aqua, International Journal of Ichthyology

Saving critically endangered fish species – utopia or a practical idea? The story of the Yarqon bleak – *Acanthobrama telavivensis* (Cyprinidae) as a test case

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Received: 11 August 2008 – Accepted: 28 September 2008

Abstract

Sixteen percent of the Israeli native freshwater fishes have become extinct and 19% are critically endangered. The situation in other arid and semi-arid countries is similar. Are all the endangered species doomed to become extinct? The case of the restoration of the wild populations of the Yarqon bleak clearly shows that there is an alternative. The Yarqon bleak, a cyprinid fish endemic to the Mediterranean rivers in Israel, almost became extinct following the drought of 1998-1999. Several days prior to the drying of the streams, ca. 150 fish from two basins were brought to the Ichthyological Laboratory at Tel Aviv University. They were carefully treated and housed in a breeding centre. Within five years, we had managed to produce more than 14,000 fish. First attempts to reintroduce the fish to the Yarqon River, made in 2002 and 2003, failed, in that the adults did not breed. Following an experiment which showed that the fish need suitable spawning sites and shelter sites for juveniles, several aquatic sites were engineered according to knowledge acquired during the research and were stocked with laboratory-born fish in 2006. During 2007and 2008, juvenile Yarqon bleak of various sizes were found in eight out of 11 monitored sites. The success to save the Yarqon bleak shows that endangered fish species can be rescued. This requires action to be taken along two fronts: 1) raising public awareness and 2) a professional approach that includes relevant research and implementation of the results.

Zusammnfassung

Sechzehn Prozent der heimischen israelischen Süßwasserfische sind ausgestorben, 19% unmittelbar bedroht. In anderen ariden und semi-ariden Ländern ist es ähnlich. Sind alle bedrohten Arten zur Ausrottung verurteilt? Wie die Wiederherstellung der freilebenden Populationen des "Yarqon-Karpfens" (Yarcon bleak) zeigt, gibt es eine Alternative. Dieser Fisch, ein Cyprinide, der in den mediterranen Flüssen Israels endemisch vorkommt, war nach der Zeit extremer Trockenheit 1998-1999 fast ausgestorben. Wenige Tage vor der Austrocknung der Fließgewässer wurden etwa 150 Fische in das Ichthyologische Labor der Universität Tel Aviv gebracht. Sie wurden in einem Zuchtbecken mit großer Sorgfalt behandelt und gehalten. Innerhalb von fünf Jahren war es uns gelungen, 14.000 Fische aufzuziehen. Die ersten Versuche 2002 und 2003, Fische wieder in den Yarqon-Fluss auszuwildern, misslangen – die erwachsenen Tiere produzierten keinen Nachwuchs. Nach experimentellen Ergebnissen brauchen die Fische geeignete Laichorte und Schutz für die Jungen. 2006 wurden mehrere Stellen im Gewässer entsprechend den Erkenntnissen gestaltet und mit im Labor geborenen Exemplaren besetzt. In den Jahren 2007 und 2008 konnten dann an acht von elf untersuchten Plätzen junge "Yarqon-Karpfen" der verschiedensten Größe gefunden werden. Der Erfolg mit dieser Art belegt, dass es möglich ist, gefährdete Fischarten zu retten. Dazu sind aber zwei Voraussetzungen erforderlich: 1) die öffentliche Aufmerksamkeit muss geweckt werden; und 2) muss professionell vorgegangen werden, was vor allem heißt: gezielte Forschungsarbeit und die Umsetzung der Ergebnisse in die Praxis.

