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Effective population size in carp hatcheries of Asom, India

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ABSTRACT

Carp hatcheries in Asom are the major source of fish seeds for aquaculture. Over the years although the state produced a large quantity of fish seeds mostly in the private sector; the state's market fish production has not increased significantly. Genetic deterioration in the hatchery population may be one of the principal factors affecting the fish production. An attempt was made to study the effective population size of randomly selected hatcheries of the state. The preliminary study revealed that Ne (Effective population size) ranged from 5.23 +2.88 to 16.51+5.56. A significant difference in the estimated effective population size was observed among the different fish species used in both government and private hatcheries. There was, however, no significant difference in the estimated effective population size of different fish species when the ANOVA was tested separately for government and private hatcheries. The study highlights the importance of effective population size in the carp hatcheries to reduce the genetic drift and inbreeding. Through this maiden study an effort was made to advocate proper policy instruments for sustainable development of fish seed industry in the State.

Key words: Asom, Carp hatchery, Effective population

A study conducted during 1999–2000 (Das 2000a) recorded a large number of hatcheries in Asom, established based on the Chinese design mostly in the private sector. These hatcheries contributed more than 95% of the total spawn production of the State.

Genetic deterioration in the hatchery stocks was reported in Asom (Das 2000 c). Hatchery stocks may be severely inbred because their overall performance has rapidly deteriorated (Eknath and Doyle 1990). Conservation of farmed stocks by planned breeding programme with large effective number of breeding population can preserve genetic variability of that stock (Lal *et al*. 2000). Carp hatcheries in Asom could be termed as genetically isolated units as this leads to genetic drift. Allendrof and Phelps (1980) first addressed this problem of a hatchery practices leading to genetic drift in cutthroat trout Oncorhynchus clarki (Wallbum). Genetic drift also led to the extinction of certain strain of channel catfish (Tave 1991). If the population size gets small, it results in inbreeding and genetic drift (Padhi and Mondal 1996), which in turn results in loss of rare alleles. This study was therefore undertaken as a maiden attempt to evaluate the effective population size at a few hatcheries of Asom in an effort to prepare proper policy instruments for sustainable development fish seed industry.

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MATERIALS AND METHODS

Carp hatcheries (18) were randomly selected from the principal seed producing districts of Kamrup, Barpeta, Nagaon, Sonitpur, Darrang, Sibsagar and Karimganj in Asom. Group discussions were held with the hatchery operators and the officials of the State Department of Fisheries, Government of Asom. Relevant information were collected from the individual hatchery operators through physical verification. All findings were later documented through survey and interview of hatchery operators (18). Information pertaining to seed productions was also collected from the State Fisheries Department for final analysis. The formula used by Eknath and Doyle (1990) was applied to estimate the effective population size (Ne) with the available information collected from a few hatchery owners.

$$\text{Effective population size, } Ne = 4(f)\,(m)/\,(f) + (m);$$

where, (f) and (m) are the number of females and males respectively.

The formula for estimation of effective population size (Ne) at the hatcheries was also described by Padhi (2000). Statistical analysis was carried out where appropriate, using the methods as described in Snedecor and Cochran (1968).

RESULTS AND DISCUSSION

In Asom, the average fish spawn production per annum from each hatchery, surveyed under the present study was about 38.34 million in numbers. The low average production

may be attributed to several factors, out of which the most important being the lack of good quality brood fish. The seed production capacity on an average per hatchery is around 200 million spawns as in most cases the hatchery system comprises 2 hatching pools. Some large-scale hatcheries even possess more than 2 hatching pools. However, through survey, it was found that no hatchery operators produce fish spawns to its full capacity. Pathak (1990) also revealed that most of the hatcheries constructed in the corporate sector do not run to full capacity. It was further observed that most fish breeders of the State are ignorant about the qualitative aspects of fish seed. Among the several probable factors responsible for poor quality fish seed production, effective population size in the hatchery was found to be the most important one.

Selection of brood fish: The study revealed that most hatchery operators select undersize carp fish as brood. Although most carps attain first maturity in their 1 or 2 years, there is an optimum age and weight at which they should be selected for induced breeding (Table 1) for quality seed production. Several scientists have provided information on recommended weight of various carp species for induced breeding programme (Hussain and Mazid 1999, Chaudhuri and Singh 1984).

Effective population and inbreeding: In a hatchery, the fishes are selected randomly for breeding. Often a small number of brood fishes are used for breeding. The ratio of number of male to female individuals varies. For example, in carp hatchery of Asom, more number of male is carp used than the females for breeding. Further, due to ineffective hormonal dose, inadequacy in environmental parameters and poor condition of brood fish, all the fishes kept for breeding fail to respond completely. As a result, the effective population size is further reduced. Effective population sizes are reported to be low in hatchery-reared catla from Bangladesh, possibly leading to inbreeding and loss of variation (Hansen *et al.* 2006).

The United Nations (FAO/UNDP 1981) recommends the effective population size as 50 for short-term work and 500 for long-term work. Tave (1986) suggested 68 to 685 number of brood fishes depending on the programme and its goal. Although there is no such universally acceptable Ne to prevent inbreeding and genetic drift, the hatchery seed producers should always use more number of brood fishes. Jhingran and Pullin (1988) recommend a rule of thumb that a bloodstock should comprise at least 50 breeding pairs. An important and well established live gene bank at Szarvas, Hungary maintains 50 individuals (25 males and 25 females) for 13 Hungarian and 12 other European and Asian common carp races, and 3 hybrid populations (Pullin 1993). As the spawning success is seldom 100% and a few brood fish may die before they can be spawned, a minimum of 100–200 brood fish need to be saved. Basavaraju and Mair (1996), studied the effective population sizes of various fish species in major hatcheries of Karnataka and revealed that the estimated 'Ne' varies from 55.50 to as low as 11.4.

