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The Impacts of Introductions and Stocking of Exotic Species in the Mekong Basin and Policies for Their Control

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Meeting the Needs, Keeping the Balance

THE IMPACTS OF INTRODUCTIONS AND STOCKING OF EXOTIC SPECIES IN THE MEKONG BASIN AND POLICIES FOR THEIR CONTROL

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Summary

A preliminary study was carried out in mid 1999 on the status and potential impact of the introduction of exotic fish species in the Mekong Basin. Introductions have been made for four main purposes: aquaculture, stocking into lakes and reservoirs, pest control (mosquito) and the aquarium fish trade. Introductions of exotic species and movements of large quantities of fish for stocking are accompanied by risks to the environment, the possibility of native fish species declining through competition, predation or genetic interference, and the possible spread of disease.

The native fish fauna of the Mekong is extremely rich and diverse. It consists of many hundreds of species adapted to a wide range of environments. The fauna appears to have adapted well to the changes made so far both in impounded waters and in the modified flows downstream. High fishing pressure and an increasing number of engineering interventions in the basin will inevitably alter its character and with it the composition and abundance of its component species.

Seventeen species were identified as having been introduced into the Mekong Basin that had either formed established populations or have strong possibilities of doing so. Eight species, mostly of small headwater fish, have a status that is unclear in that they may have entered the North of the basin along with fry of other species or they may have extended beyond their previously recorded natural range. Five species may possibly be introduced into the basin, as they are in current use in adjacent systems. A large number of species are also moving within the basin as part of the aquarium fish trade. Six significant introductions have been made of aquatic animals other than fish.

The present impacts of introduced species appear relatively minor. *Oreochromis mossambicus* is considered a local nuisance in the Mekong Delta. There are some suggestions that hybrid *Clarias* are contributing to the decline in the native *Clarias batrachus* and that established populations of *Labeo rohita* may damage native species of the same genus. Other established species such as *Oreochromis niloticus*, *Hypostomus plecostomus, Poecilia reticulata* and *Gambusia affinis* appear to have no notable adverse consequences. This lack of impact may well change if the system is altered or if over-fishing heavily modifies the fish stocks. However, in such an event, the fault will lie more with the change in environment than with the species. The positive impacts of the introductions have far outweighed any negative effects to date. Aquaculture in the basin relies heavily on the introduced species and will probably continue to do so unless satisfactory alternatives are found among the native species.

The greatest risks at present lie in the uncontrolled movement of species and genetic strains into and within the basin. It is a matter of some urgency that the present lack of policy be addressed. It is therefore suggested that that the basin countries move towards establishing harmonized policies to reduce the risks of species introductions and transfers through:

- A Code of Conduct to reduce the impacts of future introductions of exotic species;
- Regional Guidelines on Quarantine and Health Certification;
- Regional Guidelines on Broodstock management.

It is further suggested that consideration be given to organizing education, training and extension to inform workers in the fisheries sector and the general public of the dangers of unregulated movement. Eventually, any control of such movements will be through action by the people themselves rather than through centrally imposed laws.

Further studies of the fisheries sector should report any introduced species found in the catch. Other workers in the sector, such as aquaculturists, should be encouraged to record the natural occurrence of exotic species. The genetic status of certain species that are crucial for aquaculture – particularly *Oreochromis* and *Cyprinus* – is now very confused. Studies to identify and determine the origins and affinities of wild stocks and cultured stocks of these species groups are urgently needed, particularly as more strains are being added to the local gene pools. An effort should be made to harness the expertise of local scientists through workshops, collecting programmes and a network to develop a database on the status and trends of introduced species.

Measures to improve health certification and security of aquarium fish rearing installations are desirable.

ខ្លឹមសារសង្ខេប:

ការសិក្សាជំហានដំបូងមួយត្រូវបានគេធ្វើឡើងនៅពាក់កណ្តាលឆ្នាំ ១៩៩៩ ទៅលើស្ថានភាព និងផលប៉ះពាល់នៃការនាំចូលទូវពូជត្រីប្រភេទថ្មីពីក្រៅស្រុកមកក្នុងអាងទន្លេមេគង្គ។ គោលបំណងសំខាន់ៗ ៤ យ៉ាងនៃការនាំចូលពូជត្រីប្រភេទថ្មីទាំងនោះគឺ: (១)- បំរើអោយការងារវារីវប្បកម្ម (២)- សំរាប់លែងស្តុកក្នុងបឹងនិងអាងទឹកនានា (៣)- ការត្រួតពិនិត្យសត្វល្អិតចង្រៃ (មូស) និង (៤)- ការធ្វើជំនួញប្រភេទត្រីចិញ្ចឹមសំរាប់លំអរ។ វាល់ការនាំចូលប្រភេទពូជត្រីក្រៅស្រុក និងការធ្វើចរាចរនៃប្រភេទពូជត្រីទាំងនោះក្នុងបរិមាណ១ដ៏ច្រើនសំរាប់ស្តុកទុក វានឹងនាំមកផងដែរនូវគ្រោះថ្នាក់ដល់បរិស្ថាន លទ្ធភាពនៃការថយចុះនូវប្រភេទពូជត្រីក្នុងស្រុកដោយសារការប្រកួតប្រជែងគ្នា ការស៊ីគ្នា រីការបង្កាត់ពូជ និងការរីករាលដាលនៃជំងឺ។

ត្រីដែលមានដើមកំណើតក្នុងទន្លេមេគង្គមានច្រើនពូក និងច្រើនប្រភេទផ្សេងៗគ្នា។ មានពូជត្រីរាប់រយប្រភេទបានសម្របខ្លួនរស់នៅជាមួយនឹងបរិស្ថានដ៏មានវិសាលភាពធំធេងនេះ។ ពពួកត្រីប្រភេទទាំងនោះហាក់ដូចជាមានទំលាប់ផ្សំខ្លួនទៅនឹងរាល់ការប្រែប្រួលដែលបានកើតមានជាយូរលង់មកហើយ ទាំងក្នុងដែនទឹកបិទជិត និងទាំងនៅកន្លែងខ្សែទឹកហូរដែលតែងតែធ្វើអោយកើតមានឡើងនូវបំរែបំរួលដល់ដែនទឹកផ្នែកខាងក្រោម។ សម្ភាធដ៏ខ្ពស់នៃការចាប់ត្រី និងកំណើនចំនួនសំណង់វិស្វកម្មនៅក្នុងអាងនឹងធ្វើអោយផ្លាស់ប្តូរនូវចរីកលក្ខណៈពពួកត្រីទាំងនោះ ហើយព្រមជាមួយគ្នានេះ ក៏មានការប្រែប្រួលដោយឡែសមិនជុតនូវសមាសធាតុ និងភាពសំបូរបែបនៃពូជប្រភេទចំឡែកៗជាច្រើនផ្សេងទៀត។

គេបានសំគាល់ឃើញថា មានពូជត្រីចំនួន ១៧ ប្រភេទបានត្រូវគេនាំចូលមកក្នុងអាងទន្លេមេគង្គ ដែលអាងខ្លួនឯងផ្ទាល់បានបង្កើតពូជត្រីជាច្រើនមកហើយ រីក៏ជាអាងដែលមានលទ្ធភាពយ៉ាងខ្ពស់ក្នុងការបង្កើតនូវពូជត្រីថ្មី។ ពូជត្រីចំនួន ៨ ប្រភេទ ដែលភាគច្រើនជាប្រភេទត្រីតូចៗរស់នៅដើមប្រភពខ្សែទឹក មានស្ថានភាពមិនច្បាស់លាស់។ ពួកវាអាចចូលមកជាមួយពូជត្រីប្រភេទផ្សេងៗទៀតពីបែកខាងជើងនៃអាងទន្លេ រីក៏ពពួកត្រីទាំងនោះអាចរីកសាយហូសពីវិសាលភាពជាលក្ខណៈធម្មជាតិរបស់ពួកវា ដូចដែលគេបានកត់ត្រាទុកពីមុនៗមក។ គេបានសង្ស័យថា មានពូជត្រី ៥ ប្រភេទត្រូវបានគេនាំចូលមកក្នុងអាងទន្លេ ដោយហេតុថាបច្ចុប្បន្ននេះពពួកត្រីទាំងនោះកំពុងត្រូវបានគេចិញ្ចឹមនៅតាមប្រព័ន្ធស្រះបា្ (adjacent system)។ ប្រភេទពូជត្រីមួយចំនួនធំទៀតកំពុងតែចរាចរនៅក្នុងអាងដោយគេចិញ្ចឹមវាដើម្បីជាការធ្វើជំនួញប្រភេទត្រីសំរាប់លំអរ។ ក្រៅអំពីពូជត្រីថ្មីៗ គេបានសង្កេតឃើញមានការនាំចូលដ៏គួរអោយកត់សំគាល់នូវពូជវារីសត្វចំនួន ៦ប្រភេទផ្សេងទៀតមកក្នុងទន្លេមេគង្គ។

ផលប៉ះពាល់នាបច្ចុប្បន្នដែលបណ្តាលមកពីពូជត្រីនាំចូលហាក់ដូចជាមានទំហំតិចតួចនៅឡើយ។ ត្រីទីឡាព្យ៉ាខ្មៅ *(Oreochromis mossambicus)* ត្រូវបានគេចាត់ទុកជាប្រភេទត្រីក្នុងស្រុកដែលរស់នៅរំខានគេឯងនៅក្នុងដីបន់ដីសណ្តរទន្លេមេគង្គ (Mekong Delta)។ មានមតិមួយចំនួនបានលើកឡើងថា ពពួកត្រីអណ្តែងកូនកាត់ (hybrid *Clarias*) កំពុងរាតត្បាតធ្វើអោយថយចុះនូវពពួកត្រីអណ្តែងវឹងក្នុងស្រុក *(native Clarias Batrachus)* ហើយពពួកត្រីកើតថ្មី *(Labeo rohita)* អាចបំផ្លាញពូជត្រីពពួកដូចគ្នាដែលមានដើមកំណើតនៅទីនេះ។ គេយល់ឃើញថា ពូជត្រីដែលទើបបានកើតឡើងមួយចំនួនទៀតដូចជា: *(Oreochromis niloticus, Hypostomus plecostomus, Poecilia reticulata* និង *Gambusia affinis)* ពុំបានផ្តល់ផលវិបាកជាអវិជ្ជមានដែលគួរអោយកត់សំគាល់ឡើយ។ ភាពគ្មានផលប៉ះពាល់នេះអាចប្រែប្រួល ប្រសិនបើប្រព័ន្ធត្រូវបានគេបង្វែរ រីក៏ការទេសាទហួសកំរិតត្រូវបានគេធ្វើអាជីវកម្មដោយពុំបានគិតគូរអោយបានត្រឹមត្រូវជាមួយនឹងផលស្តុកត្រីដែលមាននៅក្នុងធម្មជាតិ។ ក្នុងស្ថានភាពបែបនេះ គុណវិបត្តិអាចនឹងកើតមានភាគច្រើនតែទៅលើប៉ំរែប៉ំរូលបរិស្ថាន ជាងទៅលើប្រភេទពូជត្រីនានា។ រហូតមកដល់សព្វថ្ងៃនេះផលជាវិជ្ជមាននៃការនាំចូលពូជត្រីថ្មីមានច្រើនជាងផលអវិជ្ជមាន។ វ៉ារីវប្បកម្ម នៅក្នុងអាងទាំងមូលពឹងផ្អែកយ៉ាងខ្លាំងទៅលើការនាំចូលពូជត្រីប្រភេទថ្មីទាំងនោះ ហើយសកម្មភាពនេះប្រហែលជានៅតែបន្តរហូតទាល់តែគេរកឃើញនូវជំរើសថ្មីជាទីពេញចិត្តណាមួយដោយជ្រើលរើសយកពូជត្រីមានកំណើតដើមនៅក្នុងអាងទន្លេមេគង្គមកជំនួស។

គ្រោះថ្នាក់ដ៏ធំនាបច្ចុប្បន្ននេះគឺប្រឈរមុខទៅលើការចរាចរនៃពូជត្រី ក៏ដូចជាការបញ្ចូលនិងស្តុកសេនេទិចនៅក្នុងអាងដោយគ្មានការត្រួតពិនិត្យ។ កង្វះខាតផ្នែកនយោបាយជាបញ្ហាបន្ទាន់មួយដែលត្រូវដោះស្រាយនាពេលបច្ចុប្បន្ន។ អាស្រ័យហេតុនេះហើយទើបមានសំណូមពរលើកឡើងថា ប្រទេសទាំងអស់នៅក្នុងអាងត្រូវបង្កើតអោយបានទូវនយោបាយរួមមួយដើម្បីកាត់បន្ថយនូវរាល់គ្រោះថ្នាក់នៃការនាំចូលមក និងការផ្តេរទូវពូជត្រីថ្មីៗតាមរយៈ:

- ក្រមប្រតិបត្តិមួយដើម្បីកាត់បន្ថយនូវរាល់ផលប៉ះពាល់នានាដែលបណ្តាលមកពីការនាំចូលទូវពូជត្រីក្រៅស្រុកនាពេលអនាគត
- គោលការណ៏ណែនាំសំរាប់ដំបន់ស្តីពី "ចត្តាឡីស័ក្ត និងលិខិតបញ្ជាក់សុខភាព"
- គោលការណ៏ណែនាំសំរាប់ដំបន់ស្តីពី "ការគ្រប់គ្រងផលស្តុក"

គេបានសំណូមពរបន្ថែមទៀតអោយគិតគូរពិចារណាផងដែរលើការរៀបចំការងារអប់រំ វគ្គបណ្តុះបណ្តាល និងផ្សព្វ-ផ្សាយអោយបានកាន់តែជ្រួបជ្រាបស៊ីជំរៅដល់គ្រប់ស្រទាប់ពលករទាំងក្នុងនិងក្រៅវិស័យជលផល ក៏ដូចជាសាធារណ:ជនទាំងមូលពីគ្រោះថ្នាក់នៃការធ្វើចរាចរត្រីដោយគ្មានការត្រួតពិនិត្យតាមផ្លូវច្បាប់។ ដូច្នេះហើយ

ការត្រួតពិនិត្យ នៃរាល់ចលនាទាំងនេះតាមរយៈសកម្មភាពប្រជាជនខ្លួនឯងផ្ទាល់គឺប្រសើរជាងតាមរយៈច្បាប់ដាក់ចុះពីមជ្ឈឹម ។

រាល់ការសិក្សាបន្ថែមទៀតទៅលើវិស័យជលផល គួរតែត្រូវធ្វើយ៉ាងណាអោយអ្នកនេសាទចូលរួមរាយការណ៍អំពីពូជត្រីប្រភេទថ្មីណាមួយដែលពួកគាត់នេសាទបាន ។ គប្បីលើកទឹកចិត្តពលករនានានៅក្នុងវិស័យជលផលដូចជា: វារីវប្បករអោយកត់ត្រាទុកនូវការកើតឡើងពីធម្មជាតិនៃពូជត្រីថ្មី។ ស្ថានភាពសេនេទិចនៃពូជត្រីមួយចំនួនដែលមានសារៈសំខាន់ចំពោះវារីវប្បកម្ម ជាពិសេសពូក *(Oreochromis and Cyprinus)* ដែលបច្ចុប្បន្ននេះកំពុងបង្កអោយមានភាពច្របូកច្របល់យ៉ាងខ្លាំង ។ គេត្រូវសិក្សាជាបន្ទាន់ដើម្បីសំគាល់ និងកំណត់អោយបានច្បាស់នូវប្រភពដើម និងការទាក់ទងគ្នានៃជលស្តុកធម្មជាតិ ក៏ដូចជាវារីវប្បកម្មនៃក្រុមប្រភេទពូជត្រីទាំងអស់នោះ ជាពិសេសជាមួយនឹងពូជជាច្រើនប្រភេទទៀតដែលត្រូវបានគេភ្ញាស់នៅតាមមូលដ្ឋាន ។ គប្បីប្រឹងប្រែងបំពាក់បំប៉នទូវមុខជំនាញដល់អ្នកវិទ្យាសាស្ត្រមូលដ្ឋានតាមរយៈធ្វើជាសិក្ខាសាលា បង្កើតឡើងនូវកម្មវិធីប្រមូលផ្តុំនិងរៀបចំជាខ្សែបណ្តាញមួយដើម្បីស្រង់យកនូវរាល់ទិន្នន័យស្តីពី ស្ថានភាព និងនិន្នាការរបស់ប្រភេទពូជថ្មីៗដែលទើបបានលេចកើតមានឡើង ។

