Avlsarbeid
- kan det baseres på lokale fiskestammer?
Hva er GIFT-stammen?
Hvordan vil oppdrettsfisk påvirke ville stammer, genetisk?

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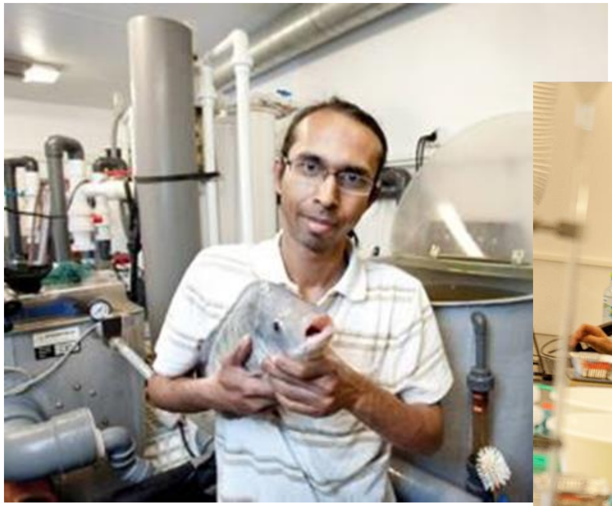
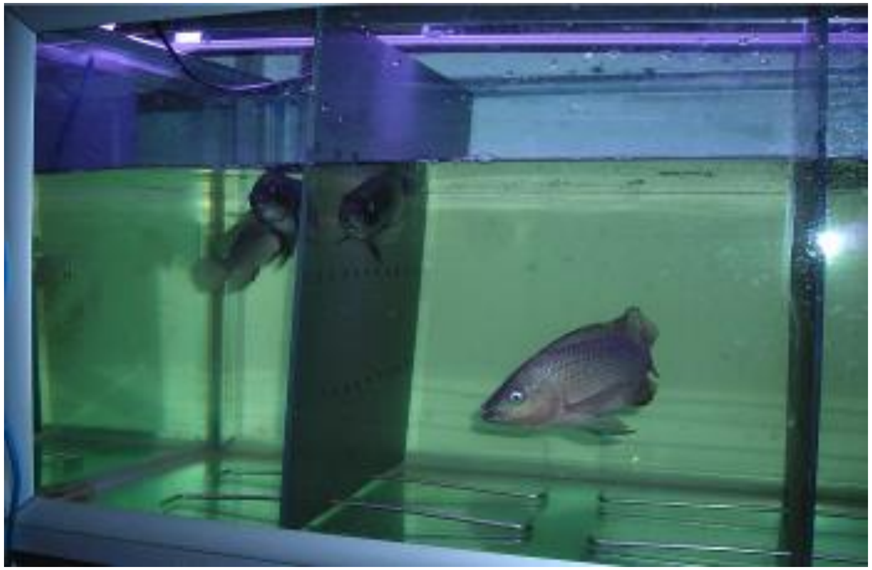
27.09.2017

AQUACULTURE
AT
THE NORWEGIAN UNIVERISTY OF LIFE SCIENCES



- a long history, both national and international

Example of use of tilapia in our fish-lab:
Testing aggressive / submissive behaviour

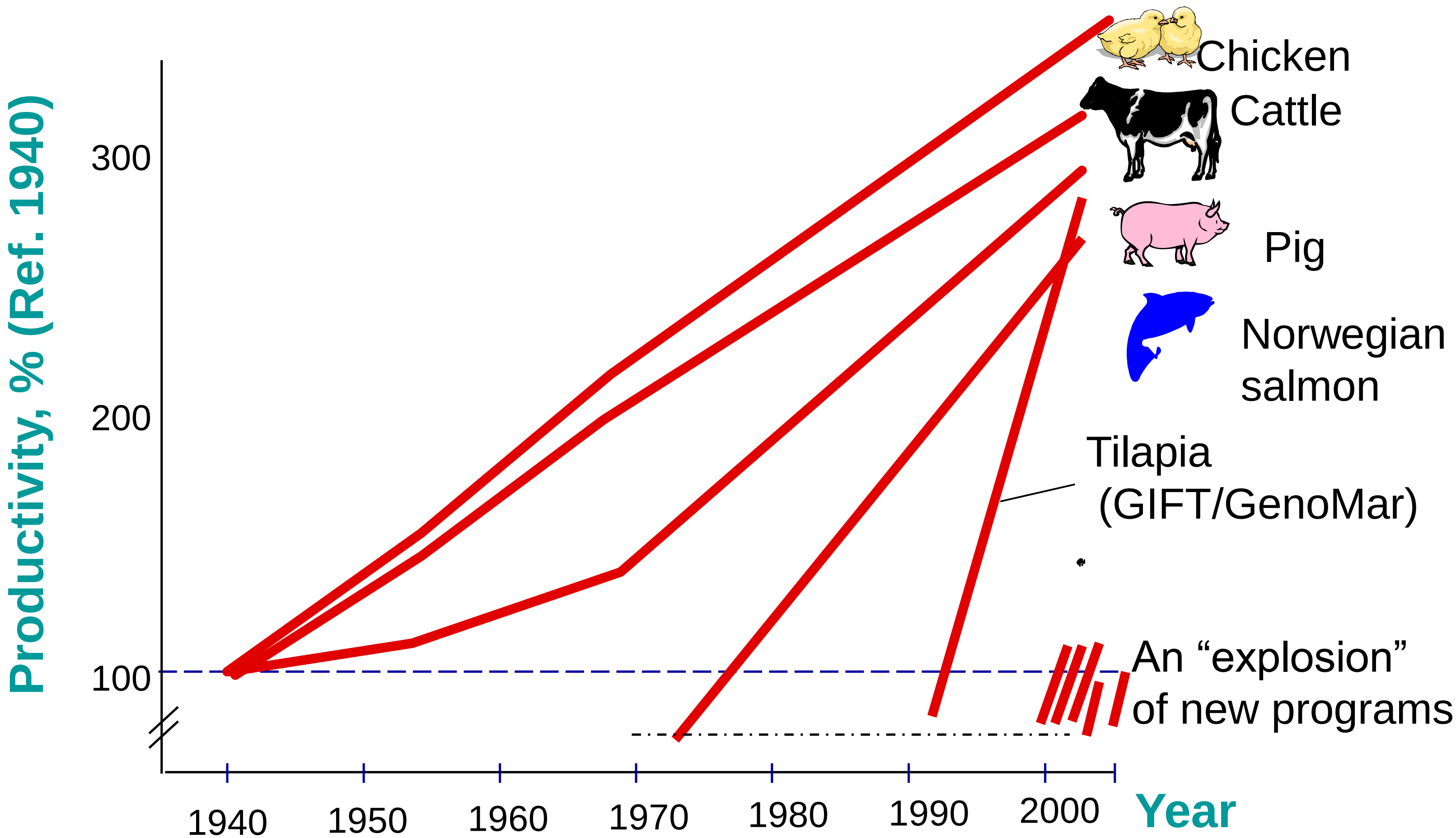


Large and small fish together → stress

Time and amount of feed
- after stressor

(Pham , 2007)

Productivity development for the most important cultured animal species since 1940



(Modified after Eknath et al., 1997)

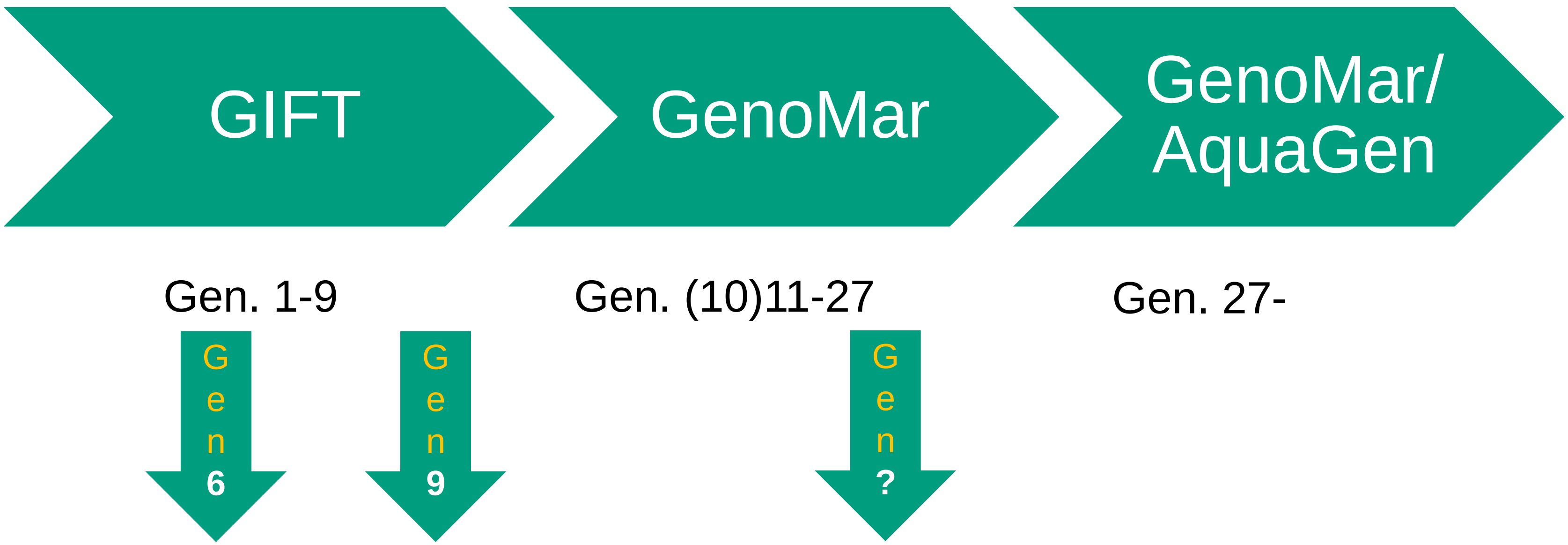
Research in tilapia – a Norwegian tradition

1988 – 1998:
the GIFT Project – UNDP/ADB. Akvaforsk had the main responsibility for the breeding program for 9 generations

1998 – :
GIFT Foundation/GenoMar agreement: GenoMar is given commercial rights and scientific responsibility for the continued development of the GIFT-strain, now called GST → 27 generations

H.M. Gjøen at NMBU has been scientifically responsible for the program

Broad history and distribution of the GIFT-strain



Distributed widely

Limited copy transferred to WorldFish

Some “leakage” to competitors

Establishment of base population for long term genetic improvement of Nile tilapia in Ethiopia

Kassaye Balkew Workagegn

Supervisors: Prof. Hans Magnus Gjøen (NMBU)
Prof. Gunnar Klemetsdal (NMBU)
Dr. Elias Dadebo (HwU)

Cont...

