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A PROVISIONAL SURVEY OF THE INTRODUCTION AND TRANSPLANTATION OF FISH THROUGHOUT THE INDO-PACIFIC REGION

by

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ABSTRACT

An account is given of the spread of fish over the Indo-Pacific Region by human action. The records are divided into :

(*a*) The scattering in historic times of the Asian varieties of *Cyprinus carpio*, *Carassius auratus*, *Ophicephalus striatus* and *Rasbora lateristriata* all over the region.

(*b*) The planned transplantation of fish between parts of the region for cultural purposes in recent time, including 18 species and 48 separate records.

(*c*) The introduction of foreign species into the region, subdivided into the importation of fish for cultural purposes (9 species) and the introduction of larvicidal fishes (3 species).

A description is given of the environmental requirements of the 20 species of fish which are mainly used for transplantation and their merits are discussed. Then follows an outline of the types of water, suitable for stocking with transplanted fish. The survey closes with a discussion of the advantages and disadvantages connected with transplantation work and a warning against the possibility of the spreading of diseases and pests by uncontrolled transplantations.

S.Y. Lin mentioned in his paper on fish-culture in China the interesting fact that common carp was cultivated in ponds five hundred years before Christ, and if we believe the reports of zoogeographers then the European races of carp as well as those reared at present in the Far East come from the stock which has been domesticated in China about two thousand years ago.

Two peculiarities seem to be the reason why the ancient Chinese showed special interest in fish-culture. Their contemplative conception of life gave them a predilection for keeping ornamental fish in miniature ponds and, being Epicureans, they preferred live fish to dead ones for culinary use. In this manner Chinese people became familiar with the ways of fish at an early date and wherever they went with their ships, carps were taken along to be presented as a symbolic gift to business friends.

A similar process may have taken place with *Ophicephalus striatus* Bl. This labyrinthic fish is often kept alive for a considerable time by Javanese fishermen and transported over long distances. At present it is even shipped alive in sailboats from Bandjermasin in South Borneo to the markets in Singapore. Its occurrence as the single species of a large family in Celebes and some of the Lesser Sunda Islands is possibly due to unintentional transplantation in historical times. Weber and de Beaufort's statement that it was introduced to the Hawaiian Arch. points in the same direction. Another biological peculiarity, the occurrence of *Rasbora lateristriata* (Blkr.) as the only Cyprinid east of the Wallace line, may be explained by the fact that this hardy species is often kept as a pet in fresh-water tanks on ships by Javanese sailors. No proof can be given that *Ophicephalus* and *Rasbora* have indeed spread in the manner described, but to everybody familiar with the ways of Indonesian fishermen, the explanation will appear plausible. In the case of carp, we may assure that the introduced varieties ran wild after some time. Fish culturists used the local stocks to obtain material for rearing in ponds and, when cultural activities reached a higher level, the breeds developed into real " noble races." When considering the origin of the *Galician* or *Bohemian* race of common carp in Central Europe and that of *Si Njonja* or *Kantjera domas* in Indonesia, one will agree that here the same process has taken place in two geographically widely-separated areas.

When considering the biological factors which made the wide distribution of carp possible we find *Cyprinus carpio* with characteristics which are rarely combined in a single sort of fish. Being greatly adaptive to climatological conditions, prolific, omnivorous and modest in its need for oxygen, *Cyprinus* possesses those qualities which may be regarded as a " standard equipment " of vagrant, non-predacious sorts of fish. *Carassius*, *Osphronemus*, *Trichogaster*, *Tilapia*—all widely-spread species—fit easily into this scheme.

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Cultural activities resulted also in a wide spreading of the species involved. Wherever bodies of water, suitable for the cultivation of fish were present, fry of domesticated species were brought there by traders or, in more recent times, by fisheries workers. Temple and monastery ponds may have been rearing places for fish in early times, but also the freshwater tanks, which can be found almost everywhere in the area, can be regarded as precursors of modern fish ponds. Even small domestic tanks become today—as they did in former days—naturally populated with minute fish, and it is obvious that the stocking of these tanks with selected fry, caught in rivers or lakes, was the most plausible beginning of the culture of freshwater fishes. When a certain sort became well-known for its rapid growth or fine taste, the fry were transported over increasingly longer distances to stock the tanks. The transplantation of *Puntius orphoides* C. V. from rivers in West Java to " situs " i.e. tanks, is an example of such a development in modern times. Fish-culture in this way seems to be one of the reasons why some species have become widely spread in the area and, since by these transplantations little attention was paid to the natural ranges of distribution, 500 to 800 years of fish-culture may have contributed largely to zoogeographical changes in the region.