ចាំបាច់ត្រូវចាត់វិធានការមួយចំនួនបន្ថែមទៀតដើម្បីធ្វើអោយបានកាន់តែប្រសើរឡើងដល់ការបញ្ជាក់ពីសុខភាពនិងសុវត្ថិភាពនៃការបង្កាត់ពូជប្រភេទត្រីចិញ្ចឹមលំអរទាំងអស់ ។

ບົດສະຫລຸບຫຍໍ້

ການສຶກສາເບື້ອງຕົ້ນກ່ຽວກັບສະພາບແລະຜົນກະທົບທີ່ອາດຈະເກີດຂຶ້ນໄດ້ ຈາກການນຳແນວພັນ ປາຕ່າງປະເທດເຂົ້າມາໃນອ່າງແມ່ນ້ຳຂອງ ແມ່ນໄດ້ເລີ້ມມາແຕ່ກາງປີ 1999. ການນຳ ແນວພັນ ປາເຂົ້າມາແມ່ນມີ 4 ຈຸດປະສົງໃຫຍ່ຄື: ເພື່ອການລ້ຽງ, ເພື່ອປ່ອຍໃສ່ອ່າງເກັບນ້ຳ ແລະ ບຶ່ງ, ເພື່ອກຳຈັດຍຸງ ແລະ ເພື່ອລ້ຽງເປັນປາເອ້ (ປາຕູ້ແກ້ວ). ການນຳຊະນິດພັນປາຕ່າງປະເທດ ເຂົ້າມາ ແລະ ມີການເຄື່ອນໄຫວເປັນຈຳນວນຫລວງຫລາຍຂອງປາດັ່ງກ່າວ ແມ່ນມີຄວາມສ່ຽງ ຕໍ່ສິ່ງແວດລ້ອມ, ອາດເຮັດໃຫ້ປາພື້ນເມືອງລຸດລົງເນື່ອງຈາກການຍາດແຍ່ງ, ບຽດບຽນ ຫລື ການ ປະສົມຂ້າມສາຍພັນ, ແລະອາດເປັນທີ່ມາຂອງການແຜ່ກະຈາຍຂອງພະຍາດ.

ປະຊາກອນປາໃນອ່າງແມ່ນ້ຳຂອງ ແມ່ນມີຄວາມອຸດົມສົມບູນ ແລະ ຫລາກຫລາຍ. ຊຶ່ງມີຫລາຍ ຮ້ອຍ ຊະນິດພັນປາ ທີ່ເໝາະກັບສະພາບແວດລ້ອມທີ່ກວ້າງໃຫຍ່ນີ້. ປະຊາກອນປາດັ່ງກ່າວເຫລົ່ານີ້ແມ່ນສາມາດປັບຕົວເຂົ້າໄດ້ຕໍ່ການປ່ຽນແປງຂອງສະພາບນ້ຳ ທັງນ້ຳຂັງ ແລະນ້ຳໄຫລທີ່ມີການ ປ່ຽນແປງລະດັບການໄຫລ. ການນາບຂູ່ທາງດ້ານຈັບປາທີ່ສູງຂຶ້ນ ແລະ ການລົບກວນຈາກການ ພັດທະນາໃນອ່າງແມ່ນບໍ່ສາມາດຈະຫລີກລ່ຽງໄດ້ ຊຶ່ງຈະເຮັດໃຫ້ລັກສະນະ, ສັດສ່ວນ ແລະຄວາມ ໜາ ແໜ້ນຂອງຊະນິດພັນປາມີການປ່ຽນແປງໄປໄດ້ໃນອານາຄົດ.

ມີ 17 ຊະນິດ ທີ່ໄດ້ວິໄຈແລ້ວວ່າ ແມ່ນໄດ້ນຳເຂົ້າມາໃນອ່າງແມ່ນ້ຳຂອງ ຊຶ່ງໄດ້ປັບຕົວເຂົ້າກັບ ສະພາບ ແລະສາມາດແຜ່ຂະຫຍາຍພັນຕາມທຳມະຊາດໄດ້. ມີ 8 ຊະນິດ ຊຶ່ງເປັນປາ ຂະນາດ ນ້ອຍໆ ທີ່ການນຳເຂົ້າມາແມ່ນບໍ່ຈະແຈ້ງ ຊຶ່ງເຂົ້າມາທາງດ້ານເໜືອຂອງອ່າງ ໂດຍອາດປະປົນມາ ນຳ ການຂົນສົ່ງລູກປາຊະນິດອື່ນ ຫລື ການຂະຍາຍການເຂດທີ່ໄດ້ບັນທຶກໄວ້ໃນເມື່ອກ່ອນ. ມີ 5 ຊະນິດ ທີ່ອາດຈະເຂົ້າມາໃນອ່າງ ໂດຍທີ່ມີການນຳໃຊ້ປາເຫລົ່ານີ້ຢູ່ອ່າງທີ່ໃຫ້ຄຸນ. ມີຈຳນວນ ຫລາຍໆ ຊະນິດທີ່ເຄື່ອນໄຫວພາຍໃນອ່າງ ທີ່ເປັນສ່ວນນຶ່ງຂອງຂະບວນການຄ້າປາເອ້. ມີ 6 ຊະນິສັດນ້ຳ ທີ່ບໍ່ແມ່ນປາ ກໍ່ໄດ້ຖືກນຳເຂົ້າມາໃນອ່າງເໝືອນກັນ.

ຜົນກະທົບ ຂອງຊະນິດພັນປາທີ່ນຳເຂົ້າມານີ້ ຖືວ່າຍັງມີໜ້ອຍ. ປາ ໝໍເທດ *(Oreochromis mossambicus)* ແມ່ນມີຜົນກະທົບຄື ລົບກວນ ແລະສ້າງຄວາມລຳຄານຢູ່ໃນຂົງເຂດ Mekong Delta. ມີການແນະ ນຳວ່າ ລູກຊອດ ປາດຸກພັນ ແມ່ນມີສ່ວນເຮັດໃຫ້ ປະຊາກອນປາດຸກລາດ ລຸດລົງ ແລະ ການປັບຕົວຢູ່ຕາມທຳມະຊາດໄດ້ ຂອງປາ ໂລ່ຮູ *(Labeo rohita)* ອາດເຮັດໃຫ້ມີ ຜົນກະທົບຕໍ່ ປະຊາກອນປາພື້ນເມືອງ ໃນສາຍພັນດຽວກັນ. ການປັບຕົວຢູ່ໄດ້ຂອງ ຊະນິດພັນອື່ນ

ເຊັ່ນ: ປານິນ *(Oreochromis niloticus)*, ປາດູດຝຸ່ນ *(Hypostomus plecostomus)*, ປາຫາງນົກຍຸງ *(Poecilia reticulate)* ແລະ ປາຄໍ *(Gambusia affinis)* ຍັງບໍ່ສັງເກດເຫັນວ່າ ມີຜົນກະທົບ. ການທີ່ ບໍ່ມີຜົນກະທົບນັ້ນ ອາດເປັນການປ່ຽນແປງທີ່ດີເຂົ້າກັນກັບລະບົບ ຫລື ຖ້າຫາກວ່າມີ ການຫາປາ ຫລາຍໂພດ ອາດຈະເຮັດໃຫ້ການປ່ຽນແປງໂຄງສ້າງຂອງແມວພັນໄດ້. ເຖິງຢ່າງໃດກໍ່ຕາມ, ກ່ຽວກັບ ບັນຫານີ້ ຂໍ້ມົກຜ່ອງ ແມ່ນຈະເກີດຂຶ້ນຈາກການປ່ຽນແປງ ຂອງ ສະພາບແວດລ້ອມຫລາຍກ່ວາ ທາງດ້ານຊະນິດແມວພັນ. ມາຮອດດຽວນີ້ ຜົນກະທົບທາງບວກ ແມ່ນຍັງມີນ້ຳໜັກກ່ວາຜົນກະທົບທາງລົບ ກ່ຽວກັບເລື້ອງການນຳແມວພັນປາເຂົ້າມານີ້. ການລ້ຽງ ສັດນ້ຳ ໃນອ່າງແມ່ນ້ຳຂອງ ແມ່ນສ່ວນຫລາຍຍັງອາໄສແມວພັນທີ່ນຳເຂົ້າ ແລະມີທ່ວງທ່າຈະດຳ ເນີນຕໍ່ໄປ ຈົນກວ່າວ່າ ຈະມີການຄົ້ນພົບ ແມວພັນພື້ນເມືອງ ທີ່ມີຄຸນນະພາບ ມາທົດແທນໄດ້.

ໃນປັດຈຸບັນ ບັນຫາຄວາມສ່ຽງທີ່ສຳຄັນແມ່ນຂຶ້ນຢູ່ກັບການບໍ່ມີການຄວບຄຸມ, ການເຄື່ອນຍ້າຍ ຂອງແມວພັນ ເຂົ້າ-ອອກ ແລະ ແມ່ນແຕ່ການເຄື່ອນຍ້າຍພາຍໃນອ່າງເອງ. ຊຶ່ງມັນເປັນບັນຫາ ຮີບດ່ວນ ທີ່ໃນປະຈຸບັນຍັງບໍ່ທັນມີນະໂນບາຍຮອງຮັບເທື່ອ. ດັ່ງນັ້ນ, ຈຶ່ງຂໍແນະນຳວ່າ ບັນດາປະ ເທດທີ່ຢູ່ໃນອ່າງ ຄວນສ້າງຕັ້ງນະໂຍບາຍທີ່ເໝາະສົມ ເພື່ອບັນເທົາ ຄວາມສ່ຽງ ໃນການນຳເຂົ້າ ແລະ ການເຄື່ອນຍ້າຍແມວພັນ ດັ່ງນີ້:

- ມີລະບຽບການປະຕິບັດ ເພື່ອຫລຸດຜ່ອນ ຜົນກະທົບໃນການນຳ ແມວພັນຈາກປະເທດ ເຂົ້າມາ ໃນອານາຄົດ;
- ມີບົດແນະນຳ ໃນລະດັບພາກພື້ນ ກ່ຽວກັບການກັກກັນ ແລະ ການຢັ້ງຢືນສຸຂະພາບ;
- ມີບົດແນະນຳ ໃນລະດັບພາກພື້ນ ກ່ຽວກັບການຄຸ້ມຄອງພໍ່ແມ່ພັນ

ຂໍແນະນຳຕື່ມອີກວ່າ ຄວນເອົາໃຈໃສ່ທາງດ້ານການສຶກສາ ອົບຮົມ ແລະ ວຽກງານເຜີຍແຜ່ ເພື່ອ ໃຫ້ຜູ້ທີ່ເຮັດວຽກງານທີ່ກ່ຽວຂ້ອງ ພາຍໃນຂະແໜງການປະມົງ ຕະຫລອດເຖິງສາທາລະນະຊົນໄດ້ ຮັບຊາບຕໍ່ອັນຕະລາຍກ່ຽວກັບການເຄື່ອນຍ້າຍສັດນ້ຳທີ່ມີຊີວິດທີ່ບໍ່ປະຕິບັດກົດລະບຽບ.
ໃນຂັ້ນສຸດທ້າຍ, ຄວນໃຫ້ອົງກອນໃນທ້ອງຖິ່ນນັ້ນຄຸ້ມຄອງ ແລະ ຄວບຄຸມເອງຕໍ່ການເຄື່ອນ ຍ້າຍ ໃດໆ ທີ່ມີຂຶ້ນໃນທ້ອງນັ້ນ ແທນທີ່ຈະໃຊ້ອຳນາດທາງກົດໝາຍຈາກສູນກາງ.

ການສຶກສາສຳຫລວດ ຂອງຂະແໜງການປະມົງໃນຕໍ່ໜ້າຕ້ອງມີລາຍງານການພົບເຫັນ ຊະນິດ ພັນປາ ທີ່ນຳເຂົ້າມາ, ຜູ້ທີ່ມີສ່ວນກ່ຽວຂ້ອງໃນຂະແໜ່ງການຕ້ອງຊຸກຍູ້ໃຫ້ມີການລາຍງານ ເຊັ່ນ: ຊຸກຍູ້ໃຫ້ຜູ້ທີ່ທຳການລ້ຽງປາ ເມື່ອພົບເຫັນຊະນິດແມວພັນໃໝ່ທີ່ຖືກນຳເຂົ້າມາໃນເຂດຂອງຕົນ ໃຫ້ ບັນທຶກ ແລະລາຍງານຫາພະນັກງານທີ່ກ່ຽວຂ້ອງຊາບ. ແມວພັນທີ່ດີ ມີຄວາມແນ່ນອນ ແມ່ນມີ

ຄວາມສຳຄັນເປັນຢ່າງຍິ່ງ ຕໍ່ການລ້ຽງສັດນ້ຳ - ໂດຍສະເພາະ ຈຳພວກ ປານິນ *(Oreochromis)* ແລະ ປາໄນ *(Cypinus)* - ໃນປັດຈຸບັນ ແມ່ນມີຄວາມສັບສົນຫລາຍ. ການສຶກສາ ເພື່ອວິໄຈ ໄຈ້ແຍກເຖິງ ຕົ້ນກຳເນີດ ແລະ ການຜູກພັນທາງດ້ານແນວພັນ ຂອງຈຳພວກປາ ທີ່ຢູ່ຕາມທຳມະ ຊາດ ແລະ ຈຳພວກທີ່ນຳມາລ້ຽງ ຂອງກຸ່ມປາເຫລົ່ານີ້ແມ່ນມີຄວາມຈຳເປັນອັນຮີບດ່ວນ, ໂດຍ ສະເພາະ ເມື່ອມີຫລາຍສາຍພັນ ເພີ້ມຂຶ້ນໃສ່ໃນ Gene pools ຂອງທ້ອງຖິ່ນ. ຄວນຊຸກຍູ້ ຢ່າງສ້າງຄວາມເຂັ້ມແຂງໃຫ້ແກ່ນັກວິຊາການທ້ອງຖິ່ນ ໂດຍຜ່ານການປະຊຸມສຳມະນາ ສ້າງແຜນ ງານ ສ້າງເຄືອຄ່າຍ ແລະສ້າງພື້ນຖານຂໍ້ມູນ (database) ກ່ຽວກັບສະພາບ ແລະທິດທາງໃນການ ນຳແນວພັນເຂົ້າມາ ໃນອານາຄົດ.

ມີມາດຕະການປັບປຸງ ການອອກໃບຢັ້ງຢືນສຸຂະພາບ ແລະ ຄວາມປອດໄພ ໃນການຄວບຄຸມ ການລ້ຽງປາເອົ້ໃຫ້ຢູ່ໃນຄວາມເໝາະສົມ.