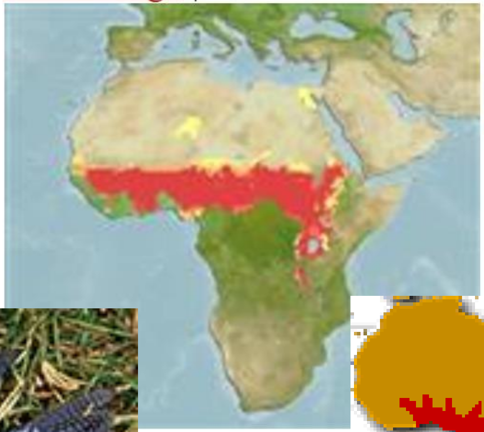
- About 200 fry per family were collected for both generations
- After a month, the number of fingerlings reduced to 100 per family and transferred to nursery hapa to rear until tagging
- When the size of fingerlings reached to an average size of 25g, about 20-30 fingerlings per full-sib family were tagged using Passive Integrated Transponder (PIT) Tags
- After tagging, the fish were randomly divided into four groups and then stocked in the two production systems, Lo-P and Hi-P, in duplicates for both generation

The average realized genetic gain for harvest body weight after 1 generation was 13.4%.

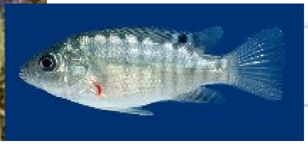
Genetic enhancement of *Oreochromis Mossambicus*

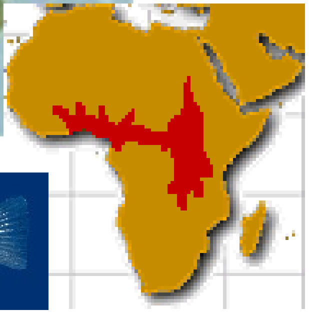
MSc-project in Mozambique
MSc student Guillermo Torres Arjona is engaged in the project "*Establishing a genetic platform and starting a selective breeding program for the tilapia species Oreochromis mossambicus in Mozambique*", which is supported by the Centre for Dev. Cooperation in Fisheries, CDCF (HI/Norad). The breeding program is operated by CEPAQ (Centro de Pesquisa em Aquacultura).