The most obvious of the " planned " transplantations are those of the Chinese carps *Ctenopharyngodon idellus* (C.V.) *Cirrhina molitorella* (C.V.), *Aristichthys nobilis* (Rich.) and *Hypophthalmichthys molitrix* (C.V.) along the East and South Coasts of Asia. Wherever Chinese people settled, they started to construct ponds and began to rear the varieties of fish well-known from their homeland but, since no technique could be developed to induce those species to spawn in their new environments, no bionomic spreading followed the transplantations.

In a similar way *Osphronemus goramy* Lac. was spread by Javanese colonists all over the archipelago and was brought to far-away countries such as Ceylon, Egypt or Sicily by people interested in fish-culture. Since goramy was able to adapt itself to local conditions, it became a popular fish in many countries where it spawned freely in rivers and lakes.

Independent of the culture of fresh-water fishes, the rearing of marine fish has been an indigenous industry in the Indo-Pacific area since time immemorial. We know from Roman classical literature that Muraena's were kept in marine fish ponds in Italy in Nero's time, but we can also mention the fact that, in accordance with old Javanese law books, *Chanos* was cultivated in salt-water ponds in Java long before the first Europeans came to the Far East. Areas, purposely embanked for the production of solar salt may have been the first marine fish ponds in East Asia, since the reservoirs from which salt fields are filled with sea-water automatically become natural fish ponds in the wet season ; however, no historian has told us about these early stages of the tambak industry. The transition from the rearing of miscellaneous fish to the planned cultivation of *Chanos* and *Puntius* was so gradual that no correct data can be given about the beginning of the transplantation of fry. It is known that already in 1400 A.D. a trade in *Chanos* fry existed in Java.

When recent intentional transplantations are taken into consideration, we find that even transitions between the fresh-water and the salt-water regions have taken place. In Java *Puntius javanicus* Blkr. was brought down to the coast to be cultivated in brackish-water ponds ; in Ceylon *Etroplus suratensis* (Bl.) was brought inland to be reared in tanks, and in India real marine species such as *Lates calcarifer* Bl., *Lutjanus argentimaculatus* (Forsk.) and *Megalops cyprinoides* (Brous.) were " acclimatized " and made suitable for the stocking of inland waters. That means that ecological as well as zoogeographical border lines become obscure when fisheries biologists succeed in populating waters with the varieties of fish which, for economic or biological reasons, are regarded as useful in a certain type of water.

Another group of transplantations of fish consists of those by which certain varieties have been unintentionally spread in recent times to areas outside their original region of distribution. In this connection " unintentionally " stands only for " not intended by fisheries biologists ", since modern means of transportation make it possible for any amateur to take live fish to places where professionals would never take them. The introduction of *Clarias batrachus* (L.) and *Trichogaster trichopterus* (Pall) into the waters of Celebes and the introduction of *Mollienisia latipinna* Le Sueur from Hawaii into the Philippines are examples of transactions of this kind.

The compiler of this survey does not flatter himself in the belief that the greater part of the transplantations, effected in the course of time, have come to his knowledge. It is his intention only to draw attention to this important subject, and to provide for a scheme into which further information can easily be fitted.

The available body of facts enabled the writer to compile the following provisional list :

A. *Unintentional spreading of fish in historical time*

Species	from	to	in
Cyprinus carpio L.	China	Countries of the continent of Asia, Java, Sumatra	
Carassius auratus L.	China	Countries of the continent of Asia, Java	
Ophicephalus striatus Bl.	Java, Borneo	Celebes, Lesser Sunda Islands, Moluccas, Hawaii	
Rasbora lateristriata (Blkr.)	Java	Lesser Sunda Islands	

