ISSN 1330-061X
CODEN RIBAEG

UDK: 639.313.06:621.642.34](282.272.8)
~~Short communication~~
Original scientific paper

NEW DESIGN FOR AIRLIFT PUMP USED IN FISH CULTURE TANKS WITH THE ENDANGERED RIO GRANDE SILVERY MINNOW (*Hybognathus amarus*)

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Summary

This article describes an airlift pump used to produce a circular flow in a fish culture tank that does not attach to the tank. The design produces an airlift pump that does not swing back and forth or float upwards while in use. It is easy to build, inexpensive, and can be quickly installed and removed so that it does not interfere with sampling or harvest. The airlift pump was evaluated during a 30-d survival trial with the endangered Rio Grande silvery minnow (*Hybognathus amarus*) in 2.44-m-diameter circular tanks (3,666 l). Because the fish is endangered, all new culture units must be evaluated in a survival trial. To be able to use a new 15-tank system, survival had to be evaluated in a random representation of three tanks. U.S. Fish and Wildlife Service, which regulates all activities with this endangered species, decided that permitted take (maximum permitted mortality) was 60% for the survival trial; consequently, survival ≥40% in each tank would be considered successful. Two airlift pumps were placed in each tank. The two airlift pumps moved a mean±SD of 33.697±5.563 l/min; this produced total tank turnovers through the airlift pumps of 110.65±16.93 min. Water velocities were measured at nine locations in the tanks. Water velocities were 0.0-0.04 m/sec. Dissolved oxygen concentration never went below 6.30 mg/l. The airlift pumps operated flawlessly and required no maintenance. They produced water velocities preferred by the fish and helped keep dissolved oxygen concentration above the permitted minimum (5 mg/l). The airlift pumps will be used in future fish culture activities in these and other tanks. Survival in the three tanks was 78%, 94% and 96%; overall survival was 89.3%. Because take (10.7%) was under the permitted level (60%), the trial was successful.

Key words: Airlift pump, Rio Grande silvery minnow, *Hybognathus amarus*

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INTRODUCTION

Airlift pumps are commonly used to move water in a wide variety of fish culture endeavors, ranging from home aquaria to recirculating systems to ponds, where they can be used to prevent stratification. Various designs and uses were reviewed by Wurts et al. (1994).

We needed to install airlift pumps on a new set of outdoor above-ground 2.44-m-diameter circular fiberglass tanks that will be used to culture the endangered Rio Grande silvery minnow (*Hybognathus amarus*). The Rio Grande silvery minnow is a riverine species and observations of the fish in both the indoor recirculating fish culture tanks and in the outdoor naturalized refugium (Tave et al., 2011) have shown that the fish orients itself against the current. In the Rio Grande, mean water velocity where the fish were collected was 0.18 m/s; they were most commonly found where velocity was <0.1m/s (Watts et al., 2002).

The Los Lunas Silvery Minnow Refugium is located in the United States desert Southwest, making water a limiting resource. Because minimizing water use is one of our management priorities, the outdoor tanks cannot be operated as flow-though systems. Consequently, the only way to produce a current in the tanks is to use airlift pumps. The airlift pumps also provide continuous aeration, which is critical. Because the Rio Grande silvery minnow is an endangered species, we must maintain water quality within ranges that are established in our U.S. Fish and Wildlife Service (USFWS) Threatened and Endangered Species Permit (TE Permit) when we culture the fish, and a major goal during all fish culture projects at the Los Lunas Silvery Minnow Refugium is to keep water quality parameters within these permitted ranges; the minimum permitted dissolved oxygen (DO) concentration is 5 mg/l (Hutson et al., 2012).

We did not want to drill holes in the fiberglass tanks and permanently attach the airlift pumps, because we did not want to risk structural damage to the tanks and we did not want the airlift pumps to interfere with sampling or harvest. Consequently, we designed an airlift pump that does not have to be attached to the tank, is stable when in use, and that is easy to install and remove.

The airlift pump was evaluated in the new tanks during a 30-d survival trial with Rio Grande silvery minnow broodstock that is mandated by our TE Permit. Because the Rio Grande silvery minnow is an endangered species, all fish culture units must be evaluated with one or more survival trials before they can be used to culture or to hold fish; some of the trials also include an evaluation of growth. After we received our TE Permit, the first two years of operation were used to conduct the initial six survival trials in the two indoor tank and the aquaria systems and in the outdoor naturalized refugium (Tave et al., 2011; Hutson et al., 2012). USFWS established the maximum permitted take (mortality for an endangered species) for each survival trial (maximum mortality by which success would be measured) in our TE Permit.

