position 3. The molecular weight as measured by mass-spectrometry was 20.4 kD.

Subsequently an antiserum with high affinity for the purified growth hormone was produced, which made it possible to develop a RIA suitable for measuring the circulating concentrations of growth hormone in the African catfish. The obtained RIA has a ED-50 value of 0.9 ng/ml and a intra-assay variability of 6%, while the inter-assay variability is no more than 9%. Immunocytochemistry and western blotting showed that the antiserum specifically recognised the growth hormone of the African catfish.

Communication affichée / Poster

ELEVAGE DU SILURE *HETEROBRANCHUS LONGIFILIS* EN BASSINS SANS RENOUVELLEMENT D'EAU : EFFETS DE L'EVOLUTION DE QUELQUES PARAMETRES CHIMIQUES DE L'EAU SUR LA CROISSANCE ET LA SURVIE

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Des silures d'un poids moyen initial de 37 g, ont été élevés, dans des bassins en bétons de 4 m^3, avec ou sans renouvellement d'eau avec des densités initiales de 10 et 20 poissons par m^3. La ration quotidienne d'aliment représentait 4% de la biomasse. La période d'observation, interrompue par une mortalité massive, a duré 7 semaines.

L'évolution des principaux paramètres physico-chimiques de l'eau a été suivie quotidiennement pour l'oxygène (O_2) et la température, et hebdomadairement pour le pH, et les substances azotées dissoutes (NH_4^+, NH_3, NO_3^-, NO_2^-). Les sulfures ont été dosés uniquement durant les derniers jours lorsque leur présence a été suspectée. La croissance et l'indice de consommation ont été relevés pour chaque période de 15 jours.

Pendant les 6 premières semaines, il a été observé que le non renouvellement d'eau n'affecte que peu la croissance et l'indice de consommation, bien que les teneurs en oxygène à 8 heures du matin soient en général situées dans la fourchette 0,1 à 1 mg/l et que les teneurs en ammoniaque atteignent parfois 0,09 mg/l.

Une mortalité massive (totalité du lot) a été observée les 46 ème et 48 ème jour pour les 2 bassins à plus forte densité, et a commencé à se manifester le 49 ème jour pour un lot à 10 poissons par m^3. Cette mortalité est attribuée à une brusque apparition de sulfures dont une teneur de 12 mg/l apparait léthale.

Ainsi, si *Heterobranchus longifilis* a une excellente résistance à des conditions hypoxiques grâce à sa respiration aérienne et supporte sans problèmes apparents des teneurs en NH_3 considérées comme limites, la gestion de l'eau des bassins d'élevage doit prendre en compte d'autres facteurs du milieu tels que les sulfures.

Communication orale

THERMAL RELATIONS OF THE CHANNEL CATFISH, *ICTALURUS PUNCTATUS*

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The channel catfish (*Ictalurus punctatus*) is one of the most eurythermal fish species ; given sufficient time to acclimate it can exist between upper and lower lethal temperatures of 40 and 0°C respectively. Its thermal tolerance calculated by combining lethal and acclimation temperatures is 1190 units almost as great as that of the common goldfish.

For maximum growth, however, the temperature range is 24 - 29°C which also includes its preferred temperature ; optimum temperatures for spawning and embryonic development are slightly lower.

Northern limits (southern Canada) of its distribution are determined by temperature as expressed by the length of the growing season during the first year of life when fish store energy reserves required to survive their first long, northern winter. Commercial fish farms are concentrated in southern states of the U. S. A.

Rates of gain and loss of thermal tolerance in juveniles were experimentally measured by following changes of critical thermal maxima of fish over time when transferred from one temperature to another. Gain of thermal tolerance was relatively slow (days) at low temperatures but rapid (hours) at the upper end of the temperature range. Loss of tolerance was slower than gain.

Communication affichée / Poster

ATIPA, *HOPLOSTERNUM LITTORALE* (CALLICHTHYIDAE, SILURIFORMES), A CATFISH FROM SOUTH AMERICA: OBLIGATE OR NON OBLIGATE AIR-BREATHER?

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Gas exchange was measured, in water, on atipa with and without access to the surface over several night and day periods. Deprivation of air access induced change neither in oxygen uptake though it was limited to uptake from water, nor in carbon dioxide output and nitrogen excretion during the first ten hours following privation of air access. Afterwards, a compensatory increase in oxygen consumption was observed whereas carbon dioxide and nitrogen excretions did not change. Further, fish were not able to maintain their natural rythm of activity. The observed data on gas exchange and nitrogen excretion suggest a shift from aerobic to anearobic metabolic pathways. Limitation of spontaneous activity and modification of metabolism lead to the conclusion that this species is an obligate air-breather, even if it can accept a privation of air access by increasing oxygen uptake from water.

Communication affichée / Poster

LACTIC ACIDOSIS IN THE TISSUES OF CATFISH, *HETEROPNEUSTES FOSSILIS* (BLOCH), ON EXPOSURE TO TEXTILE-MILL EFFLUENT

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Recognised sensitive monitoring systems of bioindices should be employed in advance, to predict hazardous effects well in time and to avoid undesirable toxic consequences. Lack of oxygen leads to anaerobic metabolism of glycogen, which may become depleted, while lactate accumulate. The amount of lactate in blood is often related to the state of fatigue in fish. Since there is a paucity of information on the lactic acid content of fish exposed to textile-mill effluent, the present work is carried out. The freshwater fish, *Heteropneustes fossilis*, was exposed to 2, 3, 5 and 7% concentration of effluent for 7, 15, 30, 60 and 120 days. Muscle, liver and blood were analysed by Barker and Summerson method for lactic acid content.

In the muscle, lactic acid content increased from 84 mg% in the control to 95 mg% in the fish exposed to 7% effluent for 7 days. The same increased to 130, 193, 320 and 435 mg% after 15, 30, 60 and 120 days exposure respectively. At the lower concentrations such as 2, 3 and 5% of effluent, the lactate content elevated from 86 to 238; 90 to 322 and 94 to 386 mg% respectively after exposure for 120 days. Similarly, in the liver also, there was a three-fold elevation in the lactic acid content after exposure to textile-mill effluent for 120 days. In the blood, the lactate increased from 29 mg% in the control to 93 mg% in the fish treated with 7% effluent for 120 days. There was 2 to 3 times elevation of lactic acid content in all the experimental concentrations. All these elevations were statistically significant.

The increase in muscle lactate suggests a respiratory distress due to exposure to effluent. These elevations could have resulted as a consequence of gill damage and difficulty for gas exchange at the gills and impaired oxygen binding and transport capacity. Increase of lactic acid in blood indicate the operation of anaerobic glycolysis in different tissues and channelling of the lactate into blood. The accumulated lactic acid in the metabolically active tissue, liver, would have been received from muscle system through blood.

Communication affichée / Poster

EFFECT OF L-ASCORBIC ACID ON THE VITAMIN C LEVEL OF LIVER AND MUSCLE AND THE PHYSIOLOGICAL STATUS OF EUROPEAN CATFISH (*SILURUS GLANIS* L.) UNDER NITRITE STRESS

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Fingerlings of European catfish (5.35 ± 0.27 g) were fed with diets containing graded levels of dietary vitamin C (0; 100; 1,000; 2,000 mg/kg). After 8 weeks feeding period fish were treated with 2.0 mg/l NO_2 (low) and fed with the same vitamin C levels for 1 week and afterward with 5.0 mg/l NO_2 (high) for 1 day. Ascorbic acid concentrations of liver and muscle samples were analysed from all groups by HPLC with UV detection. Hemoglobin concentration, hematocrit and leukocrit values, number of erythrocytes and leukocytes, as well as the blood glucose level and number of NBT positive cells were measured from blood. Fish increased their body weight from 5.4 ± 0.4 g at start to 23.7 ± 6.7 g in different groups at the end of experiment. No significant positive effect of vitamin C suplementation on growth rate was observed. The vitamin C concentration in muscle was very low 6-10 μg/g in groups. The liver had limited capacity to store the L-ascorbic acid (120 -160 μg/g AA). Enhanced hemopoesis in fish fed by vitamin C levels of 1,000 mg/kg and 2,000 mg/kg, was reflected by significantly higher numbers of erythrocytes leukocytes and NBT positive cells were significantly ($p < 0.05$) higher. Vitamin C feeding did not affect the hemoglobin and glucose concentration.

Vitamin C concentrations in liver of nitrite treated groups decreased significantly ($p < 0.05$) to 10-20 μg/g after one week treatment with low nitrite level. L-ascorbic acid concentrations of liver decreased dramatically (3-5 μg/g) in each group treated with high nitrite concentration. Tissues of control groups (without nitrite treatment) had similar vitamin C status as earlier.

Fish responded to the nitrite treatment with increased hematocrit level, blood glucose and hemoglobin concentration, as well as number of red blood cells. No positive effect of increasing vitamin C levels against nitrite stress was found.

Communication orale

UREO-OSMOTIC ADAPTATION IN THE FRESHWATER AIR-BREATHING TELEOST, *HETEROPNEUSTES FOSSILIS*

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Synthesis and accumulation of urea as one of the major organic osmolytes for hyper-osmotic adaptation has been known in osmotic conformers such as marine elasmobranchs. Aquatic amphibians exposed to hyper-osmotic ambient medium have been reported to show ureo-osmotic adaptation. Freshwater teleosts are osmoregulators with a limited hyper-osmotic adaptation. Inability of freshwater teleosts to synthesize urea from ammonia due to an incomplete ornithine-urea (o-u) cycle has resulted in their use of alternate osmolytes during hyper-osmotic adaptation.

However, the freshwater air-breathing teleost, *Heteropneustes fossilis*, has been reported to have not only a complete (o-u) cycle in its liver and kidney but also significantly induced the activities of the enzymes of the cycle to convert accumulated ammonia to urea during hyper-ammonia and water deprivation stress. The fish tolerated hyper-osmotic ambient medium up to 250 mosm manitol for at least two weeks. During this period excretion of ammonia was suppressed by 50 % but there was no accumulation of ammonia in various tissues except kidney and brain. However, excretion of urea which was suppressed by about 50% during the first week was induced by 50 % during the second week. Significant accumulation of urea occurred in all the tissues. The activity of all the enzymes of the o-u cycle (carbamyl phosphate synthetase, ornithine transcarbamylase and arginine synthetase system) except arginase was significantly induced in both the liver and kidney tissues suggesting *de novo* urea synthesis from ammonia via o-u cycle during exposure to hyper-osmotic ambient medium.

The ureo-osmotic adaptation observed in *H. fossilis* is unique for any ammoniotelic freshwater teleost and therefore, *Heteropneustes fossilis* can be an excellent model to study the evolution of nitrogen metabolism in vertebrates.

Communication affichée / Poster

TECHNIQUE DE MARQUAGE POUR LE SILURE GLANE (*SILURUS GLANIS*)

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L'identification individuelle rapide, fiable et durable (+ 12 mois) des géniteurs est indispensable en pisciculture pour toutes les recherches concernant la reproduction. Cela facilite le repérage d'individus ayant des performances particulières et leur suivi plusieurs saisons de suite.

Différentes méthodes d'identification ont été testées sur le Silure glane dans notre station :

- par marques externes, fixées soit à l'opercule, soit sur la nageoire pectorale, soit dans la musculature dorsale,
- par marquage épidermique: tatouage au bleu alcyan dans la région ventrale, ou cryomarquage sur les flancs.

Les individus marqués (poids supérieur à 1,5 kg) étaient ensuite stockés soit dans des bacs de 4 m^2 (15-20 poissons/bac), soit dans des bassins en terre (20-30 poissons pour 120 m^2).

Les résultats ont été décevants : (i) apparition de nécroses autour du point d'insertion de la marque, avec infections secondaires (mycoses), (ii) mauvaise tenue dans le temps : disparition des marques après quelques semaines, par arrachage ou expulsion, cicatrisation des tissus (cryomarquage), résorption du pigment (tatouage).

Compte tenu de ces difficultés, nous avons essayé des marques électroniques (transpondeurs) implantées à l'intérieur du corps du poisson donc non lisibles directement. Les marques (11 mm x 1,5 mm) sont injectées dans la musculature devant la nageoire dorsale. L'identification du poisson se fait par l'intermédiaire d'un "lecteur" tenu à la main et passé sur la zone d'implantation.

Après plus de 12 mois, nous n'avons constaté aucune perte sur le lot de géniteurs marqués de cette manière (N = 50). Cette méthode s'avère donc efficace pour une identification individuelle non traumatisante et durable chez *S. glanis*.

Communication affichée / Poster

THE EFFECT OF INTENSIVE CULTURE OF EUROPEAN CATFISH (*SILURUS GLANIS*) ON WATER LOADING IN RECYCLING SYSTEM

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The aim of the study was to assess the production of metabolites in intensive culture of European catfish (*Silurus glanis*) of different size. Samples of inflow and outflow water from tanks with fed and starving fish were taken in two-hour intervals for the whole 24 h periods. Changes of selected chemical parameters (NH_4^+-N concentration and COD.cr) were monitored in the samples taken every two hours whilst cumulated samples collected for the whole 24-hour period were analysed for pH, BOD5 of filtered and non-filtered sample, COD.cr, NH_4^+-N, NO_2^--N, NO_3^--N, organic N, total N, PO_4^{3-}-P and total P. Normal distribution was proved in final values so that there was no need to transform them. High variability was found in assessments of NO_2^--N, NO_3^--N and PO_4^{3-}-P loading with no statistical differences between fed and starving fish.

The loading of water by wastes is presented in grammes per 100 kg of fish per day and transferred to population equivalent. The intensive culture of 100 kg of European catfish (*Silurus glanis*) of 200 and 800 g (mean individual weight) loads the recycling water adequately to 3.2 (2.3-4.1) and 2.6 (1.9-3.7) population equivalents respectively. The loading of water by basic metabolism of starving catfish amounts 0.5 (0.4-0.6) and 0.3 equivalents respectively according to the size category.

The values of production of ammonium and organic matter in circadian cycle fluctuate between 50 and 150% of average values in fish fed. In starving fish, almost constant course of these values can be registered.

Communication affichée / Poster

BASIC HEMATOLOGICAL PARAMETERS OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*) FROM INTENSIVE WARM-WATER CULTURE

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Fish subjected to hematological investigations were cultured in recirculating system at water temperature about 25°C and fed pelleted feed mixture Alma Welsfutter. Hematological investigation was performed in two size and age groups of adult African catfish. The first group of fish consisted of 4-month-old females (14 ind.) and males (13 ind.) weighing between 93 - 445 g. The second group consisted of 10-month-old females and males (13 fish of each sex) weighing 820 - 1650 g. Basic hematological parameters were assessed (erythrocyte counts, hemoglobin concentration, hematocrit value, MCV, MCH, MCHC, leukocyte counts, leukocrit, differential leukocyte counts, total protein and total lipid levels, activity of selected plasmatic enzymes). Health condition of fish investigated was good.
Some differences were found between values of red blood picture in African catfish and other fish species, especially of carp and rainbow trout. As compared with these species, higher counts were found in erythrocytes, and also MCV and MCH values were lower. The values of hemoglobin, hematocrit and MCHC were comparable. Expressive differences between African catfish and carp and rainbow trout were registered in values of white blood picture. The leukocytes counts in African catfish are comparable with values registered in other fish species. But big differences were found in values of differential leukocytes counts. The lymphocytes ratio is expressively lower whilst the ratio of neutrophil granulocytes is expressively higher, and also the amount of monocytes is higher. The level of total blood protein and total lipid and investigated serum enzymes in African catfish is approximately adequate to values registered in carp and rainbow trout. All values characterizing the red blood picture were almost identical in males and females. But significant differences were found in white blood picture and level of total protein and total lipid. In African catfish females, there were found higher counts of leukocytes, lymphocytes and monocytes, and also higher level of total protein. On the other hand in males there was found higher level of total lipid. The activities of investigated plasmatic enzymes are, except of creatinkinase, similar in males and females of African catfish.