Nile tilapia
– from Africa to the entire world



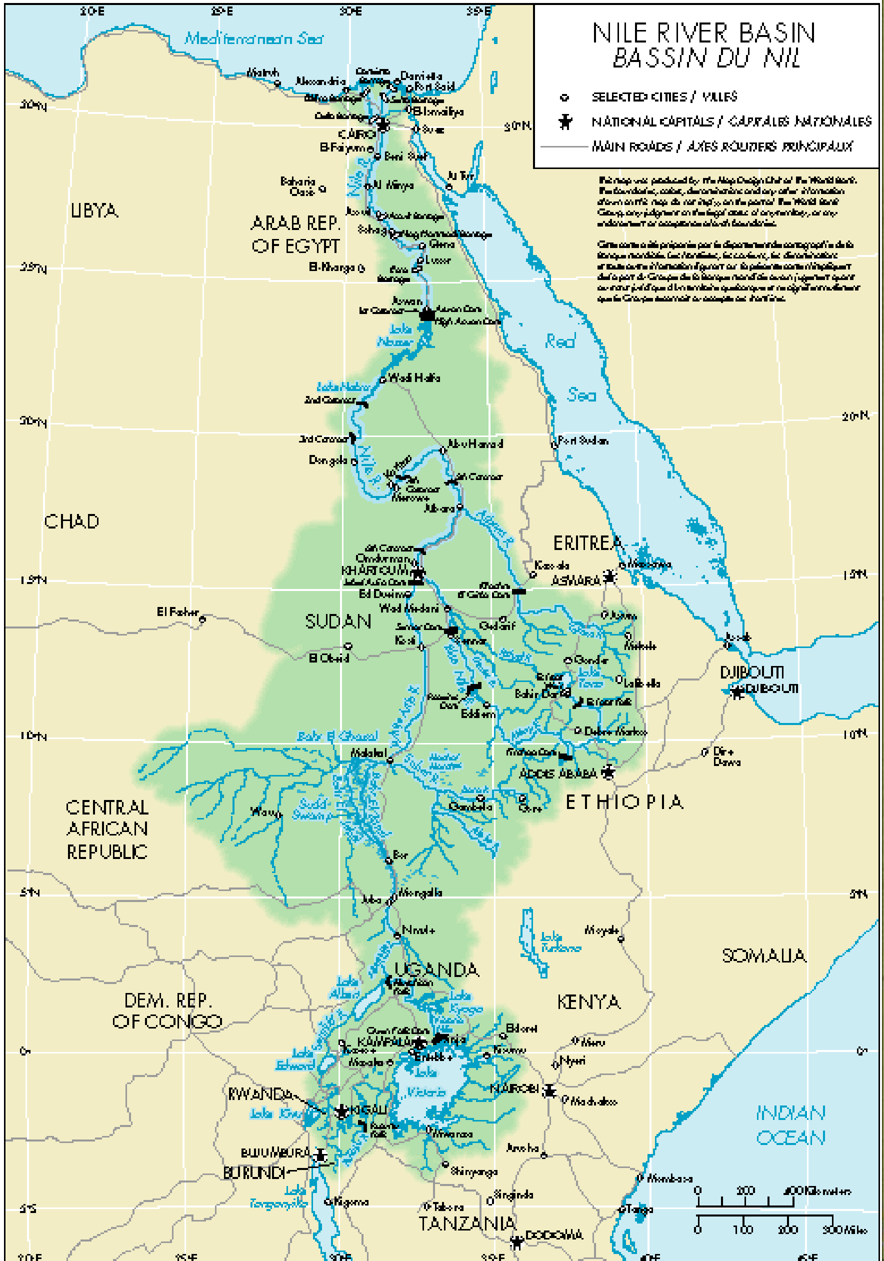
Fishbase.org

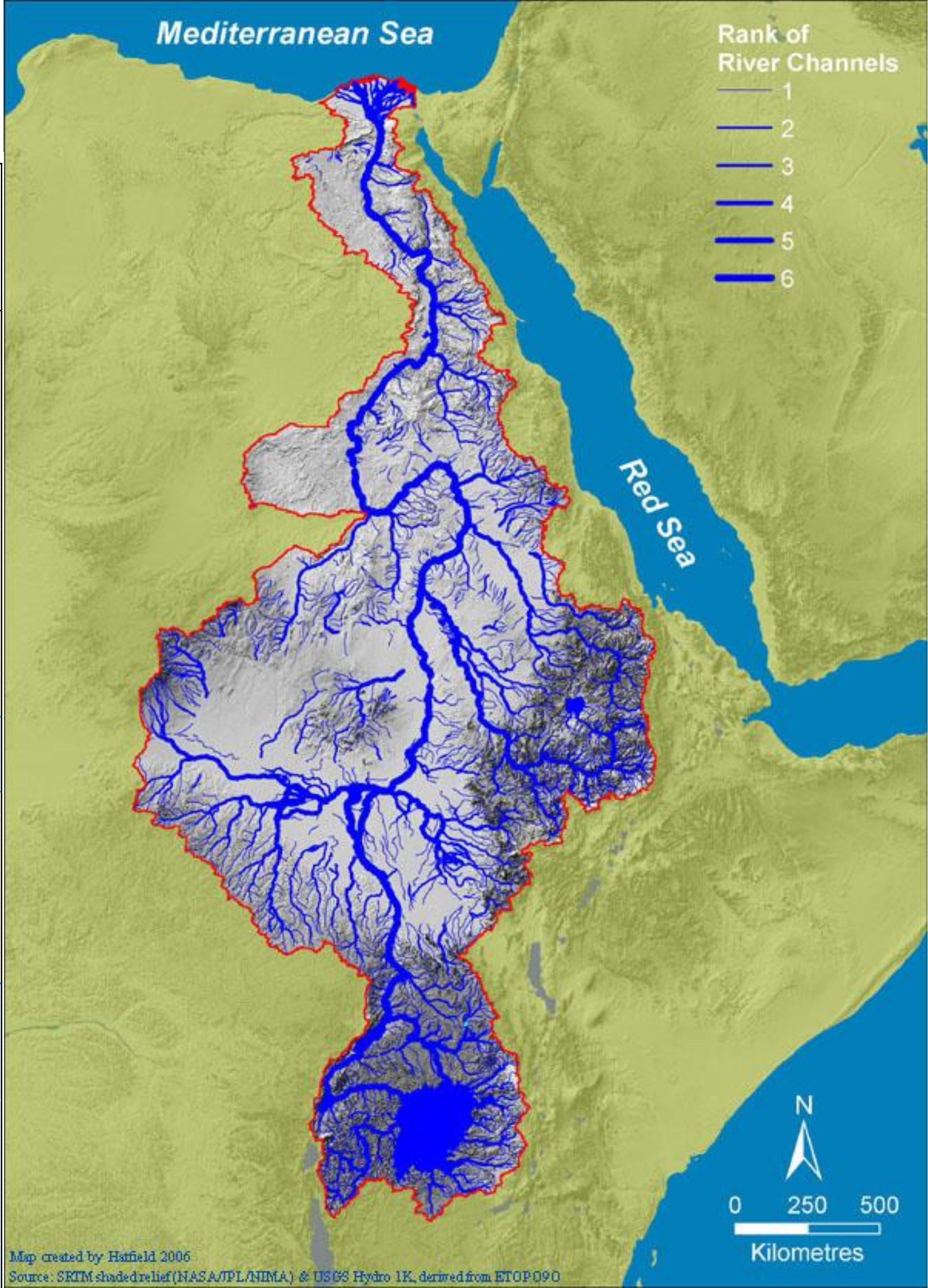




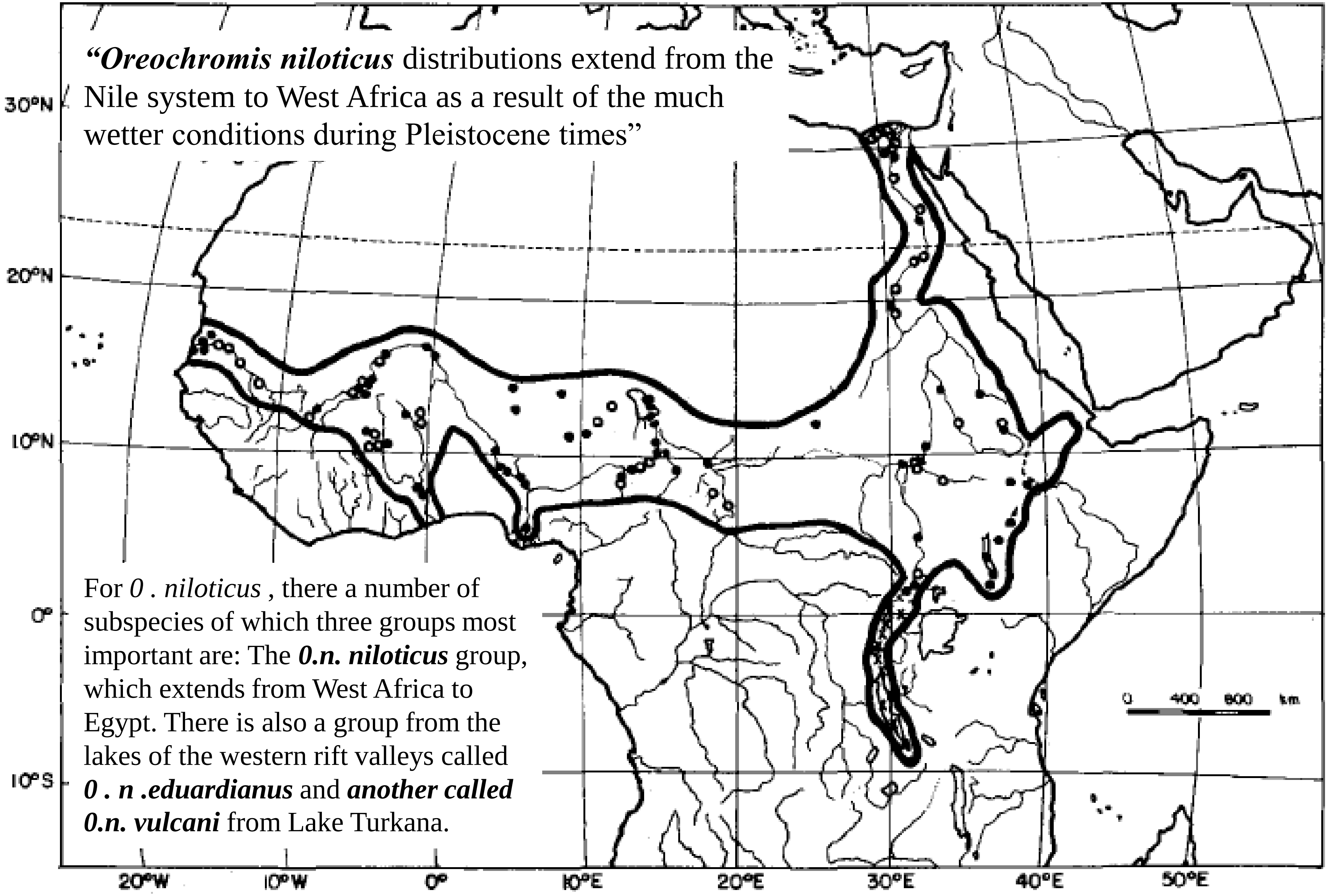
- Originates from Africa, but has now been distributed to almost every part of the world
- A lot of escapees have been reported and in many places tilapia will replace the local species (more aggressive and fast growing)
- Local government will most often accept this (exception: India up until recently)

The Nile basin





"Oreochromis niloticus distributions extend from the Nile system to West Africa as a result of the much wetter conditions during Pleistocene times"



For *0 . niloticus* , there a number of subspecies of which three groups most important are: The ***0.n. niloticus*** group, which extends from West Africa to Egypt. There is also a group from the lakes of the western rift valleys called ***0 . n .eduardianus*** and ***another called 0.n. vulcani*** from Lake Turkana.

Fig. 8. Distribution of *Oreochromis niloticus niloticus:* black dots (●) indicate samples checked personally by the author; white dots (○) indicate published records regarded as reliable. Distribution of the subspecies *O.n. eduardianus* (x) is also shown. (cf. p. 15 and Appendices I and III – Editor). (Thys van den Audenaerde. In: Tilapia genetic resources for aquaculture. ICLARM Conference Proceedings 16. International Center for Living Aquatic Resources Management, Manila, Philippines 1988)

Implications for tilapia nomenclature

There are some implications here for tilapia nomenclature. It reflects the natural situation, not the world of aquaculture. A species is never stable in nature. It may die out or spread to form other species. In taxonomy, species with a very restricted distribution are considered 'young' species and those with a wider distribution are considered 'old'. Once a species has a very wide distribution it may 'fall apart'. This happens frequently with fish species when water bodies become mutually isolated and the separate populations change through new mutations and genetic flux. The recognition of the level of differentiation necessary to assign a given population to a new species, subspecies or strain is a matter of opinion and controversy amongst taxonomists - the classic splitters vs. lumpers debate. It has been observed for some fish, amphibians, birds and even monkeys that when previously reproductively isolated allopatric species are brought together by, for example, geological events, they sometimes start interbreeding. This confusing situation has led to the concept of a 'supraspecies' - a widely distributed species that is 'falling apart', the isolated components of which do not freely interbreed unless brought together by some hazard or event.

(Thys van den Audenaerde. In: Tilapia genetic resources for aquaculture. ICLARM Conference Proceedings 16. International Center for Living Aquatic Resources Management, Manila, Philippines 1988)