สรุป

การศึกษาเบื้องต้นเกี่ยวกับสถานะและผลกระทบที่อาจเกิดขึ้นจากการนำเข้าปลาต่างถิ่นสู่ลุ่มน้ำโขงดำเนินการเมื่อกลางปี พ.ศ. ๒๕๔๒ พบว่า การนำเข้าปลาต่างถิ่นมีวัตถุประสงค์หลักสี่ประการ ได้แก่ เพื่อการเพาะเลี้ยงสัตว์น้ำ, เพื่อการนำปล่อยในแหล่งน้ำ, เพื่อควบคุมพาหะนำโรค เช่น ยุง และเพื่อธุรกิจการค้าปลาสวยงาม การนำเข้าและการเคลื่อนย้ายปลาต่างถิ่นเพื่อนำปล่อยลงสู่แหล่งน้ำคราวละมาก ๆ ทำให้เกิดภาวะเสี่ยงต่อสภาพแวดล้อมในหลายกรณี เช่น มีโอกาสที่ปลาพื้นเมืองที่มีอยู่เดิมจะลดจำนวนลงอันเนื่องมาจากการแข่งขันแก่งแย่งอาหาร, การไล่ล่า หรือการรบกวนด้านพันธุกรรมจากชนิดปลาต่างถิ่น รวมทั้งมีโอกาสที่จะเกิดการแพร่กระจายของโรคสัตว์น้ำ

ปลาพื้นเมืองในลำน้ำโขงมีจำนวนมหาศาลทั้งชนิดและปริมาณ ประกอบด้วยปลาหลายร้อยชนิดที่มีการปรับตัวอยู่รอดในสภาพแวดล้อมต่าง ๆ กัน พบว่า ถึงปัจจุบันปลาเหล่านี้มีการปรับตัวต่อการเปลี่ยนแปลงที่เกิดขึ้นได้เป็นอย่างดีทั้งในพื้นที่อ่างเก็บน้ำต่าง ๆ และบริเวณท้ายน้ำที่มีการปรับเปลี่ยนอัตราการไหลของน้ำ แต่การประมงอย่างหนาแน่นและการก่อสร้างโครงสร้างทางวิศวกรรมจำนวนมากในพื้นที่ลุ่มน้ำในอนาคต จะทำให้เกิดการเปลี่ยนแปลงคุณสมบัติของลุ่มน้ำอย่างหลีกเลี่ยงไม่ได้ และการเปลี่ยนแปลงของลุ่มน้ำนี้จะทำให้เกิดการเปลี่ยนแปลงโครงสร้างองค์ประกอบของทั้งชนิดและปริมาณปลา

มีปลา ๑๗ ชนิดที่นำเข้าสู่ลุ่มน้ำโขงแล้วสามารถพัฒนาเป็นกลุ่มประชากรหรือมีความเป็นไปได้สูงที่จะพัฒนาเป็นกลุ่มประชากรในแหล่งน้ำ ปลาอีก ๘ ชนิดซึ่งส่วนใหญ่เป็นปลาขนาดเล็กในพื้นที่ต้นน้ำ มีสถานะไม่ชัดเจนว่าอาจจะอพยพเคลื่อนย้ายเข้าตอนเหนือของลุ่มน้ำพร้อมกับปลาวัยอ่อนชนิดอื่น ๆ หรืออาจขยายขอบเขตการอพยพเคลื่อนย้ายจากขอบเขตในอดีตที่เคยปรากฏตามธรรมชาติ อาจเป็นไปได้ที่ปลาต่างถิ่นอีก ๕ ชนิดจะถูกนำเข้ามาในลุ่มน้ำเพราะมีการใช้ประโยชน์ปลาเหล่านั้นในระบบลุ่มน้ำใกล้เคียงอยู่ในขณะนี้ นอกจากนี้ ยังมีการเคลื่อนย้ายปลามากมายหลายชนิดในลุ่มน้ำในธุรกิจการค้าปลาสวยงาม รวมทั้งมีการนำเข้าสัตว์น้ำชนิดอื่นเป็นจำนวนมาก อีก ๖ ชนิด

ในปัจจุบัน ผลกระทบของปลาที่นำเข้ามีค่อนข้างจำกัด ปลาหมอเทศ (*Oreochromis mossambicus)* ถูกจัดเป็นปลาที่ก่อความรำคาญในเขตสามเหลี่ยมแม่น้ำโขง มีข้อคิดเห็นจำนวนหนึ่งที่ระบุว่า ปลาดุกลูกผสมมีส่วนทำให้ปลาดุกด้าน (*Clarias batrachus*) ลดปริมาณลง และการพัฒนาเป็นกลุ่มประชากรของปลายี่สกเทศ (*Labeo rohita*) อาจรบกวนทำลายปลาพื้นเมืองในสกุลเดียวกัน กลุ่มประชากรปลานำเข้าในแหล่งน้ำชนิดอื่น ๆ เช่น ปลานิล (*Oreochromis niloticus*), ปลาเทศบาล (*Hypostomus plecostomus*), ปลากินยุงชนิด *Poecilia reticulata* และ *Gambusia*

affinis ไม่ปรากฏผลกระทบเสียหายที่ชัดเจน แต่การที่ไม่ปรากฏผลกระทบเช่นนี้อาจมีการเปลี่ยนแปลงอย่างมาก หากระบบมีการเปลี่ยนแปลงหรือการประมงมากเกินไปทำให้เกิดการปรับเปลี่ยนอย่างรุนแรงของโครงสร้างปริมาณปลา อย่างไรก็ตาม เหตุการณ์ดังกล่าว จะขึ้นอยู่กับการเปลี่ยนแปลงของสภาพแวดล้อมมากกว่าชนิดปลา และขณะนี้ผลดีที่เกิดจากการนำเข้าปลาต่างถิ่นมีมากกว่าผลกระทบเสียหาย เพราะการเพาะเลี้ยงสัตว์น้ำในลุ่มน้ำโขงยังพึ่งพาปลาต่างถิ่นอยู่มากและอาจจะเป็นเช่นนี้ต่อไปอีกนาน นอกจากจะค้นพบปลาพื้นเมืองบางชนิดที่สามารถใช้เพาะเลี้ยงทดแทนปลาต่างถิ่นได้อย่างเหมาะสม

ความเสี่ยงที่สำคัญที่สุดในขณะนี้ ได้แก่ การขาดการควบคุมการเคลื่อนย้ายชนิดปลา (species) หรือสายพันธุ์ปลา (strains) เข้าสู่หรือภายในลุ่มน้ำ ซึ่งเป็นเรื่องเร่งด่วนที่ควรตระหนักประเทศต่าง ๆ ในลุ่มน้ำโขงจึงควรจัดให้มีนโยบายร่วมกันเพื่อลดความเสี่ยงต่าง ๆ ที่อาจเกิดขึ้นจากการนำเข้าหรือเคลื่อนย้ายปลา โดยใช้กระบวนการต่าง ๆ เช่น

- กำหนดหลักเกณฑ์ในการปฏิบัติเพื่อลดผลกระทบในการนำเข้าปลาต่างถิ่นในอนาคต
- กำหนดแนวทางในการกักกันและรับรองสุขภาพสัตว์น้ำในระดับภูมิภาค
- กำหนดแนวทางในการจัดการพ่อแม่พันธุ์ปลาในระดับภูมิภาค

นอกจากนี้ ยังควรพิจารณาจัดให้มีการศึกษา การฝึกอบรม และการเผยแพร่ความรู้แก่บุคลากรในภาคการประมงและสาธารณชน ถึงอันตรายของการเคลื่อนย้ายสัตว์น้ำโดยไร้กฎเกณฑ์ ซึ่งแท้จริงแล้ว การควบคุมการเคลื่อนย้ายสัตว์น้ำควรจะเป็นภารกิจของประชาชนโดยส่วนรวมมากกว่าการบังคับใช้กฎหมายจากส่วนกลาง

การศึกษาวิจัยของภาคการประมงในระยะต่อไป ควรมีการรายงานผลจับของปลาต่างถิ่นจากแหล่งน้ำทั่วไป ผู้ปฏิบัติงานด้านอื่นในภาคการประมง เช่น ผู้เพาะเลี้ยงสัตว์น้ำ ควรได้รับการแนะนำให้บันทึกการพบปลาต่างถิ่นในแหล่งน้ำธรรมชาติ สถานะด้านพันธุกรรมในปัจจุบันของปลาบางชนิดซึ่งมีความสำคัญยิ่งในการเพาะเลี้ยงสัตว์น้ำมีความสับสนมาก โดยเฉพาะอย่างยิ่งกลุ่มปลานิล (*Oreochromis*) และปลาไน (*Cyprinus*) การศึกษาเพื่อจำแนกและกำหนดตัดสินแหล่งกำเนิด รวมถึงความสัมพันธ์ของสายพันธุ์ธรรมชาติกับสายพันธุ์ที่ใช้ในการเพาะเลี้ยงของกลุ่มปลาเหล่านี้จึงเป็นความต้องการเร่งด่วน เพราะยังมีการนำสายพันธุ์อื่น ๆ ปะปนเข้าในฐานพันธุกรรมในระดับท้องถิ่นเพิ่มขึ้นเรื่อย ๆ ทั้งยังควรมีการเสริมทักษะแก่นักวิจัยในท้องถิ่นโดยการประชุมเชิงปฏิบัติการ การกำหนดแผนการเก็บข้อมูลและการสร้างเครือข่ายเพื่อพัฒนาฐานข้อมูลเกี่ยวกับสถานะและแนวโน้มของปลาต่างถิ่น

อนึ่ง จะต้องมีการกำหนดมาตรการเพื่อปรับปรุงการรับรองสุขภาพสัตว์น้ำและการประกันความปลอดภัยของระบบการเลี้ยงปลาสวยงามด้วย

ẢNH HƯỞNG CỦA VIỆC DI NHẬP VÀ THẢ GIỐNG CÁ NGOẠI LAI VÀO LƯU VỰC SÔNG MÊ CÔNG VÀ CHÍNH SÁCH KIỂM SOÁT CHÚNG

Robin L. Welcome & Chavalit Vidthayanon

TÓM TẮT

Nghiên cứu sơ bộ về hiện trạng và ảnh hưởng có thể của việc nhập cá nơi khác vào vùng hạ lưu sông Mê Công đã được tiến hành từ giữa năm 1999. Di nhập cá từ nơi khác nhằm 4 mục đích chủ yếu là: nuôi thương phẩm, thả vào sông hoặc hồ chứa để tăng nguồn lợi, diệt trừ sinh vật có hại (muỗi) và kinh doanh cá cảnh. Di nhập và vận chuyển số lượng lớn cá ngoại lai để thả nuôi có thể kéo theo hàng loạt ảnh hưởng xấu về môi trường, làm giảm lượng cá bản địa do cạnh tranh, ăn thịt lẫn nhau, hay lẫn giống và phát tán bệnh tật.

Khu hệ cá tự nhiên sông Mê Công rất phong phú và đa dạng. Nó gồm hàng trăm loài thích nghi với điều kiện môi trường rộng rãi. Khu hệ này trải qua sự thích nghi tốt với những thay đổi ở cả vùng mới ngập và biến động dòng chảy ở hạ lưu. Áp lực khai thác cao và sự gia tăng số lượng các công trình thủy trong lưu vực không tránh khỏi làm thay đổi đặc tính của nó, kèm theo đó là thay đổi về thành phần loài và những loài ưu thế.

Người ta đã xác định có 17 loài cá ngoài lưu vực đã được di nhập vào vùng sông Mê Công. Chúng hoặc đã hình thành nên chủng quần ở đây, hoặc có nhiều khả năng sẽ như vậy. Tám loài chủ yếu là cá nhỏ thượng nguồn ở phía bắc của lưu vực không rõ là chúng lẫn vào khi nhập cá giống các loài khác hay chúng mới được bổ sung vào danh sách cá bản địa so với ghi chép gốc chưa đầy đủ trước đây. Năm loài khác có thể được đi nhập vào lưu vực do sử dụng ở các vùng nước lân cận. Một số lượng lớn loài di chuyển trong bản thân lưu vực do buôn bán cá cảnh. Sáu loài động vật thủy sản không phải cá cũng được di nhập vào.

Ảnh hưởng của các loài cá cá di nhập vào sông Mê Công hiện nay không lớn. Loài rô phi *Oreochromis mossambicus* được coi là loài gây nhiều phiền toái cho đồng bằng sông Cửu long. Một số đề xuất cho rằng cá trê *Clarias* lai góp phần làm giảm số lượng đàn cá trê trắng bản địa (*Clarias batrachus*) và việc hình thành đàn cá rô hu (*Labeo rohita*) sẽ phá hoại các đàn cá bản địa cùng giống. Những đàn cá mới hình thành như *Oreochromis niloticus*, *Hypostomus plecostomus, Poecilia reticulata* and *Gambusia affinis* chưa phát hiện thấy có ảnh hưởng xấu rõ rệt. Ảnh hưởng xấu có thể gia tăng nếu hệ thống thay đổi hoặc khai thác quá mức làm biến đổi cấu trúc đàn cá. Tuy nhiên trong điều kiện như vậy thì lỗi do sự biến đổi về môi trường nhiều hơn là lỗi do những loài này gây nên. Ảnh hưởng tích cực của việc di nhập hiện nay được đánh giá vượt xa bất kì ảnh hưởng tiêu cực nào. Nghề nuôi thủy sản trong lưu vực hiện nay dựa chủ yếu vào các loài cá di nhập. Tình hình này chắc vẫn sẽ tiếp diễn trừ phi tìm được loài nào đó trong số bản địa thích hợp để thay thế chúng.

Điều nguy hiểm là hiện nay không có sự kiểm soát việc di nhập cá và nguồn gien vào lưu vực và vận chuyển trong lưu vực. Sự bức thiết hiện nay là thiếu chính sách quản lý. Do đó các nước trong lưu vực cần phải xây dựng chính sách đúng đắn nhằm giảm thiểu ảnh hưởng xấu của việc di nhập và vận chuyển cá nhờ có:

- Qui tắc tiến hành: để giảm thiểu ảnh hưởng xấu trong tương lai của việc di nhập các loài ngoại lai;
- Hướng dẫn khu vực: về kiểm dịch và chứng nhận Y tế;
- Hướng dẫn khu vực: về quản lý đàn cá bố mẹ;

Các nước trong lưu vực cần cân nhắc việc tiến hành giáo dục, tập huấn và triển khai thông tin đến công nhân, ngư dân và toàn thể cộng đồng về sự nguy hại của sự vận chuyển vô nguyên tắc. Cuối cùng, bất kỳ sự kiểm soát vận chuyển nào do người dân tiến hành bao giờ cũng hơn là thông qua luật từ trên xuống

Các nghiên cứu của nghề cá trong tương lai cần phải thông báo bất kỳ một loài mới di nhập nào tìm thấy trong khi khai thác. Những người làm nghề cá khác như người nuôi cá cũng cần được động viên để họ ghi chép lại sự xuất hiện tình cờ các loài cá ngoại lai. Hiện trạng di truyền của một số loài cá nuôi quan trọng, đặc biệt là cá rô phi (*Oreochromis*) và cá chép (*Cyprinus*) hiện nay rất mơ hồ. Nghiên cứu nhằm xác định giống gốc và quan hệ di truyền giữa đàn cá hoang dã và cá nuôi những loài cá này là rất cấp bách, đặc biệt là hiện nay nhiều dòng đã được nhập vào bộ gien của khu hệ lưu vực. Cần động viên tận dụng các chuyên gia địa phương thông qua các cuộc hội thảo, chương trình, mạng lưới để xây dựng cơ sở dữ liệu, hiện trạng và xu hướng các loài đã di nhập.

Biện pháp nhằm cải tiến chứng nhận y tế và an toàn khi nuôi cá cảnh là rất cần thiết.