The survival trial was a 30-d survival study in three of the 15 tanks, and permitted take during this survival trial was 60%; consequently, survival of ≥40% in each tank would be considered successful. Survival was the only fish metric evaluated in this study.

The objective of this article is to describe the airlift pump design and to evaluate its performance during the 30-d survival trial with the Rio Grande silvery minnow in the new tanks.

MATERIAL AND METHODS

Airlift pump design

The airlift pump is made from 4.9-cm (2-inch) PVC pipe, three 90° elbows, a rounded cap, and a tee (Fig 1).

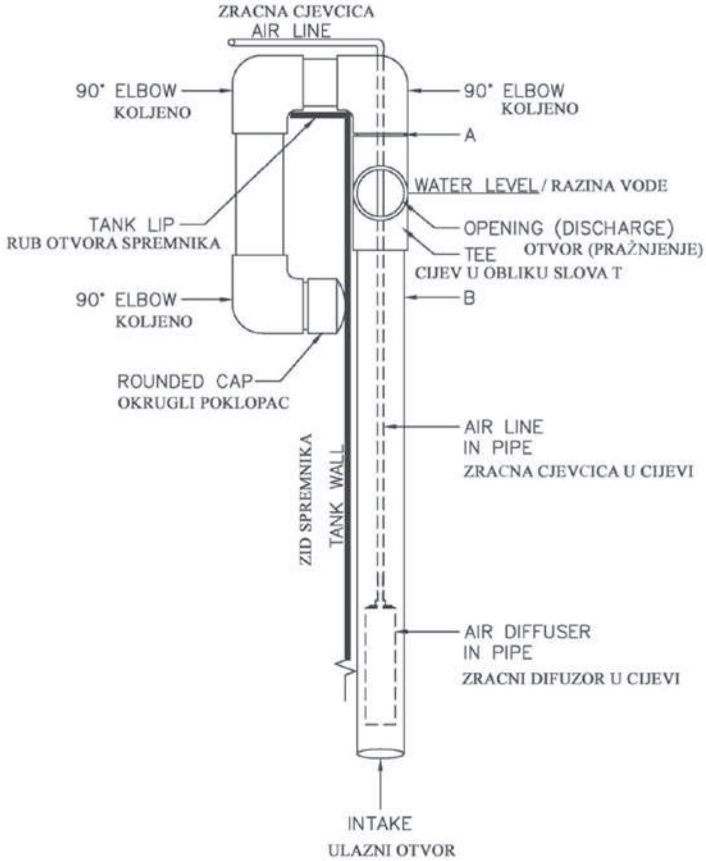

Fig 1. Design of a non-attachable airlift pump for fish culture tanks. It is made from PVC pipe and fittings. The top part sits on the tank edge and lip. The left portion is on the outside of the tank; the bottom 90° elbow and rounded cap fit against the outside of the tank and produces a snug fit. The pieces are not glued together. Pipe sections A and B can be altered to adjust the intake and outlet levels.

Slika 1. Prikaz zračne pumpe koja se ne pričvršćuje za spremnik za uzgoj ribe. Izrađena je od PVC cijevi i armature. Gornji dio je naslonjen na rub spremnika i rub otvora. Lijevi dio se nalazi na vanjskom dijelu spremnika; donje koljeno od 90° i okrugli čep točno pristaju uz vanjsku stjenku spremnika tako da pumpa potpuno priliježe. Dijelovi nisu zalijepljeni jedan za drugog. Dijelovi pumpe A i B se mogu izmijeniti kako bi se prilagodila razina unosa i istjecanja.

A 14.7- x 3.7-cm (6- x 1.5-inch) air diffuser at the bottom of the airlift pump provides the aeration that moves the water, and air is supplied to the air diffuser via 0.61-cm (0.25-inch) vinyl tubing. The portion of the airlift pump that is on the outside of the tank provides stability, so that airlift pump does not swing back and forth, and the short section with the rounded cap fits snugly to the side, which keeps the airlift pump from floating upward.

The various sections of the airlift pump are not glued together. This will enable us to alter the lengths of the pipes labeled A and B in Figure 1 to raise or lower the intake and outlet levels for different projects.

Air supply for the diffusers was produced by an Aquatic Eco-System Sweetwater Model S-51 air blower (Aquatic Eco-Systems, Inc., Apopka, FL, USA).