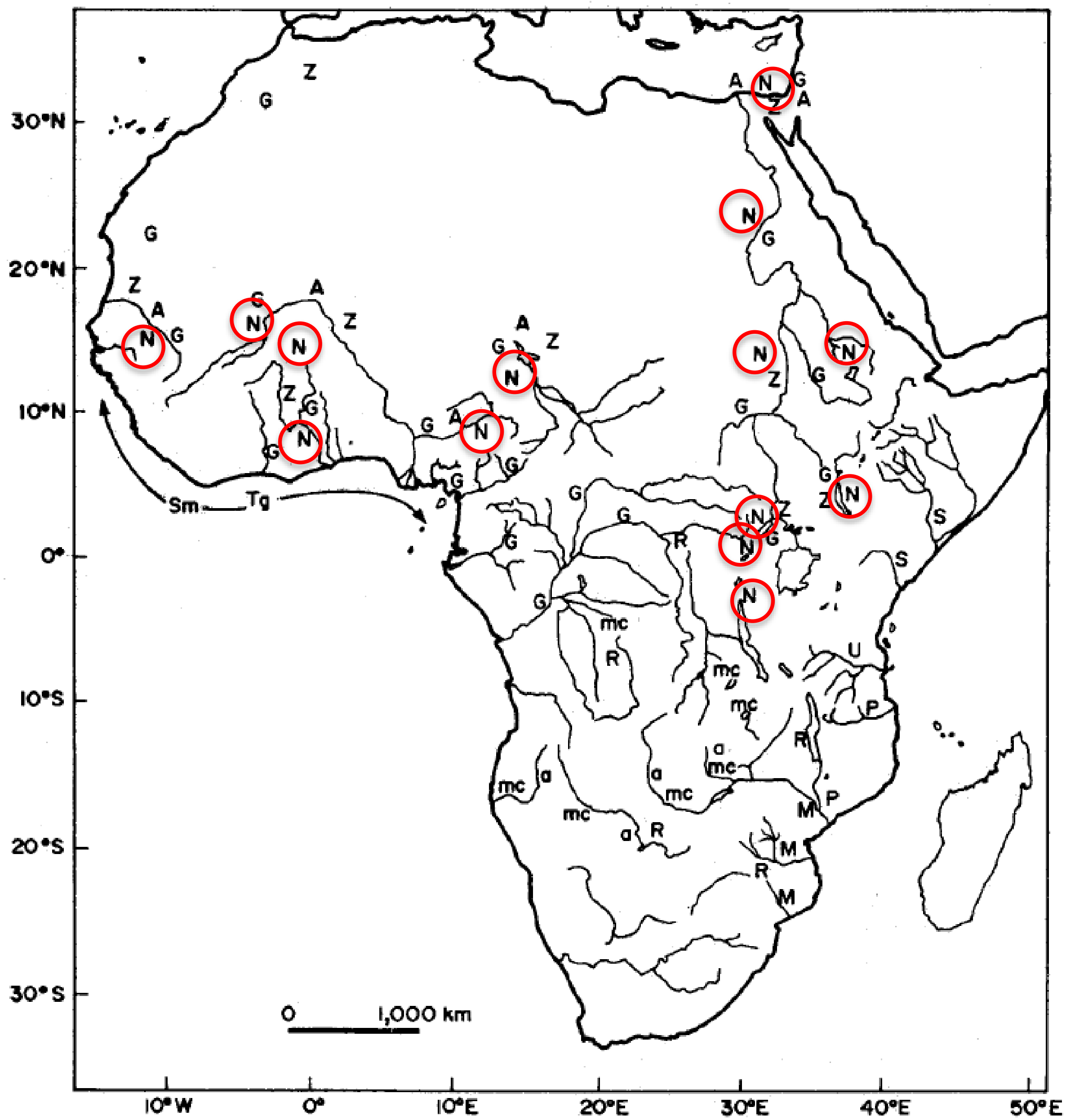


Fig. 13. The natural distributions of tilapias used in aquaculture. The species *Oreochromis niloticus* (N), *O. aureus* (A), *Sarotherodon galilaeus* (G) and *Tilapia zillii* (Z) all have a Soudanian distribution from West Africa to the Nile valley. *O. aureus*, sympatric with *O. niloticus* in the Nile delta, extends to the Jordan valley. *T. rendalli* (R) is a southern form, widely distributed in Central Africa, as is *O. macrochir* (mc) and *O. andersonii* (a). *S. melanotheron* (Sm) and *T. guineensis* (Tg) inhabit West African coastal lagoons. Distributions of east-flowing river species (including *O. spilurus* (S), *O. urolepis* (U) and *O. mossambicus* (M)) are shown in Fig. 15. Data from Trewavas (1983).

Tilapia species are intermixed in much of Africa.

(Lowe-McConnell. In: Tilapia genetic resources for aquaculture. ICLARM Conference Proceedings 16. International Center for Living Aquatic Resources Management, Manila, Philippines 1988)

Lake Kariba

There have been many undocumented introductions of tilapias to Zimbabwe. For example, ***0. andersonii*** was introduced in the 1950s, but no one had details of the introduction. It may have become mixed in with many populations of ***0. mortimeri*** and ***0. mossambicus.*** The descendants of the introductions have vanished (Jubb 1974; Toots 1969).

Lake Kariba was filled by 1963. It was assumed that it would support very few tilapia because very few had been caught in the pre-impoundment surveys on the river. However, as soon as the lake was filled, ***0. mortimeri*** flourished - breeding prolifically and growing to large sizes. Again, because of the poor tilapia catches in pre-impoundment surveys, an introduction was made of fish from the Chilanga Fish Culture Station, Zambia (the 'Chilanga cocktail').

These were intended to be ***0. macrochir*** on the premise that this species is lacustrine in Lake Mweru and would do well in Lake Kariba. It is not known why no attempt was made to import from Lake Mweru directly. The introduction contained, in addition to ***0 . macrochir, 0. andersonii*** and many other cichlids (haplochromines, ***Serranochromis*** spp., etc.). ***0. andersonii*** from the Kafue River has also been used in farm dams with drainage into Lake Kariba from the north.

Therefore the lake now has a whole host of introduced species. ***0 . macrochir*** is rarely caught in the lake. Very large fish that are neither ***0. mortimeri*** nor ***0. macrochir*** are occasionally taken by fishermen. These are possibly hybrids. Commercial aquaculturists are now planning to introduce ***0. niloticus*** and ***0. aureus.***

(Marshall. In: Tilapia genetic resources for aquaculture. ICLARM Conference Proceedings 16. International Center for Living Aquatic Resources Management, Manila, Philippines 1988)

Lake Victoria

"Lake Victoria originally had two naturally occurring species - *0. esculenhls* and *0. variabilis*. It was then stocked with T. *zillii* from Lake Albert, the intention being to introduce a herbivorous species to eat the abundant marginal vegetation. However, the shipment of T. *zillii* also included (unintentionally) some *0. niloticus* and *0. leucostictus*. Moreover, some culture trials were made with *0. niloticus* at Kajansi, Uganda, in an area that drains into Lake Victoria and *0. niloticus* probably got into the lake from this source as well. Therefore Lake Victoria received first the subspecies *0.n. eduardianus.* Verbal reports suggest that further introductions have been made from Lake Turkana *(0.n. vulcani). 0. niloticus* were also seen in 1967 in the Mwanza prison ponds bordering the south end of the lake (A.I. Payne, pers. comm.). [Despite its displacement by *0. niloticus* in Lake Victoria, *0. esculentus* now predominates over the naturally occumng *0, pangani* and *0. jipe* following its introduction into the Nyumbaya Mungu dam on the Pangani River, west Tanzania (A.I. Payne, pers. comm. to Editor)].

(Lowe-McConnell. In: Tilapia genetic resources for aquaculture. ICLARM Conference Proceedings 16. International Center for Living Aquatic Resources Management, Manila, Philippines 1988)

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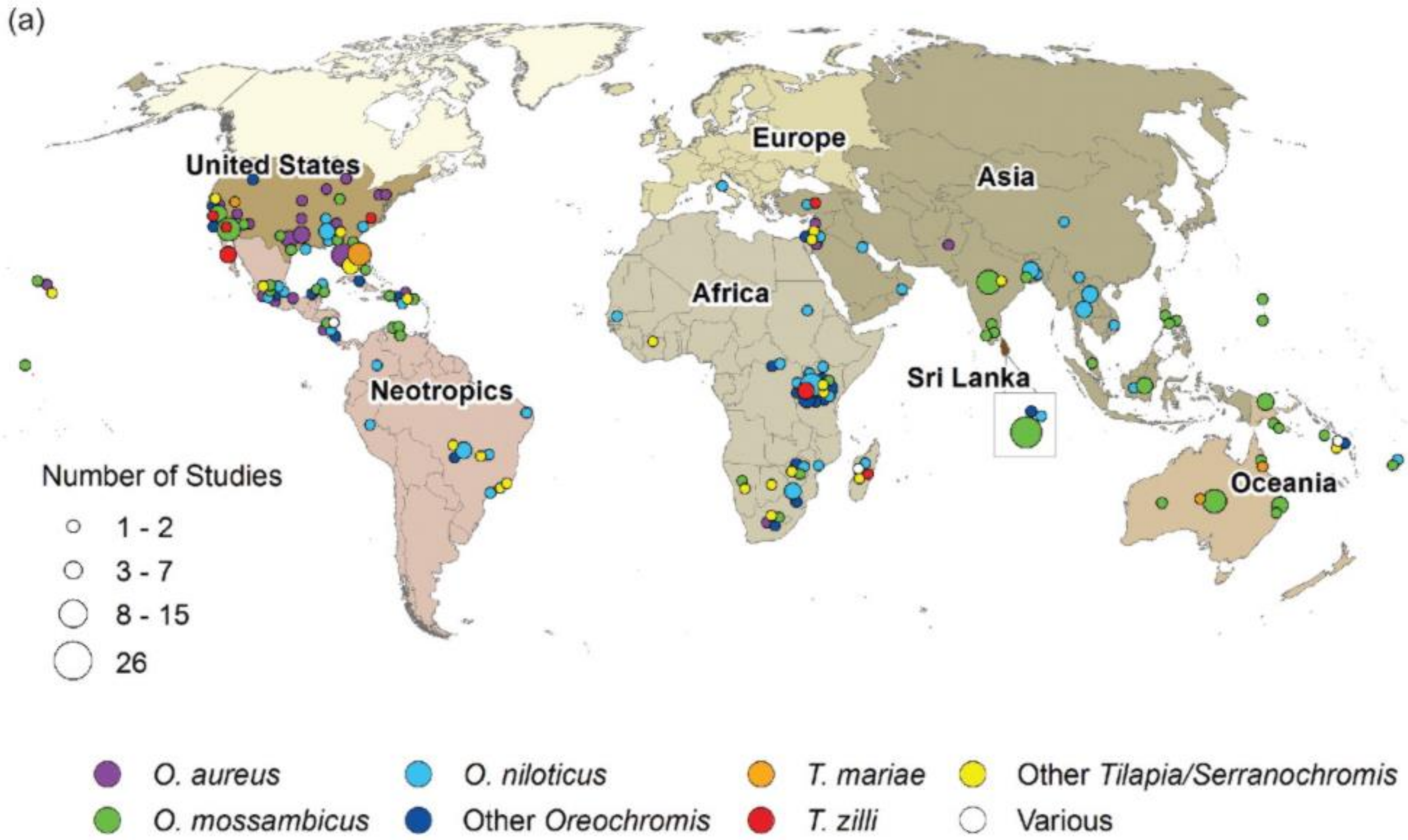
Tradeoffs among Ecosystem Services Associated with Global Tilapia Introductions