Résumé

16% des poissons d'eau douce indigènes en Israël sont éteints et 19% sont gravement menaces. Dans d'autres pays secs et semi-désertiques, la situation est comparable. Toutes les espèces menacées sont-elles condamnées à disparaître? L'exemple de la reconstitution des populations sauvages de l'ablette du Yarkon montre clairement qu'il y a une solution alternative. L'ablette du Yarkon, un Cyprinidé endémique des cours d'eau méditerranéens d'Israël, a presque disparu après la sécheresse de 1998-1999. Plusieurs jours avant l'assèchement des cours d'eau, env. 150 poissons de deux bassins ont été apportés au Laboratoire ichtyologique de l'Université de Tel Aviv. On les a traités avec soin et accueillis dans un centre d'élevage. En l'espace de cinq ans, nous avons réussi à reproduire plus de 14.000 poissons. Les premières tentatives de réintroduction des poissons dans la rivière Yarkon, faites en 2002 et 2003, ont échoué parce que les adultes ne frayaient pas. En s'inspirant d'une expérience qui montrait que cette espèce exige des sites de reproduction adéquats et des endroits ombragés pour les juvéniles, une série de sites aquatiques ont été aménagés d'après les observations engrangées lors de la recherche et ont été peuplés, en 2006, de poissons nés en laboratoire. En 2007, on a trouvé des ablettes du Yarkon de différentes tailles dans huit des 11 sites contrôlés. Le sauvetage réussi de l'ablette du Yarkon prouve que des espèces menacées de poissons peuvent être récupérées. Un tel objectif exige d'agir sur deux fronts: 1) susciter l'intérêt du public et 2) une approche professionnelle qui implique une recherché pertinente et une mise en oeuvre de ses résultats.

Sommario

Sedici percento delle specie ittiche d'acqua dolce native di Israele si sono estinte e il 19% è seriamente minacciato di estinzione. In altri paesi aridi o semi aridi la situazione è simile. Tutte le specie minacciate sono davvero destinate ad estinguersi? Il caso della reintroduzione dell'alborella di Yarqon mostra chiaramente che un'alternativa è possibile. L'alborella di Yarqon è un ciprinide endemico dei fiumi d'Israele che arrivò sull'orlo dell'estinzione in seguito ai periodi di siccità del 1998-1999. Alcuni giorni prima del completo prosciugamento dei torrenti, circa 150 esemplari di questa specie raccolti in due bacini furono portati nel Laboratorio di Ittiologia dell'Università di Tel Aviv. Essi furono trattati con tutte le cautele e mantenuti nella stazione di allevamento. Nell'arco di cinque anni si è riusciti ad incrementare il numero di individui ad oltre 14.000. I primi tentativi di reintrodurre la specie nel fiume Yarqon, compiuti nel 2002 e nel 2003, fallirono, in quanto gli adulti non riuscivano ad accoppiarsi. Successivamente, uno studio mostrò che la specie richiedeva adeguati siti di riproduzione e luoghi protetti per i giovani; sulla base delle conoscenze acquisite durante questo studio furono predisposti alcuni siti che, nel 2006, vennero ripopolati con esemplari cresciuti in laboratorio. Durante il 2007 e il 2008, individui giovani di varie dimensioni dell'alborella di Yarqon furono rinvenuti in otto degli 11 siti monitorati. Il successo ottenuto con l'alborella di Yarqon mostra che le specie ittiche minacciate possono essere salvate. Ciò richiede un'azione su due fronti: 1) un aumento della presa di coscienza pubblica e 2) un approccio professionale che includa uno studio accurato del problema e l'attuazione dei risultati ottenuti.

INTRODUCTION

The inland water habitats in Israel, as in many Middle Eastern and other arid and semi-arid countries, have suffered severe deterioration since the 1950s, caused by the abstraction of water, pollution and drainage (Gasith 1992, Goren & Ortal 1999). In addition to these problems, the introduction of alien fish species has negatively affected the indigenous fauna (Goren & Galil 2005). All this has led to the extinction of four to five fish species (out of 32 native species) and to six others becoming critically endangered (Goren 2003). A comparison with the status of circum-Mediterranean endemic freshwater fish species (IUCN 2006) shows that the extinction rate in Israel is much higher (16% in Israel *vs* 3% in the entire circum- Mediterranean freshwater systems), while the percentage of critically endangered species is similar (19% *vs* 18%).

The rise in the demand for water world wide, especially in arid and semi-arid regions, is expected to contribute further to the deterioration of aquatic habitats and consequently to increase the number of extinct and endangered species. Under these circumstances, the question arises as to whether there is any chance of slowing down, or even halting, the chain of events that leads to the extinction of fish species; or is this an inevitable development and are all our efforts doomed to failure? The case of the Yarqon bleak *(Acanthobrama telavivensis* Goren, Fishelson & Trewavas, 1973) is presented here as a test case in dealing with this dilemma.