REPORT

1. INTRODUCTION

1.1 Background to project

The objectives of the study were to:

- Review the potential impact of the introduction of exotic fish species to the Mekong Basin;
- Identify the need for further studies and activities;
- Recommend policies and strategies for the Mekong Basin in relation to the introduction of exotic fish species.

The question of exotic species and their impact is associated with policies and practices regarding stocking and movements of genetic material within the basin. We therefore also considered aspects of current practice regarding the movement of fish associated with the enhancement of fisheries in water bodies and aquaculture.

This report should be regarded as a preliminary evaluation, defining the general status of exotic fish in the Mekong Basin in mid-1999.

1.2 History of introductions

Fish species have been moved from their place of origin for aquaculture and improved capture fisheries since ancient times. The earliest such introductions were those of common carp in Europe by the Romans and the later dissemination of the species by mediaeval (5th to 15th Century) monks. Most likely, similar movements of Chinese carps accompanied the early development of aquaculture in the East. The pace of introductions has increased in recent years (Welcomme, 1985) as part of the development of aquaculture and as a means of slowing declines in fish production brought about by the increasing pressure on natural resources. As a result, certain species have become global in their distribution and are now the key species for aquaculture. Many of the introductions have been recorded as having had negative impacts on the receiving fish stocks and environments.

In view of the importance of introduced species in today's aquatic ecosystems, FAO has developed a database at: <http://www.fao.org/fi/statist/fisoft/dias/index.htm>.

All introductions reported to FAO from the Mekong River Commission countries are presented in Annex I of this report. These introductions have not necessarily been made into the Mekong Basin itself. They may have been made into adjacent basins. The pace of species introductions over the past three decades gives the impression that most introductions have already been made. While

there is still room for further introductions related to aquaculture and raising ornamentals, the current direction of aquaculture would seem to suggest that the bulk of future movements will be at lower levels of genetic organisation, involving strains and races specifically developed for aquaculture.

Global concerns for biodiversity resulted in the formulation and adoption of the Convention on Biological Diversity (CBD) by over 160 countries. The Convention calls for control on the dissemination of exotic species and other types of genetic material. A subsidiary body of the Convention, the Subsidiary Body in Science, Technology and Technical Advice (SBSTTA) addressed the question on inland water biodiversity as a matter of priority. According to the spirit of the Convention, species do not necessarily have to have negative impacts. Establishment alone alters the native species structure and as such contravenes the principles of protection of biodiversity.

Cambodia, Lao PDR and Viet Nam[1] are parties to the CBD. As 'parties', these countries accept the CBD as a legally binding document, and commit to fully implementing all aspects of the Convention. Thailand is a signatory (a step preceding being a 'party') to the CBD. A 'signature' verifies that the country supports the general objectives of the Convention and would not overtly do anything to undermine those objectives, but it is not legally bound by the Convention.

1.3 Definitions

The terminology surrounding movements of species is confused because several terms are in current use as synonyms for the same type of action while the same word may be used for several different actions. The following terminology is used in this report:

Exotic species & Introduced species	A species occurring outside its natural range.
Introductions	The human-assisted movement of an aquatic animal to an area outside its natural range (typically across international boundaries but also referring to movements into river or lake basins from which the animal was previously absent).Introductions are usually one-off operations that are discontinued once the animal is established in the receiving system.
Native species & indigenous species	A species forming part of the naturally occurring fauna.
Stocking	The release of aquatic animals into a river, lake or reservoir to achieve a specific goal related to fishery or conservation. Stocking may form part of an introduction, either with native species or with exotic species that are unable to breed in the receiving environment. Stocking may be a one-off operation in some cases but more usually consists of a repeated exercise in support of a specific management strategy.
Transfers	The movement of an aquatic animal to an area within its established range.

These definitions have traditionally applied to species. However, modern perceptions of biological diversity imply that similar definitions and provisions should apply to lower taxonomic units such as sub-species, aquaculture strains and varieties.

[1] These four countries contain the Lower Mekong Basin. The Upper Mekong Basin stretches into China and a small area in Myanmar.

2. REASONS FOR INTRODUCTIONS AND STOCKING

2.1 Introductions

Several main reasons are usually offered for introducing a new species into a lake or river:

Create new fisheries that are more resistant to fishing pressure or have greater market value than native fish. In commercial fisheries, such introductions have often involved large predators intended to benefit from smaller species of no value to the fishery. In other cases, species of known value, such as the tilapias, have been favoured. New species are introduced into recreational fisheries to improve the variety available to anglers or to insert a species of particular trophy or sporting value into an area.

Fill a 'vacant niche' where existing species do not fully use the trophic and spatial resources available. In some natural waters, geographic conditions have resulted in few native species, as in some islands, or areas where faunas have been wiped out through glaciation. More commonly, the need for introductions arises as a consequence of human activities. For example, in Latin America many new reservoirs lack native species capable of fully colonising lentic waters. In many river basins, regulation of flow by dams has eliminated or drastically reduced the native rheophilic faunas leaving the waters open to colonisation by introduced species.

Control pests - several species have been introduced in an effort to biologically control pests and vectors of human disease. For example, the widespread introduction of Poecilia and *Gambusia spp* to control mosquito larvae and several species, including *Astatoreochromis alluaudii,* for the control of the snails that carry schistosomiasis.

Control water quality - where suitable phytoplankton-eating species are lacking, species such as *Aristichthys nobilis, Hypophthalmichthys molitrix* and *Oreochromis niloticus* may be introduced to remove excessive algae in eutrophied systems.

Develop aquaculture - this remains one of the main motives for the movement of species around the world. Many species have been introduced for culture. These include rainbow trout, common carp and tilapias, which together account for a large share of inland aquaculture production. Escapes from aquaculture installations have contributed to many successful introductions into the wild. There has been a tendency in most countries to introduce a few species whose culture is well known rather than to try and develop local species. This tendency can be overcome through programmes to identify and develop local species, which often correspond more to local tastes and have higher market values.

Fulfil aesthetic and other reasons - ornamental species are now widely distributed throughout the tropical world through escapes from rearing installations and aquaria. Some species have also been introduced for particular religious or cultural reasons.

2.2 Stocking

Inland waters are stocked for several reasons, including:

Mitigation - to counter a disturbance to the environment caused by human activities such as dam-building or removal of spawning substrates;

Maintenance - where fish are regularly stocked to compensate for excessive fishing which removes more fish than can be generated through natural reproduction;

Enhancement - to maintain the fisheries productivity of a water body at the highest possible level or to increase the proportion of a species particularly favoured by a fishery;

Conservation - to retain stocks of a species threatened with extinction;

Restoration - to restore damaged habitats in which species composition has been disturbed.

Water quality control - in eutrophied systems, phytoplankton-eating species are regularly stocked to remove excessive algae and thus to lower nutrient concentration. This usually forms part of a management package, including the removal of predatory species (which prey on the phytoplankton eaters) and zooplankton-eating species, which remove algal-eating zooplankton (see Figure 1). The main zooplankton-eating species in Mekong reservoirs is the native *Clupeichthys aesarnensis* although this species is also insectivorous. Two main phytoplankton-eating species, both of which are introduced are Chinese carps (which do not breed in lakes and reservoirs and need repeated stocking) and *Oreochromis niloticus*, which is able to breed in certain reservoirs in the region.

In the Mekong Basin, the major motive for fish introductions has been aquaculture and the associated enhancement of dams and reservoirs. Many species are maintained in captivity in the basin for the aquarium fish trade. Several species have been introduced to control pests, mosquitoes and invasive vegetation.

2.3 Strategic approaches to fishery management

The circumstances leading to decisions to use introductions or stocking, among other strategies, for the development and management of fisheries, are summarized in Figure 2.

3. Risks from introductions and stocking

Any large-scale movement of species and genetic material poses risks for the receiving fauna. In the case of wild fish, the major risks are from human interventions in river and lake basins and with current fisheries management practices. Both have had a negative impact on the structure of existing assemblages. By comparison, introductions and transfers for fisheries and aquaculture seem to have had relatively little impact, especially in the Mekong to date. These introductions do, however, aggravate already stressed communities and in some cases the invaders benefit from the altered conditions. In fact, there is considerable evidence to show that the worst cases of fish proving a nuisance after their insertion into new habitats have occurred where those habitats have already been subject to other externally imposed stresses.

3.1 Introductions

Introductions pose special problems because they insert a totally new element into the fauna. The consequences are difficult to predict, but they can include the following:

3.1.1 Environmental disturbance

Introduced species can disturb habitats and in so doing, alter ecosystem characteristics to such a degree that native species are threatened. A notable example of such behaviour is the common carp, which 'digs' for food in the muddy bottoms of lakes and rivers, stirring up sediment and biological oxygen demand (BOD). This can lead to turbid conditions that reduce light penetration and plankton production. Another form of behaviour is burrowing. Many introduced crayfish varieties can seriously damage pond banks and river levees.

3.1.2 Predation

The introduction of new predatory species is one of the major causes of the negative impacts reported. There is the notorious case of the Nile perch introduced into Lake Victoria. This allegedly caused the disappearance of large numbers of the cichlid species. Species disappearances have also been associated with introductions of trout in many areas and of *Cichla ocellaris* in Latin America.

3.1.3 Competition

Competition between the introduced species and native species is frequently cited as another cause of potential difficulty. Competition may be for food, or for breeding sites among nest-building species. The disappearance of some tilapias, following the introduction of *O. niloticus,* is a case in point. While rarely leading to species disappearance, the second major negative impact has been the explosive expansion of populations of small 'r' selected species. This is often accompanied by stunting, leading to dense populations of small individuals of little use to a fishery and which then compete with and reduce the numbers of more useful species. *O. mossambicus* shows this behaviour to a certain extent as do several cyprinids and sunfishes.

3.1.4 Introduction of disease

There have been many examples of diseases and other parasitic organisms that have accompanied introduced fish species to their new home. The introduced species is often more resistant to the disease organism through long cohabitation. Species in the receiving environment are more sensitive

and readily transmit the new pathogen outside the original area of the introduction. Diseases can have a disastrous economic impact on aquaculture, as has been repeatedly illustrated in the shrimp, salmon and trout industries.

3.1.5 Genetic contamination/hybridization

The most extreme genetic effect is hybridization. Many fish species regularly hybridize with closely related species and frequently with those of greater geographic and taxonomic divergence. Hybrids may be:

i) Self-fertile and will breed true, in which case an essentially new species is created such as the various 'red tilapia'. Self-fertile strains can eventually revert to their parental forms through backcrossing.
ii) Not self-fertile but capable of producing viable offspring with one or both of the parental species.
iii) Sterile.

Hybridization among species in the natural environment can pose risks because valuable adaptive characteristics, such as timing of migration and the ability to locate natal streams may be lost in the host species. Alternatively, the hybrid can prove more successful and vigorous than the parents, in which case they may disappear through competition.

Genetic mixing of different stocks through inter-basin transfers of the same species poses similar risks of loss of adaptive characters. Naturalized stocks of exotic species, especially the tilapias and common carp are also likely to be affected by contamination with genetic material from the various specialized strains being used in aquaculture and the aquarium fish trade.

3.1.6 Co-introduction of nuisance species

Where fish are introduced as juveniles, there is a serious risk that fry of other species are also included. If proper precautions are not taken, these can readily acclimatize to the receiving habitat. The arrival of *Pseudorasbora parva* and several other species, in Europe for instance, are thought to have originated from contaminated batches of Chinese carp fry imported for aquaculture and weed control. Some of the recently recorded species from the North of the basin may have arrived in Lao PDR by the same mechanism.

3.2 Stocking

Stocking usually poses fewer problems than introductions. Inland reservoirs, lakes and rivers are usually stocked with one or more of three categories of fish:

- Native species;
- Introduced species that are already well established in the environment;
- Introduced species that do not breed in the receiving environment.

In most cases, the potential for serious environmental impacts that may be caused by introductions are not high, but the large quantities involved in stocking and the repeated nature of the operation considerably raises the following risks.

3.2.1 Genetic effects

Risks of genetic effects on host populations are greater in stocking than with introductions. These arise from two sources:

- Stocking with the species that are native to the host water body, and
- Stocking with introduced species.

Where stocking is carried out with species that are already in the receiving water body, there is a risk of 'genetic swamping', whereby the original genetic characters of the host stock are lost to the stocked material. Where particular sub-stocks of fish adapted to the local conditions exist, this may cause problems with some aspects of behaviour such as timing and location of breeding. Escapees of the modified genetic strains from the reservoir or river-reach may subsequently dilute the genetic effectiveness of the species over a wide area. In Thailand, where stocking material is drawn from a wide area and inter-basin transfers of species occur, risks of such effects are particularly high. For this reason, careful selection of broodstock for the production of stocking material is advised. Material to be stocked should be derived only from parents drawn from the receiving basin.

In contrast to the *widening* of the genetic base beyond that which is adaptive for any stock, there is also a risk from *too little* diversity. Stocking derived from too few breeders can result in a narrow genetic base (low heterozygocity) which will lead to rapid degradation of the material used for stocking aquaculture ponds and reservoirs, which in turn will lead to poor growth and reproductive potential.

3.2.2 Disequilibrium of fish population

Stocking with one or more target species can produce imbalances in the population, thus disrupting food chains and threatening the survival of non-target species. This effect is often sought deliberately to bias the fishery towards high value species or to influence the trophic status of the stocked water body.

3.2.3 Disease

Risks from disease dissemination by stocking are very high and aquaculture has a long history of financial crashes caused by the introduction or transfer of diseases along with movements of fish seed. The only way this can be avoided is through greater care and control and by certification.

3.2.4 Strategic issues

Current stocking rates into reservoirs and dams in the basin are generally low due to a shortage of fish seed. However, in some parts of Thailand, realistic stocking rates of around 6000 fish/ha are used. About 25 million individuals were stocked into lakes and reservoirs in 1998 in Northeast Thailand. An outline for decision making with respect to stocking is presented in Figure 3.

4. Fish fauna of the Mekong

The characteristics of the receiving system and host fauna are important to the readiness with which introduced species can acclimatize and insert themselves into the native assemblages. In Islands east of the Wallace Line (for instance, Australia and Papua New Guinea) the impoverished endemic faunas have been readily invaded by introductions. The establishment rate of exotics introduced into complex existing faunas is much lower.

4.1 Characteristics of the system

The Mekong River is the twelfth longest in the world. It rises on the Tibetan Plateau and flows through six countries (China, Myanmar, Lao PDR, Thailand, Cambodia and Viet Nam) before discharging into the South China Sea in Southern Viet Nam. The river is divided into three geographical regions[2]:

i) The upper basin which includes headwaters in Yunnan Province and China as far as the Myanmar-Lao PDR border;
ii) The middle basin from the Myanmar/Lao PDR border to Khone Falls;
iii) The lower basin from Khone Falls to the mouth, a region which includes the Tonle Sap system in Cambodia.

The main tributaries of the Mekong drain the uplands of Lao PDR, which contribute 35% of the runoff. Other major tributaries rise in Thailand and Cambodia, which each contribute 18% of the runoff.

There are two main floodplain areas in the system, the Tonle Sap/Grand Lac system which extends over about 50,000 km^2 in the lower basin and the smaller Songkram River basin in the middle Mekong in Thailand. Apart from these major systems, there are smaller flooded areas all along the main stream. The river and its tributaries are used to irrigate extensive rice growing areas throughout the basin.