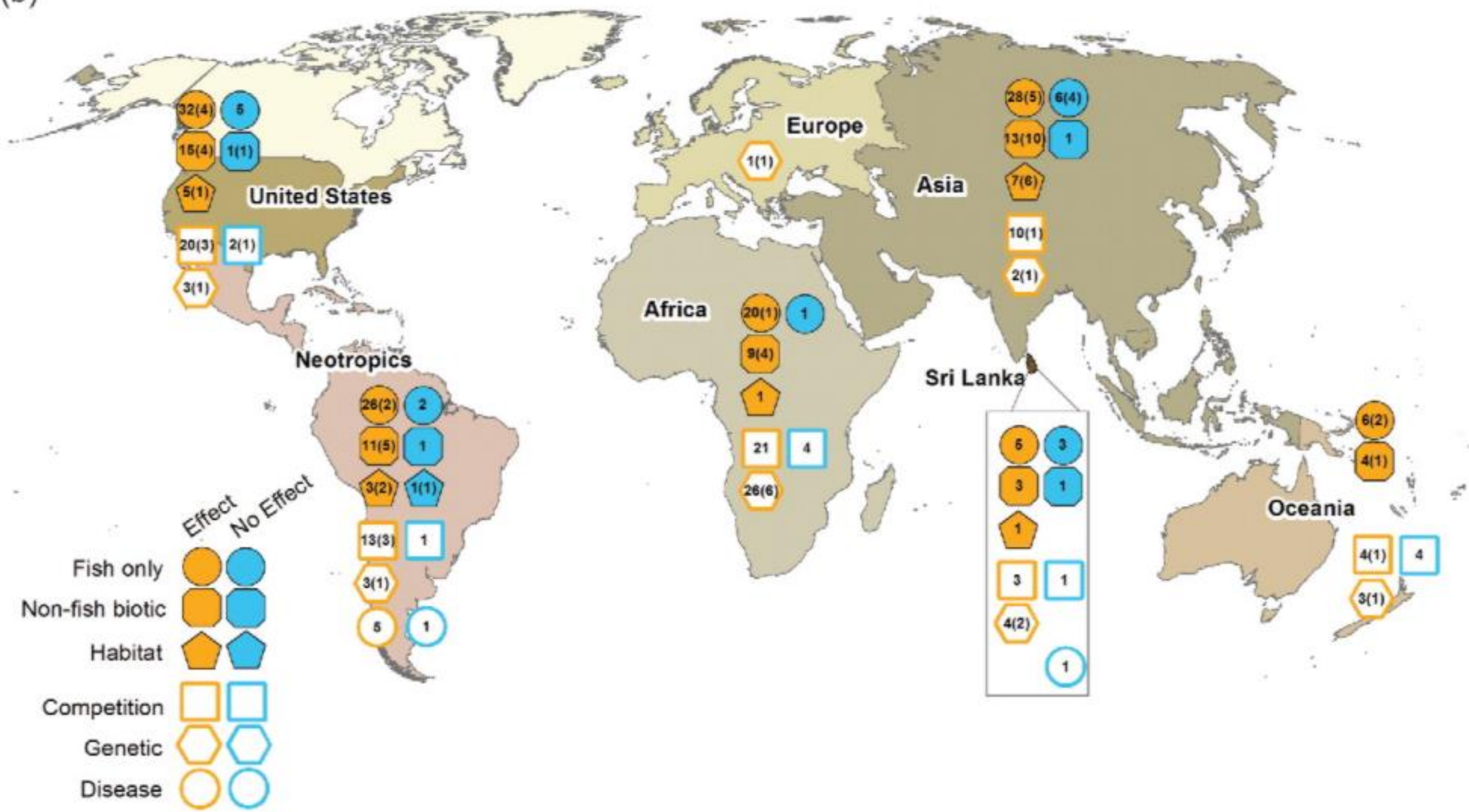
Andrew M. Deines, Marion E. Wittmann, Jillian M. Deines & David M. Lodge

Figure 1 of 4

Figure 1. (A) Map of the global distribution of reports on the ecological effects of tilapia introduction by focal species in each publication. Locations were mapped to specific waterbodies when possible, or placed in the geographic center of the country or state/province where the study took place and offset to limit overlap. (B) Map of reported ecological effects (solid symbols) and mechanisms (hollow symbols) by region. Numbers within symbols indicate the total number of studies reporting that effect or mechanism, while the number in parenthesis indicates the number of studies which report that effect and use quantitative data, and controls or reference treatments.



(b)


United States
32(4)
5
15(4)
1(1)
5(1)
20(3)
2(1)
3(1)
Europe
1(1)
Asia
28(5)
6(4)
13(10)
1
7(6)
10(1)
2(1)
Africa
20(1)
1
9(4)
1
21
4
26(6)
Neotropics
26(2)
2
11(5)
1
3(2)
1(1)
13(3)
1
3(1)
5
1
Sri Lanka
5
3
3
1
1
3
1
4(2)
1
Oceania
6(2)
4(1)
4(1)
4
3(1)
Effect
No Effect
Fish only
Non-fish biotic
Habitat
Competition
Genetic
Disease

Conclusion

•This review quantitatively demonstrates that tilapia introductions often represent a tradeoff between ecosystem services provided by tilapia and services which are negatively affected by tilapia.

•It is unequivocal that tilapia are frequently associated with undesirable ecological changes in many areas.

•There is not a global consensus on the socio-economic merits of tilapia introduction

•It is recommend that decisions be informed by comparisons of the regional and local economic benefits to the regional ecological costs now and in the future.

•While the ecological effects may be similar over much of the introduced range of tilapia, there is no reason to expect uniform socioeconomic benefits.

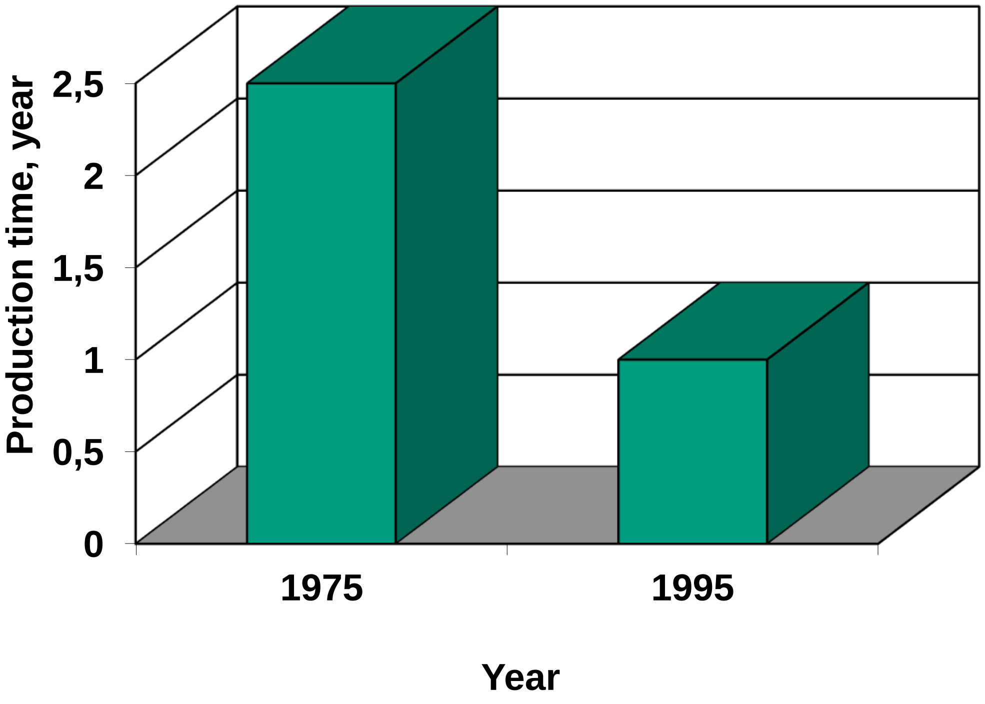
•Only about half of all tropical countries have at least one established, feral, tilapia population, i.e. an introduced wild population of tilapia.

My conclusion: we should not contribute to the spread of an invasive species,
→ base the breeding program on local strains,
since 100% faster growth can be obtained in 3 generations

Aquaculture and breeding may represent a pro for the maintenance of genetic diversity

- One of the reasons for starting up the GIFT project in the Philippines was to decrease the pressure on wild populations due to fisheries.

Why bother with breeding?