B. *Planned transplantation for cultural purposes in recent time*

Species	from	to	in
Cyprinus carpio L.	Java	Celebes	1895
		Sumatra, Borneo	1903
		Flores	1932
		Bali, Lombok	1941
	China	Philippines	1915
	China	Thailand, Indo-China	?
		Malaya, Ceylon, India	?
Ctenopharyngodon idellus (C. V.)	China	Thailand, Malaya	?
		Sumatra	1915
		Java, Ceylon	1949
Cirrhina molitorella (C. V.)	China	Thailand, Malaya	?
		Sumatra	1915
Hypophthalmichthys molitrix (C. V.)	China	Thailand, Malaya	?
		Ceylon	1948
Aristichthys nobilis (Rich.)	China	Thailand, Malaya	?
		Ceylon	1948
Mylopharyngodon aetiops (Bas).	China	Indo-China, Thailand	?
Carassius auratus L.	China	Indo-China, Thailand	?
Catla catla H.	India	Ceylon	1942
Puntius javanicus (Blkr.)	Java	Celebes	1930
		Borneo	1949
Osteochilus hasselti (C. V.)	Java	Sumatra	1903
		Moluccas	1929
		Celebes	1937
		Bali, Lombok	1941
Osphronemus goramy Lac.	Java	Thailand, India	?
		Celebes	1903
		Bali, Lombok	1941
		Philippines	1927
		Ceylon	1890
Helostoma temminckii (C. V.)	Borneo	Celebes	1925
	Java	Bali, Lombok	1941
	Thailand	Philippines	1948
Trichogaster pectoralis (Regan)	Thailand	Malaya	1921
	Java	Java	1934
		Celebes	1937
		Borneo	1940
		Bali, Lombok	1941
		Moluccas	1949
		Flores	1949
Tilapia mossambica Peters	Java	Bali, Lombok	1941
		Celebes	1944
		Moluccas	1949
Aplocheilus panchax (H. B.)	Java	Bali, Lombok	1935
		Celebes	1938
Dermogenys pusillus v. Hass.	Java	Bali	1935
Ctenops vittatus (C. V.)	Java	Bali	1935
Mollienisia latipinna Le Sueur	Hawaii	Philippines	?

C. *Introduction of fish, not autochthonous to the Indo-Pacific Region*

1. CULTIVATED SPECIES

Species	from	to	in
Cyprinus carpio L.	? Europe	Australia	
	? Europe	Japan	
	? Europe	India	
	Europe	Indonesia	1927
Tinca vulgaris Cuv.	Europe	Indonesia	1929
Carpio collari (Heckel)	Europe	Indonesia	1929
Trutta (*Salmo*) *fario* L.	? Europe	Australia	
		Tasmania	
		Japan	
		India	
Trutta (*Salmo*) *irideus* Gibb.	? N. America	Japan	
		Australia	
	Australia	New Guinea	1949
	Europe	Indonesia	1929
	? Europe	India	
Salmo gairdnerii Wal.	N. America	Japan	
	? N. America	Ceylon	
Salvelinus fontinalis Mit.	N. America	Japan	
		Korea	
Huro salmoides Lac.	N. America	Philippines	1907
Haustor catus ?	N. America	Philippines	1935

2. LARVICIDAL SPECIES

Species	from	to	in
Lebistes reticulatus (Peters)	Europe	Java	1920
	N. America	New Guinea	1943
		India	1946
		Ceylon	
		Philippines	
		Malaya	
		Borneo	1928
Gambusia affinis (B. G.)	N. America	Hawaii	1905
		Philippines	
	Europe	Indonesia	1920
		India	
		Malaya	
Mollienisia latipinna Le S.	N. America	Hawaii	1905

The introduction of fish, not autochthonous to the region, can be subdivided into the importation of domesticated species for cultural purposes and the intentional distribution of foreign species for special motives.

Of the fishes imported to be cultivated in impounded waters, in the first place, the European varieties of *Cyprinus carpio* should be mentioned. More than one country in the region attempted to obtain by importation a race of carp superior to the local varieties, but it seems that they all feel that they have come away with a flea in the ear. Indonesia made an attempt with the *Galician* and the *Bohemian* race, Japan took the *Aischgründer*, India used a Mirrorcarp of unknown race and all these carps propagated and became mixed with the local stock of carp, but enthusiastic reports about higher yields or other advantages were not forthcoming. It seems that European carps quickly lose their squat shape, whilst their mortality when cultivated under tropical or subtropical climatic conditions rises above that of the Asian races.

Much more successful was the introduction of *Salmonids* into the region. Australia, New Zealand, Tasmania, Japan, India and Ceylon all imported

trout years ago, and at present possess a stock of Salmonides which can be regarded as a valuable addition to the indigenous stock of fish.

To the second group of introduced fish belong the varieties which were brought to the Indo-Pacific region for larvicidal purposes. *Lebistes*, *Gambusia Mollienisia* and *Aplocheilus* became widely spread throughout the area because not only fishery workers, but hygienists also, took part in the distribution. War conditions supported the spreading of the " millions ", as they went with the army to every place where a medical post was set up, to be released in the waters in the neighbourhood of the station.

In those cases where the origin of the fish is uncertain it is hardly possible to make a clear distinction between transplantation and introduction. In the short period during which organized fisheries-control existed in Indonesia, four examples of the appearance of a species of fish " in terra nova " were observed.