The Yarqon bleak belongs to the small *Acanthobrama/Mirogrex* species complex. With the excep-

Fig. 1. The Yarqon bleak *(Acanthobrama telavivensis)* from the Yarqon River. Photo by M. Goren.

tion of *A. marmid* (Heckel, 1843), all these species have a very limited distribution. Two, *A. tricolor* (Lortet, 1883) and *M hulensis* (Goren, Fishelson & Trewavas, 1973), have already become extinct.

The Yarqon bleak (Fig. 1) is endemic to the coastal river system of Israel and was once the most notable representative of the Cyprinidae in this system. It lives in Mediterranean type rivers (Gasith and Resh, 1999). Some biological aspects of this species have been studied (Goren 1983, Elron 2000, Elron et al. 2004, 2006). Until the 1960s the Yarqon bleak was distributed throughout the coastal river network: the Soreq, Yarqon, Tanninim, Daliya and Na'aman Rivers (Fig. 2). It probably also inhabited the Alexander, Poleg and Hadera Rivers. Unfortunately, these rivers are now in effect sewage canals, and their fish populations were not studied before they were polluted. The continuous distribution of this fish species was interrupted only in the Qishon River, which was populated by *Acanthobrama lissneri* (Goren et al. 1973, Goren & OrtaI1999).

During the second half of the 20th century all coastal rivers in Israel were severely polluted and much of their water was used for irrigation and domestic consumption. The consequence was the extinction of the Yarqon bleak from most of its distribution range, and by 1999 only three populations still survived: two tiny populations in the Taninim and Daliya Rivers and a large population of several thousand fish inhabiting the Rosh Ha'Ayin springs (the origin of the Yarqon River) and the clean upper section of the Yarqon River.

The goal of this paper is to demonstrate, through the story of the Yarqon bleak, the possibility of saving critically endangered fish species in heavily polluted freshwater ecosystems.