In the present study the Ne (effective population size) varied from 5.23 +2.88 to 16.51+5.56 (Table 2).These estimates should be treated with some caution, due to inadequate data. Nevertheless, this data do support the hypothesis that the inbreeding is quite high which is likely to affect their culture performance. Eknath and Doyle (1985) found that Indian carp hatcheries had effective breeding numbers of only 3 to 30. As similar to Asom, in some of the carp hatcheries of the South India, the brood stocks remained genetically close. The inbreeding rate in these hatcheries was between 2 and 17% (Eknath and Doyle 1990). To keep the inbreeding rate below 1% level, Ne must be minimum 50 because a population at Ne 50 will lose about 25% of the genetic variation after 20–30 generations (Tripathi and Khan 1990). To avoid inbreeding, the effective population size (Ne) has been suggested differently by different workers i.e. 60 (Ryman and Stahl 1980), 50–500 (Kinclaid 1983) etc. A

Table 1. Shows minimum, average and maximum weight of brood fishes used by the various seed producers of Asom against the recommended weight during sampling

Species	Min. weight (g)	Avr. weight (g)	Max. weight (g)	Recom. weight (g)
Rohu	100	336*	1500	>1000
Mrigal	60	249*	900	>1000
Catla	750	1396*	3000	>3000
Gonius	40	137*	300	>500
Silver carp	200	1024**	3200	>1500
Grass carp	700	1580**	4100	>2000

*Significant at 1% level, **Significant at 5%. t-test was employed to see the significant difference between the average weight and recommended weight of brood fish species used for induced breeding at different hatcheries of Asom.

Table 2. Estimated effective population sizes ('Ne') of a few important cultivable fish species of different carp hatcheries of Asom.

Fish species	'Ne' (mean +SD) in govt. hatchery	'Ne'(mean +SD) in private hatchery	Pooled 'Ne' (mean+SD)
Labeo rohita	11.61+6.22	17.28+7.04	13.50+ 6.68
Cirrhinus mrigala	11.05+7.83	12.79+1.43	11.80 + 5.67
Catla catla	04.99+2.42	05.46+3.84	05.23 + 2.88
Hypophthalmichthys molitrix	05.99+1.33*	11.58+3.76*	09.35+ 4.09
Labeo bata	15.34+4.78	17.67+7.08	16.51+ 5.56
Ctenopharyngodon idella	NA	12.57+4.63	12.57+ 4.63

* Significant at 5% level (t-test).

breeder should spawn at least 25 males and 25 females every generation to minimize inbreeding depression (Tave 1995). Another genetic erosions occurring in the most hatcheries of Asom is the crossing between closely related species, such as crossing between brother- sister or parents-offspring leading to inbreeding which results in homozygosity (Das 2000b). In fish culture, harmful effects of inbreeding appears moderately because of the high number of offspring. Simon (1991) mentioned that inbreeding in hatchery fish populations causes loss of genetic variability of hatchery fish populations. Stock deterioration in hatchery populations due to poor broodstock management and inbreeding depression has also been observed in Bangladesh where over 700 fish hatcheries are engaged in breeding of 13 endemic and 13 exotic fish species contributing to more than 98% of the total spawn production of the country (Hussain and Mazid 1999). They further reported that a large quantity of such poor quality seed was being stocked in aquaculture ponds, flood plains and open water bodies causing a widespread concern. Rahman *et al*. (2009) revealed some degree of genetic variation between wild and hatchery population of *Catla catla* by RAPD.

In the present study the significant difference between the sample mean of effective population size was tested by t-test and ANOVA technique (Snedecor and Cochran 1968). There was no significant difference in the estimated effective population size of fishes between government and private hatcheries at 5% level when tested by t-test. In ANOVA test, significant differences in the estimated effective population size was observed among the different fish species used in both government and private hatcheries at 0.05 level. There was however, no significant difference in the estimated effective population size of different fish species at 0.05 level when the ANOVA was tested separately for government and private hatcheries (Table 2). Deepak *et al*. (2005) studied the inbreeding rates in the State owned hatcheries of Gujarat where seeds of mainly 3 Indian major carps are produced. The cumulative inbreeding rate was found to vary between 0.42 and 5.91 in 3 Indian major carps.

In many hatcheries of Asom, source of base population is not clearly known. Direct estimation of inbreeding based on pedigree information and census data could not be used as such data were not available with the hatchery operators. An effort was made to collect modest information from a few hatcheries by interviewing the hatchery operators personally. It is most unfortunate that most of these hatchery operators do not keep proper records of past production and replacement of brooders. The effective population size is inversely related to inbreeding and genetic drift. These data are however, not adequate to support the hypothesis of occurrence of inbreeding which is likely to cause a negative impact on culture fisheries in the state of Asom.

Hatcheries are the major source for fish seed used in the present day fish farming practices.The hatchery operators concentrate more on the quantity than the genetic aspect. Consequently, the quality of the material suffers due to the non-practice of selection norms, right from the brood stock management to seed production. In view of this, it is high time now to turn our attention besides quantity, towards production of quality fish seeds through genetic improvement method. It is anticipated that production and culture of quality fish seed shall improve aquaculture productivity further.

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