Communication affichée / Poster

ULTRASTRUCTURE OF THE LIVER OF RIVER CATFISH, *PARASILURUS ASOTUS*

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The general ultrastructural morphology of liver of river catfish, *Parasilurus asotus* has been described. The liver contains two hepatocytic types which can be differentiated from their electron density of cytoplasm at electron microscopic level. The predominant cell type is 'Light' hepatocytes. The second type is 'Dark' hepatocytes and its function is unknown. The observations of liver tissue excised from fingerling fish fasted for 10 days and from a fed control group was conducted at the electron microscopy levels. The results indicated that the liver of river catfish appeared an apparent increase in the number of 'Dark' hepatocytes after a relatively short period of starvations. During ovulation the liver tissue of adult female river catfish also showed increase in the number of 'Dark' cells. The variations in lipid and glycogen content of the hepatocytes of the feral carnivorous fish was compared with those maintained under similar conditions, but fed with the commercial hatchery diets. The significance of these results relative to the changes of the ultrastructure of the river catfish hepatocyte and the dimorphism of hepatocytes of teleosts is discussed.

SESSION

PATHOLOGIE ET PARASITISME

PATHOLOGY AND PARASITISM

Synthèse / Review Lecture

INFECTIOUS DISEASES OF SILURIFORMES, CULTURED FOR HUMAN CONSUMPTION

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Based on an extensive literature search this overview discusses the economic relevant diseases of Siluriformes, cultured for human consumption.
From the literature search a significant difference between double refereed journals (DRJ) and other literature is concluded. Most publications about Channel catfish (*Ictalurus punctatus*) diseases were published in DRJ while diseases of other catfish species were mainly discussed in the other literature. One herpes virus and two irido viruses are relevant for channel catfish, sheatfish (*Silurus glanis*) and yellow bullhead (*Ictalurus melas*) culture, respectively. There is only one fish species-specific bacterial disease which has an economic impact in the catfish industry : *Edwardsiella ictaluri*. Secundary infections with opportunistic bacteria and fungi are of interest in all catfish species cultured both under intensive and extensive circumstances. Etiology, pathology, prevention and treatment are shortly discussed for all diseases. Also some diseases of unknown etiology, which occur in African (*Clarias gariepinus*) and Asian (*Clarias batrachus*) catfish, are described.

Synthèse / Review Lecture

LES PARASITES DES POISSONS SILURIFORMES

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Tous les principaux groupes de parasites de poissons, aussi bien Protozoaires que Métazoaires, ont été signalés chez les Siluriformes.

Parmi les principaux parasites on peut distinguer d'après leur localisation, chez le poisson hôte.

Les Ectoparasites qui vivent sur le tégument et/ou sur les branchies. Les plus importants sont: divers Flagellés, les Trichodines, les Monogènes, les Hirudinées, les Argulidés et les Copépodes.

Les Mésoparasites que l'on rencontre surtout dans le système digestif. Les plus représentés sont les Coccidies, les Cestodes, les Trématodes, les Nématodes et les Acanthocéphales.

Les Endoparasites qui sont dans le corps (tissus ou sang). On peut citer les Trypanosomes et les Trématodes larvaires (métacercaire).

Certains parasites intra-cellulaires comme les Myxosporidies peuvent être considérés comme ecto, méso, ou endoparasites.

On distinguera aussi les parasites qui, spécifiques oioxènes, ne quittent pas l'espèce hôte et les transfuges. Ceux-ci, parasites d'autres poissons, peuvent dans certaines conditions (anthropisation du milieu, élevage, introductions) s'installer et, chez un nouvel hôte, (Siluriforme) être la cause d'une épidémie.

Si, chez les poissons classiquement utilisés en pisciculture (genres *Clarias, Ictalurus* et *Silurus*), les données sur la parasitofaune sont abondantes (de nombreux cas de pathologie parasitaire et leur étiologie ont été étudiés), elles restent fragmentaires pour toutes les autres espèces de l'ordre.

On tente une présentation des principaux cas où, chez les Siluriformes, les parasites paraissent être à l'origine de phénomènes pathologiques et de mortalité dans le milieu naturel et en élevage. On dresse le bilan des traitements utilisés et on insiste sur les précautions à prendre en cas d'introduction ou de mise en élevage de nouvelles espèces.

Communication orale

CONCOMITANT HAEMOFLAGELLATES IN *CLARIAS BATRACHUS* : ALTERATION IN BIOCHEMICAL INDICES

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Cultivable fresh water fishes are frequently parasitized by haemoflagellates belonging to the genera, *Trypanosoma* Gruby, 1983 and *Trypanoplasma* Laveran and Mesnil, 1901. The siluroid catfish, *Clarias batrachus* has served as a host for both genera but concomitant infection has been observed for the first time in 6.1 % of the infected samples. 27.6 % of the fish were positive to *Trypanosoma batrachi* Qadri, 1962. A new species of trypanoplasm parasitized the blood of *Clarias* and in view of its distinctness from the existing species, the name *Trypanoplasma rohilkhandae* n.sp. is advanced to accomodate the new identity based on its statistical data and cytomorphological features.

To verify experimentally the pathogenecity of flagellates as agents for alteration in biochemical indices, 30 fishes were equally distributed into 3 groups. Group I - control, Group II - trypanosome infected and group III - concomitant infected. Glucose, protein and cholesterol were estimated according to the standard techniques in all the three groups. The glucose content in Group II fish fell to 37 % whereas in Group III, it dwindled to 57 %. On the other hand, protein showed an insignificant rise (P 0.01) in group II and an insignificant fall (P 0.05) in group III fish which may be attributable to an imbalanced albumin-globulin ratio. Cholesterol is the predominant sterol in flagellates and sterols in general are not synthesized by parasites and are therefore essential dietary requirements. The present investigations showed a more intense hypocholesterolemia in Group III as compared to group II fishes. The results indicate that the impairment of biochemical indices under concomitant conditions far exceeded those under lone trypanosome-infected conditions due to the greater biochemical requirements of the trypanoplasms for their metabolic activities despite their lower infectivity.

Communication orale

EFFECT OF SOME ENVIRONMENTAL AND TECHNOLOGICAL STRESS FACTORS ON PHYSIOLOGICAL PARAMETERS OF EUROPEAN CATFISH (*SILURUS GLANIS* L.)

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Environmental and technological stress factors were studied on intensively cultured European catfish. Fish were produced and raising in recirculation system of Fish Culture Research Institute (Szarvas, Hungary) according to the technology developed in the Institute. Fish were fed a dry feed and held in different fibre glass tanks (300-2000 l) at 20-22°C. The gradual (1°C/day) and fast (28-->15°C) temperature decreases, hypoxia (1.4 mg/l O_2), low (2 mg/l) and high (5 mg/l) nitrite concentration, Rhabdovirus infection, different dietary vitamin C doses (100, 1000, 2000 mg/kg) and effects of immunostimulation (glucan and ISK) were determined. Hematocrit and leukocrit values, hemoglobin concentration, erythrocyte and leukocyte counts, numbers of cells producing oxidative radicals (NBT positive cells) were determined from whole blood. Adrenaline and noradrenalin levels, glucose concentration, transaminase and lysozyme enzymes activity, protein level were investigated from plasma. For different experiments, different hematological and physiological parameters were used.

The obtained values represent the normal hematological and physiological values of intensively reared European catfish and the typical changes after different alterations. Based on these information it is easy to control the health condition of cultured European catfish. By the determination of typical changes in hematological and physiological parameters it will be possible to make more complete the early diagnosis of diseases as well as the adverse effect of water environment.

Communication affichée / Poster

THE SENSITIVITY OF EGGS AND LARVAE OF *SILURUS GLANIS* AND *CLARIAS GARIEPINUS* TO PREVENTIVE ANTIMYCOTIC AND ANTIPARASITIC SHORT-TERM BATHS

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The experiments were performed in glass dishes with 2-4 times water exchange during incubation. In *Silurus glanis*, survival rates 1.07-1.33 times higher were reached in baths of malachite green at concentrations of 0.5-20 $mg.l^{-1}$ for 2 min, and in baths of Wescodyne (0.2 and 0.5 $ml.l^{-1}$ for 2 min) these rates were 1.26 and 1.30 times higher, respectively. The best hatching rates in *Clarias gariepinus* reached 50 % in malachite green (5 $mg.l^{-1}$ for 2 min) and an average 33.5 % in Wescodyne (0.02-2 $ml.l^{-1}$ for 10 min). The lower results of egg hatchability were obtained in other combinations of exposure time and concentrations. Basic lethal concentrations (LC50 and LC5) and route-identification lethal concentrations (LC1 and LC0.1) were found using the modified method of acute toxicity assessment of routinely employed preparations (NaCl, formaldehyde, Chloramine B) in preventive and therapeutic baths of larvae of both species at time periods 15-120 min. There was proved that the effect of the age on larvae mortality is very low. Similarly, very small differences were found when monitoring the effect of larvae satiation, short-time starvation, and type of food respectively. Larvae of *Silurus glanis* are more tolerant against the above mentioned therapeutics as compared with larvae of many other routinely farmed cyprinid species.

Communication orale

ECOLOGICAL ATTRIBUTES IN REGULATING MONOGENEAN DIVERSITY ON *WALLAGO ATTU* FROM RIVER GANGES AT ALLAHABAD, INDIA

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The continuous invasion on gills of *Wallago attu* by one of the four monogeneans viz. *Silurodiscoides indicus* occurred all the year round. It starts in the autumn and coincided with other three monogeneans, *S. sudhakari, Thaparocleidus allahabadensis* n.sp. (Malhotra and Pandey, in press) and *T. euzeti* n.sp. (Malhotra and Pandey, in press). The latter two species disappeared by the end of the summer period while *S. sudhakari* disappeared by mid-summer. The data indicated a shorter post-embryonic period and seasonal breeding cycle in this species. *S. indicus* was a very adaptable eurythermal species capable to produce a population of both "warm tolerant" and "cold tolerant" specimens. The most preferred micro-habitat for monogeneans was gill I of the fish. Their number declined gradually from gills II to IV. Its maximum abundance occurred in the anterior gill region while minimum encountered in the posterior-middle gill region. The significant regulatory niches of water temperature and pH in the dynamics of individual monogenean species have been worked out. Immune responsiveness of *W. attu* under varied temperature conditions apparently played a dominant role in the development and establishment of monogeneans.

Communication affichée / Poster

EXPERIMENTAL EVALUATION OF THE PATHOGENICITY OF *TRICHODINA MARITINKAE* TO FRY OF CULTURED AFRICAN CLARIID CATFISHES

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Trichodina maritinkae, initially observed from *Clarias sp.* in South Africa is now widely reported in the African continent with an affinity for the Clariidae. In view of the known differences in pathogenicity of trichodinid ciliates, studies were conducted to determine the pathogenic potentials of *T. maritinkae.*

In controlled experiments, larvae of hatchery-produced Clariidae (*Clarias gariepinus* and *Heterobranchus sp.*) were infected with *T. maritinkae* after 7, 14, and 21 days post-hatching. Cumulative mortality was monitored in both infected and control groups over a period of 28 days. The onset and severity of mortality were related to age at initial infection. Within 14 days post infection, mortality had reached 100% in both the 6- and 14-day old fry compared with 5% in the controls. 70% of the 21-day old individuals survived the infection. Histopathological effects included increased mucus production, hypertrophy and hyperplasia of gill epithelium, lamellar disintegration and extreme extravasation of formed elements.

It is concluded that *T. maritinkae* is a definite pathogen of juvenile African clariid catfishes and an important factor in the large-scale production of catfish fingerlings for aquaculture in the continent.

Communication orale

ISOLEMENT ET CARACTERISATION D'UN VIRUS A ADN, ICOSAEDRIQUE, ISOLE DU POISSON-CHAT *(ICTALURUS MELAS)*

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A l'occasion d'une mortalité massive de poissons-chats dans un étang, au printemps 1990, nous avons isolé sur cellules EPC, à 20° C, à partir des organes de sujets moribonds, un virus qui se multiplie également sur cellules BF2 et CCO, entre 15 et 25° C. En microscopie électronique, sa taille est de 150 à 160 nm et sa forme hexagonale ; certaines particules sont enveloppées. Ce virus est sensible au chloroforme et sa réplication est interrompue par la 5-iodo-2-désoxyuridine.

Ces propriétés permettent de le qualifier d'Iridovirus-like et de le rapprocher de l'Iridovirus de la nécrose épizootique hématopoïétique (EHNV) de la perche, isolé en Australie, et de l'Iridovirus du silure, isolé en Allemagne lors de mortalités répétées. Ces trois virus ont en effet une morphologie voisine (icosaédrique, 153 nm) et une structure polypeptidique identique en nombre et poids de polypeptides. Ils possèdent des antigènes communs (immunofluorescence croisée). Ces caractéristiques les rendent proches du Frog-virus 3 qui appartient au groupe des Ranavirus au sein des Iridoviridae.

La reproduction expérimentale du pouvoir pathogène de l'Iridovirus du poisson-chat permet d'affirmer que ce virus est responsable de la mortalité constatée. Par ailleurs, au mois de juillet 1992, suite à une mortalité massive spécifique de poissons-chats (1,2 t) sur le plan d'eau de Miribel-Jonage dans le Rhône, nous avons isolé, à nouveau, un virus. A l'aide de la microscopie électronique et par immunofluorescence croisée avec des sérums anti-iridovirus de silure et de poisson-chat, il s'est révélé être un iridovirus comparable à celui isolé en 1990. Un épisode clinique similaire avait été signalé en 1988 (mortalité estimée à 2 t) et des investigations, uniquement bactériologiques, avaient suggéré une Aéromonose à *Aeromonas hydrophila*.

Afin de comparer le virus du silure et le virus du poisson-chat, une étude de pouvoir pathogène expérimental a été réalisée par inoculation IM de virus aux silures de 12 cm. La mortalité a concerné 100 % des sujets inoculés en 6 à 10 jours et 100 % des cohabitants en 16 jours. Le virus a pu être réisolé à des titres très élevés à partir des poissons morts, inoculés et cohabitants.

Communication affichée / Poster

SOME CLINICAL ASPECTS OF INTRAMUSCULAR INJECTIONS OF AEROMONAS HYDROPHILA ON THE WALKING CATFISH (*CLARIAS GARIEPINUS*)

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A comparative study was made on the effects of intramuscular injection of *Clarias gariepinus* with (1) saline suspensions of living washed Aeromonas hydrophila bacteriae (A.h.), (2) unwashed suspensions of living A.h. and (3) suspensions of sonicated A.h. respectively. Doses of 10^6, 10^7 and 10^8 bacteriae/ml were used.

With doses of 10^6 and 10^7 bacteriae per ml, both washed and sonicated bacteriae induced some inflammation and hemorrhages. Fish clinically recovered after 48 hrs. The unwhashed bacteriae induce a stronger reaction with a clinical recover after 120 hrs. With the highest dose of both washed and sonicated bacteriae, inflamation and hemorrhages were more marked. The recover was after 120 hrs too.