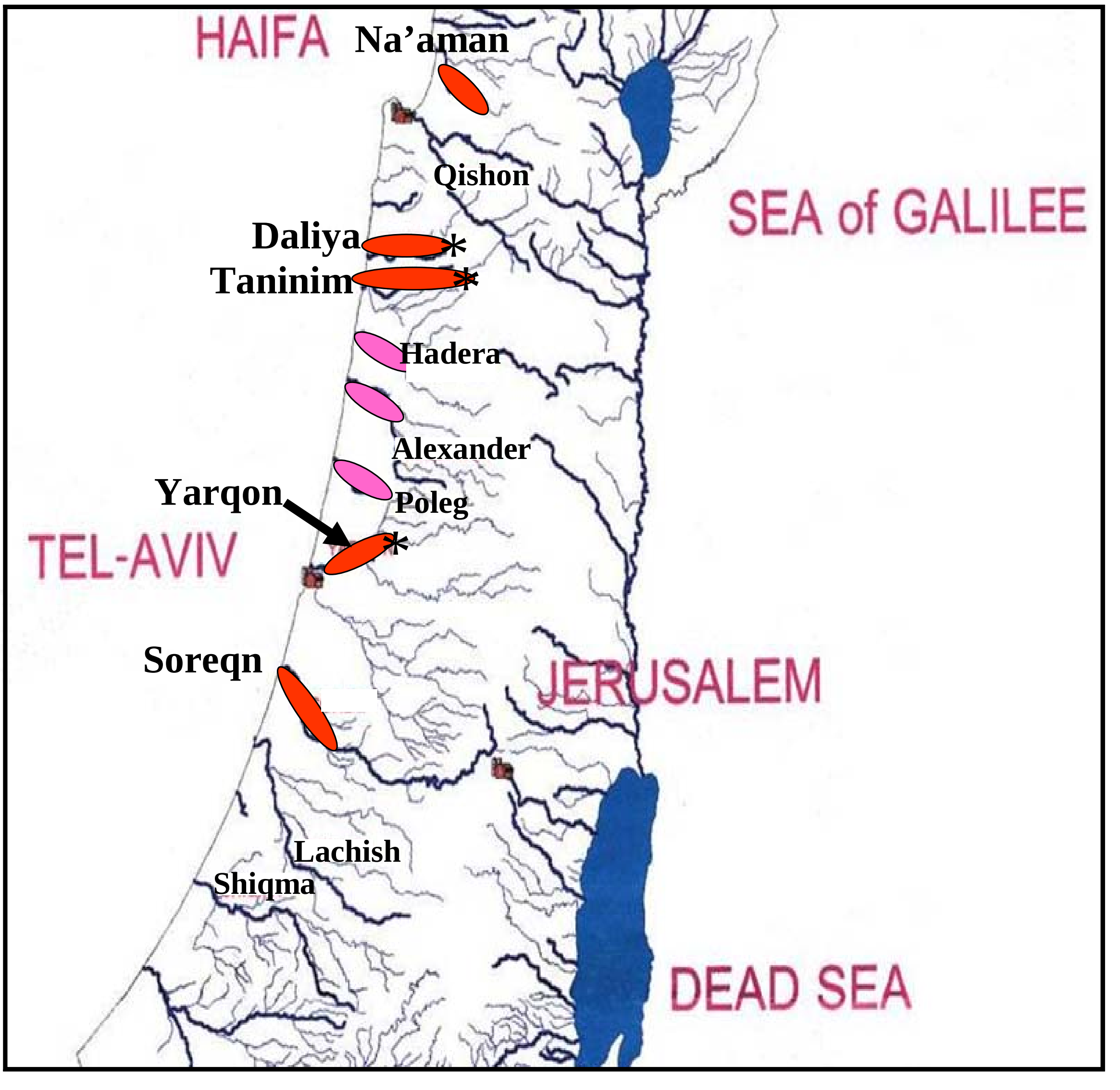

Fig. 2. The distribution of the Yarqon bleak in the 1960s (red ovals) and in 1999 (asterisk). Pink ovals indicate heavily polluted rivers in which the fish probably occurred until 1950s.

THE DISASTER AND THE VISION

During the winter of 1999 Israel suffered a severe drought that followed several years of low precipitation. In July we realized that the last existing habitats of the Yarqon bleak were going to become dry (Figs 3-5). Consequently, the author approached the authorities and suggested hosting a few thousand fish in his laboratory for a year or two, until conditions in nature would improve. The Yarqon River Authority, the Nature and Parks Authority and the Ministry for Environmental Protection agreed to co-operate in the project of saving the Yarqon bleak. Within three months we had managed to raise the needed funds and to build the facility for maintaining the fish in the Ichthyological Laboratory at Tel Aviv University (Fig. 6).

Unfortunately, during this period, the rivers were continuing to dry out; not much was left of the

Fig. 3a-b. Habitats of Yarqon bleak. - Yarqon River; **a.** Early spring 1999, **b.** September, 1999. Photo by M. Goren.

habitats and most of the fish were already dead (Figs 3-5). After several days of fieldwork we managed to collect ca. 100 fish from Rosh Ha'Ayin Springs and the clean upper section of the Yarqon River, and ca. 50 fish from Ein Tut, one of the tributaries of the Daliya River. The upper part of the Taninim River, which the fish inhabited, appeared completely dry (although later on it was found that a small hidden stream had survived). All the fish were very thin and covered with copepod parasites *(Lernea* sp.). Following careful treatment, ca. 120 fish survived. At this point it was clear that it was necessary to alter our strategy and to turn the facility into a breeding centre for this species, involving a plan to develop a method for mass production of the Yarqon bleak. The fish raised in this facility were intended for eventual reintroduction into suitable habitats.

Fig. 4a-b. Habitats of Yarqon bleak. - Upper Taninim River, **a.** Early spring 1999; **b.** September, 1999. Photo by M. Goren.

DILEMMAS AND SOLUTIONS

Since the Yarqon bleak is a wild animal about which we had very little knowledge, we faced several professional dilemmas.

1. How many fish to introduce into each tank? At that time we did not know the sex ratio and we were not able to distinguish males from females. We also did not know whether the fish prefer to spawn in pairs, small groups or large schools like its relative *Mirogrex terraesanctae* in Lake Kinneret (Gafny et al. 1992). We finally decided to introduce 10 fish into each tank, hoping that there would be at least two to three fish of the same gender.

2. What is the best substrate for spawning? We offered the fish a variety of substrates, such as various aquatic plants, stones, flower pots, plastic ropes and bricks arranged atop one another to form a T-shape. The fish chose to spawn on the bricks, usually in the narrow crevice between two bricks. The bricks were checked every morning (the fish spawn at night) and the bricks with eggs were removed. The others were cleaned every week.