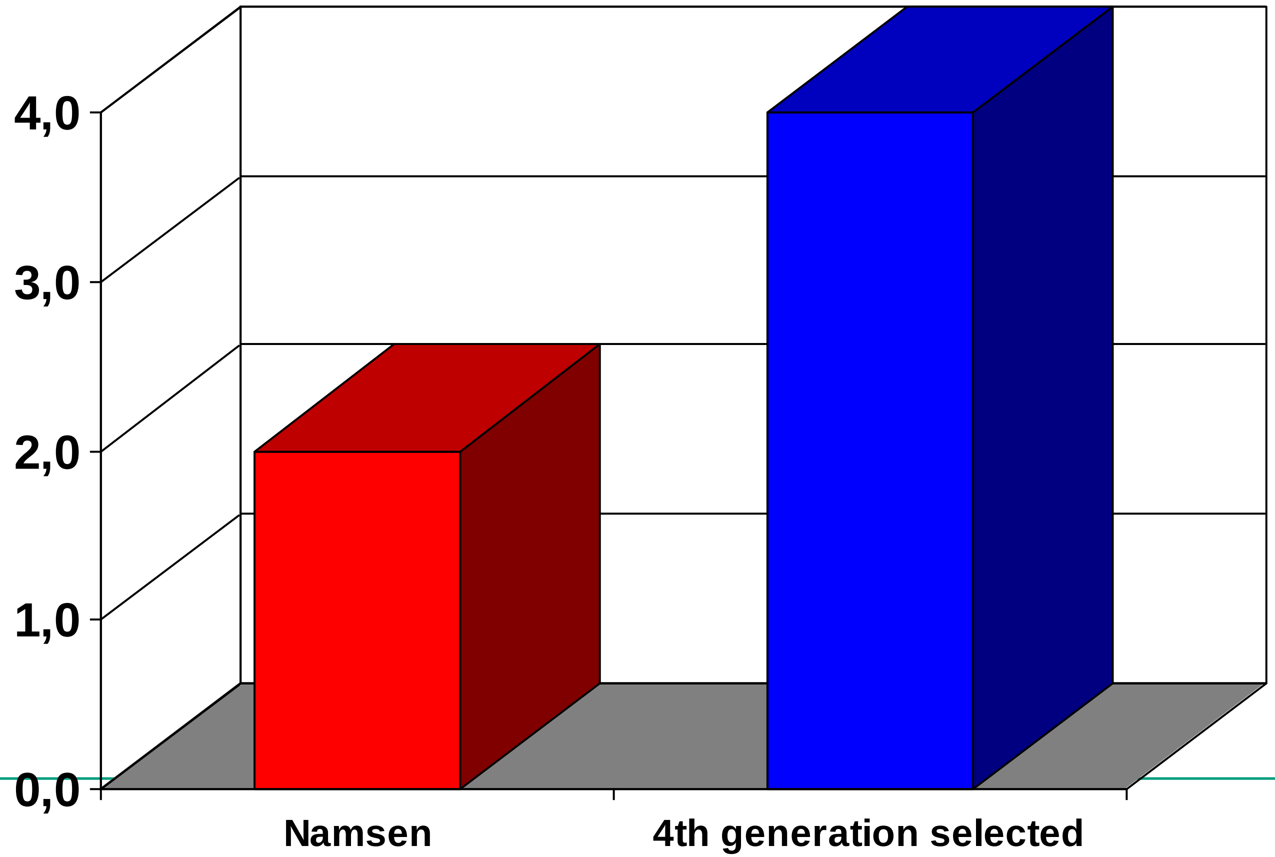


Time needed in sea to get a salmon to 3.5 kg

- Breeding has probably been the single most important factor for the success of Norwegian salmon industry

Growth for wild and selected salmon (sea-period)

Growth of salmon in sea-water:



Details of Nile tilapia *(Oreochromis niloticus)* germplasm collected by the GIFT Project from Africa.

Strain Code	Collection sites	Date	Numbers collected
E1	Egypt		
	(First Collection)	May 1988	
	1) Lake Manzallah		30 breeders
	2) Creeks along Desert road to Port Said		25 breeders
	3) Lakes around Alexandria		70 fingerlings
E2	Egypt		
	(Second Collection)		
	1) Abassa	August 1989	60 breeders
	2) Ismailia		90 breeders
E3	Egypt		
	(Third Collection)		
	1) Monsour	October 1992	22 breeders
	2) Manzalla		41 breeders
	3) Timsah Lake		63 fingerlings
	4) Ismailia		7 fingerlings
	5) Abassa		153 fingerlings
	6) Mariut		266 fingerlings
	7) Suez Canal		4 breeders
	8) Idku		10 breeders
Gh	Ghana		
	Volta River System	October 1988	200 fingerlings
Ke	Kenya		
	First generation progeny from a founder stock collected in August 1988	August 1989	800 fingerlings
Se	Sénégal		
	1) Dagana	October 1988	120 breeders
	2) Dakar-Bangos		40 breeders
	3) Mbane		40 fingerlings

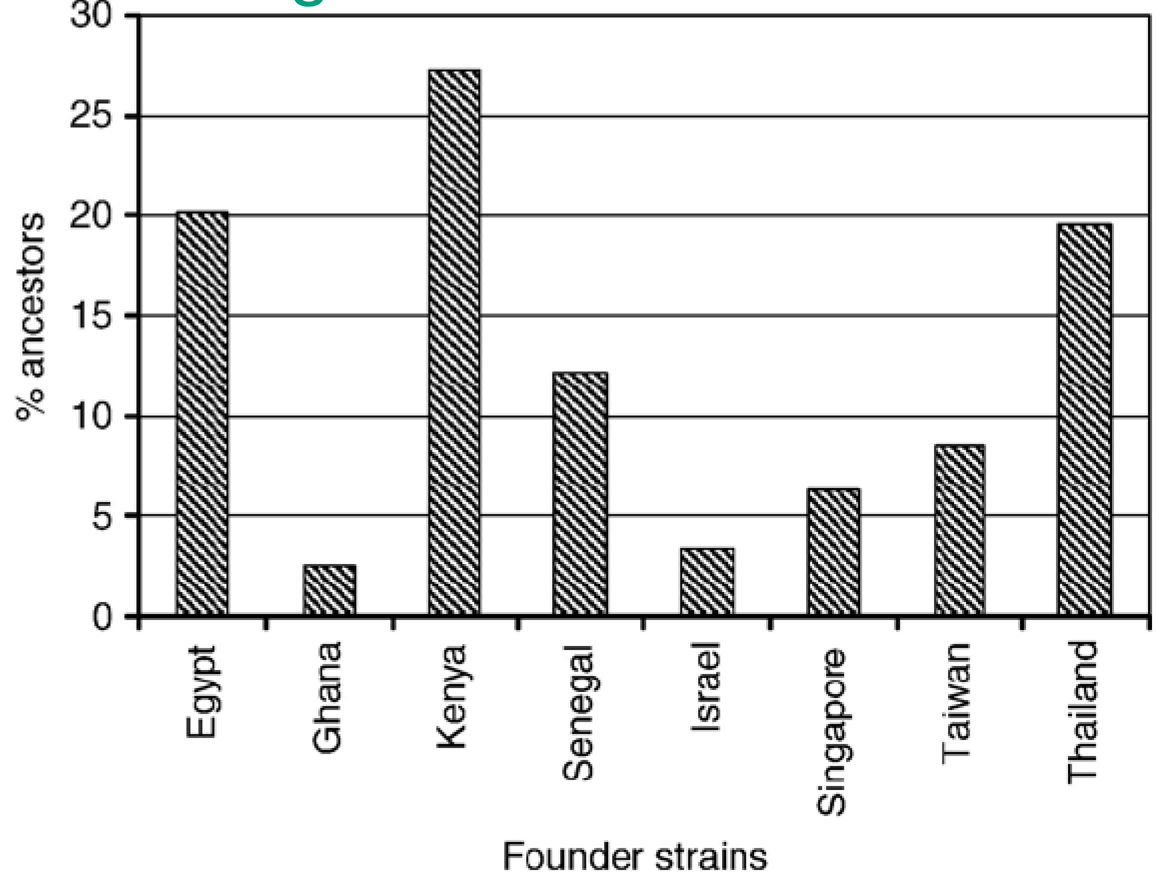
GENETIC IMPROVEMENT OF FARMED TILAPIAS (GIFT) PROJECT

FINAL REPORT 1998

Origin of the four farmed Nile tilapia *(Oreochromis niloticus)* strains used by the GIFT project in the Philippines.

Strain Code	Popular name	Origin
Is	Israel	Derived from founder stocks of Ghana origin kept in Israel. The original founder stock (1974) was 9 females and 2 males. Fry from 100-200 single pair mating shipped to the Philippines in 1979.
Si	Singapore	Descended from a founder stock of Ghana origin shipped from Israel to Singapore, then to the Philippines in 1979.
Th	Thailand	Egypt origin. Introduced in the Philippines from Thailand in 1987. The Thailand founder stock was introduced from Japan in 1965 (50 fish formed the founder stock, however, the number which actually survived to breed is not clear).
Tw	Taiwan	Descended from the founder stocks introduced to the Philippines from Taiwan in 1983-84; previous history not certain but most likely of Ghana origin.

The proportion of original strains in the GIFT-population after 5 generations

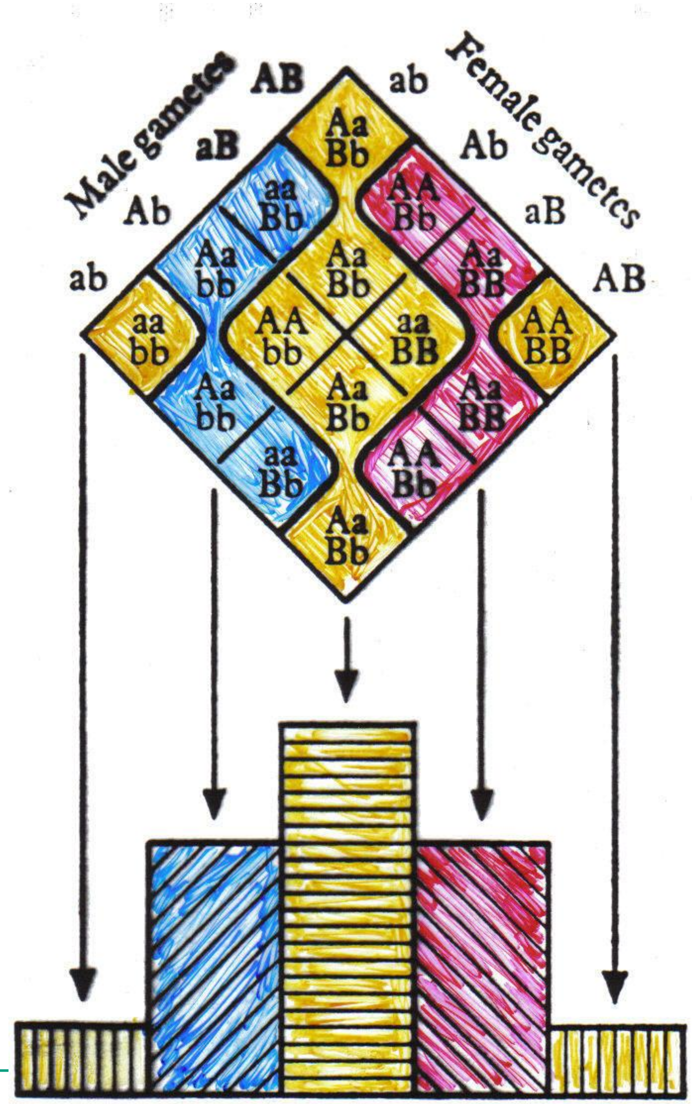


The proportion of ancestors from Ghana, Israel, Singapore and Taiwan strains was low (3 to 8%) and mainly due to a restriction that all parent strains should be represented in the synthetic base.