Unwashed suspended bacteriae at the highest dose killed all the fish after 48 hrs. Furthermore, the erytrocytes were completely hemolysed.

Communication affichée / Poster

THE OCCURENCE OF BRANCHIOMYCOSIS IN EUROPEAN CATFISH (*SILURUS GLANIS*)

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The first description of branchiomycosis in European catfish originates from Hungary (Danko, Szabo and Szakolszai, 1966). *Branchiomyces sanquinis* was indicated as the pathogenic agent of this disease. Two cases caused by branchiomycosis were diagnosticated in Czech Republic. The first one was described in May 1969 when branchiomycosis was diagnosticated in catfish spawners in Southern Moravia after a long warm period. Eleven of 80 spawners died. No signs of the disease were found in carp from the same pond. Growth style and size parameters (wall thickness of hyfae, spore size) of fungi which were responsible for the disease corresponded to species *Brachiomyces demigrans*. Patho-anatomical and histopathological changes in gills were described and documented. The second case of acute branchiomycosis in catfish spawners was diagnosticated in experimental pond of Research Institute of Fish Culture and Hydrobiology at Vodnany in pre-spawning period in early June 1992. The whole stock of the pond (40 males) died within 5 days. Physico-chemical parameters of pond water before and during the disease situation were documented. These parameters were characterized above all by higher water temperature (21.4°C) and especially by low oxygen concentration (1-2.9 $mg.l^{-1}$). This case of branchiomycosis can be considered as a typical example of disease resulting from unconvenient environmental conditions.

SESSION

TRANSFORMATION ET QUALITE DES PRODUITS

TRANSFORMATION AND QUALITY OF PRODUCTS

Synthèse / Review Lecture

TRANSFORMATION AND QUALITY OF PRODUCTS IN SILURIFORMES

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Traditional aquaculture of siluriformes in Europe and Asia is more directed to whole fish products but some traditional processing have been developped as it is for instance in Africa to allow storage of fish. Recent developments in aquaculture of silurids in Europe and catfish in USA have been associated with further processing of fish. Dressing and filleting are often necessary due to the external appearance of siluriformes and the commercial size of some species. Other processes have been implemented to obtain products adapted to specific markets. Processing seems not only possible in siluriformes but also well adapted due to the intrinsic characteristics of their flesh, especially its visual aspect, composition, texture and flavor.

The yields for processing of siluriformes are either relatively high for dressing (60 %) and relatively low for filleting (40 %) compared to other fish species. The low amounts of visceral fat and the specific shape of these fish explain such differences. The relative development of the different body compartments which explain these yields are controlled both by intrinsic factors (size, genetics origin) and extrinsic factors (diet).

The aspects and texture of the flesh are rapidly described. The absence of coloration of the flesh is rather positive not only for fillets but also for further processing of the flesh. There are few studies on variability of color. The tissues which composed the flesh : connective tissues and muscle tissues, have specific characteristics of structure and composition. These characteristics explained probably the higher mechanical strength of silurid fish compared with salmonids and cyprinids and its stability during ice storage and freezing.

Large changes occured during cooking especially for water holding capacity and texture and siluriformes could be classified for their thermal behaviour as intermediate between salmonids and cyprinids. Further processing have been tested and applied on siluriformes flesh mainly based on the use of fish paste. There are however few informations on the relative ability of siluriformes for such processing compared to marine fish or to carp generally used as a model for experimental studies.

One interesting aspect of siluriformes is their flavor. The flavor (smell and taste) of flesh is not intense and this is probably a consequence of low levels of fat in their flesh compared to other species. A specific subtile flavor could be attributed to some siluriformes and they are considered as high quality fish in some countries. The variability of this flavor has been studied for american catfish and some of the published data are reviewed.

The development of off-flavor is however especially important in siluriformes due to its low flavor. Off-flavor could be a consequence of oxidation of lipids and especially polar lipids during storage. But off-flavor could be also a consequence of environmental tainting directly related to the condition of rearing (ponds, recirculated systems). The compounds responsible for environmental off-flavor but also the microorganisms producing these compounds have been identified. Recent data on the possible control of these compounds are discussed.

Communication orale

GENETIC AND NUTRITIONAL INFLUENCE ON THE TOTAL LIPID FATTY ACID PROFILE OF *CLARIAS GARIEPINUS* MUSCLE

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The fatty acid profile of four different genetic strains of *Clarias gariepinus* (Gold, Netherlands, RAU & Wild, Olifants River system) were evaluated. Fertilized eggs and larvae of the four strains were maintained under identical environmental conditions. After nine weeks, the two fastest growing strains (G & W) had less total body lipid than the others (N & R). The total saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids of the four strains were: G - 32,03; 26,81 & 37,84%; N - 33,40; 27,96 and 35,30%; R - 32,72; 29,00 and 34,99%; W - 32,86; 27,65 and 36,55%, respectively. The major fatty acids that showed statistically significant differences between strains were: C16:0, C18: 1ω9, C22:5ω3 and C22:6ω3. The G strain had a significantly higher ω3/ω6 ratio (2,20) compared to that of the other strains (N - 1,87; R - 1,92 and W - 1,88). In a second trial, juveniles of strain G were fed an artificial diet for 60 days containing no lipid (A, control), or the following lipids at 10% of the diet, sunflower oil (B, a high level of C18: 1ω9 and C18:2ω6), cod liver oil (C, a high level of 20 and 22 carbon ω3 fatty acids) and tallow (D, predominantly SFA & MUFA). Muscle total lipid composition was strongly influenced by diet and contained the following SFA, MUFA and PUFA percentages, and a ω3/ω6 ratio of: A - 36,33; 45,13; 15,70% and 0,52; B - 30,78; 34,54; 33,96% and 0,11; C - 33,51; 38,75; 24,59% and 1,87; D - 38,87; 46,03; 13,06% and 0,44, respectively. The influence that these results may have on muscle quality in terms of human nutrition is reviewed.

Communication affichée / Poster

PRELIMINARY STUDIES ON PROCESSING OF AFRICAN CATFISH (*CLARIAS GARIEPINUS* BURCHELL,1822) IN HUNGARY

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Fish processing started in Hungary in 1950. Although fish processing has never become a big industry in Hungary, various products have been developed and processed on fairly small scale mainly from Chinese carps, common carp and trout. African catfish that has been cultivated in Hungary only for few years, seems to be a promising species for production and processing in the future. This species might contribute to the increase of fish consumption in Hungary that is not higher than about 2.6 kg/caput/year.

The development of African catfish processing in Hungary is based on the following facts:

1. This species is not well-know in Hungary at present thus the consumers do not prefer the live fish.
2. The African catfish has a very good growth rate, i.e. the 500-700 g body weight that is needed for the processing, can be reached within a fairly short period of time.
3. It can be produced all the year round in industrial systems thus the fish processing plants can be supplied with fish continuously.
4. The quality of fish flesh is good, it's fat content is low.

The present study covered the experiments carried out for determination of slaughtering value, processing losses and production costs of various products of African catfish.

Communication orale

CONTRIBUTION A L'ETUDE DES COMPOSANTES DE LA QUALITE DE LA CHAIR DU SILURE (*SILURUS GLANIS* L)

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Une étude a été entreprise dans la Région Centre (France) afin de préciser les rendements en chair et de caractériser la composition chimique, la texture et fournir une évaluation sensorielle de la chair du Silure glane.

L'étude portant sur le rendement en filets a concerné plus d'une tonne de poissons : les rendements en chair obtenus après filetage manuel sur des poissons de 0,8 à 2,5 kg sont en moyenne de 41 % pour des filets sans peau et de 50 % pour des filets avec peau. Ces rendements augmentent avec la taille et dépendent du sexe du poisson. Le rendement moyen atteint 85 % après éviscération et 65 % après éviscération et étêtage.

La composition chimique du filet de Silure glane a été étudiée sur 80 poissons, à quatre périodes de l'année suivant le niveau d'intensification et la composition des aliments de quatre piscicultures. La teneur en matière sèche est en moyenne de 22 % pour une teneur en matières grasses de 13,5 %. Le rapport acides gras saturés sur insaturés varie de 42 à 48 % selon l'époque de l'année et le régime alimentaire, avec une faible quantité de C20 et C22 et une plus forte représentation des C16 et C18. Les matières azotées représentent 81,6 % de la matière sèche et les matières extractibles non azotées représentent 1,1 % de la matière brute. La valeur énergétique atteint 92,4 kcal/100 g et aucune trace de micropolluant organochloré, phosphoré ou de métaux lourds n'a été détectée.

Les évaluations de la qualité organoleptique, réalisées sur des poissons après passage en eau claire et un jeûne de 4 jours mettent en évidence avant cuisson, l'absence d'arêtes intramusculaires, une couleur blanche à beige nacrée, la faiblesse de l'intensité aromatique et après cuisson, une couleur blanche nacrée avec des notes aromatiques de noix et noisettes. La consistance de la chair est ferme et elle présente une résistance mécanique ainsi qu'une onctuosité satisfaisantes. Les évolutions de la qualité par le chauffage sont comparables à celles observées pour la truite élevée en mer. Une maturation de la chair par la congélation ou la réfrigération modifie favorablement la texture.

En conclusion, les résultats, qui font l'objet d'un traitement statistique, montrent que le Silure glane présente des caractéristiques favorables à une commercialisation en filets frais et à une transformation en produits plus élaborés.

Communication affichée / Poster

PIGMENTATION TRIALS ON COMMON CATFISH (*ICTALURUS MELAS*)

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Common catfish (*Ictalurus melas*, Raf.), with a production of about 2,000 mt/year, is the third fish species most farmed in Italy.
Because catfish caught in natural waters present a yellow pigmentation on bell, yellow-greenish on the sides, dark green or brown on the back, the market requires the same characteristics of pigmentation also for the farming fishes. On the contrary, these latter are generally white in the belly with various tonality of grey on the sides and on the back.
The experiment was carried out in order to verify the pigmentation capacity of catfish livery of a balanced feed containing astaxanthin (100 ppm/kg) compared to the same diet without pigment.
The trial lasted 85 days. The fishes were subdivided in 4 thesis of 100 specimen each, stocked in 4 tanks of which 2 with pigment diet and 2 as control. The fishes had an initial mean weight of 77.2 g.
Every two weeks, 5 fishes/tank were analized from the chromatic and chemical point of view.
Starting from 45 days, the animal fed on pigment feed showed significant chromatic differences compared to the control. These differences became more evident in the long run.

Communication affichée / Poster

PROCESSING YIELD OF SURUBIM *PSEUDOPLATYSTOMA CORUSCANS* (AGASSIZ, 1829) (SILURIFORMES, PIMELODIDAE)

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The flesh quality and high market value have inspired the examination of the aquaculture potential of the surubim (*Pseudoplatystoma coruscans*). Head, viscera, dressing, fillet and residue weights were obtained, as well as the relationships between these parameters and total weight, expressed in percentage. The analysis showed dressing and fillet yields of 71.3% and 48.3%, respectively. Despite the current believe that this fish has a voluminous head, it means only 15.9 % the total weight, which is in agreement with similar values from other commercial cultured fish.

Communication affichée / Poster

RESIDUES OF POLLUTANTS IN SILURIFORMES FROM VARIOUS LOCALITIES OF CZECH REPUBLIC

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Tissues (muscle, kidney, liver, gonads) were investigated for residues of pollutants in European catfish (*Silurus glanis*) from Orlik reservoir and 6 big ponds (Bezdrev, Spolsky, Vrkoc, Jindrichohradocky, Novovesky, Bezruc) and brown bullhead (*Ictalurus nebulosus*) from Labe river. 8 (1700-5700 g) and 30 individuals (1800-4100 g) of catfish were investigated from Orlik reservoir and ponds respectively. 34 individuals of bullhead (70-347 g) were investigated from various localities of Labe river. Among pollutants, metals (Hg, Cd, Cr, Pb, Al, Cu, Zn, Ni), PCBs as amount of technical mixtures used in Czech Republic (Delor 103 and Delor 106) and as 7 indicator congeners (K28, K52, K101, K118, K138, K153, K180), DDT and its metabolites, HCH izomers, triazins (atrazin, simazin, prometryn, desmetryn, terbutryn) were assessed. The values of individual pollutants found in tissues of catfish from ponds were very low and corresponded to hygienic limits in all cases. Much higher values of pollutant residues were found in catfish from Orlik reservoir, and they exceeded the hygienic limit in some cases (PCB). Also values of pollutant residues found in bullhead captured from various localities of Labe river were increased. Above all, PCB values exceeded our valid hygienic limit in some cases.
Siluriformes representatives were proved to be good indicators of surface waters contamination.

Communication affichée / Poster

QUALITE DU SILURE, *SILURUS GLANIS* L., EN ELEVAGE INTENSIF

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Dans le cadre de tests d'aliments réalisés sur le silure (*Silurus glanis)* en Dombes (Ain, France), un suivi de la qualité alimentaire de la chair a été engagé sur quatre lots de poissons alimentés chacun avec un aliment différent (aliment A: 49,0/9,5 [1] ; aliment B: 50,0/9,0; aliment C: 32,4/3,7; aliment D: 41,7/8,3). A la fin de la saison d'élevage (octobre), trois types d'analyses ont été effectuées:
- des mesures du rendement en chair, en fonction de la taille des poissons;
- des analyses biochimiques (5 x 4 répétitions) du muscle, limitées à quelques éléments (protéines, lipides, eau, cendres);
- des tests organoleptiques réalisés sur les filets afin de comparer la qualité alimentaire de chaque lot, après définition et sélection de critères d'évaluation propres au silure.

L'objectif de ces analyses, auxquelles s'ajoute un suivi de la qualité du milieu d'élevage, est d'établir à terme les principales relations entre la qualité de ce milieu, des aliments utilisés et de la chair des poissons obtenus.

L'étude du rendement en chair réalisée sur 50 poissons de 700 à 2500 g indique un rendement moyen en chair de 91,8 à 92,9% du poids vif après éviscération, et de 36,3 à 37,7% de filet sans peau, selon la taille des poissons, les meilleurs rendements en filet étant obtenus avec les individus les plus gros (plus de 1,5 kg). Les analyses de composition biochimique de la chair donnent des teneurs moyennes en protéines de 20,6%, en lipides de 1,4%, en eau de 79,3% et en cendres de 1,4%. Les analyses sensorielles comme les analyses biochimiques ne présentent globalement pas de différences significatives pour les 4 aliments testés.

D'autres séries d'analyses viendront compléter ces premiers résultats et permettront d'étudier d'éventuelles évolutions de la qualité de la chair du silure, en fonction de la saison d'abattage et de l'âge des poissons.

(1) : Protéines (%)/Lipides (%)

Communication orale

EFFECT OF AGE AND SEX ON PRODUCT QUALITY IN AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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The African Catfish (*Clarias gariepinus*) is one of the most important catfish species cultured. Intensive research has been carried out on propagation, breeding and production technic, but - when compared to other fish-species - little is known about its product quality and the influences on the corresponding traits.

For the evaluation of the product quality in this species, samples of fish originating from intensive production conditions (recirculation systems) of german and dutch fishfarms were investigated. Serial slaughtering and subsequent quality evaluation was applied referring to four different growth periods. Several parameters characterizing the outer and inner product quality, e.g body measurements, tissue and organ percentages, physical and chemical flesh-quality-criteria, were analyzed for the effect of age and sex on these traits.