Most obvious was the occurrence of *Tilapia mossambica* Peters in 1939 when five specimens, caught in a lagoon of a small river in Java, became the progenitors of a fresh- and brackish-water stock which at present yields thousands of tons of fish a year. Another example is the occurrence in West Java in 1948 of *Carassius auratus* L. in a variety much resembling the " Crucian carp " of European or Japanese waters. Earlier, in 1925, *Trichogaster trichopterus* (Pall.) suddenly appeared in lakes in North Celebes ; no explanation could be given as to how it got there.

Experienced hydrobiologists do not give much credit to the story of fish eggs being transferred by waterfowls, and so man with his queer habits and character will in most cases have to be regarded as the originator of those "inexplicable " happenings. In 1939 *Clarias batrachus* (L.), a predator which causes harm in stocked waters by feeding on spawn, appeared suddenly in rivers in South Celebes. Since *Clarias*, a Siluroid, does not naturally occur east of the Wallace line, the interesting question arose as to how it got there. Investigation showed that a foreman of a rural waterboard, who went on leave to Java, transported some specimens alive over a distance of more than 900 miles because, as he said, he was fond of *Clarias* which he remembered from his childhood as a good fish to be caught with hook and line. This example, given *in extenso*, serves to illustrate what modern means of transportation can do. Clarias could not be expelled from Celebes again and there is a 20,000 tons inland fishery at stake. Things like these will happen everywhere in the region and the only means of controlling them is by a fisheries-service which is ahead of developments and is prepared to act quickly when it comes to the point.

Fish belong to Fisheries and all matters concerned with fish should be dealt with by fisheries biologists. The introduction of *Lebistes reticulatus* into Java and that of *Mollienisia latipinna* into Hawaii and the Philippines are striking examples of the fact that even scientists, unacquainted with limnological problems, may cause grave harm when trespassing on somebody else's premises. Disappointing or even negative results have been attained, and things like that will happen again whenever operations are carried out without careful calculation of the whole range of consequences. But lack of experience or the absence of printed information must never lead to a haughty rejection of all introduction or transplantation work ; but unfortunately such a tendency is noticeable today.

In Indonesia an absolutely new fishery, yielding 15,000 tons of fish annually, could be built up in five years' time by transplantation of two species of fish into a new area. The introduction of *Tilapia* resulted in the production of another 5,000 tons of fish a year in Java alone. These examples are ample proof that great advantages can be achieved with work of this kind, and since the practical issues of transplantations and introductions are the only available guide for future work, the recording of all operations is a matter of the utmost importance.

We are anxious to increase the production of our waters by managing them in the most efficient way and that includes, among other measures, the stocking or restocking with fish which under prevailing conditions are able to yield better than the original stock. We therefore want to have at our disposal such a number of species and varieties that selection of a suitable sort of fish for every type of water will be possible. Workers in the region, as well as the biologists outside, want to know how the species and varieties involved react when transplanted from open water to ponds, what they do when reared in confined waters and how they behave when used for rough release. This is what we want but we must agree that little has been done to achieve this end.

Every country in the Indo-Pacific Region possesses at present a number of species and varieties which have been investigated and tested to some degree but it is difficult to judge their suitability, as hardly any reliable comparative work has been done. Ecological conditions show little difference in the equatorial zone of the region ; however, nobody can say at present which species of plankton and detritus feeders, herbivores, carnivores or omnivores reared there can be regarded as superior in production or staying power.

The compiler of this survey tried to draw up a list of the known properties of the species commonly used for transplantation. The records in this list are still far from complete and some species had to be omitted because of lack of reliable data, but it will have to suffice until more reliable information becomes available.

A. Omnivores

1. *Cyprinus carpio* L., Asian varieties.

Feeds on : Chironomidae, Ephemeridae, Crustacea, Mollusca, Trichoptera and many kinds of farinaceous feeding-stuffs.

Suitable for cultivation under tropical conditions between 100 and 1000 m above sea-level. Resistant to low oxygen tension and restricted space. Spawns in captivity. Natural annual production in ponds up to 600 kg per ha. Suitable for rearing in rice fields and impounded waters, which dry out regularly. Not suitable for release in waters where it is difficult to remove all fish. Mediocre food-fish.

2. *Cyprinus carpio* L., European varieties.

Feeds on : Chironomidae, Ephemeridae, Tubificidae, Crustacea, Mollusca and many kinds of farinaceous feeding-stuffs.

Suitable for cultivation under tropical conditions from 500 to 1000 m above sea-level. Spawns in captivity. Natural annual production about 500 kg per ha. Not suited for cultivation outside ponds. Good food-fish.

