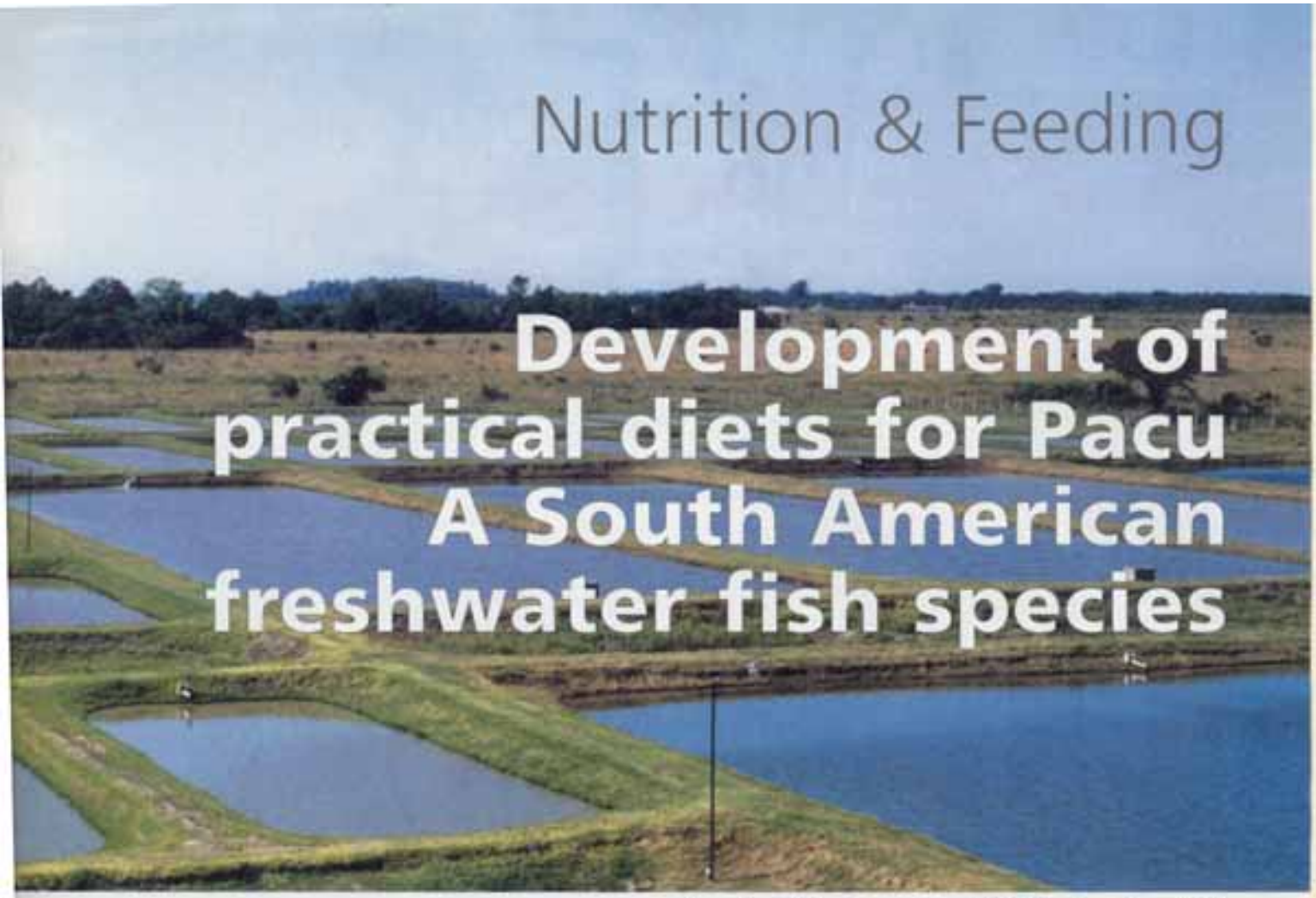

Development of practical diets for Pacu A South American freshwater fish species

Experimental feeds were formulated using locally available ingredients according to nutritional requirements set in Brazil

Pacu (Piaractus mesopotamicus) is a fast-growing freshwater fish species inhabiting the La Plata basin in South America. However, the species disappeared over 20 years ago from the Uruguay river and more recently from a great portion of the Paraná river. The disappearance has been mainly due to environmental changes in the basin, and in particular to dam construction (Quiros, 2003).