The outer product quality parameters - which still represent the most important aspects in practical fish marketing - were significantly influenced by the age and the sex of the fish. During the growth period analysed, the degree of corpulence increased. In relation to body weight, an increase of intestines can be observed due to the ongoing gonad development. Important parameters of flesh quality, e.g. water-binding-capacity, texture and intramuscular fat content, improve continuously with increasing age. The sex effect was found to be of major importance, too. Contrary to a slightly better growth in females in late-slaughter-dates, males were found to give a better dressing-percentage due to their lower gut-weight and a better fillet-percentage. However, the main difference between both sexes was found in physical and chemical flesh quality. Females have a higher intramuscular fat content and a significantly lighter flesh. Both characteristics are preferred under German market conditions.

With regard to these results, the optimal duration of the fattening period under intensive production conditions must represent a compromise between the quantitative outer parameters and the qualitative inner parameters. It can be generalized, that older fish do have some negative traits, but are advantageous in many aspects of flesh quality. Moreover, sexual differences in product characteristics increase with increasing age, too. These observations may be of importance for processing operations, storage and marketing.

SESSION

REVUES REGIONALES

WORLD OVERVIEW OF SILURIFORMES CULTURE

Synthèse / Review lecture

STATUS AND PERSPECTIVES OF CULTURING SILURIFORMES IN EAST AND SOUTHEAST ASIA

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Freshwater fish production in Asia is dominated by carps (5,582,294 t) and tilapias (347,665 t), compared to these volumes the 75,836 tons of cultured catfish species reported in 1991 seems to be insignificant. Even adjusting the statistics by including catfish production in those countries that does not report freshwater fish culture by species (e.g. Bangladesh, Laos, Myanmar and Vietnam) would not alter this picture significantly. However, indigenous *Clarias* and *Pangasius* species (mainly *C. batrachus, C. macrocephalus, C. fuscus* and *P. hypophthalmus, P. micronema, P. larnaudii)* play a significant role in South and Southeast Asia by providing higher grade fish at still acceptable prices for the general public. Out of the total cultured catfish volume in 1991 about 80 % was provided by Clariid species, the rest by Pangasiids.

Introductions of exotic catfishes over the past decades were not particularly successful in Asia, with one notable exception. Three *Ictalurus* species were introduced to 11 Asian and Pacific countries from the U.S., but neither of these proved to be competitive with the indigenous species. The African *Clarias gariepinus*, however, made history in Southeast Asia : its hybrids with local Clariids (especially with *C. macrocephalus*) retain the rapid growth and hardiness of the introduced species but provides the quality required by the local market. Currently most, if not all, of the *Clarias* catfish farmers in Southeast Asia produce exclusively hybrids.

Typical East/Southeast Asian culture systems are : (1) super intensive pond culture of Clariids ; (2) intensive pond culture of Pangasiids ; (3) cage culture of Pangasiids (4) integrated pond culture of Pangasiids with livestock and/or human waste disposal ; (5) Clariids in rice/fish culture.

Despite a steady growth in the volume of production, catfish culture in the region does not show the dynamics witnessed in the case of several other species groups (including carps and tilapias). This may be explained by the important but limited market niches of Siluriformes species, the almost complete lack of export markets, consequently declining inflation-adjusted prices and profitability of production. Further constrains are persisting problems in mass-production of hatchery-reared seed and increasing prices of locally available feed ingredients. Improvements in culture techniques (induced breeding, health management, feed development, pond management) and especially in processing and marketing (development of export markets) are needed to expand production.

Synthèse / Review Lecture

PRESENT STATUS AND PERSPECTIVES OF CLARIAS CULTURE IN AFRICA

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The African sharptooth catfish, *Clarias gariepinus* is undoubtedly one of the most suitable species for aquaculture throughout its distributional range. The reasons for this, which relate principally to the biology and ecology of the species, are briefly reviewed and commented upon. The species is currently farmed on a commercial and subsistence basis in over 12 African countries, the most important of which in terms of tonnage produced are Nigeria, South Africa, Zambia and Ghana. The scientific and technological foundation for the farming of African catfish is sound, and has been developed mainly in The Netherlands, South Africa and Belgium. Most of the important culture parameters, inclusive of spawning, incubation, larval nutrition and rearing, production and feed formulation have received adequate attention, and extension, for the successful farming of the species in Africa. Despite the technological knowhow, total production of *Clarias* in Africa in 1992 was a mere ca. 4,000 tonnes. The reasons for this are manifold and can be primarily pinned on inadequate regional infrastructures, the socio-economics of production, a flawed perception of demand, the philosophy upon which catfish farming is based and the marketing of the product. Production levels, depending on the type of operation, range from < 1 to 40 tonnes/hectare per year, and exceed 800 kg/m^3/year under ultra-high density commercial culture conditions. Food conversion ratios vary between 1:4 and 1:12 using agricultural waste, to 1:1.1 using formulated, least-costed feeds. Given the aquaculture potential of the species, the technological knowhow and the cardinal limiting factors, a perspective is presented to promote the advancement of catfish farming in Africa.

NOUVELLES ESPECES DE SILURIFORMES POUR LE DEVELOPPEMENT DE LA PISCICULTURE AFRICAINE

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Outre le *Clarias* (*gariepinus*), introduit en pisciculture au début des années 1970, d'autres Siluriformes africains ont vu leurs potentialités aquacoles faire l'objet d'une évaluation approfondie depuis une dizaine d'années. Il s'agit des espèces appartenant aux genres *Chrysichthys* (Bagridae) et *Heterobranchus* (Clariidae) étudiées principalement en Côte d'Ivoire, au Nigeria et au Bénin, et pour l'essentiel dans le cadre d'une aquaculture en milieu lagunaire ou estuarien. C'est en Côte d'Ivoire, au début des années 1980, que la reproduction de *Chrysichthys nigrodigitatus*, puis celle de *Heterobranchus longifilis*, a été obtenue pour la première fois en captivité suite aux travaux conduits par le CRO d'Abibjan. Depuis, les cycles d'élevage des ces deux espèces ont été maîtrisés et un premier transfert vers le développement effectué.

La pisciculture de *C. nigrodigitatus* est principalement du type intensif, monospécifique, en enclos lagunaires (Côte d'Ivoire) ou en étangs saumâtres (Nigeria). En Côte d'Ivoire (lagune Ebrié), le développement de son élevage, depuis 1991, se concrétise par une production annuelle de l'ordre de 350 à 400 tonnes.

H. longifilis présente une biologie très similaire à celle de *C. gariepinus*, mais avec l'avantage d'une croissance plus rapide. La production commerciale de cette espèce s'initie actuellement en Côte d'Ivoire. L'élevage de type intensif en enclos lagunaires semble constituer l'une des voies appropriées pour le développement de l'élevage de ce poisson ; mais sa pisciculture en étangs d'eau douce connait également des résultats encourageants. A partir de l'expérience ivoirienne, des projets de développement de l'aquaculture de *H. longifilis* sont en cours de réalisation au Niger et au Cameroun. La littérature récente fait également état d'élevages expérimentaux de *H. bidorsalis* au Nigeria. Des hybrides entre *H. longifilis* ou *H. bidorsalis* et *C. gariepinus* ont été produits en Afrique du Sud, en Côte d'Ivoire et au Nigeria. Toutefois, jusqu'ici, aucun avantage clair de l'utilisation aquacole de ces hybrides, par rapport à celle des espèces du genre *Heterobranchus*, n'a été mis en évidence.

Les résultats obtenus en lagune Ebrié indiquent que *C. nigrodigitatus* et *H. longifilis* constituent désormais une possibilité de diversification de la production, voire une alternative à l'utilisation du *C. gariepinus*, pour la pisciculture africaine. Dans le cas de la Côte d'Ivoire, il faut toutefois noter que l'amorce du développement de leur élevage a été possible grâce à un certain nombre de facteurs favorables, et en particulier l'existence sur place des industries d'aliments pour animaux.

Synthèse / Review lecture

ETAT ACTUEL ET PERSPECTIVES DE LA PRODUCTION AQUACOLE DE SILURIFORMES EN EUROPE

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La production aquacole de Siluriformes en Europe concerne le silure glane (*Silurus glanis*), indigène, et des espèces introduites assez récemment, comme le silure africain (*Clarias gariepinus*) ou les poissons-chats américains tels que *Ictalurus punctatus*, *I. nebulosus* et *I. melas*. Quelques tentatives de production expérimentale d'*Heterobranchus longifilis* et *H. bidorsalis* sont aussi rapportés.

Ces différentes espèces de Siluriformes sont produites dans différents systèmes d'élevage, en monoculture dans les circuits en eau chaude, fermés ou non, en polyculture d'étang ou en système intensif en cages ou en bassins. Les Clariidés sont le plus souvent produits dans des circuits fermés thermorégulés, mais quelquefois en étang, lors de la saison chaude. Les Ictaluridés sont élevés en étang en conditions intensives ou semi-intensives. Le silure glane est majoritairement produit soit en polyculture d'étang comme carnassier d'accompagnement, soit en eau chaude (effluents industriels ou sources géothermiques), les circuits fermés tendant à être abandonnés. En France particulièrement, des systèmes de production intensive en bassins sans renouvellement d'eau ou avec lagunage de l'eau d'élevage tendent à se développer ; les coûts de production sont relativement bas et les rejets à l'environnement quasi-inexistants.

La production de Siluriformes en Europe, peu importante actuellement, ne concerne que peu de pays, notamment, l'Allemagne, la France, l'Italie, la Belgique, la Hongrie, la République Tchèque et les Pays-Bas. Les chiffres font apparaître des évolutions de la production de Siluriformes très variables suivant les espèces et les pays.

Dans les Pays de l'Est, la consommation interne est en régression, du fait du renchérissement du coût de production et de la baisse du niveau de vie mais aussi de la difficulté d'exporter vers l'Union Européenne.

En Europe de l'Ouest, la transformation du poisson sous forme de filet (près de 90 % de la production de *C. gariepinus*) permet d'accroître les marges et d'améliorer d'une manière générale, la commercialisation des silures en gagnant des marchés dont il reste toutefois à préciser l'importance. Les caractéristiques de la chair des Siluriformes (chair blanche sans arêtes intramusculaires, bon rendement, qualités organoleptiques...) augurent favorablement d'un développement de la production en Europe dans les années à venir.

PRESENT STATUS AND PROSPECTS OF CATFISH CULTURE IN SOUTH ASIA

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Except for Plotosidae and Ariidae which have marine representatives, the Siluriformes comprise largely a group of freshwater fishes including both air breathing and non air-breathing species. The commercially important fishes which contribute substantially to the total inland fish production in South Asia are *Mystus aor, M. seenghala, M. cavasius* and *M. gulio, Wallago attu, Ompok bimaculatus, Heteropneustes fossilis, Clarias batrachus* and *Pangasius pangasius*. These are widely distributed in all the South Asian countries viz. Pakistan, India, Bangladesh, Sri Lanka and Myanamar excepting Nepal and Bhutan.

While scientific carp culture has made tremendous strides and an economic impact in the region, catfish culture has just begun. Techniques of seed production have been standardized in respect of *Clarias batrachus, Heteropneustes fossilis* and *Wallago attu* which can be spawned even repeatedly at short intervals of 30-40 days. Such methods are, however,in an experimental stage for other species.

Of the various species, *C. batrachus* is the most popular and its traditional culture in rice fields is well known. It is now being incorporated in carp ponds and semi-intensive and intensive monoculture systems have also been developed. The species fetches a very high price in India and Bangladesh and has a great export potential. *C. macrocephalus* and *C. gariepinus* have also been introduced in Bangladesh and India in recent days with considerable success but their impact on the indigenous species needs to be studied. An exclusively export-oriented channel catfish farm has been established in peninsular India. *Wallago attu* is another equally priced fish in certain parts of India, Pakistan and Myanamar.

A vast grow-out potential for small catfishes in carp nurseries as a second crop exists all over the region. Extensive culture of large catfishes in derelict ponds could be an intermediate step in their improvement through control of all trash fish. With increased seed availability, semi-intensive and intensive mono-culture systems, tried experimentally, would be possible on modern scientific lines. Water quality management through aeration and partial replenishment, use of pelletised feed based on blood meal and animal offal will help in industrial production of catfishes and offer them as new export items from this region .

Synthèse / Review Lecture

OVERVIEW OF SILURIFORMES CULTURE IN NORTH AMERICA

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Production of channel catfish (*Ictalurus punctatus*), the dominant aquaculture foodfish in the U.S., is confined for the most part to the southern part of the U.S. The states of Alabama, Arkansas, Louisiana, and Mississippi account for more than 95% of total commercial production and processing, with Mississippi accounting for more than the rest of the U.S. combined.

Channel catfish are native to the U.S. However, the "farm-raised" catfish, processed into many different consumer products, is considered to be a "newly developed" fish for marketing purposes.

Production methods include intensive tank culture, raceway culture and open pond systems. The open pond method accounts for almost all of the commercial production because of economics. The other methods usually represent special situations as opposed to general cost effective systems.

A brief history of the industry in the U.S. will be presented with its growth to its current level. Production will be traced from brood fish to foodfish. A brief description of the processing and marketing practices and the major consumer product forms marketed will be presented.

SESSION

SYSTEMES DE PRODUCTION

PRODUCTION SYSTEMS OF SILURIFORMES

Communication orale

INTERACTIONS OF DENSITY AND SURVIVAL AND THEIR IMPACT ON GROWTH AND YIELD OF CHANNEL CATFISH FINGERLINGS

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A stochastic model to predict the population structure was used as a production plant to prove the growth rate and yield of channel catfish, *Ictalurus punctatus*, in ponds. The model, based on probability values assigned to each size class and the associated standard deviation, was successful in predicting the population structure during the culture period.

Earthen ponds (0.04 ha) were stocked at 150,000, 300,000, and 600,000 fish per hectare in 1992 and 300,000 and 600,000/ha during the 1994 season. In 1993, based upon the predicted population structure, 10 and 3 % of the population were partially harvested in ponds stocked at 300,000/ha at 60- and 90-day post-stocking, respectively. Similarly, 25 and 6 % of the initial stocking density were removed in ponds stocked at 600,000/ha at 60 and 90 days after stocking.

Size variation was related to the number of fish in pond ($r = 0.69$). The coefficient of variation was greater at the higher stocking density and exceeded 24 % when the standing crop increased above 2300 kg/ha. In 1992, the total yield (kg/ha) did not differ by stocking density. Mean average weight and survival were greater at 150,000/ha than at 300,000/ha. In 1993, partial harvests improved the total survival and yield at the stocking density of 600,000/ha but not 300,000/ha. Average weight was not affected by density or partial harvests.

Communication affichée / Poster

THE CULTURE OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*) IN PONDS OF TEMPERATE CLIMATE DURING SUMMER PERIOD

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Production results of pilot experiments with African catfish pond culture in South Moravia (warmest region of Czech Republic) are dependent especially on climatic conditions during the growing season. Catfish were stocked in polycultures with Nile tilapia (*Oreochromis niloticus*) with the aim to control the numbers of its progeny.

Although fish were fed artificial feed mixtures this source formed just about one half of food ingested by African catfish. Natural food items consist mostly of (according to importance): chironomids larvae and pupae (*Chironomus plumosus*, *Phytotendipes gripekoveni*), cladocerans (*Daphnia galeata*), *Corixa affinis*, *Oecetis ochracea*, *Asellus aquaticus*, ostracods and *Cloeon dipterum*. The share of natural food in catfish stomachs was much higher in ponds supplied weekly with 150 kg/ha of fresh grass and meadow plants. This material served as a substrate for the development of assemblages of phytophilic animals serving as an important natural food for catfish. Tilapia fed also directly on decaying or fresh plant material. Catfish from these ponds grew by about 30%, and tilapia by about 10% better as compared with non-supplied ponds.