3. *Carassius auratus* (L.)

Feeds on ; Chironomidae, Tubificidae, Crustacea.

Suitable for cultivation under tropical conditions between 200 and 1000 m above sea-level. Spawns in captivity. Natural annual productivity about 400 kg per ha. Not suited for cultivation outside ponds. Only advantage over *Cyprinus carpio* : firmer flesh.

4. *Osphronemus goramy* Lac.

Feeds on : soft leaves of aquatic and land plants, fruits, insects, and many kinds of vegetable and animal feeding-stuffs.

Suitable for cultivation under tropical conditions to 800 m above sea-level. Resistant to very low oxygen tension and restricted space. Spawns in captivity. Natural annual production in ponds approaches 200 kg per ha. Suitable for rough release in lakes and rivers. Excellent food-fish.

5. *Tilapia mossambica* Peters.

Feeds on : Chlorophyceae, Cyanophyceae, Conjugatae, Characeae, Diatomeae, Crustacea, detritus.

Suitable for cultivation under tropical conditions to 1000 m above sea-level. Resistant to low oxygen tension and restricted space. Spawns in captivity. Natural annual production some 500 kg per ha. Suitable for cultivation in ponds, impounded waters and for rough release in lakes. Especially important for stocking swamps or marshes which dry up annually. Adapts itself easily to brackish-water conditions. Good food-fish.

6. *Etroplus suratensis* (Bl.)

Feeds on : Cyanophyceae, Chlorophyceae, Copepoda, Cladocera, Ostracoda.

Suitable for cultivation under tropical conditions. Spawns in captivity.

Suitable for cultivation in ponds, impounded waters and for rough release in lakes. Is a brackish-water species which adapts itself easily to fresh-water. Mediocre food-fish.

7. *Cirrhina mrigala* (C.V.)

Feeds on : Cyanophyceae, Diatomeae, Mollusca, Vermes, " scavenger ".

Suitable for cultivation under tropical conditions. Does not spawn in captivity. Natural production some 300 kg per ha. Often cultivated in combination with other species. Suitable for cultivation in ponds, impounded waters and for rough release in rivers. Good food-fish.

B. Plankton and Detritus Feeders

1. *Trichogaster pectoralis* (Pall.)

Feeds on : Diatomeae, Cyanophyceae, Flagellata, Ciliata, Rotatoria, Cladocera, Copepoda, detritus.

Suitable for cultivation under tropical conditions to 800 m above sea-level. Resistant to low oxygen tension. Poor yields when cultivated in ponds. Spawns in captivity. Suitable for rearing in rice fields and for rough release in marshes and swamps. Mediocre food-fish, suitable for processing as dried fish.

2. *Helostoma temmincki* (C.V.)

Feeds on : Diatomeae, Cyanophyceae, Flagellata, vegetable detritus.

Suitable for cultivation under tropical conditions to 800 m above sea-level. Resistant to low oxygen tension. Often cultivated in ponds in combination with other species. Natural annual production about 500 kg per ha. Spawns in captivity. Suitable

for rough release in marshes and slow running rivers. Good food-fish, suitable for processing as dried fish.

3. *Aristichthys nobilis* (Rich.)

Feeds on : Flagellata, Diatomeae, Cyanophyceae, Ciliata, Rotatoria, detritus.

Suitable for cultivation under tropical and subtropical conditions. Resistant to low oxygen tension and restricted space. Often cultivated in combination with other species. Annual production in manured ponds about 1000 kg per ha. Does not spawn in captivity. Not suitable for rough release. Excellent food-fish.

4. *Hypophthalmichthys molitrix* (C.V.)

Feeds on : Flagellata, Diatomeae, Cyanophyceae Ciliata, Rotatoria, detritus.

Suitable for cultivation under tropical and subtropical conditions. Resistant to low oxygen tension and restricted space. Often cultivated in combination with other species. Annual production in manured ponds about 1,000 kg per ha. Does not spawn in captivity. Not suitable for rough release. Excellent food-fish.

C. Herbivores

1. *Puntius javanicus* (Blkr.)

Feeds on : Characeae, Ceratophyllaceae, Polygonaceae, Lemnaceae, Najadaceae, Chlorophyceae, Conjugatae, Gramineae.

Suitable for cultivation under tropical conditions to 800 m above sea-level. Natural annual production in ponds some 500 kg per ha. Suitable in restricted measure for rearing in rice fields and ponds with a salinity up to 8 per mille. Suited for rough release in swamps and marshes with a dense, submerged vegetation. Mediocre food-fish, suitable for processing as dried fish.