Consumers' habits in Argentina prefer large sized Pacu, with cultivated fish reaching a preferred market size of 1.2kg in 180 to 240 days in the Northeastern region of Argentina (the important production area for this species in the country; Wicki et al., 2001). The reported market price of Pacu in Argentina is reported to be between US$3.0 and 4.0/kg (whole, eviscerated and frozen).

The reported growth period required to reach this market size under semi-intensive pond culture conditions at low stocking densities (0.2 ind/m2) and with no water exchange or supplementary aeration is approximately 16 months (or two summer periods; Wicki, 2002) with a carrying capacity lower than 500-600g/m2 (Bernardino et al., 1998).

Pacu has a molar-like dentition suited for cutting and grinding, a long gastro-intestinal tract, and as such is adapted to a natural diet rich in fruit and seeds (Pereyra de

Continued on page 26

by G. Wicki and L. Luchini***

** Centro Nacional de Desarrollo Acuícola (CENADAC), Paseo Colón 982-Anexo Pesca, Buenos Aires 1063, Argentina*

*** Dirección de Acuicultura Paseo Colón 982-Anexo Pesca Buenos Aires 1063 Argentina*

Email: guillegus@arnet.com.ar
Email: lluchi@mecon.gov.ar

Table I: Feed rations tested during the feeding trial (value expressed as % diet)

Ingredients	Ration Soybean	Feather	Cottonseed	Silage	Control
Fish meal	8.0	8.0	8.0	-	20.0
Meat meal	10.0	15.0	20.0	18.0	10.0
Soybean meal	50.0	15.0	15.0	50.0	27.0
Blood meal	-	7.0	5.0	-	-
Feather meal	-	10.0	-	-	-
Cottonseed meal	-	-	15.0	-	-
Corn meal	-	16.0	12.0	-	11.0
Rice bran	27.0	27.0	23.0	18.0	30.0
Silage	-	-	-	12.0	-
Cassava Gel	3.0	-	-	-	-
NaCl-Vitamins	2.0	2.0	2.0	2.0	2.0
TOTAL	100.0	100.0	100.0	100.0	100.0

From page 23

Godoy, 1975). However, Ringuelet et al (1967) points out that Pacú may also have carnivorous tendencies and according to Machado (1980) the species should be considered as being omnivorous.

Long term pond feeding trials with Pacú carried out at the Centro Nacional de Desarrollo Acuícola (CENADAC) found that high dietary fish meal inclusion levels were unnecessary during final growth out. In these trials, two diets containing 32% and 20% fish meal were compared, with fish fed the lower fishmeal diets exhibiting better growth, higher weights and lower feed conversion ratios (Wicki, 2003). In view of these results, the aim of the present study was to reduce the level of dietary fish meal within compound feeds for Pacu so as to further reduce feed and production costs.

Materials and methods

Feeding trials were carried out at CENADAC in the Argentinian Northeast region (Corrientes province) from October 2001 to March 2002 (146 culture days) in a semi-intensive pond culture system with no water exchange (water only being supplied in case of leakage or to make up for evaporative losses). Fifteen 500m2 excavated experimental ponds in clay soil were stocked and managed similarly, with three ponds allocated per dietary treatment.

Animals (570 – 720g initial body weight) were obtained from CENADAC and stocked at a fixed density of 0.2 ind/m2. Neither fertilization nor any other previous pond treatment were performed prior to stocking the animals. Experimental feeds were formulated using locally available ingredients according to nutritional requirements set in Brazil by Cantelmo (1993): 30-35% protein and a minimum 6% fat for the grow-out culture. A total of five experimental feeds were formulated, a control diet containing 20% fish meal and four rations composed of mixtures of different animal and plant proteins, including one with fish silage (Table 1).

Fish silage was prepared following the method of Manca and Carrizo (2002) by mincing and blending fish viscera (obtained from fish caught from the La Plata basin) with sufficient formic acid (ca. 2.11% w/w) to attain a stable pH of 3.5. The resulting digest generally had a floating surface layer of oils and lipids which had to be removed by decantation so as to avoid oxidation and staleness. The chemical composition of the silage was as follows: moisture 76.8%, crude protein 12.8%, fat 8.6%, and ash 1.6%. The stabilized silage was stored at room temperature within sealed flasks until used.