Evaluation of airlift pump during the survival trial

Two airlift pumps were placed in each of three randomly chosen 2.44-m-diameter circular fiberglass tanks. Water depth during the study was 0.784 m; volume was 3,666 l. The inlet for the airlift pumps was 9.2 cm above the tank bottom, and the outlet was at the surface. Both the inlet and outlet were screened with 0.61-cm netting to prevent fish from entering the airlift pumps.

The volume of water moved by an airlift pump was evaluated by collecting a 30-s discharge in a plastic bag and measuring the volume, as described by Parker and Suttle (1987).

The current produced by the two airlift pumps in each tank was measured, using a Marsh-McBirney Flow-Mate (Hach Co., Loveland, Colorado, USA), following U.S Geological Survey Protocols (USGS, Open File Report 01-50). Velocity was measured at nine locations in each tank; velocities were taken at three depths 11 cm from the tank edge, 57.6 cm from the tank edge (midway between the tank edge and central standpipe), and 11 cm from the standpipe. Standard depth at which velocity is taken is 0.6 of depth (USGS, Open File Report 01-50), which was a depth of 47 cm; velocity was also taken at depths of 7.35 cm and 74.1 cm to provide a velocity profile of the tanks.

Fifty 3- and 4-year-old Rio Grande silvery minnow were stocked into each of the three tanks on March 21, 2012; the fish were acquired from the City of Albuquerque BioPark, Albuquerque, NM and were from lot numbers ABP08-008, -009, -012, and -013 and ABP09-004. Stocking rate was 106,931 fish/ha.

Mean weight at stocking was 4.41 g. Biomass at stocking was 220.5 g/tank or 471.57 kg/ha.

A cover with 1.7-cm mesh was placed on each tank.

During the survival trial, water was added to replace that lost due to evaporation and to keep water quality parameters within permitted (Table 1) values.

Fish were fed 2% body weight (4.41 g; 9.43 kg/ha) on March 21 and 23. This produced an algal bloom in each tank, so feeding rate was reduced to 1% of body weight (2.20 g; 4.70 kg/ha) twice a week for the rest of the study. A total of 22.02 g (47.09 kg/ha) of feed was added to each tank during the study.

Maintaining water quality within permitted parameters (Table 1) is the key component of fish culture management at the facility. Because of this, water quality is intensively monitored, and if the parameters go outside the permitted ranges, corrective actions must be taken (Hutson et al., 2012). During the study, DO, temperature, and pH were measured at dawn (ca 0600-0700), and DO, temperature, pH, and un-ionized ammonia were measured at mid-afternoon (ca 1400-1500) seven days per week. One afternoon per week, nitrite, alkalinity, chloride, and turbidity were also measured. Hardness was measured at the beginning of the study. Secchi disc visibility was to the bottom (78.4 cm) until March 28; thereafter, Secchi disc visibility was measured to the nearest 0.5 cm with a 20-cm Secchi disc each afternoon. DO and temperature were measured with a YSI 550A Dissolved Oxygen meter; pH was measured with a YSI pH 100 meter; all other water quality parameters were measured with a YSI 9500 Photometer (YSI, Inc., Yellow Springs, Ohio, USA).

The three water quality parameters which require intensive management are DO, un-ionized ammonia, and pH. The permitted minimum DO concentration is 5 mg/l, the permitted maximum un-ionized ammonia concentration is 0.5 mg/l, and the permitted maximum pH is 9.0.

Maintaining afternoon pH below 9.0 is difficult, because there is an imbalance between total alkalinity and hardness in the water used at the facility; mean alkalinity and hardness in the tanks at stocking were 161.6 mg/l and 48.3 mg/l, respectively. This imbalance means that afternoon pH can exceed 10 as a result of algal photosynthesis (Boyd, 1990). This can be mitigated by the addition of finely ground agricultural gypsum (Boyd, 1990), and it has been used to maintain pH in the permitted range during fish culture operations in the naturalized outdoor refugium (Hutson et al., 2012). When pH approached 9.0, agricultural gypsum was added to the tanks to keep pH $\leq$9.0, as described by Boyd (1990): the concentration used was twice the difference between total alkalinity and hardness. On March 22, afternoon pH exceeded 8.9 in one tank, so 0.825 kg of agricultural gypsum as added to each tank on March 23. On March, 27 afternoon pH exceeded 8.9 in all tanks, and an additional 0.825 kg was added to each tank. A total of 1.65 kg (3,528 kg/ha) of agricultural gypsum was added to each tank during the study.

During the study, 805 l of water was added to each tank to replace water lost to evaporation. On March 29, un-ionized ammonia was 0.03 mg/l in C8 and C9 and 0.01 mg/l in the C5. Even though these concentrations were below the permitted maximum, a 20% water exchange (741 l) was done in all tanks to reduce the ammonia concentration. Total water exchange during the study was 1,546 l or 42.17% per tank.