(Genetic improvement of farmed tilapias: Composition and genetic parameters of a synthetic base population of *Oreochromis niloticus* for selective breeding. Eknath et al., 2007)

From single gene models to normal distribution

Allele value:
a=1
A=2



Genotype value: 4 5 6 7 8

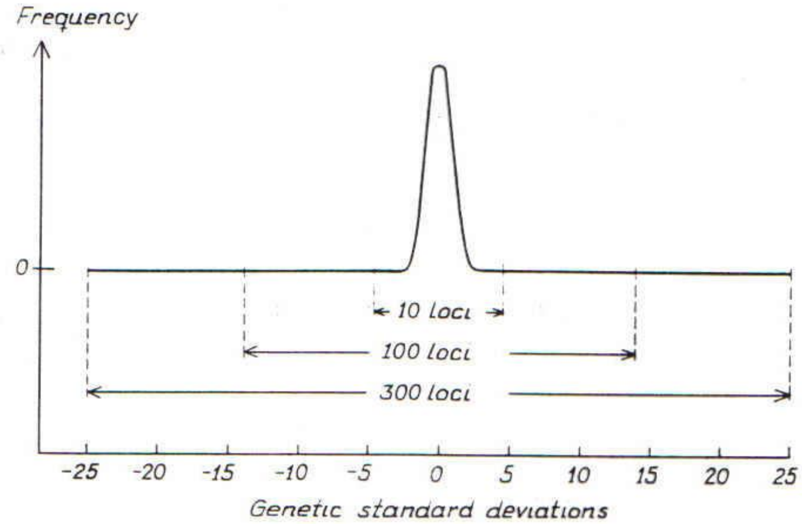


Figure 2. The distribution of genetic values and the theoretical genetic span measured in additive genetic standard deviations for different numbers of loci affecting the trait. The standard deviations are computed at allele frequencies of 0·5 according to the simplified polygenic model (see text).

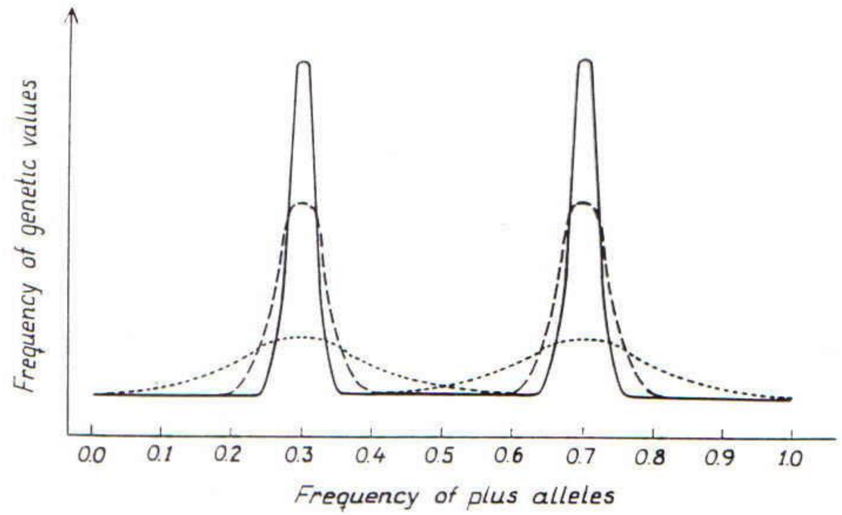


Figure 3. The distribution of genetic values in two populations with allele frequencies of the plus alleles of 0·3 or 0·7 according to the simplified polygenic model (see text) when the number of loci affecting the trait is 10 (dotted line), 100 (broken line) and 300 (unbroken line). The units on the horizonatal axis may be transformed from frequency of plus alleles to genetic values by multiplying with twice the number of loci.