Diets were produced by first mixing the dry ingredients for 10 minutes, adding water (ca. 40% w/w), and then mixing for a further 20 minutes. Sinking dry pellets were obtained by extruding the resultant moist mash through a meat grinder and then air drying. The proximate analysis of the silage and diets was performed by the National Institute for Fishery Research and Development (INIDEP) and is presented in Table 2.

Water parameters were monitored twice daily, including temperature, dissolved oxygen and pH during the early morning and late in the afternoon prior to feeding. Feeds were fed once daily, six days per week, initially at 1.5% of body weight per day and then reduced to 1.0% by the end of the culture. Rations were offered at a maximum of 35kg/ha/day so as to avoid the risk of serious oxygen depletion.

Fish samples (10% of population) were taken on a monthly basis so as to ascertain fish weight, fish health and calculate required food ration. All the fish were weighed at the end of the feeding trial and treatment groups compared by variance analyzed using one way ANOVA.

Table 2: Proximate analysis of the experimental diets (% by weight)

Analysis	Soybean	Silage	Ration Cottonseed	Feather	Control
Protein	32.1	33.7	34.0	34.8	32.5
Fat	8.1	6.1	6.4	6.6	8.5
Moisture	8.9	11.5	7.5	7.2	9.36
Ash	10.6	13.23	15.1	16.9	15.7
Carbohydrate	40.0	35.2	36.7	32.3	33.7

Table 3: Growth performance of Pacú fed the experimental diets

	Soybean Meal	Silage Meal	Ration Cottonseed Meal	Feather Meal	Control Diet
Initial weight (g)	721.25	699.92	673.09	676.17	574.92
Final weight (g)	1552.82	1524.63	1488.24	1533.41	1228.11
Period culture (days)	146	146	146	146	146
Weight Gain (g)	831.57	824.71	815.15	857.24	653.19
Increment W/D (g/d)	5.70	5.65	5.58	5.87	4.47
Specific Growth Rate (%/d)	0.52	0.54	0.55	0.56	0.52
FCR average	2.02	1.96	1.92	1.75	2.02
Survival (%)	100.00	100.00	100.00	100.00	100.00
Average Production (kg/ha)	3106	3049	2976	3067	2456

Specific Growth Rate = (lnWf-ln Wi) x 100 / t
FCR (Feed Conversion Ratio) = Food Offered/Weight Average Gain

Table 4: Comparatives experimental results on the culture of Piaractus mesopotamicus

Authors	Protein (%)	FCR	Culture (days)	Initial Weight(g)	Final Weight(g)
Roux & Bechara (1998)	31	2.3	350	1.0	734.7
Jacobo, et al. (1992)	25	2.29	431	3.0	965.5
Silva, et al. (1997)	22	4.67	375	30.0	817.0
Bernardino & Ferrari (1989)	22	2.47	365	11.4	624.0
Pereira, et al. (1988)	19	5.7	334	35.4	501.4
Mendonca, et al. (1988)	25	3.08	148	141.4	603.4
Ferraz de Lima, et al. (1988)	25	2.06	89	235.2	683.6

Results

Water quality

Mean water temperature during the feeding trial ranged from 25.8 to 28.3°C, with an overall mean of 27.3°C (Figure 1). Dissolved oxygen levels reached maximum and minimum peaks in January, ranging from 13.8mg/L in the afternoon to 0.89 mg/L in the early morning (Fig.2). Water pH values exhibited daily variations of between 6.7 and 8.5, displaying an average of 7.6 over the culture cycle.