3. What is the best temperature for spawning (should we heat or cool the water)? In nature the fish breed during late winter and early summer (Goren 1983, Elron et al. 2006) when the water temperature is ca. 12-15°C. However, when the water temperature in the tanks was set to 14°C the fish showed apathy and did not eat. The water temperature was thus raised to 24°C and the fish became active.

4. What kind of diet should we provide for the fish? A study of the diet of the Yarqon population, based on analysis of stomach contents and isotopes of carbon, showed that the fish feed on invertebrates, *Cladophora* sp. and diatoms (Elron 2000). We fed the fish daily with fish pellets (ca. 10% of body weight) and twice a week with defrosted chironomids or bloodworms *(Tubifex).*

The fish of both populations (Yarqon River and Daliya River) were kept separately, since in a preliminary molecular study some minor differences had been found (Levy 2004).

In order to maximize survival of eggs and larvae, a protocol for handling the fish, eggs and larvae was developed (Fig. 7).

After the first year (October 2000) ca. 700 fish were counted and after the second year (October, 2001) ca. 10,000 fish were counted. At that point, the available facilities (tanks, electricity, space, etc.) limited the number of fish we could hold in the breeding centre.

RESEARCH CARRIED OUT AT THE BREEDING CENTRE

The opportunity of having the fish under controlled conditions enabled us to study various aspects of the biology and ecology of the Yarqon bleak, which provided us with interesting and useful information regarding the needs of the fish.

The following topics were studied: sex ratio; morphological differences between males and females; ability of the fish to climb fish ladders; growth rate; seasonality in breeding; effect of density on spawning; effect of water current on spawning; the relationship between fecundity and age; the relationship between age and body condition factors; habitat selection (juveniles and adults); cannibalism of eggs and fry. In addition, a comparison was made between the "Yarqon" and "Daliya" breeding stocks regarding the above-mentioned topics. The results will be published elsewhere, but two findings

Fig. 5. Habitats of Yarqon bleak. - Ein Tut, June 1999. Photo by E. Elron.

Fig. 6. The facility for maintaining the fish (Ichthyological Laboratory at Tel Aviv University). Photo by M. Goren.