4.2 Assemblage characteristics

4.2.1 Diversity

The fish fauna of the Mekong is the third most diverse freshwater river fauna in the world, with a total of at least 1200 known species. Of these, only about 700 species have been formally described. The Mekong Fish Database currently includes 915 species. Freshwater fish faunas can be divided into primary and secondary species, according to their evolutionary origin and salinity tolerance. Primary species such as the cyprinids, most catfishes, loaches, snakeheads and gouramies are relatively intolerant of saline environments, as they have evolved entirely in fresh water. Secondary species, which evolved in marine environments and later adapted to freshwater habitats, are generally more tolerant of salinity. The upper and middle reaches of the Mekong are occupied mainly by primary species – over 400 species of carps, barbs and minnows, 350 species of loach, 150 species of catfish from 10 families, 15 species of anabantoids and snakeheads and 5 species of bony tongue and featherbacks. This portion of the Mekong may also be colonised by some secondary species such as stingrays, sardines, ricefish and pipefish. However, the secondary species are more abundant in the lower reaches, including the Delta where there are over 120 species of goby, about 40 species of croaker and 25 species of mixed origins (see Figure 4).

[2] This differs from the usual MRC definition of the Lower Mekong Basin, which includes the Mekong basin of the four MRC member countries, i.e. Cambodia, Lao PDR, Thailand and Vietnam.

4.2.2 Size composition

Fish in the Mekong fauna range in size from the world's third smallest, a minnow *Boraras micros* of 1.35 cm SL, to the largest, *Pangasianodon gigas*, which attains lengths of up to 2.5 m and the stingray *Himantura chaophraya,* which reaches 3 m in width and 600 kg in weight. Any assemblage of fish conforms to a log-normal distribution of species as classified by the maximum length attained. This distribution is shown in Figure 5 for the Mekong species, described by Rainboth (1996). Several hundred species remain to be described but, as these are mostly species from headwater streams, their inclusion would increase the percentage of small fishes. This figure is of interest in showing where an exotic species would fit in the general size structure of the existing assemblage. For example, a species such as *Clarias gariepinus,* at 150 cm maximum length, would be exceeded by only 10 species and matched by another 4. A species such as *Oreochromis niloticus,* at 45 cm, would be exceeded by 84 species.

Length alone is not significant for ease of establishment or degree of impact. In fact, with the present trend in parts of the basin for the fish assemblage to become 'fished down', size may be a disadvantage in the long term. This coincides with the results of an analysis of known introductions worldwide, which indicates that smaller species have a better chance of becoming established.

4.2.3 Zonation

The ease with which species can become established and their impact will differ in the Mekong system according to the fauna present in the different zoogeographical sub-basins and the proportion of certain types of habitats such as major floodplains and rapids. The Mekong Basin fauna has affinities with four aquatic zoogeographic zones (Figure 4):

- The headwaters of the river on the Tibetan Plateau and the upper reaches share elements with the Salween and Ganges Rivers to the West and the Red River and East Asian elements to the East;
- The Middle and Lower basins have many endemic species but also share elements with the Thai-Chao Phrya system;
- The Delta has some similarities to the Sundaic sub-region (Malay Peninsula and North Borneo).

Large species (> 70 cm SL), including the pangasiid, bagrid and siluroid catfishes, the large cyprinids and large channids, most often occupy the main channels of the river and the larger tributaries where they tend to dwell in deeper pools. During the flood season, these species may move to deeper areas of the floodplain to forage and to find nursery areas for the juveniles. Medium size species (30-70 cm SL) inhabit a wide range of areas from main stream habitats and tributaries to floodplains, marshland and rice fields. This group includes most of the carps, barbs medium sized catfishes, featherbacks and the sand goby *Oxyeleotris marmoratus*. Small species (< 30 cm SL) tend to have much more restricted habitats and show a great degree of endemism, especially in the highland tributaries. Here there are several species of balitorid loaches, stream gobies, *Rhinogobius* spp., some sisorids, *Oreoglanis* spp. and *Exostoma* spp.. Marshlands, permanent floodplain lakes and rice paddies tend to attract specialised faunas of small species, including *Boraras micros* (endemic to Northeast Thailand), *Indostoma sp.*, dwarf pipefish, *Nandus* spp., small anabantids, *Betta* spp., *Trichopsis* spp. and small gobies.

4.2.4 Biology

The Mekong fish fauna includes species showing most known feeding and breeding strategies. The fauna is divided into two main components:

- Blackfish, which are associated with the floodplain and swamp systems. These fish show limited migrations between floodplain habitats and local river channels. They often have supplementary breathing mechanisms that allow them to breath low dissolved oxygen, and complex parental care to safeguard the young fish from predators and adverse environmental conditions. These species probably have populations that are isolated from one another because of their inability to survive in the main channel.
- Whitefish, which migrate for long distances in the main channel to move between breeding and feeding habitats. These species are possibly separated into migratory sub-populations that are adapted to specific reaches of the river.

An assessment of the sub-specific structure of the species in the basin is needed to provide information for conservation and management. It is also an important element in evaluating the vulnerability of a species to competition from exotics.

5. HUMAN INTERVENTIONS

This section does not aim to provide a detailed analysis of the impacts of various human activities in the Mekong Basin. Rather, it examines activities only insofar as they might influence the likelihood of establishment and the impacts of introduced species.

5.1 Damming

Damming rivers has severe effects on river fish faunas. These effects arise from two main sources: interruptions to migratory pathways and control of flow.

Interruptions to migratory pathways can directly impact whitefish species, preventing them from moving between their reproductive and feeding habitats. Dams can also interrupt the drift so that the young fish fail to reach the floodplains.

The control of flow can have biotic effects by changing the magnitude and timing of flooding. Where fish species are closely attuned to the flood regime of a river for their breeding and migratory patterns, such changes can send inappropriate signals causing fish to mature sexually at the wrong time of year, or not to mature at all. Flow control also has morphological effects in that it frequently reduces or suppresses flooding on the floodplain and thereby causes the disappearance of floodplain (blackfish) spawning species. In such cases, introduced species may be able to adapt better than natives. Other effects are also common. Deposition of silt in dams changes the productivity of the floodplains downstream, thus inducing changes in vegetation patterns, which in turn can influence the capacity of native phytophilous fish to survive.

The net effect of damming is to convert previously free-flowing rivers with pronounced pulse behaviour into rivers with flows that are evened out over a longer period than before construction of the dam. In extreme cases, peaks in the hydrograph are suppressed to a point where little flooding occurs. This transition has resulted in cases of infestation with common carps in South American, South African and Australian rivers and Western coastal rivers of the United States. The suppression of the native rheophilic faunas has generally favoured the expansion of more limnophilic forms such as the common carps, goldfish and tilapias. However, elements of the Mekong fauna have shown a capacity to form limnophilic faunas in reservoirs and could probably, in a similar way, make the same transition in rivers.

5.2 Reservoirs

The mass of water behind a dam forms a new lake. In many systems the natural river fauna is unable to adapt to the new situation and fails to colonize the new waterbody. In others, the original fauna may maintain itself by ascending inflowing tributaries to breed; but such species are at risk if a second dam is constructed upstream of the first, thereby cutting these species off from spawning sites. Other species are able to fully colonize the reservoir. Native species have been able to cope well with impoundment in the Mekong system (Virapat et al. 2000). In some cases, Ubolratana in Thailand and some upland Vietnamese dams for instance, *Oreochromis niloticus* form important populations. Several other introduced species appear in many reservoirs in Thailand without contributing greatly to the catch.

Most reservoirs and lakes are stocked in Thailand, although no clear strategy for stocking is applied due to the shortage of fry. Fry are generally stocked as a public service by Government hatcheries at no cost to the fishermen. In South Viet Nam, stocking is also now common practise. Here reservoirs are managed by a contractual agreement with the Government, whereby a manager is assigned the right to stock and manage the fishery in return for payment of an agreed fee.

5.3 Channelization

Channelization has the effect of reducing habitat diversity by eliminating meander bend, point bar and island structures in the main channel in favour of a straight and more or less featureless water course. The loss of diversity threatens specialized species, whose habitats disappear, and favours generalists. Channelization also cuts the river channel off from the floodplain by raising levees into embankments to prevent overspill, thereby endangering blackfish species. It also accelerates flow down the restricted channel, which may have negative effects on whitefish species with semi-pelagic eggs or whose larvae form part of the drift. Species with fixed eggs and static fry such as those species showing parental care would be less affected. In other systems that have been heavily channelized, distortions in fish populations have occurred with losses in diversity of native fish assemblages and increases in the numbers of exotic species such as common carps. As projects for poldering floodplain areas or raising levees for flood control become more widespread in the basin, problems of this type will increase.

5.4 Agriculture

5.4.1 Rice

Rice culture, a main feature of Asiatic floodplains, replaces natural floodplains with an artificially flooded habitat. Many species of fish can live with this situation but have problems with the large quantities of pesticides and fertilizers that are used in rice cultivation. Rice-fish culture, where ponds, ditches are used to retain fish, is another common feature of the region. This practice usually relies on natural incursions of fish and there is an abundance of native blackfish to fill this role. In some areas the rice fields may be stocked with native or exotic species.

The greatest impact from irrigated farming is the gradual elimination of the flooded forest in the lower part of the basin along with the reduction in flooded area associated with the poldering of certain areas. Drastic changes in the nature of floodplain habitats together with the loss of floodplain area may result in the disappearance of many of the species that depend on these habitats, although in other river systems fish faunas have adapted well to similar threats.

5.4.2 Hill slope/siltation

Dry land agriculture on hill slopes together with deforestation usually accelerates the transport of silt to the river from the surrounding land. Excessive silt can smother breeding substrates and food organisms and drastically affect the survival of species adapted to cleaner waters.

5.5 Pollution/Eutrophication

Although these are two separate phenomena, the whole question of reduction in water quality is important. The Mekong is not a heavily polluted system but intense agriculture, particularly in Thailand, is adding a quantity of pesticides and fertilizer to the river and to associated reservoirs through percolation and runoff. At the same time, the growth of urbanization in the basin means that sections of the river are eutrophied by urban waste and that urban drains accumulate polluted material. Severe degradation of water quality affects fish directly and the more sensitive species will disappear while species with supplementary breathing adaptations will increase. The spread of contaminated water in and around towns seems to encourage the expansion of a limited set of species that can cope with the degraded conditions. This includes three introduced species – stunted *Oreochromis niloticus, Poecilia reticulata* and *Pterygoplichthys plecostomus* and one native *Trichogaster tricopterus*. Eutrophication of reservoirs, with the accompanying blooms of blue-green algae, will also eliminate many of the more sensitive native species. Heavily eutrophied lakes, dams and reservoirs are likely to attract populations of common carps, *Oreochromis niloticus* as well as native snakeheads.

5.6 Fisheries

The Mekong system is heavily fished (van Zalinge et al. 1999). As a result many of the larger, predatory species are disappearing from the Mekong as part of the fishing-down process. As the larger species tend to be predators, fishing down the assemblage involves a shift from predatory to lower food chain fishes. The failure of many potential introductions to establish has been attributed to predators. If this is correct, lowering the percentage of predators in the system would lower this barrier, leading to a greater naturalization rate. On the other hand, large species such as *Clarias gariepinus* and *Labeo rohita* should be equally vulnerable to the tendency to eliminate the larger species from the fish assemblage as the native ones. The ability of some species, such as the tilapias, to reduce their size under fishing pressure enables them to profit from the fishing-down by forming stunted populations. It is possible therefore, that as fishing pressures increase, stunted tilapias will appear more in the catches.

5.7 Aquaculture

Aquaculture draws heavily on a limited range of species whose culture is well understood. Foreign experts have frequently been called upon to advise people in the region on aquaculture, and local personnel have been sent abroad to study. There has been a tendency for such externally oriented specialists to rely on species with which they were familiar rather than to risk failure through the development of new, local species. This means that a number of species have been introduced into the countries of the region for culture, and that present culture practices are firmly rooted in these species. Inevitably, cultured fish have escaped from fish farms and some have become established in the wild. In Lao PDR, supplies of fish seed for aquaculture are low and the country depends largely on material imported from Thailand, China and Viet Nam. The Thai seed is usually of satisfactory quality but seed from China and Viet Nam appears to be mainly mixtures of wild, caught species, many of which are of little value.

5.8 Enhancement

The practice of stocking reservoirs, smaller dams, rice paddies and temporarily impounded channels is widespread throughout the region. Further enhancement may be carried out through the fertilisation of such water bodies, especially in Thailand and Viet Nam. Enhancement of fisheries in this manner is one of the cornerstones of rural fisheries development and is often seen as the quickest way to increase food production from aquatic systems. The direction of enhancement programmes is towards the creation of artificial faunas using the Chinese/Russian model of stocking a mix of species to exploit all levels of the food chain. If applied, this methodology would radically alter fish populations in the smaller dams and reservoirs.

It is Government policy in some countries of the basin to subsidize capture fisheries by free distribution of seed or fry. In these cases, the same species are used as for aquaculture. As an example of the magnitude of Government sponsored stocking programmes, about 720 million common carps, tilapia, puntius, and Indian carps were stocked into Thai waters in 1998. Even so, stocking requires an enormous number of fry that exceeds the production capacity of local hatcheries. As a result, fry are withdrawn from wild stocks or are traded within and between countries. In Thailand, this trade is mainly between the Mekong and Chao Phrya Basins, where much mixing of genetic strains of the same species may result in the possible loss of locally adapted stocks. In Lao PDR, the cross-border trade with China and Viet Nam has resulted in the appearance of several non-native fishes from the Red and other rivers.

5.9 Aquarium fish trade

Thailand and Viet Nam are both important centres for the aquarium fish trade in the region. Urban areas of these countries are major markets and there are several hatcheries breeding and rearing aquarium fish around Bangkok and Ho Chi Minh City. Fish move from these centres all over the region and are exported to Japan, Germany, France and the USA. The trade is completely uncontrolled. Some species of exotic ornamental species have already appeared in the natural environment, particularly two species of *Poecilia* and *Gambusia,* which are also used for mosquito control, and the black sucker (Loricaridae).

The fact that such species are small does not mean that they do not have nuisance value. The cyprinodonts and poeciliids for instance are though to be the cause of egg and fry predation in areas to which they have been introduced. The cichlid *Petenia krausi* has caused serious infestation problems after it spread through the Orinoco River. Inspection of the species on sale in the weekend market in Bangkok and the aquarium fish sellers in Ho Chi Minh City shows a range of exotic cichlids, including some notorious predators such as *Cichla ocellaris*, which have also been implicated in species destruction. In general, ornamental species are kept in aquaria in towns. Owners sometimes release fish when they get too large. Many such introductions are made into polluted waters unsuitable for survival. However, most of the rearing centres are in less urban areas and there is a fair chance of escape from ponds through drainage systems to the natural environment. Escaped ornamentals can survive in natural habitats as shown by Professor Mai Dinh Yen, who recorded several species in Lake Sun Hun in the highlands of Viet Nam.

Species do not necessarily have to have negative impacts on becoming established. The fact of establishment alone alters the native species structure and as such contravenes the principles of protection of biodiversity. The lack of restriction on the ornamental fish trade therefore carries the risk of contaminating the local biodiversity with additional exotic species and the possibility of introducing a new nuisance species or co-introducing disease organisms.

5.10 Local traditions

As part of their Buddhist tradition, the peoples of both Thailand and Lao PDR release wild creatures into the wild during certain festivals, particularly birds and fish. In the case of fish, they draw heavily on fry production stations, as well as on fish caught in the wild and transported around the country for this purpose. Many of the fish are released into polluted waters near temples. Some are released into village ponds and reservoirs and can thus result in genetic mixing and the establishment of non-native fishes in new environments.

Local eating taste can also play a part in the choice of species and the speed with which they are adopted. An example is *Colossoma macropomum*, which, despite its excellent qualities for culture, is too bony and does not suit local tastes in Northeast Thailand. The species has so far failed to be adopted in Lao PDR and Thailand, although it is widely cultured in China and in the South of Thailand. Its general acceptance in central Thailand, including the Bangkok area, indicates that tastes are not fixed and that an eventual change in acceptability might occur. In general and throughout the region, native species are preferred to introduced ones and captured species are more popular than those produced by culture. Some species such as *Oreochromis niloticus* and the hybrid clarias have gained a measure of acceptance.