2. *Ctenopharyngodon idellus* (C.V.)

Feeds on : aquatic plants and leaves of land plants.

Suitable for cultivation under tropical and subtropical conditions. Resistant to low oxygen tension and restricted space. Often cultivated in combination with other species. Annual production approaches 1000 kg per ha when additional feeding is given. Does not spawn in captivity. Not suitable for cultivation outside ponds or enclosed waters. Excellent food-fish.

3. *Labeo calbasu* (H.B.)

Feeds on : " Higher-organized, aquatic plants and plankton ".

Suitable for cultivation under tropical conditions. Does not spawn in captivity. Natural annual production about 300 kg per ha. Often cultivated in combination with other species. Suitable for cultivation in ponds, impounded water and rough release in rivers. Good food-fish.

4. *Labeo rohita* (H.B.)

Feeds on : " Higher-organized, aquatic plants and plankton ".

Suitable for cultivation under tropical conditions. Does not spawn in captivity. Natural annual production some 400 kg per ha. Often cultivated in combination with other species. Suitable for cultivation in ponds, impounded waters and for rough release in rivers. Excellent food-fish.

5. *Catla catla* (H.B.)

Feeds on : " Higher-organized, aquatic plants and plankton ".

Suitable for cultivation under tropical conditions. Does not spawn in captivity. Natural annual production about 500 kg per ha. Often reared in combination with other species. Suitable for cultivation in ponds and rough release in rivers. Excellent food-fish.

6. *Chanos chanos* (Forskal)

Feeds on : Cyanophyceae, soft parts of Chlorophyceae, Conjugatae and Characeae, Diatomeae, detritus, conditional : Crustacea, Protozoa, Vermes.

Suitable for cultivation under tropical conditions. Does not spawn in captivity. Natural annual production about 500 kg per ha. Marine species which adapts itself easily to fresh-water conditions. Suitable for cultivation in ponds and impounded waters. Excellent food-fish.

D. Carnivores

1. *Salmo* (*Trutta*) *fario* L.

Feeds on : " air-food ", Gammaridae, Chironomidae, Ephemeridae, Trichoptera, fry of fish.

Suitable for cultivation under tropical conditions at 1000 m above sea-level. Suitable for rough release in streams. Artificial fertilization of eggs recommended. Excellent food-fish.

2. *Salmo (Trutta) irideus* Gibb.

Feeds on: Cyclopidae, Gammaridae, Chironomidae, Ephemeridae, Tubificidae, Trichoptera and many kinds of animal food-stuffs.

Suitable for cultivation under tropical conditions at 1000 m above sea-level. Suitable for cultivation in ponds. Annual production some 200 kg per ha. Suitable for rough release in streams. Artificial fertilization of eggs recommendable. Excellent food-fish.

With this range of fish at our disposal we are able to provide for proper technical stocking of all types of water we meet in the region. Of course, we are not absolutely sure that the species recorded are the best available in the area but in practice those mentioned have proved to be of good use.

To decide whether and with which sorts of fish a water should be stocked, we may follow the classical rules indicated in Wundsch " Die Arbeitsmethoden der Fischereibiologie ". However, the methods developed in Europe call for a trained staff of field-workers and since nowhere in the region is there a team of experienced limnologists at work, conditions at present often necessitate the application of simpler techniques.

In actual practice the first step to be taken is to draw up an inventory of the species of fish occurring in the water in question. Then the position of each important species in the biocoenose of the water has to be established on the basis of the feeding and spawning-habits. The next thing is to investigate the amount of fish-food present in the water which is not used by the natural stock of fish, and that is a point where exact methods let us down.

The primary food-resources of our inland waters consist of the aquatic microfauna and flora, the higher organized water-plants and the refuse matter which a water receives from the shore-vegetation. This primary food may be completely or partly consumed by fishes directly suitable for human consumption, but, on the other hand, primary food is often used by small or inferior species which have to serve as food to predators first to achieve economical value.

When a system of water in a tropical area is left to its own resources for a long time, a prevalence of predacious species will usually be the result. A decision about the measures to be taken to develop such a water depends on the following questions:

Is the full amount of vegetable fish-food used up by the autochthonous primary feeders or not ?

Will the density of predators permit of the introduction of a new, prolific species of primary feeders ?

Is it rational to maintain a preponderant carnivorous stock of fish when we assume that 10 to 40 pounds of primary feeders are necessary to yield one pound of flesh of predators ?