Fish were harvested on April 19 and counted to determine survival.

RESULTS AND DISCUSSION

The airlift pumps worked well, and no maintenance or adjustments were required during the study. They were stable during operation, and we were able to install and remove them quickly.

Mean±SD pump discharge was 16.842±3.882 l/min. The total mean±SD discharge for the two airlift pumps per tank was 33.697±5.563 l/min, and this created a mean±SD tank volume turnover through the pumps of 110.65±16.93 min.

Mean water velocities in the tanks are shown in Fig 2. The velocities were similar to those produced in the stream runs in the naturalized outdoor refugium where velocity is produced by two 5-hp pumps (Tave et al., 2011; Hutson et al., 2012) and in the indoor recirculating tank systems, where velocity is produced by the directed spray of inlet water (Hutson and Tave, 2009; Tave and Hutson, 2009). The water velocities are in the range where the fish are most commonly found in the river (Watts et al., 2002).

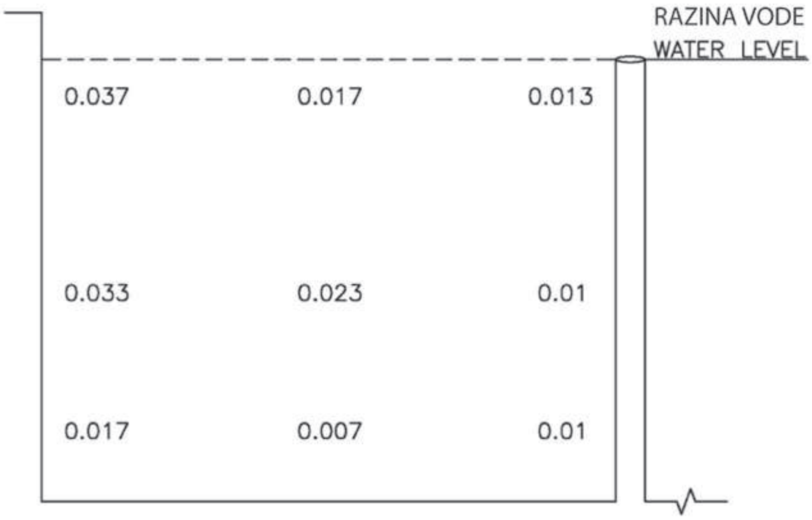

Fig 2. Mean velocities (m/s) that were produced by two airlift pumps in 2.44-m-diameter circular tanks

Slika 2. Srednje vrijednosti brzine (m/s) koje su nastale pomoću dvaju zračnih pumpi u kružnim spremnicima dijametra 2,44 metra.

Water quality in the tanks were similar, so the data were pooled, and overall means, SD, and ranges, along with their permitted ranges are shown in Table 1. No water quality parameter went outside the permitted range during the study. The airlift pumps helped ensure that DO never went below 5 mg/l; the lowest recorded value was 6.30 mg/l. Afternoon pH ranged from 8.35-8.95, so the agricultural gypsum kept afternoon pH from exceeding the permitted maximum of 9.0.

Survival was: 48 of 50 (96%) in C5, 39 of 50 or 78% in C8, and 47 of 50 or 94% in C9; overall survival was 134 of 150 or 89.3%. Because take was 4% in C5, 22% in C8, and 6% in C9, we were under the permitted take of 60% and the survival trial was successful. After USFWS approves the report of this survival trial, the tanks can be used to culture/hold Rio Grande silvery minnow. The airlift pumps will be used in future fish culture projects in these tanks and in similar tanks in a new quarantine building.

Table 1. Mean, SD, and ranges for dissolved oxygen (mg/l), temperature (°C), pH, un-ionized ammonia (mg/l), nitrite (mg/l), alkalinity (mg/l), chloride (mg/l), turbidity (FTU), and Secchi disc visibility (cm) during the Rio Grande silvery minnow 30-d survival trial in 2.44-m-diameter circular tanks. Also listed are the permitted ranges.

Tablica 1. Srednja vrijednost, SD, vrijednosti otopljenog kisika (mg/l), temperature (°C), pH, neioniziranog amonijaka (mg/l), nitrita (mg/l), alkaliteta (mg/l), klorida (mg/l), neprozirnosti (FTU), te vidljivost Secchi diska (cm) tijekom 30-dnevnog testa opstanka srebrne bjelice u kružnim tankovima dijametra 2,44 metra. Također su navedene dozvoljene vrijednosti.