6. Capacity of local fish populations to adapt

Visits to two reservoirs (Nam Ngum and Ubolratana) and reports from others have revealed that local species are well able to make the transition to lacustrine conditions. For example, some 70 species have adapted to Nam Ngum with no breeding exotic species. One hundred and twenty species are found in Ubolratana of which only one, *O. niloticus* (the third species in abundance), is the single exotic to form a significant proportion of the population.

6.1 Pelagic communities

All but the smallest reservoirs develop populations of the planktonophage *Clupeichthys aesarnensis* or *Parambassis siamensis*, which form the basis for light fisheries. Other cyprinids, particularly the predatory *Hampala spp.* also occupy the pelagic zone but, as their numbers have dwindled in response to heavy fishing, so have populations of the smaller species risen.

6.2 Rheophilic vs. Limnophilic habit

At present, most species are able to continue breeding in reservoirs. Some species are said to be ascending inflowing tributaries to breed, whilst others are said to be able to breed within the lake itself. It is an open question whether species that migrate would be able to further modify their behaviour should the inflowing streams themselves be dammed. Similar questions will eventually arise as the number of large dams on major tributaries increases or when main stream dams control the flow in the main river channel.

6.3 Preferred species for aquaculture

In Thailand, most aquaculture uses *Labeo rohita* (introduced), *Oreochromis niloticus* and its hybrids (introduced), common carps (introduced), *Barbodes gonionotus* (native) and hybrids between *Clarias macrocephalus* (native) and *C. gariepinus* (introduced). Three varieties of exotic Chinese carps and two further Indian major carps are also used. Most of the species used for aquaculture have escaped and have either established or give strong indications of having done so. Large concentrations of tilapias are found near hatcheries and the hybrid *Clarias* is now thought to be partly responsible for greatly diminished catches of native *Clarias batrachus*.

Labeo rohita is preferred to native labeos for aquaculture, as it is easier to breed artificially, survives handling better and has much better growth rates.

No clear preferences have yet emerged for aquaculture in Cambodia or Lao PDR. In Viet Nam a wide range of fish are cultured. These include three Chinese and three Indian carps (all introduced), tilapias (introduced), giant gourami (semi-native as an albino strain has been introduced from Indonesia), Barbodes gonionotus (native), Pangasius (native), common carps (introduced) and hybrid catfish (one component introduced).

There is a growth in specialized strains of *Oreochromis*. The GIFT tilapia is now reared in and distributed from the Government hatchery in Khon Kaen (Thailand), which is further developing the strain to meet local conditions. Several private hatcheries are now licensed to produce this fish for sale to both pond and cage culture locations. GIFT tilapia is also being investigated in Viet Nam, in collaboration with the GIFT foundation at Central Luzon State University. The ‘red tilapia’ is also

part of common aquaculture practice in both pond and cage culture. The Khon Kaen hatchery uses supermales to create mono-sex hybrids in conjunction with the Egyptian Manzalla strain of *Oreochromis niloticus.* Red tilapia, supermale, Chitlada and Manzalla strains are all in use in Viet Nam. All this implies that, as aquaculture becomes more sophisticated throughout the region, so will the number of specialized strains in use. It implies too, that with the inevitable escapes, stocks in the wild will undergo a considerable degree of genetic mixing.

Attempts are being made to identify and promote further local species for aquaculture. This initiative is commendable and is certainly preferable to further imports of new species. However, the major introduced species for aquaculture are well established throughout the region and further problems are likely to arise through genetic mixing of stocks. It is also evident that aquaculturists, even in the rural sector, are well aware of the competitive advantage between strains of the same species. An example is the popularity of a strain like the GIFT tilapia, which confers a growth advantage of about 10%. Any local species that are developed will have to compete on equal terms at this level of advantage. At present, only one species, *Barbodes gonionotus* is popular and competes with the introduced species in ponds. Two main native species are used for cage culture in rivers, *Channa* and *Pangasius. O. niloticus* however is still preferred for cage culture in reservoirs.

6.4 Preferred species for stocking

Mixtures of fish used for stocking are similar to those used for pond aquaculture, since the stocking material is likely to come from the same source.

6.5 Evaluation

On the whole, the native fauna of the Mekong has adapted well to the changes brought about by impoundment and to other changes within the basin. They are forming populations within the reservoirs that are reaching levels of productivity comparable to those of tropical reservoirs elsewhere in the world. Therefore, it would appear that introduced species are unnecessary under the present levels of impoundment.

In aquaculture, the situation is somewhat different. With the exception of *Barbodes,* the native species tried so far do not match the ease of culture, resistance and general growth rate of introduced species. On the other hand, in riverine cage culture, native species are again predominant. The degree to which the gains from aquaculture in Thailand and Viet Nam and the potential for development in the other two countries justify the environmental risk of introducing new species is a matter for debate. However, without the stimulus provided by reliable and easy-to-culture species such as the tilapias, carps and clarias, it is doubtful whether the aquaculture and enhanced fisheries sectors would have made the gains they have. Certainly, future potential for expansion and development to meet growing demand would be severely compromised.

7. PRESENCE AND IMPACT OF KNOWN INTRODUCTIONS

7.1 List of species introduced into the mekong basin

This section is based on data from:

a) The FAO database on introduced species (DIAS) which has also been incorporated into FISHBASE

b) Information provided by M. Kottelat from his own experience and from photographs

c) Reported information from national colleagues during this mission

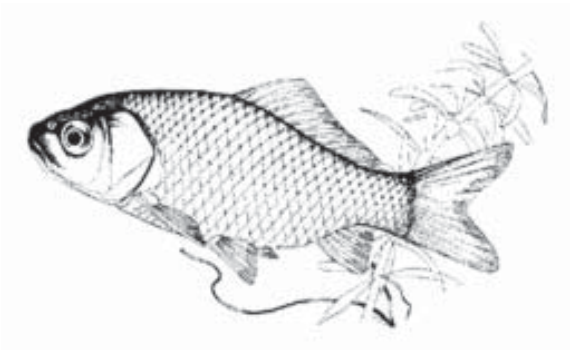
The superscripts after the species names in the following section refer to the primary sources of information listed above.

7.1.1 Finfish

Arapaima gigas [c] **(Arapaima)**

This species is commonly found in the aquarium fish trade. Some experiments have been made for its culture. Escapees have been found occasionally in natural waters in central Thailand. The species is long-lived and grows to a very large size. It is a voracious predator and a mouth brooder. Its natural habitat in the forested river closely resembles parts of the Mekong.

Carassius auratus [a, b] **(goldfish)**



Introduced into Thailand as an ornamental fish from China around 1300 AD and into Viet Nam at an unknown date. The species reproduces naturally in captivity but does not apparently do so in the wild in Thailand. More recently, a variety of this species was recorded as diffusing into the Mekong Basin from the Red River Basin in Viet Nam and from Lao PDR, and is presumed to be breeding naturally. The wild form of this species ('funa' in Japan) was introduced to Thailand from Japan but later disappeared. The wild form has posed a threat to Japanese endemic species through competition and hybridization. The gibelio sub-species has formed massive populations of stunted fish in the Danube in Europe. Goldfish are a generalized feeder and stick their eggs onto aquatic plants.

Cirrhinus cirrhosus [a, b] **(Mrigal, Indian major carps)**

This Indian major carp was introduced for aquaculture into Lao PDR (1977) and Thailand (1979) from India, and into Viet Nam (1984) from Lao PDR. The species is also used for stocking dams. It is thought to be breeding naturally within the basin, since its fry have been found in the main stream of the Mekong in Northeast Thailand. However, no natural stocks or impacts have been clearly identified. There are two native species of *Cirrhinus,* which have better eating qualities, but do not respond well to culture in ponds. The species is still used for aquaculture throughout the basin, where it is regarded as generally beneficial. The mrigal lays demersal eggs and feeds on detritus and periphyton.

Clarias gariepinus [a, b] **(African catfish)**

The African catfish was first introduced into Viet Nam from the Central African Republic in 1974 for aquaculture. It has since been introduced into other countries of the basin by internal transfer. It has been widely used for aquaculture and has been hybridized with the native *Clarias macrocephalus* (*C. gariepinus* male x *C. macrocephalus* female). It is recorded as established in the wild throughout the basin, although its status is unclear. There is little reason why this species should not enter the Mekong fauna as a permanent element. No immediate detrimental environmental effects have been noted in the Mekong or other areas to which the species has been introduced. The status of the hybrid is equally in doubt, since some report the hybrids as being self-fertile to at least F4. Others say that the hybrid is self-sterile but may backcross with both parents. As the hybrid readily escapes from aquaculture stations and is stocked into the wild, its capacity to breed is important. This should be clarified especially since there are reports that the hybrid may be responsible for a decline in the abundance of *C. batrachus* in the Chao Phrya and Mekong Basins. Commercially, the species is not as popular as the native clarias, although the hybrid is preferred to native species both for its better growth under culture conditions and its eating qualities. Clarias have a wide range of feeding habits from predation to generalized benthic feeders. They migrate to shallow flooded areas to spawn large quantities of adhesive eggs. Both the African parent and the hybrids are highly tolerant of poor water quality and deoxygenated conditions. This tolerance gives the species and the hybrid a competitive advantage over native clariids.

Ctenopharyngodon idella [a, b] **(Grass carps, Chinese carps)**

The grass carp was one of the first species introduced in the region. It was moved from China and Hong Kong to Thailand in 1932, to Viet Nam from China in 1958 and to Lao PDR at an undetermined date. The species is used for aquaculture throughout the basin and is highly appreciated by consumers. It may also be stocked into reservoirs as a control for invasive, aquatic vegetation in ditches and canals. The species does not breed naturally in any of the countries and is maintained by artificial reproduction and continuous stocking. There is, however, a risk that it might acclimatize in parts of the Mekong, as it has already done in the Danube and the Mississippi. As its name suggests, the grass carp is one of the few fish to feed primarily on higher vegetation. It lays numerous semi-pelagic eggs and the young enter the drift.

Cyprinus carpio [a, b] **(Common carps)**

There is evidence that *C. carpio* is not one species but rather a complex of species with two clearly differentiated groups – the silver varieties originating from Southern China and Northern Viet Nam and the yellow varieties originating from Eastern Europe. The Common carp has been the keystone of many aquaculture development projects and as such has been introduced into the region from several sources on several occasions. It was introduced into Thailand from 1913 onwards from China, Japan, Israel and Germany, into Lao PDR from Thailand and India in 1977, and into Viet Nam from Hungary during the period 1969–1975. There is considerable movement of *C. carpio* from Thailand and China into Lao PDR as stocking material for aquaculture and reservoirs. The species complex is widely established in the wild and in many areas is now regarded as a permanent element of the fauna. Despite the disfavour with which this species is regarded in many areas, it is not perceived as an immediate problem in the Mekong. However, there are some local concerns about this species in Southern Lao PDR where fishermen blame it for declines in local fish species because it eats the eggs of other fish. Common carps are notorious for the way their populations rapidly increase following environmental disturbances by dams. Their habit of digging around in the bottom and muddying the water can seriously alter the environment to the detriment of other species. Given that the species is now firmly established, there seems little that can be done to eradicate this potentially troublesome fish. Common carps are basically detritus and mud feeders. They breed on the vegetated margins of lakes and rivers where they deposit their adhesive eggs on submerged vegetation.

Gambusia affinis [a, b] **(Mosquito fish)**

Gambusia was introduced throughout the basin at an unknown date for mosquito control. It was widely disseminated in drainage ditches from which it has been washed into the main rivers. It is now found at the margins of most water bodies including rice fields and floodplain lakes. It is tolerant of salinity. It is not regarded as detrimental although its habit of eating eggs and larvae of other fish may do some damage to fish stocks. Gambusia feeds on surface-living insects and other particulate matter falling on the surface. It is a live-bearer.

Gilbelion (Catla) catla [a, b] **(Catla, Indian major carps)**

This species was introduce into Lao PDR (1977) and Thailand (1979) from India. Subsequently, some of Lao stock were introduced to Viet Nam (1984) for aquaculture purpose. The species is also used for stocking dams. It is recorded as breeding naturally within the basin but no natural stocks have been clearly reported. Due to its low growth rate, culture of this species has been largely abandoned in Thailand and Viet Nam. There seems to be no reason why this species cannot establish in the Mekong, which is similar ecologically to its native Ganges River system, although sufficient individuals may not have been added to the system to form a critical breeding mass. The Catla feeds on phytoplankton and detritus and normally lays demersal eggs in the main stream of the Ganges. The fry later swim up to form part of the drift.

Hypophthalmichthys molitrix [a, b] **(Silver carp, Chinese carp)**

This species was introduced into Thailand from China in 1913 and into Viet Nam in 1958 from the same source for aquaculture. The species is widely used throughout the basin for aquaculture and is artificially bred for this purpose. The species is recorded as having established in the Saigon River. Its fry have been found in the Mekong, indicating that it has possibly established in that river as well. The species feeds on detritus and phytoplankton and may compete with species of similar habit in the Mekong. It lays semi-pelagic eggs that form part of the drift.

Hypophthalmichthys nobilis [a, b] **(Bighead carp, Chinese carp)**

This species was introduced into Thailand from China in 1932 and into Viet Nam in 1958 from the same source for aquaculture. The species is widely used in Thailand. The species does not breed naturally in ponds and continues to be artificially reproduced. However, the species is recorded as having established in the Red river and the Saigon River. Its fry have been found in the Mekong indicating that it has possibly established in that river as well. The species feeds primarily on phytoplankton. It lays semi-pelagic eggs that form part of the drift.

Hypostomus plecostomus [c] **(Black sucker catfish)**

This species was apparently introduced throughout the region for the aquarium fish trade. It appears to be naturalized in many areas and has been found in rice fields in Northeast Thailand for at least ten years. It is also particularly visible in small urban water bodies. In its natural environment, the species ranges from rapids to floodplain pools. Therefore it can be anticipated that it will spread throughout the Mekong and its tributaries. The situation regarding this species is complicated, as a number of colour varieties and body forms have been seen. In addition, at least three other Loricariid catfishes have been identified in aquaria and at aquarium rearing stations. Loricariid catfishes scrape algae off rocks and other surfaces as well as ingesting detritus. They are also implicated in attacking egg masses of phytophilous fishes. They are nest builders and brood guarders.

Labeo rohita [a, b] **(Rohu, Indian major carp)**

This species was introduced for aquaculture into Thailand in 1968 from India, into Lao PDR in 1977 from Thailand and India, and into Viet Nam during the period 1982-84 from Lao PDR. The species is widely used throughout the basin for aquaculture and for stocking dams and reservoirs. It is preferred to the native species because it is easier to breed artificially and responds better to handling. Its fry are occasionally found in the main stream of the Mekong, indicating that the species is breeding naturally although some fry may be released from culture installations. Labeos are generally periphyton and detritus feeders and lay semi-pelagic eggs that enter the drift.

Mylopharyngodon piceus [b] **(Black carp)**

Introduced for aquaculture from China into Thailand in 1913 and in 1980 and has since disappeared. No natural stocks or impacts have been reported.

Oreochromis aureus [b]

This species was introduced into Thailand in 1970 from Israel. It was not used for aquaculture as intended and there is no evidence of its having reached the Mekong Basin. It is however listed as established, a fact which is indicated by naturally breeding populations in reservoirs on Mekong tributaries in Northern Thailand. These populations are still in existence and the spread of the species further downstream cannot be excluded. *O. aureus* is a generalized feeder with a preference for detritus and decanted phytoplankton. It also eats small fish and fish larvae. The species is a maternal mouth brooder that constructs nests in shallow water for breeding and fertilization. For this reason, it is vulnerable to rapid changes in water level and depends on suitable substrates for nest building.