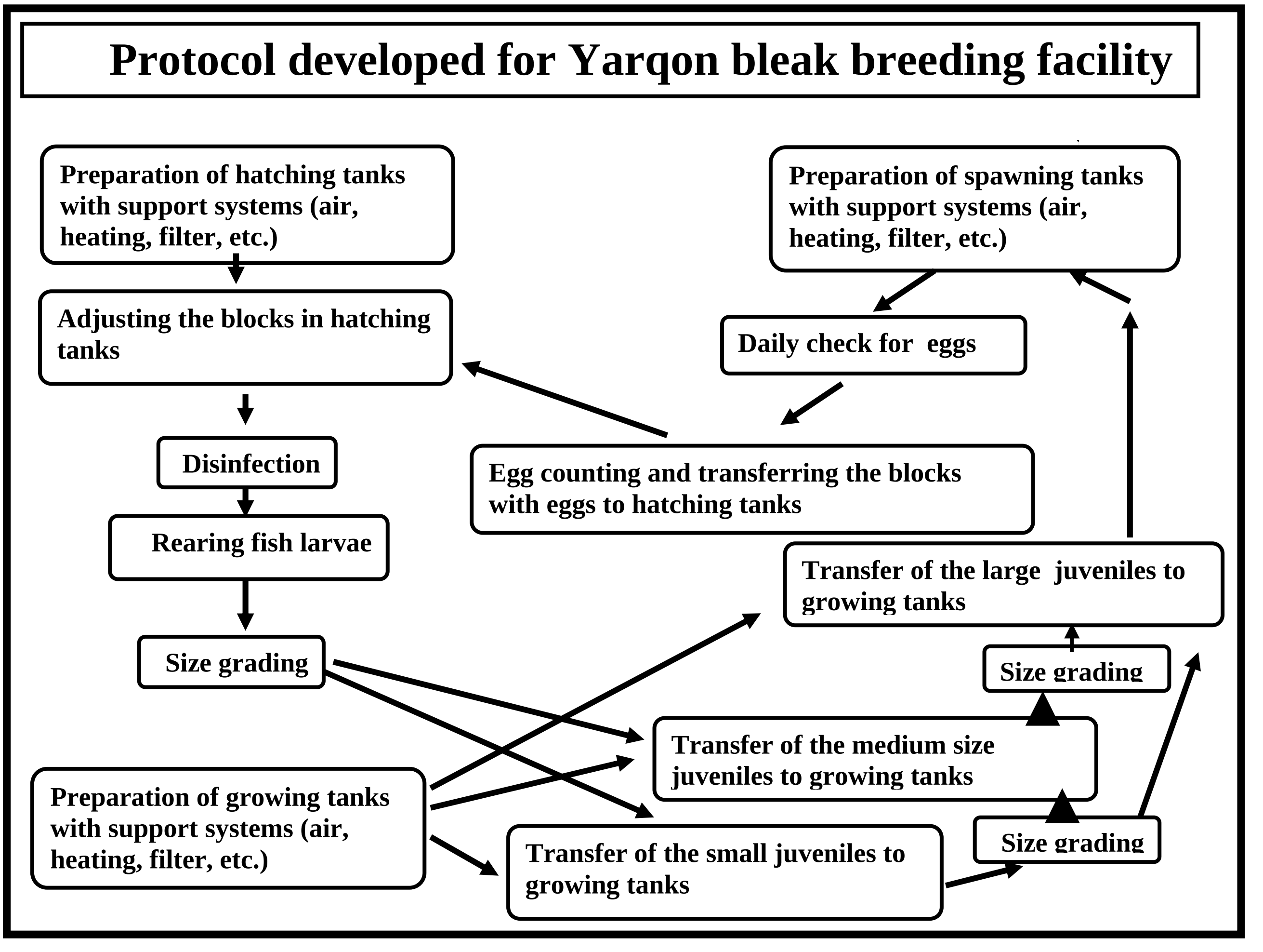

Fig. 7. The procedure for handling the fish, eggs and larvae of Yarqon bleak in the Ichthylogical Laboratory.

should be mentioned here. Firstly, we found cannibalism of eggs and larvae; secondly, the two populations (Yarqon and Daliya Rivers) differ from each other significantly in a variety of physiological and morphological parameters, justifying keeping them as separate breeding stocks (Liebes 2003).

FIRST ATTEMPT TO REINTRODUCE THE YARQON BLEAK TO NATURE

During 2000-2001, the Nature and Parks Authority reached an agreement with the government that would ensure a permanent, minimum discharge of high quality water into the upper part of the Yarqon River in order to prevent future drying of the river, even during a drought. This enabled the return of the fish to nature.

It is clear that the survival of fish depends on the good will of the decision-makers, who must guarantee a reasonable quota of high quality water for the river, a decision that is not easy to make in an arid country that suffers from a severe shortage of water. Thus, the return of the fish to the river was accompanied by public relations and educational campaigns. The first reintroduction of the Yarqon bleak into the Yarqon River was in the presence of the General Directors of the Ministry of Environmental Protection, the Nature and Parks Authority and the Yarqon River Authority. The ceremony was covered by television reports and newspaper articles. Soon after, the then Minister of Environmental Protection also returned fish to the river in the presence of the Mayor of Tel Aviv. We turned the reintroduction of the fish into a public event too, at which children and their parents came to the Yarqon River, received an explanation on the importance of nature conservation, were told the saga of the Yarqon bleak, and themselves released some fish back into the river (Figs 8 -10). During 2002 and 2003 more than 5000 fish were returned to the river.

FAILURE AND CONCLUSIONS

During the following year (2004) we sampled the upper part of the Yarqon River in order to monitor the success of returning the fish to nature. We found many adults in good body condition, but no juveniles. This was an indication that the ecological conditions in the river were not suitable for the fish to breed, but it was not clear whether the problem lay in the quality of the water (which was constantly checked), or in the biotic/structural composition of the river (on the synergic effect of bad water conditions and the presence of *Gambusia affinis* and *Cyprinus carpio* on fish communities,

Fig. 8. First attempt to return the Yarqon bleak to nature. Photo by M. Goren.

Fig. 9. First attempt to return the Yarqon bleak to nature. A ceremony with the presence of the General Directors of the Ministry of Environmental Protection, the Nature and Parks Authority and the Yarqon River Authority. Photo by M. Goren.