To reach the marketable size of catfish and tilapia in September, the size of stocking material in May must not be below 100-150 g at densities about 10,000 fish per hectare. The average yield amounted 1,500 to 2,000 kg/ha according to climatic conditions in 1991-93.

Communication affichée / Poster

PRELIMINARY RESULTS ON THE INTRODUCTION OF *HETEROBRANCHUS LONGIFILIS* (PISCES, CLARIIDAE) IN FISHCULTURE IN CAMEROON

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In a recent paper Legendre et al. (1992) compared growth rates of two African clariid catfishes *Heterobranchus longifilis* Valenciennes, 1840 and *Clarias gariepinus* (Burchell, 1822) in Ivory Coast. Under identical conditions, the former showed a growth rate which is twice that of the latter. From the economical point of view it is thus recommended to culture *H. longifilis*.

Two strains of *Heterobranchus longifilis* have recently been introduced in the Fishculture Research Station of Foumban (West Cameroon): a local strain originating from the Mbam River (Sanaga Basin) and a cultured strain from Layo (Ivory Coast). Despite important differences in climate (Foumban: altitude 1.160 m; water temperature 19,7-25°C; salinity 0‰ / Layo: altitude 0 m; water temperature 25-32°C; salinity 0-10‰), the Layo strain showed similar growth performances (3.04 g/day) as in Ivory Coast, using a 40% protein mixture of fishmeal and rice bran.

Integrated culture of *Heterobranchus longifilis* and rabbits was started. Dry rabbit dung is added weekly (2.5 kg/are) in ponds containing catfish; the dung is used directly as a food source. The protein content of rabbit dung (15%) is higher than that of rice bran (9-11%), and therefore makes it an interesting additional food source for catfish; experiments on optimal rate and frequency of manuring are in progress. Earlier experiments on the effect of rabbit dung on the water quality (Breine et al., in press) revealed no negative impact on physico-chemical parameters compared to results obtained for other organic manures such as poultry dung.

Communication orale

L'ELEVAGE DE *PANGASIUS BOCOURTI* (SAUVAGE) EN CAGES FLOTTANTES DANS LE DELTA DU MEKONG : CARACTERISTIQUES ZOOTECHNIQUES ET SOCIO-ECONOMIQUES

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Au Viet Nam, la pisciculture en cage flottante contribue pour 15 % à la production piscicole totale et pour 5 % des recettes à l'exportation des produits halieutiques. Cette activité est dominée pour 73 % (13 400 t) de la production par une seule espèce de poisson chat (Siluriforme) : *Pangasius bocourti* (dénommé jusqu'à présent *Pangasius pangasius)*, appartenant à la famille des Pangasiidae.

L'essentiel de la production est réalisé sur le Mékong, dans la région du delta à proximité de la frontière cambodgienne où les conditions hydrologiques sont globalement favorables.

Les juvéniles de *P. bocourti* sont capturés dans le milieu naturel durant la saison des pluies, essentiellement au Cambodge. L'élevage se décompose en une phase de pré-grossissement, suivie d'une phase d'embouche destinée à produire des poissons de taille marchande, de poids individuel supérieur à 700 g. Ces deux phases durent en moyenne 7 et 11 mois respectivement. Elles sont réalisées dans des cages distinctes, et donnent lieu à une organisation locale de la filière. Pour améliorer les résultats d'élevage, *P. bocourti* est souvent élevé en polyculture avec d'autres espèces de poissons, des Cyprinidés principalement. L'aliment est fabriqué directement sur la cage (broyage, mélange, cuisson) par les pisciculteurs à partir d'issues de céréales, de végétaux supérieurs et de poisson (frais ou séché). Il est distribué sous la forme d'une pâte humide (30 à 50 % d'eau). La qualité de la ration est soumise à des fluctuations liées à la disponibilité en matières premières, ainsi qu'à la stratégie économique et au profil du pisciculteur. Le déséquilibre du régime alimentaire serait la cause du niveau d'engraissement élevé des poissons et de l'indice de consommation élevé (11,2). Les biomasses élevées (jusqu'à 200 kg/m3 de cage) accentuent les problèmes pathologiques, notamment en saison sèche.

La production brute peut atteindre plus de 110 t pour des cages de grande dimension (jusqu'à 1600 m3) qui sont en général détenues par de grandes compagnies. Mais neuf cages sur dix appartiennent à des familles qui vivent et travaillent sur leur(s) cage(s), le plus souvent organisées de façon informelle.

Les *P. bocourti* de taille marchande sont vendus à deux usines de tranformation qui produisent des filets congelés, destinés à l'exportation. Les poissons morts et les sous-produits sont également commercialisés, généralement sur les sites de production. Les retombées socio économiques de la filière sont importantes pour la Province d'An-Giang (principale zone de production), puisque 7 000 personnes environ résident sur les 1 000 cages d'élevage et que 2 500 personnes au moins tirent leur emploi à plein temps des activités de la filière.

Communication affichée / Poster

PERFORMANCES ZOOTECHNIQUES DE *CLARIAS ANGUILLARIS* (CLARIIDAE) DANS LES MARES ARTIFICIELLES DU DELTA CENTRAL DU NIGER

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Clarias anguillaris est un Clariidae très présent dans les cours d'eau du delta central du Niger. Ses caractéristiques biologiques (habitudes alimentaires, forte tolérance à l'hypoxie) en font une espèce très adaptée aux conditions d'élevage particulièrement "drastiques".

Le delta central du Niger est une zone de tradition halieutique. Cependant, elle recèle également d'importantes mares naturelles et artificielles qui constituent des zones potentielles d'élevage des poissons dès la décrue. Ainsi, deux mares artificielles situées aux environs de Mopti (Thiaboly et Diambadougou) en zone exondée ont été empoissonnées en décembre avec des fingerlings de *Clarias* capturés dans les zones inondées rizicoles. Avec une densité à la charge de 3 poissons par m^2, les deux mares ont reçu respectivement 6000 et 1500 individus de poids moyens respectifs de 37 et 41 g pour des longueurs standards moyennes de 145.5 mm et 149 mm.

La particularité de cette étude est que les poissons de l'une des mares, celle de Thiaboly, ne reçoivent aucune complémentation alimentaire. La ration distribuée aux poissons est composée de 80 % de farine basse de riz, 15 % de sang et 5 % de poudre d'os. Les quantités distribuées étaient de l'ordre de 5 % de la biomasse totale.

Des pêches de contrôle mensuelles sont effectuées afin d'apprécier l'évolution des performances zootechniques (condition) des poissons. L'évolution des caratéristiques physico-chimiques de l'eau des mares est également suivie par des mesures bimensuelles.

Bien que les caractéristiques des milieux aient souvent été modifiées, les premiers contrôles font apparaître une amélioration de l'état d'embonpoint des poissons complémentés même en période jugée d'arrêt de croissance. Les résultats de cette étude originale dans le delta central du Niger doivent nous permettre de préciser les conditions d'élevage (biotope et alimentation) des *Clarias* dans des milieux "difficiles" des mares artificielles. A terme, une analyse économique de l'opération est envisagée pour apprécier la rentabilité de la complémentation.

Communication affichée / Poster

REPLACEMENT STUDIES OF *CLARIAS BATRACHUS* AND *OREOCHROMIS NILOTICUS* (RED TILAPIA) IN PONDS UNDER DIFFERENT FEEDING MANAGEMENT

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Influence of intra- and inter-specific competition was investigated between two fish with different feeding habits, *Clarias batrachus* known as a carnivorous fish and *Oreochromis niloticus* (red Tilapia) as a plankton feeder, in monoculture and biculture using rice bran (12 % crude protein) and commercial feed (32 % crude protein).
From this experiment, *Clarias batrachus* has a higher yield in monoculture.
Interspecific competition appeared in the biculture and caused higher growth of *Oreochromis niloticus* than *Clarias batrachus*. The growth of fish fed with commercial feed was higher than fed with rice bran, but the difference was relatively small for red Tilapia.
Total two times yield in biculture was higher than in monoculture. From an economical point of view, using rice bran in biculture was more profitable.

Communication orale

INTENSIVE POND CULTURE OF EUROPEAN CATFISH (*SILURUS GLANIS* L.) WITH ARTIFICIAL FEED

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The European catfish is basically very suitable for rearing in ponds, Its requirements as to pond and water conditions are very similar to those of the carp. However it is not as a rule economical to carry out intensive rearing with preyfish. For this reason, experiments in raising catfish on an artificial feed basis have been carried out for the last 8 years at the Substation for Carp Pond Culture.

Rearing of the different age groups was carried out either in monoculture, or in polyculture with carp. Thus for example in July, 2,500 catfish larvae (Wo) were released into a 200 sq.m. nursery pond, which is equivalent to a population density of 125,000 Wo per hectare. In October, 2,450 W1 were fished out. This corresponds to a loss of only 2%. The extent of growth of the fish amounted to 1, 062 kg per hectare with an individual weight per fish of 8,6 g.

In other experiments three further age groups of catfish, W2, W3 and W4 were reared in ponds together with carp. The proportional percentage of catfish to carp, expressed as the relationship (W : K), in the ponds extended from 23: 76 to 94: 6. The extent of growth of the catfish, but also the individual weight were invariably highest, when their stock proportion was very high. On the other hand, if the proportion of carp was relatively high, these dominated the automatic feeding machines. The growth rate of the catfish was then reduced.

They were fed with trout feed with about 40% crude protein. The feed conversion was between 1,0 and 2.6, in some cases also under 1,0. Interestingly, no case of cannibalism was observed.

In conclusion, measure against ichthiophthiriosis and the optimisation of population density are discussed.

Communication orale

AN ASSESSMENT OF THE IMPACT OF INTRODUCED SILURIDS ON PHILIPPINE AQUACULTURE

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Four species of silurids, namely , the Thai catfish (*Clarias batrachus*), American channel catfish (*Ictalurus punctatus*), Mekong River catfish (*Pangasius sutchi*) and African catfish (*Clarias gariepinus*) were introduced in the Philippines by the private sector to enhance aquaculture production.

Difficulty in spawning the American catfish in captivity and poor consumer acceptance of the Mekong River catfish and Thai catfish have limited the farming of the species. Only the African catfish has had some success.

The African catfish is cultured mainly in concrete tanks and freshwater ponds at densities of 5-10/m². Fry are produced by a number of commercial hatcheries through induced spawning. Market prices for the fish have, however, declined with over-production and low demand.

With the escape of *C. gariepinus* into natural waters, concern on its possible negative impact on endemic fishes has been raised. Preliminary evaluation studies on the African catfish have shown it to be highly predaceous.

Communication affichée / Poster

L'AQUACULTURE DU MACHOIRON, *CHRYSICHTHYS NIGRODIGITATUS* : UNE METHODE ADAPTEE EN MILIEU LAGUNAIRE DE COTE D'IVOIRE

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Chrysichthys nigrodigitatus est un siluriforme très apprécié sur toute l'Afrique de l'Ouest. Son élevage, tenté pour la première fois, au début de 1980, a connu un réel progrès grâce à un vaste travail de recherche. Actuellement, une production de 350 à 400 tonnes par an marque un tournant vers un développement durable grâce à une consolidation vers une professionnalisation mise en place par un projet de développement de ce secteur. Il est donc jugé opportun de présenter ici un état des connaissances sur son cycle d'élevage. Le mâchoiron présente une reproduction typiquement saisonnière (de septembre à novembre). A l'issue de chaque saison de reproduction, les géniteurs sont maintenus en lagune dans des enclos où ils sont nourris avec une ration journalière de 3 % de la biomasse. La vitellogénèse débute en mars-avril et s'achève en juillet-août. Sélection des géniteurs (critères morphologiques et biopsie ovarienne) et formation des couples s'effectuent aussitôt. Les couples de géniteurs sont maintenus confinés dans des "nids" artificiels. La durée de confinement varie entre 3 à 5 semaines. Les oeufs pondus, fécondés, sont collés en masse sur le substrat du nid. Ces oeufs sont extraits du nid et sont incubés artificiellement (pendant 5 jours) avant de parvenir à l'éclosion. Les larves écloses sont dotées chacune d'une importante réserve vitelline (résorption complète au bout du 15ème jour). La première prise de nourriture est observée au 11ème jour après l'éclosion. Les alevins sont nourris directement de composés artificiels inertes contenant 40 % de protéines. L'alevinage ou l'élevage larvaire a lieu dans des bacs circulaires de 1 m^3. Ces larves croissent de 25 mg à 75 mg au bout de 15 jours. Le pré-grossissement se réalise en deux étapes : étape extensive en étang (de 75 mg à 5 g, durée 3 mois) et étape intensive en cage-enclos (pendant 3 mois). On aboutit ainsi à des "fingerlings" de 30 g qui sont prêts pour être engraissés en enclos jusqu'à la taille marchande (350 à 400 g) au bout de 8 à 12 mois. Pour le moment, les fermes aquacoles privées n'assurent que cette dernière étape, le grossissement (étape à faible risque de mortalité). L'approvisionnement en "fingerlings" est assuré par une écloserie privée. Après une période de démarrage difficile, la commercialisation des produits aquacoles s'organise et se professionnalise peu à peu (vente et transport des poissons frais, vivants, fumage dans les fermes, réseau de distribution,...). Par rapport au produit de la pêche, inconstant, l'aquaculture lagunaire présente plus de facilités pour prévoir et régulariser l'offre et la demande. Ceci constitue un atout qui devrait aider à promouvoir ce secteur dans les proches années à venir.

Communication affichée / Poster

THE DESIGN AND OPERATION OF A LOW COST INTENSIVE SYSTEM FOR EUROPEAN CATFISH (*SILURUS GLANIS* L.)

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Several intensive systems have been designed and operated for the production of high value species, however, very few of them operates economically, and there is an increasing need for low cost systems that can be used for the intensive production of high value species. The Fish Culture Research Institute, Szarvas, Hungary has developed a special flow through system with "minimal flow" that was tested in semi-scale production. The system combines the advantages of the conventional fish ponds and flow-through systems. The basic production unit comprises two parallel trapezoid-section earth channels that are lined with plastic sheet and covered with agricultural green houses.

In our experiment, the volume of one channel was 150 m^3. The water bodies of the parallel channels are connected to each other through air-lift pumps that are installed at both ends of the channels. These air-lift pumps maintain a continuous water flow through the channels.

The optimal water temperature was maintained by waste geothermal effluent through heat exchangers.

During an eight-month period European catfish was produced in the system, and 3.3 tons weight gain was reached.

The specific water requirement of the system is 10 m^3/kg.

Communication affichée / Poster

POLYCULTURE EN CAGE-ENCLOS DE *CHRYSICHTHYS NIGRODIGITATUS* ET *OREOCHROMIS AUREUS*

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Le siluriforme *Chrysichthys nigrodigitatus* et le tilapia *Oreochromis aureus* sont deux espèces d'écologie différente, notamment en ce qui concerne leur alimentation. Leur association en élevage en cage-enclos (lagune Ebrié), en prenant comme poisson cible la première espèce citée, a donné des résultats assez satisfaisants.

En 203 jours d'élevage, l'indice de consommation et les taux de survie obtenus en polyculture (1,63 et 84,4 à 94,7 %, respectivement) sont nettement meilleurs que ceux obtenus dans les cages "témoins" monospécifiques (3,6 à 6,3 et 61,7 à 79,7 %, respectivement). La biomasse nette récoltée est plus élevée en polyculture (34 kg) qu'en monoculture (15-22 kg).