Oreochromis mossambicus [a, b] **(Red throat tilapia)**

This tilapia is one of the most widespread species used for aquaculture and stocking of reservoirs in the region. It was first introduced to Thailand in 1949 from Malaysia and into Viet Nam from Africa and the Philippines during the period 1951-55, into Lao PDR in 1955 from Thailand and into Cambodia at an unknown date. It has escaped from its original environments and may possibly form established stocks in the Mekong system, particularly in saline environments such as Lake Nont Bo in Northeast Thailand, as well as throughout the Delta. *O. mossambicus* is notorious for forming dense populations of stunted fish, particularly in brackish water areas and small canals and lakes, as has happened in the Mekong Delta. It has become one of the pan-tropical species but is regarded as a pest in many areas of the world, where unsuccessful attempts have been made at its elimination. The species is not appreciated as highly as *O. niloticus* for its eating qualities and its former popularity for aquaculture has waned in favour of the latter species. *O. mossambicus* is a generalized feeder with a preference for detritus and decanted phytoplankton. It also eats small fish and fish larvae. The species is a maternal mouth brooder that constructs nests in shallow water for breeding and fertilization. For this reason it is vulnerable to rapid changes in water level and depends on suitable substrates for nest building.

Oreochromis niloticus [a, b] **(Nile tilapia)**

This introduced species is one of the most popular for aquaculture and for stocking into dams and reservoirs throughout the tropical world, including the Mekong region. It was introduced into Thailand from Japan in 1965, into Viet Nam in 1973 and 1994 from Taiwan, the Philippines and Thailand, and into Lao PDR and Cambodia at an unknown date. It is widely disseminated as fry from numerous hatcheries and is part of established commercial practice in support of stocking and aquaculture. *O. niloticus* is established in rivers and reservoirs throughout the region, although in some areas it has tended to disappear. It is not known to have any detrimental environmental impact throughout its introduced range and has become one of the pan-tropical species, although small native species in Southern Thai streams disappeared once this species became established. *O. niloticus* is a generalized feeder with a strong preference for phytoplankton. It is one of the few species that can readily digest blue green algae and as such is of value in the control of eutrophication. It also eats detritus and can feed on small fish and fish larvae. The species is a maternal mouth brooder that constructs nests in shallow water for breeding and fertilization. For this reason it is vulnerable to rapid changes in water level and depends on suitable substrates for nest building.

The GIFT strain of *O. niloticus* is now reared in and distributed from the Government hatchery in Khon Kaen (Thailand), which is further developing the strain to meet local conditions. Several private hatcheries are licensed to produce this fish for sale to both pond and cage culture locations. The Khon Kaen hatchery maintains the Egyptian Manzalla strain of *Oreochromis niloticus.*

Red tilapias [c]

Red tilapias have been formed from hybrids between *O. niloticus and* O. *mossambicus,* introduced from Latin America via Florida (U.S.A), and from *O. niloticus* and *O. hornorum,* bred in Central Thailand, which is saline tolerant. Both hybrids breed true but tend eventually to revert to their parental strains through backcrossing. Red tilapia is popular in Thailand and is also moved into Lao PDR for aquaculture and cage culture.

Poecilia reticulata [a] **(Guppy)**

This is an ornamental species introduced into Thailand for the aquarium trade and also for mosquito control It has escaped and become established in the wild throughout the region in small streams and ditches, at the margins of rice fields and other shallow, still water habitats. The species is a live bearer and feeds mainly on surface material, including small insects.

Poecilia velifera [c] **(Sailfin molly)**

The Sailfin molly was first introduced into Thailand for the aquarium fish trade around 1970 and in 1987 from Taiwan as a control on algal flocs in shrimp ponds in the Gulf. The species is also found in the Mekong Delta in Viet Nam. The species is a live bearer and is a microphagous omnivore.

Tilapia rendalli [b] **(Red cheek tilapia)**

This was introduced into Thailand from Belgium in 1955 for aquaculture. Established populations of this species exist in reservoirs around Sakhon Nakhon in Northeast Thailand. *Tilapia rendalli* is known to eat higher vegetation and has been used for weed control. It also feeds on detritus and is not particularly efficient at keeping down invasive plants. It is a parental guarder that lays its eggs in a series of small pit-like nests. It is vulnerable to fast changes in water level, which may be the reason it has not spread further that the area of original stocking.

7.1.2 Species whose distributional status is unclear

Abottina rivularis [a] **(mud gudgeon)**

This species is spreading into the Mekong Basin in Northern Lao PDR from China, either with fry for aquaculture or as natural diffusion. It was recorded in the Mekong in 1995 when a few specimens were obtained from the main stream in N. Thailand and tributaries in Yunan, China. The species feeds on periphyton and detritus. It lays demersal eggs on coarse sandy bottoms.

Acheilognathus sinensis [a] **(Chinese bitterling)**

This species is spreading into the Mekong Basin in Northern Lao PDR from China either with fry for aquaculture or as natural diffusion. Its presence has been established from photographic evidence only. This species may pose a threat to related endemic species. In Japan, it has contributed to the decline of other species through competition and hybridisation. The species is a zooplankton feeder, which lays its eggs in the mantle cavity of freshwater mussels. The mussel does not suffer any damage.

Acheilognathus barbatulus [a]

This species is spreading into the Mekong Basin in Northern Lao PDR from China either with fry for aquaculture or as natural diffusion. Its presence has been established from photographic evidence only.

Cyprinus sp. [a]

An introduction into Lao PDR whose status is unclear, it was recorded by M. Kottelat.

Hemibarbus labeo [a)]

This species is spreading into the Mekong Basin in Northern Lao PDR from China, either with fry for aquaculture or as natural diffusion. Its taxonomic status in the Mekong is unclear but the records of this species may represent an extension of its natural range.

Hemibarbus maculatus [a)]

This species is spreading into the Mekong Basin in Northern Lao PDR from China, either with fry for aquaculture or as natural diffusion. Its taxonomic status in the Mekong is unclear but the records of this species may represent an extension of its natural range.

Misgurnus anguillicaudatus [a)] **(Loach)**

This species is spreading into Northern Lao PDR from the Red River Basin in Viet Nam and Lao PDR. Its taxonomic status in the Mekong is unclear but records of this species may represent an extension of its natural range.

Pseudorasbora parva [a)]

This is spreading into the Mekong Basin in Northern Lao PDR from China either with fry for aquaculture or by natural diffusion. The species is primarily a plankton feeder that lays adhesive eggs on rocky substrates. The records of this species may represent an extension of its natural range.

Puntius semifasciolatus [a)]

This is spreading into Northern Lao PDR from the Red River Basin in Viet Nam and Lao PDR. The records of this species may represent an extension of its natural range. The species is primarily a plankton feeder that lays adhesive eggs on rocky substrates.

Rasborinus lineatus [a)]

This is spreading into the Mekong Basin in Northern Lao PDR from China, either with fry for aquaculture or by natural diffusion.

Rhinogobius sp. [a)]

One species of this genus is possibly present in stocking material spreading into the Mekong Basin in Northern Lao PDR from China.

7.1.3 Other organisms

Pomacea canaliculata [b)]

Introduced into all countries of the basin for aquaculture and ornament from 1988 onwards.

Pomacea gigas [b)]

Introduced into Thailand and has established in the wild.

Apple snails have a major impact on aquatic habitats, including rice paddies, through their habit of destroying the growing stems of aquatic plants at the base. They cause enormous economic losses for rice farmers and degrade natural wetland habitats by stripping vegetation. They have a very broad spectrum of feeding habit, using most aquatic plants including water hyacinths. Habitats thus denuded lose their fish populations. In addition, the introduced snails compete with natural forms such as *Pila* spp., which are relatively benign in their effect, since they only attack already moribund plants. Apple snails are tolerant of salinity and are thus able to penetrate coastal habitats. The species are preyed upon by open-bill storks, which are then at risk as they accumulate toxic material picked up by the snails. For the same reason, duck farmers who have used crushed snails as feed have suffered mortalities among their flocks. The case of the apple snail is an example of the disastrous consequences that can follow from an inappropriate introduction.

Procambarus clarkii [b)] **(Louisiana crayfish)**

Introduced into Thailand from an unknown source for aquaculture, this species is reported as established in the wild where it is regarded as a nuisance.

Pelodiscus sinensis [c}] **(Chinese soft shell turtle)**

This turtle has been introduced in Thailand on several occasions since 1977. It is now regularly reproduced in captivity and has formed natural populations. These have impacted on native turtle species. In Viet Nam the species was also introduced to the basin from the north of the country.

Pseudemys scriptac [c}] **(American painted turtle)**

This turtle was introduced to Thailand in 1975 for the aquarium trade. It is now bred in captivity and has formed natural populations in Central Thailand. It is probably in the Mekong watershed because there is a tendency on the part of owners to release them when they have grown beyond an acceptable size.

Rana catesbiana [b] **(American bullfrog)**

The American bullfrog was introduced into Thailand for aquaculture. It has become established in the wild although not in the Mekong Basin. Its ecological impact is unknown although it is thought that it will prove to be a nuisance. As the species can spread overland, its eventual appearance in the basin here is possible. The species is apparently already in the basin in Viet Nam (introduced from Cuba), having been released by farmers when it was apparent that the culture of this species was not profitable.

7.2 Introductions in adjacent waters

7.2.1 Finfish

Commercial species

Anguilla japonica [b] **(Japanese eel)**

Introduced into Thailand in 1973 for aquaculture, this species is rarely used for culture and there is no indication that it has entered the Mekong Basin. A few escapees from culture were found in Central Thailand in the 1980s, after which no further individuals have been found.

Colossoma macropomum [c] **(Pacu)**

The pacu is a species of growing importance for aquaculture in the region. Its use is widespread in China, Indonesia and Central Thailand. The species is not popular in Northeast Thailand at present because its bony nature and taste are not appreciated and it has not been adopted for culture. However, it is cultured in the central region of the country, where it is found in regular markets and supermarkets. This indicates that it is potentially acceptable and may eventually be cultured in the Mekong Basin. As a large species whose native habitat resembles parts of the Mekong system, it could become established, given the right conditions. Four or five individuals have been caught from the Chao Phraya River system. *Colossoma* are primarily known for their fruit-eating habit in flooded forests and could compete with native fruit eaters such as *Tor, Pangasius* and some cyprinids, should it ever become established. It undertakes migrations to marginal flooded zones for breeding.

Ictalurus nebulosus [b] **(American catfish)**

This species was introduced into Viet Nam, probably from the USA at an unknown date and for an unknown purpose. Its fate and impact of introduction are still unclear. There are also proposals to introduce this species into Thailand for aquaculture. It is a generalized bottom feeder that can adopt predatory habits. It builds a nest for its eggs, which are later guarded by the parents.

Ictalurus punctatus [b] **(Channel catfish)**

This was first introduced into Thailand in 1989 from the USA for aquaculture. It was also introduced into Central and Northern Thailand where it was cultured experimentally. All fish escaped during the great flood of 1995 and were later found in the natural habitat. However, there are no further records of the fate of this introduction. This species is a generalized bottom feeder that can adopt predatory habits. It builds nests for its eggs, which are later guarded by the parents.

Onchorhynchus mykiss [b] **(Rainbow trout)**

The Rainbow trout was introduced into Thailand from Canada in 1963 to establish a sport fishery in the mountainous area in the North of the country. The introduction was unsuccessful and did not affect the Mekong system. However, similar proposals surface from time to time in the interests of tourism and some eggs have been introduced into Northern Thailand for experimental culture. It is doubtful that this species would establish in the lower reaches of the river but may do so in the high mountainous tributaries in China. It has shown itself in other areas to be of value for recreational fisheries and cold water aquaculture at high altitudes in the tropics. Trout feed on insect larvae and small fish and have the potential to compete with and predate on native upland stream species. They have eliminated small native species in Asian, Southern African, New Zealand and South American localities where it has been introduced. Trout spawn in redds cut in fine gravel bottoms and depend on an even flow of well-oxygenated water for hatching and survival of fry.

Ornamental species

A large number of small, medium-sized and potentially large species are cultured and sold through the aquarium fish trade. Among these are additional ornamental strains of several of the species currently used in aquaculture which, although valid for ornament, may not have genetic qualities satisfactory for aquaculture. As the custom is to release unwanted fish, especially when they grow too large for the home aquarium, there is a clear possibility that eventually some species will establish. This risk is heightened because there are several enterprises culturing native and exotic species for export and local markets. These enterprises are making little effort to prevent escapes into nearby natural waters.

8. POLICY ISSUES

The following two basic principles should be recognised:

- Any introduction of a species into a river basin for whatever purpose, even into a secure installation, should be regarded as an introduction into the wild;
- Inter-basin introductions from adjacent rivers or lakes are potentially as risky as introductions that cross international boundaries.

8.1 Policy of individual member nations of the Basin Commission

Thailand has a policy of not permitting further introductions from regions outside its immediate neighbours. Cambodia and Laos have no policy on introductions and, while Viet Nam would prefer to use local species for aquaculture and fisheries wherever possible, it does not exclude the possibility of further introductions. Thus the four countries of the basin have very different approaches to further introductions of exotic species.

The situation with regard to transfers and material for stocking is even more open. In this case, all countries permit free movement of material within their countries, irrespective of whether or not it is crossing basin boundaries. Free movement of material between the countries of the basin is also permitted, as is importation from the other basin countries, China and Myanmar.

8.2 International agreements

The confused and generally uncontrolled movement of genetic material within the basin increases the risk of introducing nuisance species, genetic degradation of stocks and dissemination of disease. The solution lies not in a blanket ban on all future introductions, although this is certainly one possibility. Blanket bans of this type have proved almost impossible to enforce. Furthermore, in an area with a heavy dependence of fish and a growing aquaculture sector, such regulations limit possibilities for future development. The mission therefore considers it important that this issue be addressed by the Mekong River Commission. The following actions are possible.

8.2.1 Adoption of a Code of Conduct to reduce the impacts of future introductions of exotic species.

Formal Codes of Conduct adopted by countries sharing the same river or lake basin avoid the possibility of introductions effected by one country having negative effects on the other states. It also provides individual countries with a framework for the consideration of new introductions into their own national territories. This issue is considered a high priority by the Convention on Biological Diversity. Such a Code has already been developed by the International Council for the Exploration of the Sea (ICES) (ICES, 1995) and adopted in modified form by the European Inland Fisheries Advisory Commission (EIFAC) (Turner, 1988). The ICES/EIFAC Code has been offered for consideration to other Inland Regional Bodies. It has been accepted by the IPFC Working Party on Inland Fisheries as a possible basis for developing such a code for the Southeast Asian Region. It was recognized at that time that some of the provisions of the Code as developed for Europe were not appropriate for developing economies. The development and adoption of codes of this type are now consistent with the requirements of the Convention on

Biological Diversity and the emerging policy that all countries and regions should develop basin management plans. Figure 6 presents a decision-making tree summarizing some of the steps that should be taken in considering a new species for introduction.

8.2.2 Regional Guidelines on Quarantine and Health Certification

Regional Guidelines on Quarantine and Health Certification for the Responsible Movement (Introductions and Transfers) of Live Aquatic Animals in Asia are being negotiated by the Regional Expert Working Group of the Regional Programme on Quarantine, Health Certification and Information Systems for the Responsible Movement of Live Aquatic Animals in Asia. It is recommended that the Commission consider its formal participation in this code as a means of reducing the risks of the spread of disease through uncontrolled movement of stocking material.