Parameter/Parametar	Mean/ Srednja vrijednost	SD	Range/ Vrijednost	Permitted range/ Dozvoljena vrijednost
Morning/Jutro				
Dissolved Oxygen/Otopljeni kisik	7.56	1.83	6.3-15.7	>5
Temperature/Temperatura	12.20	3.24	5.7-15.9	5-33
pH	8.59	0.15	8.27-8.94	6.5-9.0
Afternoon/Popodne				
Dissolved oxygen/Otopljeni kisik	7.36	1.45	6.34-9.95	>5
Temperature/Temperatura	15.46	5.63	8.8-18.9	5-33
pH	8.63	0.16	8.35-8.95	6.5-9.0
Un-ionized ammonia/ Neionizirani amonijak	0.001	0.005	0-0.03	<0.5
Nitrite/Nitrit	0.01	0.01	0-0.02	<1.5
Secchi disc	73.17	13.39	53.0-78.5	>20
Chloride/Klorid	5.67	1.25	3.7-8.0	<250
Alkalinity/Alkalinitet	161.67	7.72	145-170	>100
Turbidity/Prozirnost	2.67	3.43	0-8	NA

Acknowledgments

Funds for operations and maintenance of the Los Lunas Silvery Minnow Refugium are provided by grant agreement no. 08-FG-40-2803 from the U.S. Bureau of Reclamation. Fish were cultured under U.S. Fish and Wildlife Permit TE169770-4 and TE169770-5 and New Mexico Department of Game and Fish Permit 3417. We thank the Albuquerque BioPark for the fish used in this study. We thank Ken Ferjancic for reviewing the paper.

Sažetak

NOVI DIZAJN ZRAČNE PUMPE KOJA SE KORISTI U SPREMNICIMA ZA UZGOJ RIBE KOD UGROŽENE SREBRNE BJELICE IZ RIJEKE RIO GRANDE (*Hybognathus amarus*)

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Ovaj rad opisuje zračnu pumpu koja se koristi za stvaranje kružnoga toka u spremniku za uzgoj ribe koja se ne pričvršćuje za spremnik. Takav dizajn pomaže pumpi da se ne miće naprijed-nazad ili da pluta prema gore dok se koristi. Lako ju je izraditi, nije skupa te ju je jednostavno montirati i ukloniti da ne smeta prilikom uzorkovanja ili ulova. Zračna pumpa je ispitivana tijekom 30-dnevnog testa preživljavanja ugrožene vrste srebrne bjelice iz rijeke Rio Grande (*Hybognathus amarus*) u kružnim tankovima dijametra širine 2,44 metra (3.666 l). Budući da je ova vrsta ugrožena, potrebno je procijeniti sve nove jedinice za uzgoj pomoću testa preživljavanja. Kako bi bilo moguće koristiti novi sustav od 15 spremnika, potrebno je procijeniti preživljavanje u nasumičnom prikazu triju spremnika. *Fish and Wildlife Service* iz S.A.D.-a, koji regulira sve aktivnosti ove ugrožene vrste, odlučio je da je maksimalna dozvoljena smrtnost 60% za test preživljavanja; prema tome, preživljavanje ≥40% u svakom spremniku se smatra uspješnim. Po dvije zračne pumpe su stavljene u svaki spremnik. Dvije zračne pumpe su pomicale prosječno±SD od 33,697±5,563 l/min; ovo je proizvelo kompletnu izmjenu volumena spremnika pomoću zračnih pumpi od 110,65±16,93 min. Brzina vode se mjerila na devet mjesta u spremnicima. Brzina vode je bila 0,0-0,04 m/s. Koncentracija otopljenog kisika ni u jednom trenutku nije pala ispod 6,30 mg/l. Zračne pumpe su radile besprijekorno i nisu zahtijevale održavanje. Proizvodile su brzinu vode koja je pogodovala ribi te je omogućavala da se koncentracija otopljenog kisika održi iznad dozvoljenog minimuma (5 mg/l). Zračne pumpe će se koristiti u budućim aktivnostima uzgoja ribe u ovim i drugim spremnicima. Preživljavanje u trima spremnicima bilo je 78%, 94% i 96%; ukupno preživljavanje bilo je 89,3%. Budući da je smrtnost bila (10,7%) ispod dozvoljene razine (60%), test se smatra uspjelim.

Ključne riječi: zračna pumpa, srebrna bjelica, Rio Grande, *Hybognathus amarus*

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Received: 11. 5. 2012.
Accepted: 7. 9. 2012