Les croissances journalières enregistrées sont de 0,77 g/j (siluriforme) et 1,26 g/j (tilapia) en élevage associé pour 1,14 g/j et 1,17 g/j en monoculture, respectivement. Des essais complémentaires sont actuellement en cours pour préciser les conditions optimales de réalisation de cette polyculture.

Communication orale

ASSOCIATION SILURE AFRICAIN-TILAPIA : POLYCULTURE OU CONTROLE DE LA REPRODUCTION?

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L'idée d'associer un prédateur à l'élevage de tilapias pour en contrôler la reproduction anarchique est maintenant acquise auprès d'un nombre croissant de pisciculteurs africains. L'association d'un Siluriforme (*Clarias sp.* ou *Heterobranchus sp.*) a longtemps été considérée comme ayant une double fonction : contrôle de la reproduction des tilapias et participation quantitative à la production de l'étang c'est à dire en fait prédation et polyculture.

Les résultats d'élevages associés *Clarias gariepinus-Oreochromis niloticus* présentés dans ce papier montrent à l'évidence qu'un nombre important d'individus de la première espèce est nécessaire au contrôle total de la reproduction des fingerlings d'*O. niloticus* mis en charge et qu'ils exercent une compétition vis à vis des ressources alimentaires disponibles (aliment et/ou engrais) dans l'étang. Pour contrôler une population de 1200 tilapias non sexés en étang de 10 ares, une population de 260 *Clarias gariepinus* de poids moyen initial supérieur à 150 g est nécessaire et la croissance des tilapias est inférieure à celle d'un élevage identique dans lequel *C. gariepinus* est remplacé par un prédateur strict (*Hemichromis fasciatus*).Ces résultats, confirmés avec *Heterobranchus isopterus* conduisent à privilégier dans le Centre Ouest de la Côte d'Ivoire la pratique d'une polyculture basée sur 3 espèces : *O. niloticus*, un prédateur strict (*Hemichromis fasciatus* ou *Parachanna obscura*) et un siluriforme, *Heterobranchus isopterus* qui n'a pas pour vocation à contrôler la reproduction des tilapias mais à contribuer quantitativement et qualitativement à la production finale. *H. longifilis*, quant à lui, présente une croissance trop élevée pour ce type d'association, entraînant rapidement un écart de taille avec les tilapias mis en charge sur lesquels il exerce une prédation de même que sur les carnassiers stricts sans contrôler correctement la prolifération d'alevins de tilapias.

Les rendements en *H. isopterus*, mis en charge à la densité de $0,1.m^{-2}$ peuvent atteindre $1t.ha^{-1}.an^{-1}$ et leur poids moyen 500 g après un cycle d'élevage de 6 mois. Sur la base de ces résultats, obtenus en vraie grandeur, la logique de la polyculture de tilapias avec un prédateur strict et un poisson d'accompagnement, notamment un silure s'est déjà imposée auprès de nombreux pisciculteurs ivoiriens et semble devoir être vulgarisée à l'avenir. Cette pratique peut se comparer, en Afrique, avec les cultures associées. Toutes deux permettent, au paysan, en produisant plusieurs espèces, de minimiser ses risques et en proposant plusieurs espèces à la clientèle, de conférer une valeur accrue à chacune d'elles. Toutes les données relatives à cette polyculture sont exposées et analysées selon la logique des orientations retenues par les pisciculteurs ivoiriens dans le cadre d'une dynamique de développement axée sur une valorisation préférentielle de la force de travail.

Communication affichée / Poster

CAGE CULTURE OF CATFISH (*CLARIAS MACROCEPHALUS* X *C. GARIEPINUS*) IN TILAPIA PONDS

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With an estimated production of 40,000 tonnes/year, the Clarid catfish (*Clarias* spp.) have been the major species of cultured freshwater fish in Thailand. The major production system is monospecific intensive culture of hybrid (*Clarias macrocephalus* x *C. gariepinus*) in earthen ponds.

The present experiment was conducted for 122 days in central Thailand to test rearing of the hybrid catfish in cages in earthen ponds, where tilapia (*Oreochromis niloticus*) was stocked to utilize the waste products derived from intensively reared catfish. Catfish fingerlings (12-17g size) were stocked in plastic net cages (1 m^3/cage) at 220 fish/cage. Six earthen ponds (250 m^2 ; 220 m^3 each) were used to suspend the cages in two loading densities as experimental treatments - 4 and 8 cages/pond or 440 and 880 catfish/pond. Each loading density was replicated in 3 ponds. Each pond was stocked with 440 sex-reversed male tilapia of 6-7 g size in open water, giving catfish and tilapia stocking ratios of 2:1 and 4:1. Catfish was fed twice daily at 3-10% BWD with commercial floating pellets containing 25-30% crude protein. Water quality was analyzed bi-weekly for dissolved oxygen, ammonia, alkalinity, total nitrogen, total phosphorus and phytoplankton biomass.

Results showed that there was no significant difference in catfish growth rate and survival between the two loading densities. The mean weight of catfish harvested was 259 and 255 g/fish, giving the extrapolated yield of 9,908 and 17,794 kg/ha in low and high loading density, respectively. Tilapia was harvested at 172.3 and 290.5g/fish with extrapolated yield of 3,094 and 4,600 kg/ha for low and high loading density, respectively. Water quality was in favorable conditions throughout the culture period.

Communication orale

INTRODUCTION OF CHANNEL CATFISH CULTURE IN THE TROPICS

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Channel catfish (*Ictalurus punctatus*) was introduced to tropical lowland in Thailand from North America in 1989. With mean annual water temperature range of 20-30°C the fish grew at an average rate of 5.5 g/day and reached 2 kg/fish in 1 year. Small percent of fish population sexually matured and spawned in 1.5 years with body weight of 2-3 kg. Most spawnings occurred during the annual cool and dry cycle from October through April. Approximately 5% of the 2.5-year-old females spawned with egg mass weight from 100 to 700g. Swim-up fry were fed with live *Artemia* nauplii in cement tanks and followed by nursing with powdered feed in nylon-net cages suspended in earthen pond. A total of 12,000 fingerlings from first spawns and 50,000 from the 2nd year spawns. Mature fish did not respond to induced spawning with hormone injections.

Histological examinations on developmental stages of male and female gonads were also conducted. Although the fish was able to mature in tropical environment, the fecundity and reproductive cycle was grossly altered from its temperate ancesters, presumably due to marked seasonal differences in temperature and photoperiod.

The uncertainty of seed production imposes the major obstacle in developing channel catfish culture in the tropics.

Communication affichée / Poster

THE COMMERCIAL USE OF GROUND CHICKEN BONES TO RAISE HYBRID CATFISH (*CLARIAS GARIEPINUS* X *CLARIAS MACROCEPHALUS*) IN THAILAND

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The development of a large industry to raise, process and export broiler chicken in Thailand as coincidentally led to systems recycling the byproducts through intensive pond culture of hybrid catfish (*Clarias gariepinus* x *Clarias macrocephalus*). Finely ground bones form the basis of the raw materials although chicken viscera is also used.

Nursery and high stocking densities are used to achieve high and predictable yields (46-62 t/ha/crop) and survival (>90%). Fingerlings (6g) are stocked at around 40 fish/m2 after nursing on-farm for a 4-5 month grow-out period depending on the intended market. The securement of adequate supplies of chicken bones is essential and the location of catfish farms in the vicinity of chicken processing plants is important. Water quality is maintained by periodic exchange of irrigation water. Effluent waters are often used for raising the phytoplanktivorous Nile tilapia, *Oreochromis niloticus*, in a separate pond.

Feeds are given twice daily as a wet mash including finely ground chicken bone and noodle waste or rice bran as a binder together with vitamin supplements. Farmers using chicken bones are less affected by the periodic drops in farm-gate price of hybrid catfish, typically to a low of US$0.88/kg, than farmers feeding pelleted feeds. Generalised management of chicken bone fed catfish systems are described in this paper together with a macroanalysis of the industries integration.

Communication affichée / Poster

INTENSIVELY BRED EUROPEAN CATFISH (*SILURUS GLANIS* L.) AND THEIR POSSIBLE USE AS STOCK FISH

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The present study aimed to prove that European catfish (*Silurus glanis L.*) cultivated intensively for eleven months in warm water and artificially fed were capable of re-adaptation to natural conditions. Studies were carried out in two stewponds in 1992 and in three in 1993, differing in both their stock and natural resources of small prey fish.

The fish were stocked at ca 11 months of age and average weights of 498 and 469 g (1992) or 138, 281 and 394 g (1993) respectively. When they were harvested at the age of 15-16 months, the average weights had increased to 1,461 and 2,125 g (survival 97 to 100 %) for the 1992 stock, and to 658, 1,323 and 2,057 g (survival 86, 100, and 87 %) for the 1993 stock. In the vegetation season the European catfish in the stewponds were not fed.

The results proved that European catfish cultured intensively under controlled conditions did not lose their capability for actively seeking and feeding on live prey. Furthermore no losses (0 % in 1992) were recorded in the pond, although among the stock were predatory fish in heavier weight categories and the ponds were subject to the attentions of fish-eating birds. Therefore, there should be no fear of using intensively cultivated European catfish as stock fish under natural conditions. Intensive cultivation enables the use of stock material at the age of one year, with the individual weight approaching 1 kg.

Communication affichée / poster

LES SYSTEMES DE PRODUCTION DE SILURE (*SILURUS GLANIS*) EN REGION CENTRE (FRANCE)

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L'élevage du silure (*Silurus glanis*) se développe depuis quelques années dans le Centre de la France, région traditionnelle d'étang (30 000 ha) avec la Sologne et la Brenne.
Sous l'impulsion de l'Association pour le Développement de l'Aquaculture en Région Centre «A. D. A. R. C.», 25 nouvelles fermes aquacoles ont été créées au cours de ces quatre dernières années. Les principaux systèmes d'élevage sont donc bien représentés :
- l'étang traditionnel avec des productions variant, selon le niveau de gestion, de 100 kg à 1 000 kg/ha en polyculture où le silure représente de 0 à 10 % de la biomasse produite ;
- les bassins en eau non renouvelée (0,1 à 5 ha) pour des productions en monoculture de poisson de 4 semaines à 3 étés avec des rendements pouvant atteindre, selon les années, 7 tonnes/ha ;
- les bassins en eau recyclée sur étang lagunaire (système Deckel) de 250 à 1 000 m^3 ou en monoculture, les productions obtenues variant de 1 à 21 $kg/m^3/an$ pour des poissons de 2 ou 3 étés ;
- les bassins en terre sous serre pour l'hivernage ;
- les systèmes en circuit fermé thermorégulé surtout réservés au prégrossissement.

Les coûts nets actuels de production varient pour les poissons commercialisables (MERVAL) de 0,8 à 4 kg selon les systèmes de production, la technicité de l'exploitant, le niveau d'amortissement, les frais financiers, le type d'approvisionnement en juvéniles et les conditions climatiques estivales de 10 à 18 F/kg. Ils devraient être améliorés dans les années à venir grâce à la Station Expérimentale Piscicole Interrégionale du Blanc (36) «S. E. P. I. B.».

Communication affichée / Poster

PERFORMANCE OF AFRICAN CATFISH, *CLARIAS GARIEPINUS*, AS POLICE-FISH IN TILAPIA GROW-OUT PONDS IS INFLUENCED BY THE QUALITY OF THE SUPPLEMENTAL FEED AND BY THE FEEDING REGIME

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Unchecked recruitment of Nile tilapia, *Oreochromis niloticus* (L.), is a severe constraint in developing semi-intensive tilapia pond culture in Africa. African catfish, *Clarias gariepinus* (Burchell 1822), may be stocked as police-fish in tilapia grow-out ponds, with the objective of controlling tilapia recruitment. However, African catfish proved unsuitable as police-fish at the Lagdo Fisheries Station in northern Cameroun (Benue watershed).

Results from two tilapia-catfish polyculture experiments are discussed. While the tilapia sexing-error was confirmed at harvest at only 1 or 2 large tilapia females per pond, still tilapia recruits contributed more than 20% to net pond production. Availability of high-protein supplementary feed, i.e. cottonseed cake, provide an easier source of protein for the catfish than chasing tilapia recruits, and so indirectly reduced the 'voraciousness' of the catfish. African catfish are known to feed mainly at night and in the early morning, while Nile tilapia are most active in the afternoon but do not feed after dark. It was shown that actual feeding practices at the Lagdo Fisheries Station favoured the catfish.

It is now hypothesized that when the daily supplementary feed ratio is fed between about 12.00 h. and 15.00 h., most feed will be consumed by the tilapia, leaving the catfish relatively hungry and therefore more piscivorous. It is recommended that the proposed feeding regime will be tested under field conditions, in order to evaluate the effects on tilapia recruitment control, and the possible side-effects on net catfish and net tilapia production.

Communication affichée / Poster

INTENSIVE EUROPEAN CATFISH (*SILURUS GLANIS* L.) PRODUCTION IN COMBINED BASIN-FISHPOND SYSTEM

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According to the new agricultural policy, the family farms and the integrated small farms have priorities in Hungary.

The goals of our study were, to elaborate and to investigate a new technology and an advanced production system to produce catfish (*Silurus glanis L.*).

We have obtained the data from small fish ponds of 0.4 ha (1.8 m deep) each at the Fisheries Research Institute, and from a warmwater basin system comprising 40 m^3 and 120 m^3 basins operated by the Szarvas-Fish Ltd.

In the small fish ponds the yearly net fish production was 5745 kg/ha and the feed conversion ratio was 3.6.

In the warmwater basins the small fingerlings (14 g/fish) have grown up to market size (above 1000 g/fish) within 440 days, and the feed conversion ratio was 2.3.

With the combination of the above mentioned two production technologies - where the fish is reared in warmwater basin in winter time and in small fish ponds in summer time - the market size (1200-1500 g/fish) can be achieved within 18 month.

The recommended family size model farm consists of 0.55 ha fish pond and 35 m^3 of warmwater basin where the European catfish production is profitable as follows.

- Requirements :

0.7-0.8 ha of land
60 l/min of surface water
35 l/min of warm water (22-24°C)

30000 US$ of fixed capital
6000 US$ of working capital
36000 US$ of total capital

- Results of production

annual fish production	5410 kg
annual gross income	19000 US$
material costs	11000 US$
depreciation	2000 US$
other expenses	750 US$
net income before tax	5250 US$
tax	250 US$
family net income	5000 US$

Since fish can be harvested regularly throughout the year either from fish ponds or from the warmwater basins, combination of the two systems improves the cash-flow for the farmers, and reduces the risk as well.

African catfish (*Clarias gariepinus B.*) can also be produced in the combined system, with similar economical performances.

Communication affichée / Poster

THE USE OF LIVE MAGGOTS (*LUCILIA SERICATA*) IN THE FEEDING OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*) IN CAGES

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The feeding value of live greenblow fly maggots (*Lucilia sericata*) for African catfish (*Clarias gariepinus*) was investigated by their substitution for a pelleted diet at five level in a researcher managed trial carried out over an eight week period on a commercial farm in Udorn Thani, Northeast Thailand. The five levels of maggot substitution were T1 : 100 % maggot, T2 : 75 % maggot + 25 % pellet, T3 : 50 % maggot + 50 % pellet, T4 : 25 % maggot + 75 % pellet, T5 : 100 % pellet.