Fig. 10. First attempt to return the Yarqon bleak to nature. Children return the fish into the river. Photo by E. Elron.

see Goren & Galil 2005). *Gambusia* fish are regularly introduced into the river by the Yarqon River Authority as an anti-mosquito agent. Carps and tilapia were introduced by unknown (and unauthorized) persons.

In order to be able to distinguish between the issue of water quality and the problems of shortage of appropriate spawning sites and predation pressure, we planned a separate side pond of ca. 400 m^2 near the Yarqon River. The bottom of the pond was partly covered with gravel and stones of ca. 10-15 mm in diameter. Piles of stones, ca.1 m height, were built on the bottom (Fig. 11). The pond was supplied with running Yarqon water through a pipe in which a small mesh net filter was installed to prevent the penetration of predators from the river. The residence time of the water in the pond was ca. 20 hours. Four hundred Yarqon bleaks from the breeding facility were stocked in the pond during December 2004. From April to June many thousands of juveniles were observed in the pond (Figs 12-13).

The conclusion was that the water quality was suitable, and that the problem lay in other ecological parameters (probably a shortage of suitable substrate for spawning and shelter sites for the juveniles).

Fig. 11. The engineered bottom of the experimental side pond near Yarqon River. Picture by Y. Raz.

SECOND ATTEMPT – IMPLEMENTATION OF CONCLUSIONS AND A SUCCESS

Following the success of the experimental pond, more sites were engineered during 2006 in order to provide the Yarqon bleak with its essential habitat needs (Figs 14-15). About 9000 fish were stocked in 12 sites in the water systems of the Yarqon River (offspring of the Yarqon River population) and of the Daliya River and the Na'aman River (offspring of the Tut River population). During summer and autumn of 2007 and the summer of 2008, juveniles of various sizes of Yarqon bleak were found in

Fig. 12. Juveniles of Yarqon bleak (3-4 weeks old) in the experimental pond April 2006. Photo by Y. Krotman.

Fig. 13. Juveniles of Yarqon bleak (7-8 weeks old) in the experimental pond April 2006. Photo by Y. Krotman.

eight out of 11 sites monitored, in some of which huge schools of fish were observed. One site was not checked for technical reasons.

FINAL CONCLUSIONS

The success of our eight-year effort to prevent the extinction of the Yarqon bleak clearly demonstrates that critically endangered fish species can be saved. This can be achieved by the determination of professional ichthyologists and nature conservationists and in co-operation with the decision-makers. In the case of the Yarqon bleak, the combination of

Fig. 14. Ein Afek (Na'aman River basin) November 2006. An example of a new engineered habitat for the Yarqon bleak. Photo by M. Goren.

Fig. 15. Ein Afek (Na'aman River basin) July 2008. A mature engineered habitat with a large population of Yarqon bleak. Photo by M. Goren.

experience and scientific research enabled us to keep the "refugee fish" alive, although initially they were sick and in very bad condition; to produce a large number of fish in the laboratory; to identify the reasons for the failure of the first reintroduced fish to breed; and to suggest effective solutions to these problems.

Following our success we can conclude that action to save an endangered fish species should follow two approaches: 1) raise public awareness in order to gain the support of decision-makers, which is a prerequisite for the success of any project of this kind; and 2) employ professional scientists to conduct the relevant research. For this approach we suggest that the following protocol be implemented in similar cases:

Establishment of an efficient breeding facility;

Rehabilitation of the river that is planned to accommodate the fish, and ensuring a constant supply of high quality water; in addition, engineering the habitat to provide suitable spawning sites for adults and shelter for juveniles;

Experimental stocking of the fish in the rehabilitated habitats and monitoring the survival of the fish and their reproduction success;

Stocking the fish in sites that have been found to be suitable for the fish in the experimental stage;

Continuous monitoring of the habitat and of the fish population.

ACKNOWLEDGEMENTS

I would like to thank The Yarqon River Authority, the Nature and Parks Authority and the Ministry for Environmental Protection for their support and co-operation in the project of saving the Yarqon bleak. I am grateful to the students in my laboratory, especially to E. Elron, B. Libes, Y. Krotman and Y. Gueta for the endless time they spent and for their devotion to the project of saving the Yarqon bleak. I also thank Naomi Paz for editing the manuscript.

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