Example of changes made by selection

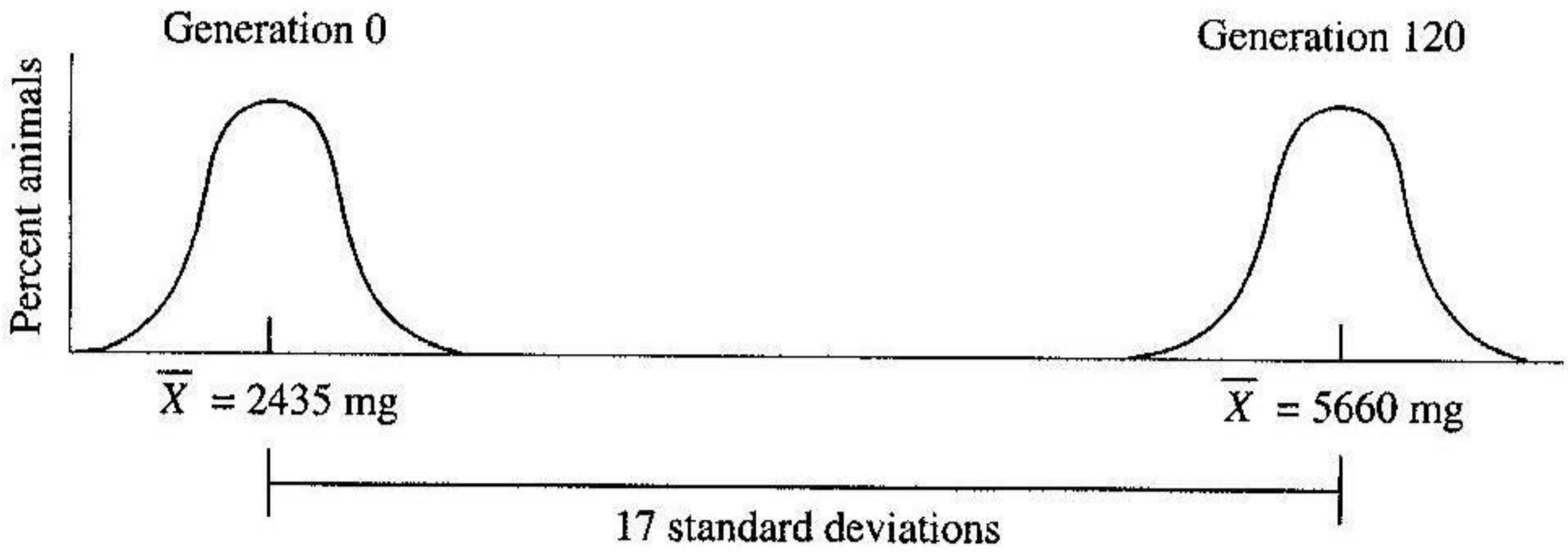
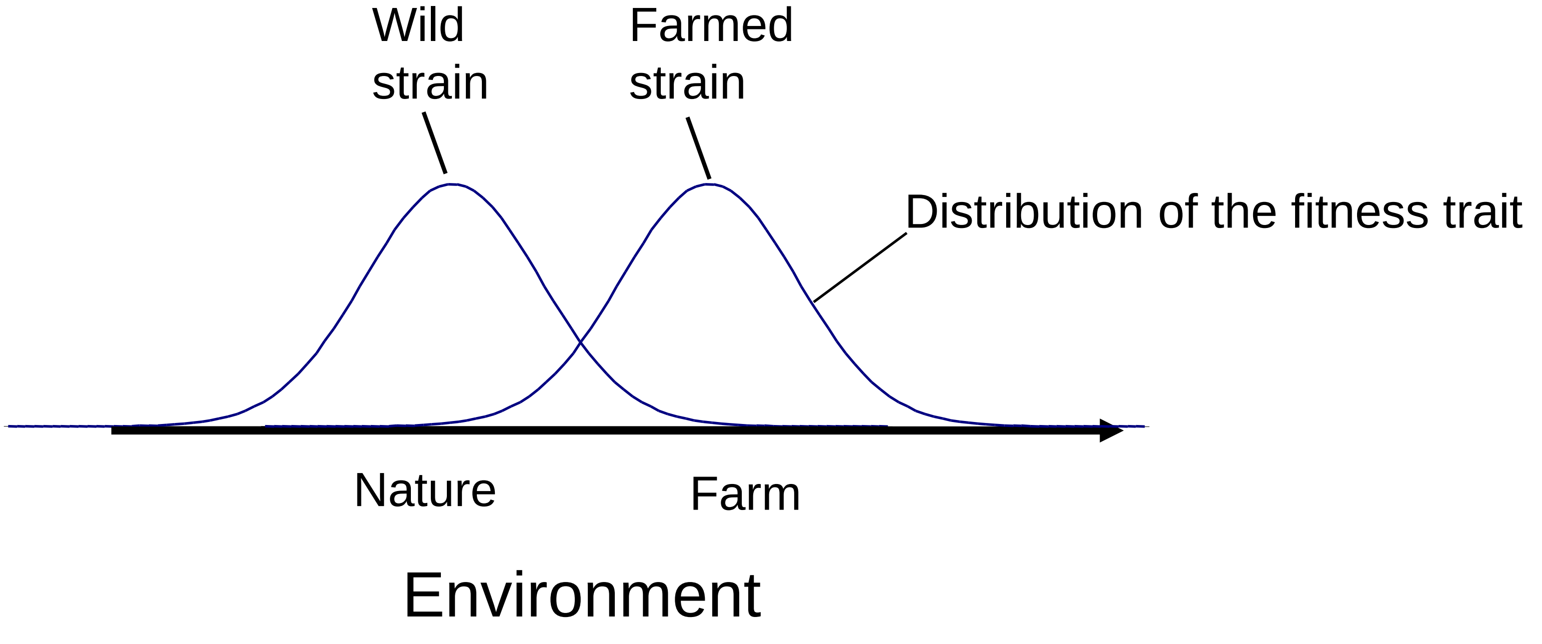
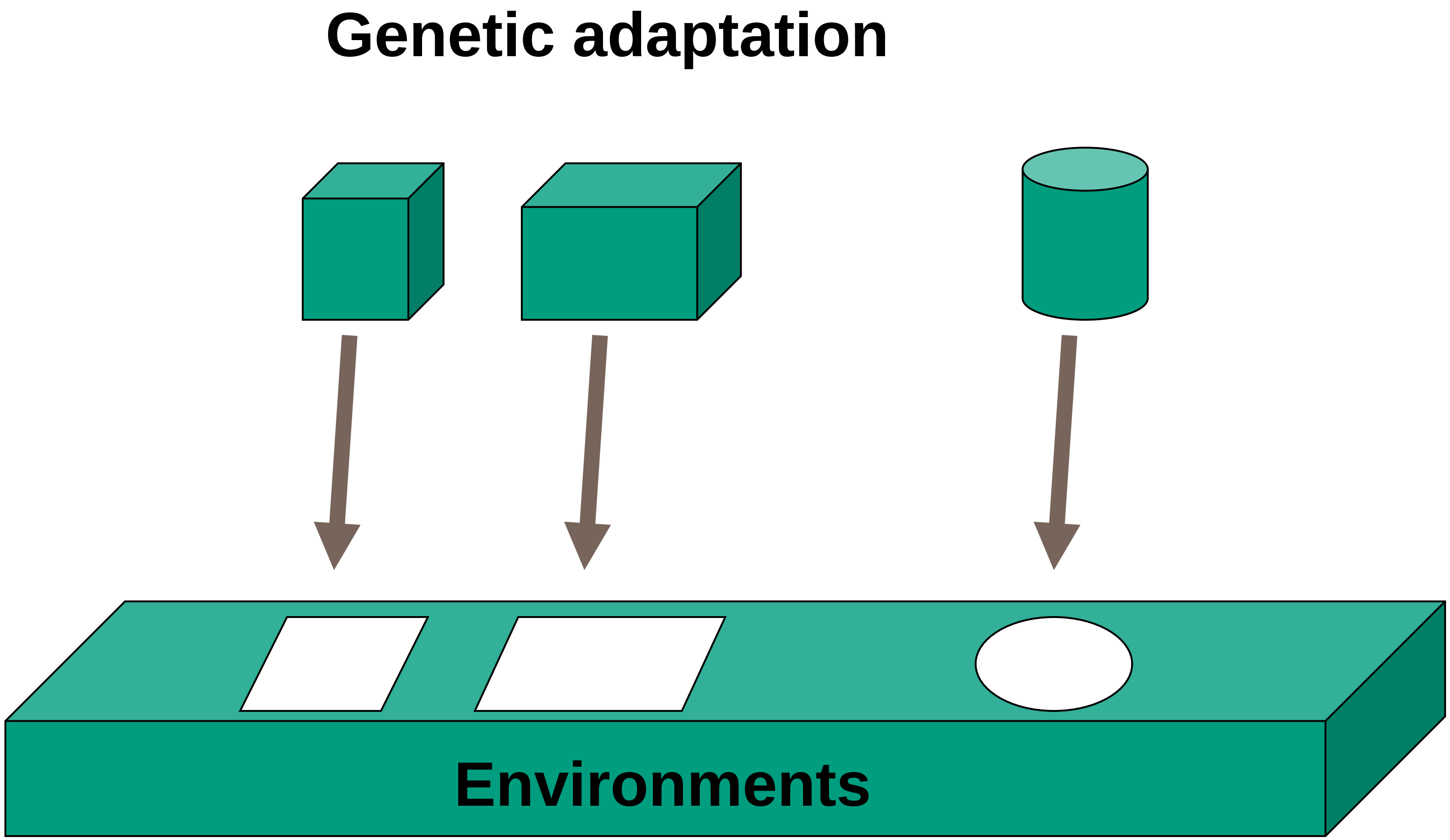


Figure 7.11b. Average and distribution curves for pupa weight for generation 0 and generation 120, the curves are drawn based on data from Figure 7.11a.

A more dynamic and realistic ”fitness model”

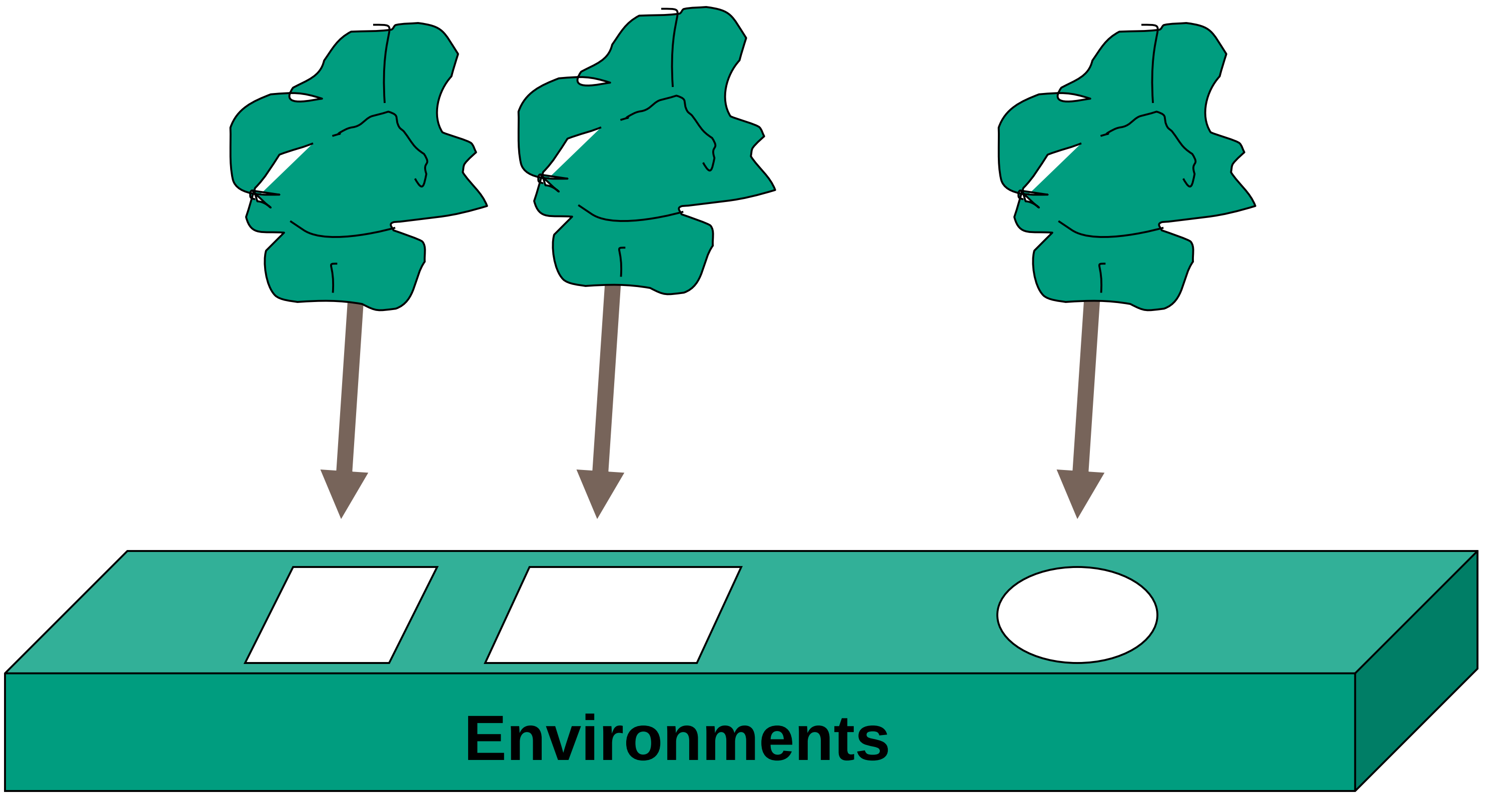


Two different genetic views



Two different genetic views

Genetic adaptation



Hva har jeg prøvd å si….?

- Oppdrett kan basere seg på lokale arter eller stammer
- Mye har allerede «gått galt» mht spredning av Niltilapia

  … men vi skal selvsagt ikke bidra ytterligere i så måte
- Det er nesten umulig å unngå at oppdrettsfisk spres i naturlige habitater

  ….. men påvirkningen av ville populasjoner av samme art er som regel begrenset