Fingerlings (mean weight 6 g) were stocked in triplicate cages (1x1x1.2 m) suspended in a single earthen pond at a density of 250 fish per cage. The relationship between level of maggots fed and growth rate and production were investigated. All cages were fed three times daily to a level of 21 g crude protein per kg fish per day.

Mean individual weights of fish from all treatment levels exceeded that required by the market within an eight week period (> 100 g). Survival rate of fish fed more than 50 % of the diet as live maggots was slightly depressed (75-80 %) compared to those receiving greater amounts of dry diet (> 84 %). A maggot only diet also reduced PER and ANPU compared to those receiving pellets. Net production and individual growth rates were optimised by using 25 % maggots and 75 % pelleted diet.

At current conditions in Northeast Thailand, where the study was carried out, only the use of maggots alone, or with small amounts of pellets (T1 and T2 respectively) gave positive economic returns.

Communication affichée / Poster

EFFECT OF DIFFERENT REARING PERIODS ON THE PRODUCTION OF F1 HYBRID CATFISH (*CLARIAS GARIEPINUS* (F) X *HETEROBRANCHUS LONGIFILIS* (M)) FINGERLINGS

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Fingerling production of hybrid catfish (*Clarias gariepinus* x *Heterobranchus longifilis*) was investigated over three rearing periods of 3 weeks, 4 weeks and 5 weeks in fertilized earthen ponds during the rainy season. At harvest, fingerling mean weight was directly related to length of rearing period, while survival rate and production were inversely related to rearing duration. ANOVA showed that rearing duration was highly significant in either survival rate ($P > 0.05$) or fingerling mean weight ($P > 0.05$). Fingerling size variation was observed in all the harvests. Mean ammonia - N and nitrite - N levels in the ponds were 0.62 ± 0.19 mg/l and 0.03 ± 0.02mg/l respectively.

Communication affichée / Poster

PISCICULTURE DE *PANGASIUS HYPOPHTHALMUS* (PANGASIIDAE) EN ETANGS A LATRINES AU SUD VIET NAM

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La pisciculture en étangs à latrines est la technique d'élevage la plus ancienne et la plus répandue au Viet Nam. Arrivée de Chine il y a plus de trois siècles, elle constitue à l'origine le principal système de recyclage des effluents domestiques, particulièrement dans les campagnes. Elle est souvent intégrée au système traditionnel VAC (verger, élevage, étang), qui permet la valorisation de tous les déchets domestiques, d'élevage et de culture. L'élevage piscicole est pratiqué au niveau familial en complément d'une activité principale, dans le but d'assurer un revenu complémentaire au foyer. Une partie de la production est en général destinée à l'auto-consommation. Les facilités d'approvisionnement en intrants et effluents d'élevage ajoutées au faible coût de revient, font que l'on retrouve cette activité dans une multitude d'exploitations, depuis les "micro-exploitations" pratiquant une pisciculture extensive jusqu'aux fermes piscicoles developpant un élevage intensif. Les conditions de survie des poissons sont difficiles et ce type d'élevage requiert des espèces très rustiques. C'est pourquoi l'espèce la plus courante dans ce type d'élevage est *Pangasius hypophthalmus* (dénommé jusqu'à présent *Pangasius micronemus*) souvent élevé en polyculture avec des tilapias (*Oreochromis mossambicus*), des gouramis géants (*Osphronemus goramy*) ou des carpes. La reproduction de *P. hypophthalmus* maîtrisée depuis 1989 commence à être répandue depuis 1992, ce qui facilite l'approvisionnement en juvéniles. L'essentiel des juvéniles n'en provient pas moins du milieu naturel où ils sont capturés durant la saison des pluies. Ces deux sources fournissent les nombreuses nurseries qui ont vu le jour récemment, auxquelles les pisciculteurs s'adressent pour aleviner leurs étangs. La phase de grossissement dure entre 8 et 14 mois, pour produire des poissons de taille marchande, dont le poids oscille entre 300 g et 1,5 kg. L'hétérogénéité des exploitations ainsi que leur dispersion expliquent l'absence de circuit de distribution organisé. La majorité de la production commerciale est vendue sous forme de poisson frais sur les marchÈs locaux. *P. hypophthalmus* jouit d'une très mauvaise image auprès de la population, surtout chez les citadins. De ce fait le prix de vente est assez faible pour une espèce d'eau douce (3 à 4 francs français le kilo). La pisciculture en étangs fait actuellement l'objet de recherches pour une meilleure intégration au développement agricole du Viet Nam. Malgré ses atouts, deux obstacles majeurs freinent l'exploitation optimale de la production de *P. hypophthalmus* en étangs à latrines : la rareté de la stabulation en eau claire avant commercialisation et consommation et les conditions de transport archaiques, qui nuisent à la qualité du poisson.

Communication affichée / Poster

ELEVAGE INTENSIF DE JEUNES POISSONS-CHATS AFRICAINS (*CLARIAS GARIEPINUS*) EN CIRCUIT FERME CHAUFFE PAR L'ENERGIE SOLAIRE

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Cette communication relate des expériences d'élevage de jeunes clarias dans une installation piscicole pilote (Projet Piscisol) constituée d'un circuit fermé expérimental de grande capacité (40 m^3; recirculation: 20 m^3/h) équipé de systèmes de chauffage solaire passifs (isolation + effet de serre) et actifs (capteurs plans pour le réchauffement de l'eau de puits servant au renouvellement à raison de 4 m^3/j en moyenne). Les expériences ont porté sur un nombre initial de 9 450 *Clarias* de 6-20 g livrés par une écloserie hollandaise et élevés en bassins (0,45 -1,60 m^3) à Piscisol de manière à optimaliser la production de sujets de 100 g utilisables pour le grossissement commercial en eau chaude industrielle. Les résultats se sont révélés positifs à tous points de vue: i) absence de maladies au cours des 6 mois d'expérience ; ii) croissance très rapide telle que des alevins de 8 g atteignent en moyenne 100 g (1:12,5) en moins de 40 jours à 28 °C ; iii) coefficients de conversion alimentaire très favorables compris entre 0,60 et 0,80 dans le cas d'une alimentation avec des granulés riches en protéines (48-49 %) ; iv) possibilité de constituer des biomasses finales (poissons de 100 g) équivalentes à près de 250 kg/m^3 de volume de bassin et des charges de près de 12 $kg.l^{-1}.min^{-1}$ et, v) obtention de productions atteignant $\pm$ 8 $kg.m^{-3}.j^{-1}$ avec des poissons passant de 40 à 100 g en 19 jours. De telles productions nécessitent une gestion stricte des stocks, impliquant des tris fréquents pour éviter le cannibalisme (cause majeure de mortalité chez les jeunes qui montrent une très grande variabilité individuelle de croissance), ainsi qu'une alimentation riche et bien rationnée en fonction de la taille des poissons et de la température.

Communication affichée /Poster

AFRICAN CATFISH (*CLARIAS GARIEPINUS* BURCHELL, 1822) CULTURE IN HUNGARY

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The African catfish culture has short history in Hungary. The first twelve African catfish of 3-4 g body weight were imported to Hungary in 1984 from the Netherlands for experimental purposes, then 2000 individuals of feeding larvae were also imported from the Netherlands in 1987. The Tuka Farm of Hortobagy State Farm imported its white colour variety from Denmark in 1988.

Based on the promising results of the first experiments African catfish production started to expand within a few years. However the recognition of the fact that the most of the Hungarian geothermal waters are suitable for the African catfish culture was of crucial importance in the increase of its production.

In spite of the favourable production conditions, the annual production shows high fluctuations due to the varying domestic and foreign market demands. The annual production of the species was not higher than 200 t in 1993. The existing 10-12 farms show a great variety in size and applied technology, however the utilization of geothermal water is a common feature in most of the farms.The capacity of these farms varies between 2-50 t/year.

Two farms were specialized for fry production and sale but there are farms where farmers produce their own stocking material by themselves.

In most of the farms home made pelleted catfish feed is applied although there were some trials with tbe utilization of slaughterhouse wastes and by-products.

The market size of the fish is 500-700 g that can be reached within 8-10 months with 1.0-1.5 feed conversion ratio.

The stocking density is varying between 2-200 kg/m3 depending on the production technology at the farms.

Communication affichée / Poster

IS THE ARMOURED CATFISH *HOPLOSTERNUM LITTORALE* (HANCOCK, 1828) A SUITABLE CANDIDATE FOR AQUACULTURE ?

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Several aspects of the biology of *Hoplosternum littorale* were examined in an effort to evaluate the fish as a candidate for culture. A hatchery technology based on the use of brine shrimp nauplii as a live food was developed. It was found that after a period of 61 days, the juveniles weighed 1.8 g $\pm$ 0.3 and measured 41.8 mm $\pm$ 3.2. The survival rate was 84 %. There were two critical stages in larval rearing. The optimum dietary protein requirement was determined experimentally by feeding isocaloric diets of varying protein content and it was found to be 35 % at a temperature of 26°C. This suggests that *H. littorale* is an omnivore rather than a detritivore as previously reported. A commercial ration of assay 35 % crude protein was formulated and manufactured and a field trial was conducted in a 0.8 ha earthen pond employing 12,000 hatchery-produced juveniles. After a grow-out period of 28 weeks, the fish were harvested. The mean weight was 67.2 g and the per cent survival was 45. The high mortality rate possibly resulted from predation of the juveniles by aquatic insects particularly dragonfly larvae. The high feed conversion ratio of 3.38 : 1 was a direct result of the high mortality rate. It is suggested that the nursery phase is very important in the culture of the fish. The study has shown that the culture of *H. littorale* is technically feasible. It is concluded that although the cost of production is high, averaging about $US 2 per kg, culture of *H. littorale* is economically viable since the fish fetches a high price of up to $US 8 per kg.

Communication affichée / Poster

REPRODUCTION ARTIFICIELLE ET ELEVAGE LARVAIRE DE *SILURUS GLANIS* EN TOUTES SAISONS

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Confrontés en 1988/89 - au début de notre pisciculture de *Silurus glanis* - à une véritable pénurie d'alevins, nous avons consacré, à partir de Janvier 1990, un effort important au règlement de cette question, dans les conditions spécifiques du site de La Castillonne ; ce site se caractérisant par une ressource en eau d'origine géothermique (forage à -1500 mètres) à 26.4 ° C constants.

L'écloserie -très rudimentaire- 2 incubateurs de 130 l, 4 raceways de 250 l, 4 bassins sub-carrés de 2200 l fonctionne en circuit ouvert, avec passage de l'eau sur des colonnes de désaturation.

Les maturations, vers l'âge de 15 mois, sont atypiques avec notamment une absence de cycle. Fait essentiel, actuellement et depuis 1991, elles sont l'objet d'un contrôle précis et sont obtenues tout au long de l'année, notamment en agissant sur l'environnement (température, éclairement...) des géniteurs , tous nés sur le site après 1991 d'une manière opératoire. En phase finale, elles sont programmées par hypophysation, d'une manière classique (extrait hypophysaire de carpe, femelles 5 mg/kg, mâles 2 mg/kg). Le sperme est obtenu exclusivement par massage abdominal, en quantité suffisante, 15 à 30 ml pour un mâle d'environ 10 kg. Les ovocytes - 90 à 120 au g, extraits par massage abdominal - représentent 12 à 20 % du poids de la femelle. La durée d'incubation, où aucun traitement n'est appliqué, varie de 35 à 50 h et plus. Les taux de fécondation-éclosion sont passés de 15 % - 50 % en 1990 à près de 100 % dans de nombreux cas aujourd'hui, alors que le taux de malformation est tout à fait insignifiant. La survie "post-résorption" est estimée à environ 90 % et si l'élevage larvaire demande beaucoup de vigilance -seul un désinfectant de l'eau est utilisé- les seules pertes notables sont dues au cannibalisme, difficile à maîtriser.

La progression a été rapide, au prix de nombreuses répétitions qui ont permis une accumulation d'observations et d'informations. Commencé début Janvier 1990, et après un résultat fortuit le 21 janvier 1990, notre travail a conduit à un premier résultat positif programmé le 5 avril 1990 suivi de 4 autres résultats positifs consécutifs en avril, mai et juin 1990. Ces résultats furent régulièrement et constamment confirmés en 1991, 92, 93, 94, toujours à "contre-saison" de novembre à juin. Obtenus dans des conditions atypiques, de nombreux "aspects" de ces résultats peuvent être transposés en milieu conventionnel. En outre, ils apportent d'intéressantes informations sur la biologie de l'espèce qui autorisent un "nouveau regard" sur *Silurus glanis*.

Communication affichée / Poster

FINGERLING PRODUCTION OF THE AFRICAN CATFISH *CLARIAS GARIEPINUS* (BURCHELL 1822) IN FED AND UNFED PONDS IN RWANDA

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Many authors have assessed that the supply of fingerlings was the major bottleneck of the development of a commercial culture of the african catfish, *Clarias gariepinus*.
The biggest problem in fingerling production in ponds is a relatively low and unreliable survival, related to the lack of appropriate feed and the presence of predators. This study aims at comparing the effect of supplemental feeding on growth, mortality and feeding habits of african catfish fingerlings cultured in earthen ponds.
The larvae were obtained by an artificial reproduction, using *Clarias* pituitary glands (2 glands per female) in the RFCRS hatchery. Yolksac larvae were obtained after 1 day incubation of fertilized eggs in two 50- liter aquaria at 26°C. The free-swimming larvae after yolksac absorption were fed ad libitum fresh zooplankton, mostly cladocerans collected from nearby ponds, for 2 days before pond stocking at a density of 42 larvae per m2. Six 6-are ponds were fertilized one day before stocking using 45 kg DM per week of a mixture of grass compost: chicken manure (80:20); the mixture calculated for 6 weeks of rearing was applied at once at the beginning. Three of the ponds were fed daily 3 kg of fine rice bran divided in two meals distributed at 10h00 and at 15h00. The fish sampling was done once a week and 25 larvae per pond were anesthetised and weighed. Five of them were killed for stomach content analysis while the remaining ones were returned into the pond. After 6 weeks the ponds were drained and the fingerlings counted and weighed on a 25-sample basis. Throughout the experiment frog tadpoles were captured and weighed.
Significant differences ($p < 0.05$) were found for individual average weight between fed and unfed larvae at harvest. The individual average weight was 5.5 g and 2.5 g and the survival rate was 2.2% and 4.4% for fed and unfed groups respectively. The phenomenon of fast growing was observed in other experiments to result from feeding and high mortality which reduced the density considerably. The effect of feeding was not detected for the first 3 weeks but was important after this period. In both groups the larvae seem to feed mostly on zooplankton during the first two weeks while their food items are diversified after this period with insect larvae accounting for more than 40 % of prey. Rice bran was taken at 6% of items.
This study has shown that catfish fingerling production is feasible under rice bran feeding and fertilisation. More research is required to stabilize and increase the survival of fingerlings in ponds, to provide an adequate artificial food and to determine the appropriate period for pond feeding in Rwandese pond conditions.

Communication affichée / Poster

LOW COST PRODUCTION OF *CLARIAS GARIEPINUS* FINGERLINGS

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Acetone-dried pituitary extracts obtained from piscine and non-piscine sources - tilapia species, the common toad, *Bufo regularis*, and the African bull frog, *Rana adspersa*- were administered at 60 mg/kg intramuscularly for the spawning of the African catfish (*Clarias gariepinus*). Stripping and incubation were carried out in laboratory aquaria tanks. The swim-up fries were raised in concrete tanks with sand sediment for 28 days using inorganic fertilizers and practical diets of 40 % crude protein levels.