8.2.3 Broodstock management

The genetic status of several of the species forming part of current aquaculture and stocking practice is extremely complex. Several strains of *Oreochromis* and common carps are in use as are hybrids of *Clarias.* In addition, different strains of the same species are mixed between the Mekong and adjacent basins and between various reaches of the Mekong itself. The potential ecological penalties for such indiscriminate mixing of stocks and the investment that resides in the development of high yielding strains suggests that greater care is needed in the transport, keeping, rearing and release of this material. To this end it is suggested that a protocol for broodstock management be developed for the basin to ensure a common approach to these issues.

8.3 Education, training and extension

Many of the uncontrolled movements of fish in the Mekong Basin are made because the general public and many in the fisheries and aquaculture sectors are ignorant of the dangers. It is suggested that consideration be given to preparing training and extension material and promoting public awareness campaigns to inform interested groups of the problems with the movement of genetic material of fish. NGOs as well as other conservation and rural-extension-interest agencies could also be involved in these efforts.

9. Conclusions and recommendations

9.1 Environmental concerns

Present levels of environmental modification do not appear to be causing any problems for the native fish fauna of the Mekong, although excessive fishing is causing classic signs of a fishing down of the species assemblage, especially in Cambodia. Plans for damming plus river training, together with growing pollution and the impact of encroachment of agriculture on the floodplains of the basin are likely to produce severe environmental stress in the future. Therefore, the present low impact of the introduced species is likely to change, as will the balance of existing native populations.

9.2 Establishment of species

The following introduced species now seem to have established breeding populations in all or part of the basin:

Cirrhinus cirrhosus
Clarias gariepinus
Gambusia affinis
Helostoma temminki (albino strain introduced from Indonesia)
Labeo rohita
Oreochromis mossambicus
Oreochromis niloticus
Poecilia reticulata
Pterygoplichthys plecostomus (more than one species may be present)

The following species have an ongoing presence for aquaculture; fry have been recorded, at times, from the Mekong main stream, indicating possible establishment:

Hypophthalmichtys molitrix (breeding in Northern Viet Nam rivers)
Aristichthys nobilis

The following species are used widely for aquaculture but have not shown any evidence of having established in the Mekong:

Ctenopharyngodon idella
Gilbelion (*Catla*) *catla*
Numerous aquarium species

9.3 Present impact

Most introductions recorded from the Mekong system appear to have been absorbed by native populations with little difficulty. Most do not form significant populations anywhere although *Oreochromis niloticus* may form a high proportion of catches in some dams and reservoirs. *Oreochromis mossambicus* is causing a nuisance in the coastal shrimp farms and waterways in Viet Nam by forming dense populations that are competing with the shrimp for food. The mosquito fishes *Poecilia* and *Gambusia* are everywhere in shallow fringing areas and drainage ditches. A specialized poor water quality fauna has emerged in urban habitats, which contains two introduced species *Hypostomus plecostomus* and *Oreochromis*.

Most of the species that have become established in the Mekong are fairly generalized feeders, usually preferring bottom living organisms and detritus. As this is the most widespread and common feed available in the basin, it probably does not cause any competition, despite the fact that many of the native species are also benthic feeders. Should this food source become limited because of restrictions to the floodplain, acceleration of flow preventing deposition, or inorganic sediment degrading the quality of the detritus, competition may increase with unpredictable results.

9.3.1 Negative impacts

Following an introduction or transfer, there are four categories of impact:

1. Severe effects causing economic or environmental damage
2. Establishment of species leading to local extinction of native species
3. Establishment of species with genetic mixing with local stocks, or production of viable hybrids between introduced and native species
4. Establishment of species with no noticeable impacts

The only impact noted that would fall into category 1 is the local damage to shrimp farms in the Mekong delta by *O. mossambicus*.

There is a possibility that *C. gariepinus,* together with the hybrid *Clarias,* may be producing declines in the native *C. batrachus* and that *Labeo rohita* may be affecting native labeos. However, until further evidence is forthcoming, the introduction of *C. gariepinus* should be regarded as a possible category 3 impact and that of *L. rohita* as a case of category 4.

Introductions of *Oreochromis* and *C. carpio* are of special interest, in that they are both well established in many areas and should be regarded as fully incorporated into local faunas. Their genetic status is complex because the species have been introduced in several waves of diverse origin. Much genetic mixing has occurred between these different strains (or even possibly different species), giving local stocks a distinct character that has yet to be evaluated. At present, these species seem to be classifiable as category 4.

Most other introductions pass without comment, although species such as *Hypostomus plecostomus* appear widespread in certain types of habitat, while guppies and mosquito fish are present in all suitable habitats. This would suggest that serious impacts have not been registered either officially or by local fishermen.

One cause for concern is the aquarium fish trade that is disseminating large numbers of exotic fish around the region, without any apparent control. Many of these species could potentially find their way into the local waters and establish themselves. Most such species are of no recorded danger but some, *Cichla ocellaris* for example, have caused local damage in other areas to which they have been introduced.

9.3.2 Positive impacts

On the positive side, several of the introductions are highly successful economically and socially. Thus, while native fishes are well acclimatized in natural reservoirs, introduced species (tilapias, hybrid clarias, *L. rohita,* and Chinese and Indian major carps) are preferred for aquaculture and stocking in reservoirs. Without major introductions, it is doubtful whether there would be a viable aquaculture industry of any size in the freshwaters of the region.

9.4 Potential impact

The present assessment is valid for existing levels of environmental impact in the Mekong. At present the river is not heavily impacted by river engineering or by pollution. Native species are therefore not heavily stressed by environmental effects and have shown themselves capable of adapting to those impacts which do exist, such as impoundment and pollution. However, many records of nuisance from introduced species in other areas of the world have coincided with excessive levels of environmental stress. Therefore, the present low impact scenario from introduced species cannot be guaranteed, should major changes occur in the future.

9.4.1 Negative impacts

Based on the history of other river basins, the following possible future negative impacts may arise if the Mekong River environment becomes degraded:

- A rise in abundance of the common carps in the river as a major element of the fauna;
- Development of stunted populations of tilapias in reservoirs;
- Emergence of an unforeseen pest species, drawn either from the native fauna or from existing and future exotics.

The niche filled by the pest may not be filled by native species. Thus, were the pest not there, there would be a net loss in productivity within the system and the risk of even greater biotic degradation.

Given the chaotic nature of current practices for species introductions and species movements within the basin, there is a serious risk of:

- Dissemination of diseases within the aquaculture sector;
- Degradation of the genetic quality of wild stocks and of the species and strains used for aquaculture.

9.4.2 Positive impacts

There is every sign that the capture fisheries within the basin will continue their present decline in quantity and quantity. In a region that is heavily dependent on fish, the anticipated shortfall can only be met from aquaculture. In Thailand, the culture sector already supplies a significant part of the consumption. In other areas of the basin, the sector is still relatively undeveloped, although there are signs of rapid expansion in Viet Nam. At present, aquaculture depends heavily on introduced species and, while these do not meet with universal approval in the face of competition with wild caught fish, tastes may change as the quality of the natural fish stocks declines. There appear to be few native species that can fully replace those already forming part of culture practice and the economic role of the exotic aquaculture species is expected to increase.

9.5 The aquarium fish sector

This sector is at present completely unregulated. Some controls are necessary in view of the potential of the trade to transmit diseases throughout the region, to introduce through escapes potentially troublesome species and to further confuse the genetic status of some species used in aquaculture. The trade is an important earner of foreign currency and attempts at imposing regulations may

lessen the competitive edge compared to other exporting countries. However, some degree of regulation, particularly with regard to disease certification, would improve the market image of fish exported from the basin. At present, farms rearing these fish have ready access to natural stocks of local fish species. Some control of potential escapes is also needed.

9.6 Suggestions for action

It is suggested that that the countries of the basin move towards establishing harmonized policies to reduce the risks of species introductions and transfers through:

- A Code of Conduct to reduce the negative impacts of future introductions of exotic species.
- Regional Guidelines on Quarantine and Health Certification
- Regional Guidelines on Broodstock management.

It is further suggested that education, training and extension be used to inform workers in the fisheries sector the general public of the dangers of unregulated movement of species, races or strains. Eventually, effective control of such movements will be through action by the people themselves rather than through centrally imposed laws.

Further studies of the fisheries sector should clearly report any introduced species found in the catch. In addition, other workers in fisheries, such as aquaculturists and fishermen, should be encouraged to record any exotic species found in natural waters.

These studies could be supplemented by a workshop bringing scientists from the region together to assess the present impact of introduced species within aquaculture and on the natural environment. Both Thailand and Viet Nam, for instance, have much more information on these topics than could be developed in this report. An initiative of this type could provide the basis for a network to compile information and establish a basin-wide database on species introductions, their economic evaluation and impact assessment.

The genetic status of certain species that are crucial for aquaculture, particularly *Oreochromis* and *Cyprinus,* is now very confused. Studies to identify and determine the origins and affinities of wild stocks and cultured stocks of these species groups are urgently needed, particularly as more strains are being added to the local gene pools.

It is considered a matter of urgency that better controls of the aquarium fish trade be established. These should include health certification and measures to reduce the chances of fishes escaping from aquarium fish-rearing installations.

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ANNEX I

Extract from http://www.fao.org/fi/statist/fisoft/dias/index.htm showing species introduced into countries of the Mekong basin.

The introductions listed have not all been made into the basin itself.
This and other information in this report may be based on outdated and superseded information. If the reader is aware of this it would be appreciated if they could amend the database at the website above using the form provided.

Species	Introduced from	Year	Reason	Established in the wild	Established through	Use for aquaculture	Ecological impact	Socio economic impact
Cambodia								
Clarias gariepinus	Viet Nam	1982	aquaculture	unknown	unknown	widely used	probably yes	beneficial
Oreochromis mossambicus	unknown	unknown	aquaculture	unknown	unknown	widely used	unknown	beneficial
Oreochromis niloticus	unknown	unknown	aquaculture	unknown	unknown	widely used	unknown	beneficial
Pomacea canaliculata	Asia	1990s	aquaculture	unknown	unknown	rarely used	adverse	adverse
Lao PDR								
Catla catla	Thailand, India	1977	aquaculture	yes	natural reprod'n	rarely used	unknown	Unknown
Cirrhinus cirrhosus	Thailand, India	1977	aquaculture	yes	natural reprod'n	rarely used	unknown	unknown
Clarias gariepinus	Viet Nam	1980	aquaculture	unknown	unknown		unknown	unknown
Cyprinus carpio	Thailand, India	1977	aquaculture	unknown			unknown	unknown
Labeo rohita	Thailand, India	1977	aquaculture	unknown		rarely used	unknown	unknown
Oreochromis mossambicus	Thailand	1955	unknown	unknown	unknown		unknown	unknown
Oreochromis niloticus	unknown	unknown	aquaculture	unknown	unknown	widely used	unknown	beneficial
Pomacea canaliculata	Asia	1992	ornament /aquaculture	unknown		unknown	adverse	adverse

Species	Introduced from	Year	Reason in the wild	Established through	Established aquaculture	Use for	Ecological impact	Socio economic impact
Thailand								
Anguilla japonica	Japan	1973	aquaculture	no		rarely used	unknown	unknown
Carassius auratus	China	1692-1697	ornament	yes	natural reprod'n			
Carassius carassius	Japan	1980	aquaculture	probably no		rarely used	unknown	unknown
Catla catla	Bangladesh	1979	aquaculture	probably no		rarely used	unknown	unknown
Cichlasoma octofasciatum	Brazil Amazon R.	1950s	ornament	yes	natural reprod'n	unknown	probably yes	beneficial
Cirrhinus cirrhosus	Japan	1980	aquaculture	probably no		rarely used	unknown	unknown
Clarias gariepinus	Laos	about 1987	aquaculture	probably no			unknown	unknown
Clarias macrocephalus	unknown	unknown	aquaculture	unknown		unknown	unknown	unknown
Ctenopharyngodon idella	China and Hong Kong	1932	aquaculture	probably yes	continuous restocking	rarely used	unknown	unknown
Cyprinus carpio carpio	China, Japan, Israel and Germany	1913 +	aquaculture	yes	natural reprod'n	widely used	probably yes	beneficial
Gambusia affinis affinis	unknown	unknown	mosquito control	yes	natural reprod'n		unknown	unknown
Gymnocorymbus ternetzi	Paraguay and Argentina	1950s	ornament	yes	natural reprod'n	unknown	unknown	
Hypophthalmichthys molitrix	China	1913	aquaculture	no		rarely used	unknown	unknown
Hypophthalmichthys nobilis	China	1932	aquaculture	probably yes	continuous restocking	rarely used	unknown	unknown
Ictalurus punctatus	USA	1989	aquaculture	unknown		unknown	unknown	unknown
Labeo rohita	India	1968	aquaculture	probably no		rarely used	unknown	unknown
Mylopharyngodon piceus	China/Hong Kong	1913	aquaculture	no			unknown	unknown
Oncorhynchus mykiss	Canada	1973	aquaculture	no				
Oncorhynchus rhodurus	Japan	1981	aquaculture	no				
Oreochromis aureus	Israel	1970	aquaculture	yes	natural reprod'n	rarely used	unknown	unknown
Oreochromis mossambicus	Malaysia	1949	aquaculture	yes	natural reprod'n		unknown	unknown
Oreochromis niloticus	Japan	1965	aquaculture	yes	natural reprod'n	rarely used	unknown	unknown
Osphronemus goramy	unknown	unknown	unknown	probably no			unknown	unknown
Pomacea canaliculata	Taiwan	1990	ornament/aquaculture	yes	natural reprod'n	adverse	Adverse	
Pomacea gigas	Taiwan	unknown	unknown	yes	natural reprod'n		adverse	unknown
Procambarus clarkii	USA	ca 1987	aquaculture	yes	natural reprod'n		adverse	unknown
Rana catesbeiana	USA.	1977	aquaculture	yes	natural reprod'n		adverse	unknown
Tilapia rendalli	Belgium	1955	aquaculture	probably yes	natural reprod'n	rarely used	unknown	unknown

Species	Introduced from	Year	Reason in the wild	Established through	Established aquaculture	Use for	Ecological impact	Socio economic impact
Viet Nam								
Carassius auratus	China	unknown	aquaculture	unknown	unknown		unknown	unknown
Catla catla	Laos	1984	aquaculture	yes	natural reprod'n	widely used	undecided	undecided
Cirrhinus cirrhosus	Laos	1984	aquaculture	yes	natural reprod'n	widely used	beneficial	beneficial
Clarias gariepinus	Central Africa	1974	aquaculture	yes	natural reprod'n	rarely used	undecided	undecided
Ctenopharyngodon idella	China	1958	aquaculture	yes	both	widely used	beneficial	beneficial
Cyprinus carpio	Hungary	1969, 1975	aquaculture	yes	natural reprod'n	widely used	beneficial	beneficial
Hypophthalmichthys molitrix	China	1958	aquaculture	yes	both	widely used	beneficial	beneficial
Hypophthalmichthys nobilis	China	1958	aquaculture	probably yes	natural reprod'n	widely used	beneficial	beneficial
Ictalurus nebulosus	USA probably	unknown	unknown	unknown	unknown		unknown	unknown
Labeo rohita	Thailand, Laos	1982, 1984	aquaculture	yes	natural reprod'n	widely used	beneficial	beneficial
Mylopharyngodon piceus	China	unknown	aquaculture	yes	continuous restocking	rarely used	unknown	unknown
Oreochromis mossambicus	Africa, Philippines	1951,1955	aquaculture	yes	natural reprod'n	widely used	beneficial	beneficial
Oreochromis niloticus	Taiwan (Prov. of China), Philippines, Thailand	1973, 1994	aquaculture	yes	natural reprod'n	widely used	beneficial	beneficial

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