Will it be possible to reduce the density of predators by directing the capture-activities, for instance by the distribution of special gear or the award of premiums on the capture of undesirable species ?

The fisheries biologist in the Indo-Pacific Region depends to a high degree on his own insight and on his knowledge of local circumstances in deciding these questions. To be able to decide whether a new species should be introduced, a reasonable knowledge of the ecological conditions as well as a clear outline of the possibilities is necessary.

A brief outline of the different types of water may be of some use to indicate the waters into which fish can be introduced.

1. *Ponds or pond-like waters* as domestic fresh-water tanks and small irrigation tanks which, like real ponds, can be drained. Since removal of predators and cleaning and tilling of the soil is possible, every type of fish culture is possible in waters of this type in accordance with local conditions. The desirability of the introduction of new species depends on the yielding capacity of the indigenous species.

2. *Swamps, marshes* and *wet rice fields*, flooded during 6 to 10 months and dry during the rest of the year. Often very productive waters with a dense aquatic vegetation, but due to their intermittent character lacking the capacity to develop naturally an economically important stock of fish. Annual stocking with seed or full-grown specimens of quickly spawning species is advisable. Recommendable: *Cyprinus carpio* and *Trichogaster pectoralis* for rice fields, *Tilapia mossambica*, *Trichogaster pectoralis* and *Puntius javanicus* for swamps and marshes. Under special circumstances *Etroplus suratensis* and *Chanos chanos* may also be used.

3. *Lakes, large irrigation tanks* and *perennial swamps*. When situated west of the Wallace line, these waters commonly bear a natural fish-population, mainly consisting of *Siluroidae*, *Cyprinidae* and *Labyrinthici*. Seldom duner-populated. Development depends on the possibility of suppressing predators. The sorts of fish to be used for introduction, when predators are under control, must be chosen in accordance with food-resources. Water east of the Wallace line, usually lack a varied, natural stock of fish and are therefore of great promise for cultural purposes.

4. *Rivers, streams* and *deltaic waters.* West of the Wallace line these waters are usually densely populated with *Siluroidae* and *Cyprinidae.* The capacity depends on the soil conditions in the watersheds and the density of the shore vegetation. In the slow moving rivers a surplus of plankton and decayed vegetable matter may often be found. Stocking of middle courses with *Osphronemus goramy* and of lower courses and deltaic waters with *Helostoma temmencki* and *Trichogaster pectoralis* can often be successful. Development can be achieved by directing fisheries activities to the suppression of predators and the protection of primary feeders. The riverine waters, east of the Wallace line, are often underpopulated and open to introduction of new species.

A retrospective view of the introductions, which have become an avowed success, shows that relatively little effort is necessary to adapt a well-chosen species to new surroundings. Ten full-grown specimens of *Trichogaster pectoralis*, brought from Malaya to Indonesia in 1930, were sufficient to build up a huge population of this species in Java, Borneo and Celebes. In 1930 a small pot filled with fry of *Puntius javanicus* was shipped to Celebes and now the yield of this fish there amounts to about 15,000 metric tons a year. And finally, the immense stock of *Tilapia mossambica*, now present in the Far East, is descended from the 5 specimens caught in Blitar, East Java in 1939. The thousands of tons of fish, now produced in areas where the involved species were unknown a few years ago, are a clear manifestation that transplantation-work can be of great importance for the development of the fisheries in a certain area.

When the disadvantages which arose in consequence of the intentional or unintentional introduction of fish are taken into consideration, the following can be stated.

Actual harm was caused by the transplantation of predators—the transplantation of *Clarias batrachus* to Celebes can be mentioned as an example. Since no hydrobiologist will give his consent to such inconsiderate action as the transplantation of a prolific predator of low economic value to a new area, an incidental case should not be regarded as a condemnation of transplantation-work generally.

A disadvantageous effect also occurred when *common carp* was introduced into deep lakes. This clever fish withstands all efforts at capture and becomes a competitor for food to better yielding species. It should be borne in mind that *Cyprinus carpio* should be stocked only in waters that are easy to drain or fish.

Another weak point is the intentional spreading of larvicidal species which is still on the programme in many countries. *Lebistes reticulatus* and *Mollienisia latipinna* are causing grave harm now as competitors for food in fresh-water and brackish-water ponds in the area, and the advantages of these species over autochthonous ones are doubtful to say the least of it. It should be clearly recognized that the effect of anti-malarial efforts does not depend only on the voracity of a larvicide species of fish, but also and even to a great extent on the condition of the water in which the mosquitoes breed.