The fishes attained weight range of above 2 g after 28 days. The results compared favourably with results got through homoplastic hypophysation and feeding with *Artemia* at the same temperature regime (28-30°C) in a simple hatchery. The economics of the cost of production showed that the cost of producing *C. gariepinus* fingerlings using synthetic and homoplastic hypophysation in a simple hatchery was 200 % and 150 % respectively more than the methods employed in this study.

Communication affichée / Poster

INFORMATION ON BIOLOGY AND CULTURE OF AN AIR-BREATHING SILURIFORME *HETEROPNEUSTES FOSSILIS* (BLOCH) INHABITING INDIAN WATERS

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Heteropneustes fossilis (Bloch) is an important air-breathing siluriforme found abundantly in India sub-continent. It fetches a market price between US $ 1-2 per kg. It possesses all the traits of farmed fish and hold good potential for wide scale cultivation. The adult of fish feeds on insects, crustaceans, plant and miscellaneous matter. The peak period of intensive feeding are before and after spawning. The fish attain mean lengths of 175, 209 and 235 mm respectively in Ist, IInd and IIIrd years. The causative factor of age ring formation on pectoral spine is cumulative effect of stress of maturation and low feeding intensity during May-June.

The growth equation can be expressed as $l^t = 355(1 - e^{-.2345(t + 1.33)})$.

The length-weight relationship generally follows cube law. The spawning season coincides with monsoon rains and varies from May to August in different parts of India. The fish mature at the end of first year of its life and exhibit sexual dimorphism with sex-ratio of 1:1. The fecundity range between 2,000-40,000 eggs. The fish migrate to low-lying areas for breeding and respond well to induced breeding techniques using pituitary gland at 8-10 mg/100g of recipient. The fish indulge in courtship followed by mating acts at frequent intervals shedding 40-200 eggs at each act. The fertilised eggs are demersal, adhesive, and spherical in form measuring 1,2-2,6 mm with incubation period ranging 18-20 hrs. The culture of *H. Fossilis* in small ponds for a shorter duration is economically viable and can also be adopted for intensive culture as well as culture practice.

Communication affichée / Poster

CROISSANCE ET MATURATION SEXUELLE DE *HETEROBRANCHUS LONGIFILIS* VAL. EN EAU RECYCLEE THERMOREGULEE

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Des larves de *Heterobranchus longifilis* en fin de résorption vitelline, provenant de la Côte d'Ivoire, ont été reçues en octobre 1992 dans les infrastructures du GAMET à Montpellier (France) à des fins strictement expérimentales. Ces larves ont été élevées en circuit fermé (25°C) et nourries avec des nauplii d'*Artemia* jusqu'à l'âge de 15 jours. Les poissons ont ensuite reçus une alimentation à 49 % de protéines pendant 6 mois environ. Durant cette phase de prégrossissement, une mortalité importante, résultant d'infections par *Aeromonas hydrophila* et *Flexibacter* sp., a été enregistrée et attribuée à des structures d'élevage peu adaptées, avec notamment absence de stérilisation.

A l'âge de 190 jours, 409 poissons (229 g de poids moyen) ont été transférés dans une unité d'élevage conçue pour la maintenance de cette espèce jusqu'au stade adulte. Ces nouvelles installations comportent: un stérilisateur U.V, un système de thermorégulation (24-26 °C), un décanteur cyclonique, un filtre à sable sous pression (surface: 0,5 m^2) et un réacteur biologique (3,3 m^3) à flux ascendant. Ce dernier, utilisé comme château d'eau, alimente par gravité 6 bacs de 1,5 m^3 chacun. Répartis par classe de taille dans ces structures à une charge initiale moyenne de 10,5 kg/ m^3, les poissons ont reçu un aliment granulé (46 % de protéines) distribué 6 jours par semaine à raison d'une ration quotidienne de 1% de leur biomasse.

Chaque mois, environ 20 poissons par bac ont été échantillonnés pour le suivi de la croissance et l'ajustement des rations alimentaires. A partir d'un âge de 428 jours, 30 poissons (4 femelles et 1 mâle par bac) ont été sacrifiés mensuellement pour examen macroscopique des gonades et détermination du pourcentage d'individus matures et du RGS. Aprés une période de 349 jours dans ce circuit fermé, tous les poissons (âge 539 j) ont été sexés d'après l'aspect de leur papille urogénitale et pesés individuellement.

Dans ces conditions, l'âge de première maturation sexuelle, défini comme l'âge auquel 50 % des individus se trouvent à un stade avancé du premier cycle sexuel (présence de sperme intratesticulaire ou présence d'ovocytes en vitellogenèse), a été de 12-14 mois chez les mâles et 16-17 mois chez les femelles. A l'issue des 349 j de suivi, le poids moyen est de 1758 $\pm$ 82 g (croissance journalière moyenne de 4,4 g/j), la biomasse totale s'élève à 519 kg, soit une charge de 58 kg/ m^3, avec une survie de 95 % (individus sacrifiés exclus) et un indice de consommation global de 1,3. A ce stade, les poids moyens des mâles et des femelles sont de 1432$\pm$72 g (n=147) et de 2083$\pm$128 g (n=148), respectivement. Ces données suggèrent l'existence d'un important dimorphisme de croissance en faveur des femelles chez *Heterobranchus longifilis*. Cependant, il est important de noter qu'un tel dimorphisme n'avait jamais été mis en évidence dans les conditions d'élevage pratiquées en lagune Ebrié, d'où les poissons suivis dans cette étude sont issus. Ce résultat, devra donc être confirmé par des observations complémentaires.

Communication orale

PROPAGATION OF EUROPEAN CAFFISH (*SILURUS GLANIS*) IN PONDS

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Several years experience in semi-artificial reproduction of European catfish in Germany is reported.

Spawners should be separated by sex, if possible, already in autumn and kept in different ponds during winter. To provide for good condition of the spawners in the ponds stocking with live cyprinids as food for the catfish (2 kg/kg body weight of catfish) is necessary. In spring (March to April) again trash-fish are to be stocked (4 kg/kg body weight of catfish). Before stocking these fishes must be treated against ectoparasites.

The used spawning pond was 5,000 m^2 in size with a depth of 1.5 m near the inlet and the outlet. Willow roots were best suited as spawning substratum. The prepared nests have to be fixed strongly on the bottom of the pond. The catfish spawned during June at water temperatures of 22 - 24 °C. Spawning did not occur in years with unfavourable climatic conditions (low water temperature). Water current in the pond is advantageous for propagation of catfish. Fertilization rate averaged to more than 80 %. Eggs were incubated in net cages, hatching amounted to about 60 %. The average number of fry was 43,000 per female.

Nursing ponds were stocked with 60,000 fry/ha. Important food organisms are tendipedid and ephemerid larvae and crustaceans. After 14 days dry diet was used for supplementary feeding. Within 4 weeks fry reached a size of 1.2 g. Survival rate averaged to 33 %.

Communication affichée / Poster

PRELIMINARY NOTES ON THE BIOLOGY AND CULTURE OF *CLARIAS JAENSIS* (PISCES, CLARIIDAE) IN CAMEROON

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The Clariid catfish, *Clarias gariepinus* (Burchell, 1822) generally used in African fishculture does not occur in the coastal basins of Cameroon. Rather than cultivate this exogenous fish in this part of the country, it is preferable to study the biology and growth performance of local *Clarias* species in view of fishculture.

Faunistic surveys in the Ntem (South Cameroon) and Sanaga (Central Cameroon) River basins show that *Clarias jaensis* Boulenger is the dominant *Clarias* species therein. This wide distribution could be conducive to the eventual propagation of the species in Cameroon.

Monthly monitoring of the catches from November 1993 to February 1994 has shown that *Clarias jaensis* represents 83.6 % of the *Clarias* catches in Lake Bamedjing (Sanaga River Basin). Physicochemical parameters of the sites as well as habitat descriptions have been noted in view of its ecology and possible introduction in local aquaculture.

From ovary content analysis, *Clarias jaensis* appears to be quite prolific, the egg count oscillating around 7000 for individuals of about 100 g in body weight. However, eggs of up to 0.8 mm in diameter were seldom, suggesting that November to January (the first part of the dry season) is not the spawning period.

From stomach content analysis, *Clarias jaensis* appears to be omnivorous. On basis of this observation, an artificial feed comprising 25 % fishmeal, 15 % rice bran, 15 % soybean cake, 15 % cotton seed flour, 15 % palm kernel and 15 % groundnut cake has been prepared and successfully fed to a broodstock. The growth rate and food conversion are presently being determined.

Communication affichée / Poster

THE CAGE CULTURE OF EUROPEAN CATFISH (*SILURUS GLANIS*) IN A SHALLOW MEDITERRANEAN LAKE

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The experiment on the cage culture of European catfish was performed in fresh-water Vransko lake, which is situated only a kilometer from the Adriatic sea. In spite of some underwater connections, the salinity at the place of culture never exceeded 0.84 $g.l^{-1}$ (mean of 0.78 ± 0.04 $g.l^{-1}$). This is an alkaline lake (133 ± 26 mg $CaCo_3.l^{-1}$) and very shallow, so the depth varied between 1.5 and 2 meters. The floating cages were rectangular (5 x 5 m). The one year old catfish, of an initial individual mean mass of 105 g in the first year and 224 g in the second year, were transported from the continental part of Croatia and fed by pelleted food, which contained 31.5 % proteins. The experiment ran during two cultural seasons. The first one was between May 20th and September 21st, while the other one ran between May 3rd and October 17th.

In the first year fish were stocked at the density of 5.6 $kg.m^{-2}$ (3.4 $kg.m^{-3}$). After 124 feeding days, the biomass gain was 29.4 $kg.m^{-2}$ (18.5 $kg.m^{-3}$), with a mortality rate of 7 %. These good results encouraged higher stocking density of 23.2 $kg.m^{-3}$ (15.5 $kg.m^{-3}$) for the following year. As fish obtained from one farm suffered of protozoan *Ichthiophthirius multifiliis*, the mortality was as high as 25 %. After 168 feeding days, a biomass gain of 29.5 $kg.m^{-2}$ (19.6 $kg.m^{-3}$) was achieved. The food conversion ratios in these two trials were 3.03 and 3.84 respectively. Total production of catfish was of more than 3,000 kg in the first year and more than 5,000 kg in the second one. The water quality slightly changed in an area of 100 m around the cages, but at this level of production the cages influence stayed inside acceptable values.

These results indicate that the cage culture of European catfish is possible even in very shallow habitats, but the greatest precautions should be paid to prevent "ich" disease to happen.

Communication orale

LA CULTURE DE *CLARIAS GARIEPINUS* AU RWANDA (1300-2200 m)

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La culture de *Clarias gariepinus* au Rwanda a commencé très récemment en 1989 à la Station Piscicole de Rwasave, station expérimentale de l'Université Nationale du Rwanda. On y a développé assez vite les techniques adaptées de reproduction, de production d'alevins, de production de poissons marchands et de transformation de ce poisson. Ces 4 domaines sont devenus également les domaines clés d'un projet de développement et de recherche sur *Clarias gariepinus* au Rwanda depuis 1991.

Le développement de la technique de reproduction s'est basé sur la méthode décrite par Viveen et al. (1985) avec l'injection d'extrait hypophysaire. Les oeufs sont incubés sur des treillis moustiquaires en grands bacs (Fastank) ou en aquariums à une température comprise entre 22 et 24°C. Les larves sont alimentées pendant 2 jours après la résorption du sac vitellin avec le zooplancton vivant (95 % cladocères) ou zooplancton congelé. Les post-larves sont empoissonnées dans des étangs fertilisés (herbes et fumier) et mis sous eau 2 jours avant l'empoissonnement. Le taux d'empoissonnement varie entre 30 et 100 larves par are suivant la nourriture disponible. On développe actuellement la stratégie consistant à transférer cette étape aux pisciculteurs privés (ruraux) en fournissant les larves. Le taux de survie varie entre moins de 1 % et 30 %. Des alevins de 5 g sont récoltés après environ 6 semaines.

La production de poissons marchands est réalisée dans un système de polyculture avec *Oreochromis niloticus* (sexes mélangés en milieu rural, monosexe en station). Les étangs ruraux sont empoissonnés généralement à un poisson par m2, dont 20 à 30 % de *Clarias gariepinus*. Le taux d'empoissonnement en station est de 300 poissons par are : 250 tilapias mâles et 50 poisson-chats. La productivité rurale varie autour de 25 kg/are/an, celle en station se situe entre 75 et 100 kg/are/an. Les intrants principaux sont les herbes, le fumier organique et le son de riz. Une association à l'élevage (poules, porcs, canards, chèvres, moutons et lapins) est pratiquée presque uniquement dans les stations, l'association à l'agriculture est beaucoup plus répandue en milieu rural. La polyculture de tilapia et Clarias s'étend de 1300 m jusqu'à 2200 m d'altitude. A cette dernière altitude la croissance est réduite de moitié par rapport à la croissance à 1600 m mais elle reste satisfaisante. La polyculture de *C. gariepinus* avec *O. niloticus* est bénéfique pour les raisons suivantes : meilleure utilisation de la production naturelle, élimination des concurrents de *Oreochromis niloticus* (grenouilles, têtards,...) et une meilleure situation sanitaire (élimination des mollusques). Le contrôle de la surproduction d'alevins de tilapia ne vient qu'en tout dernier lieu et seulement à des altitudes inférieures à 1600 m.

La transformation en filets et en filets salés et fumés a été développée afin de faciliter la commercialisation en milieu urbain. C'est ainsi qu'a été construit un séchoir-fumoir solaire adapté aux besoins et aux matériaux disponibles. La commercialisation en milieu rural ne pose aucun problème : le Clarias est préféré au tilapia du fait de sa taille, du faible nombre d'arêtes et du bon rendement en chair par rapport au poids vif.

Communication affichée / Poster

THE PROSPECT FOR AQUACULTURE OF CATFISH IN PEOPLE'S REPUBLIC OF CHINA

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Nowadays, some foreign new fish species are progressively and actively introduced into China beside the traditional aquaculture of Chinese carps. The most wildely cultured Siluriforme fish are the Channel catfish and *Clarias* catfish.

The Channel catfish (*Ictalurus punctatus*) was first introduced into China in 1986, after that introduction was continued at the end of the eighties and the beginning of the nineties. After a few years of rearing and breeding, this food fish is now coming on the market and can be shown in the aquarium of the restaurant throughout southeast China. So the development is looking forward to the future. The author carried out experiments on the Channel catfish, 500 kg per mu (1 mu = 667 m^2) of fish were produced using pellets from the United States, and clam and snail meat or fish meal prepared as pelleted feed, or in ponds polyculture with Chinese carps. All the methods led to successful and economical results.

Another catfish species is the *Clarias fuscus* (Clariidae) introduced at the end of the seventies. recently the culture is widespread. The *Clarias* catfish have accessory air breathing organ, which enable them to survive for about 100 hours out of the water. The market price is the same than that of Chinese carps. People would like to take them as food at 0.5-1 kg which is the most appreciated size. 350,000 kg of *Clarias* were sold in Wuxi City only, during 1993.

The fish are omnivorous and present few fishbones. Any feed can be used but, of course, meat feeds are preferred. We utilize silk-worm, clam and snail meat in a pelleted form. The fish reaches marketable size after 1 year of culture. The economical results are good. Breeding occurs earlier in southern China, so the fish produced in the southern part are introduced into eastern part of the country every year. The culture is of minor importance in the northwest China due to cold water temperature.

INDEX DES NOMS D'AUTEURS

AUTHORS INDEX

INDEX DES AUTEURS

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