None of the malaria-carrying Anopheles breeds in open water ; they all deposit their eggs in plant-masses or floating debris. Mats of algae and semi-submerged grasses growing in shallow ponds have become notorious for the number of anopheles-larvae which develop there, protected from attack by fish. No larvicidal fish is able to intrude into thick layers of vegetation and the efficiency of anti-malarial measures therefore mainly depends on the degree to which a water is covered with floating vegetation or other materials among which the larvae can shelter. A clean pond can be kept free of larvae by stocking it with about 20 specimens of larvicidal fish per acre, while a water covered with algae or grasses may be stocked without effect with a much greater number of fish.

In concluding this survey a point should be brought up for discussion which deserves our full attention.

The countries of the Indo-Pacific Region have so far been spared disastrous fish diseases. We know *Enteritis* of carps, caused by unsuitable or decayed food ; we know that our fish are infected with protozoa as *Gyrodactylus, Dactylogyrus* and *Ichthyophthirius* ; we know gillrot caused by the fungus *Branchyomyces* and infections with parasitic *Trematodae* and *Nematodae.* We have seen fishes infected with *Argulus, Piscicola* and *Diplostomum* but no infection was ever so widespread that it became an actual danger to the pond industry of a country. But what would happen if *Pseudomonas punctata* for instance, a bacterium well-known from Europe as the originator of the dangerous abdominal hydropsy of Cyprinids found its way to the Far East ? Thousands of acres of rice fields in Indonesia are stocked with carps, and ponds covering hundreds of thousands of acres are to be found all over the region. We just cannot imagine what would happen if really dangerous infectious fish-diseases spread here. The interests involved are immense and international cooperation in defending them is highly necessary. At least one biologist working in the region should be specially trained in recognizing and fighting fish diseases, to act as an

adviser when it comes to the point. Europe with its comparatively small inland fishery has a number of laboratories where highly-skilled techniques have been developed in recognizing and fighting the diseases of cultivated and wild fish. A single specialist for the whole Indo-Pacific Region would surely be no luxury.

All that the common fisheries worker can do at present is to keep an eye on all introductions of fish from outside the area, and to make up his mind as to the isolation measures that will have to be applied. Some places in the area are already heavily fouled with pests and there is absolutely no need to extend the range of spreading. Almost all fish from Singapore are infected with Protozoa and as this place is a junction in international trade in aquarium fish, the possibility that new diseases will come via Singapore is great.

If we venture to make any suggestions for the development of inland fisheries by the introduction and transplantation of fish we should emphasize in the first place the necessity for international cooperation in exchanging information. Planning of introductions or transplantations can only be carried out with reasonable certainty when information is available concerning the yielding capacity of a fish and its suitability for cultural purposes in the country of origin. Gaining of production data and recording of the results of transplantations should be considered of the highest importance in every Fisheries Department.

Another suggestion is that the importation of live fish into a country should be supervised by the local fisheries department which, even in the case of ornamental fish, should decide whether importation may be permitted or not. If each consignment of fruit entering a country can be inspected, surely the same can be done with live fish. We cannot make sure by quick inspection whether a batch of fish is infected with parasites or not, but we can check the importation of Cyprinids and Poecilids which may cause trouble as carriers of bacterial diseases or spread to become competitors for food.

The last point of my survey is the suggestion to take under observation the species which show an inclination to spread. It is quite likely that species, such as *Tilapia* intentionally or unintentionally will spread all over the region and it would be better to be informed about the cultural possibilities under local conditions than to wait until the fish has spontaneously made its entrance.

With these suggestions I should like to conclude my survey, and I hope that the information collected will be a stimulant to the continuation of investigations in this direction.

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METHODS AND PROBLEMS OF COLLECTING EGGS AND FRY FOR TRANSPLANTATION

by

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ABSTRACT

A brief survey is given of the methods of collecting eggs and fry in this region. Particular attention is paid to methods in use in the Philippines, especially for handling *Chanos chanos*. The problems are discussed and some suggestions made for improvements.

Within recent years, great attention has been focused on the methods employed in the collection of fish eggs and fry in the Indo-Pacific area because of the growing importance of pond fisheries within this region. Collection is being undertaken under very diversified conditions from well-controlled hatcheries and artificially-built ponds down to rivers and lakes and the sea. This results in various methods being used. Another reason for this diversity is found in the width and geographic isolation of the region as a result of which peculiar local practices have developed. The methods appear to be a product of long and slow development arising from necessity and utilizing whatever materials are easily procurable within the different localities. It is important to compile and compare these methods and to note the short-comings and merits of each, with the idea of adopting the best for the general good of the area,

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