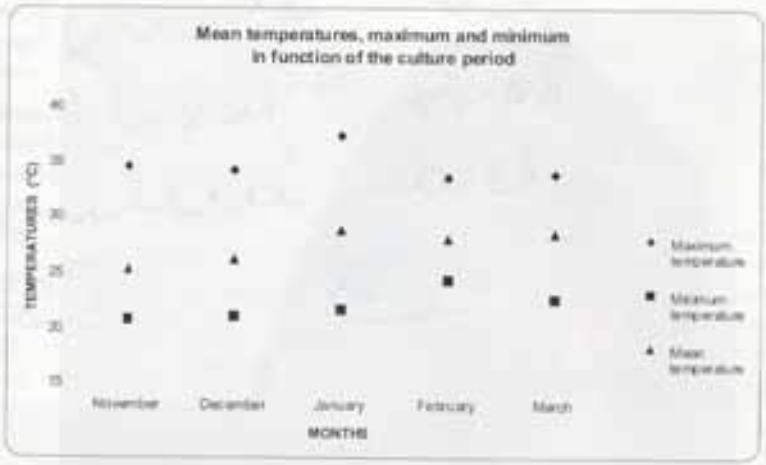

Figure 1: Mean water temperature registered during the culture cycle

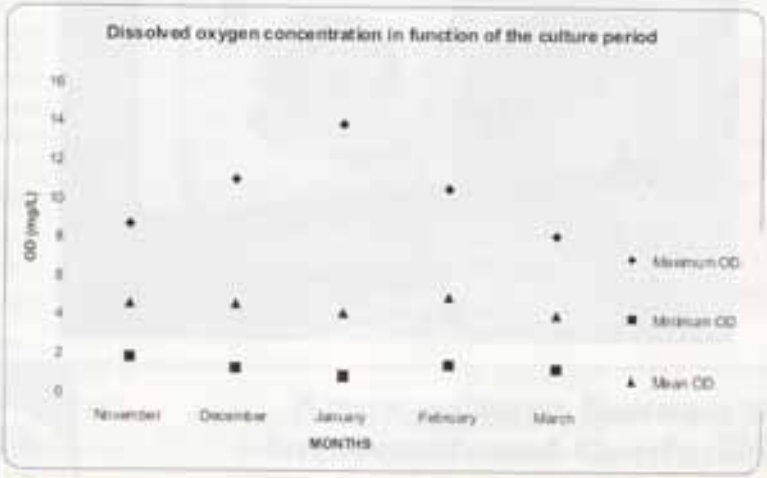

Figure 2: Mean dissolved oxygen levels registered during culture cycle

Growth response

Average final fish weights at the end of the 146-day culture period ranged from 1,228.1 to 1,552.8g, with the lowest weight recorded for the control group. This difference was believed to have been due to the lower weight of the control group at the start of the experiment (Fig. 3)

Average weight gains (Wf-Wi) ranged between 653.1 and 857.2 g and were not statistically significant ($P < 0.05$) between treatments, with 100% survival being recorded for all treatments at harvest (Table 3).

Out of 146 stocking days fish had been fed for a total of 113 days, with calculated Feed Conversion Ratio (FCR = Food offered / Weight average Gain) varying from 1.73 and 2.14 with an average of 1.92 for the cottonseed meal diet, varying from 1.66 and 1.90 with an average of 1.96 for the silage diet, varying from 1.85 and 2.24 with an average of 2.02 for the soybean meal diet, and varying from 1.80 and 2.11 with an average of 2.02 for the control diet. However, none of these differences between treatments were statistically significant ($P < 0.05$).

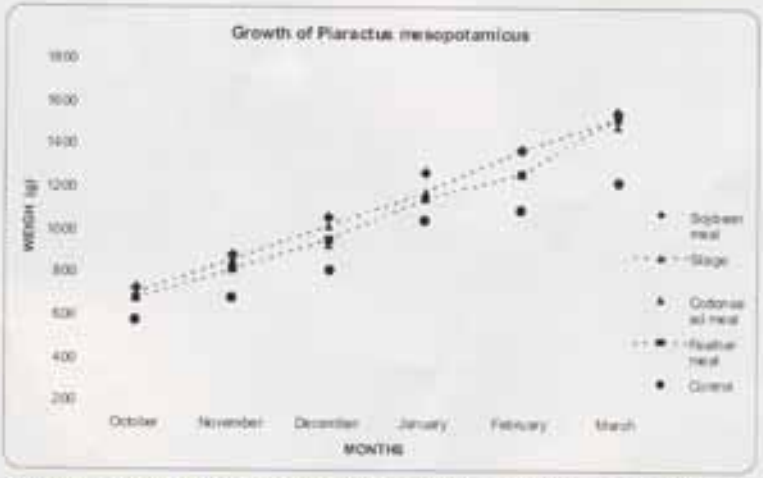

Figure 3: Growth of Piaractus mesopotamicus fed experimental diets

Discussion

Compared with previous Argentinian and Brazilian studies (Table 4) the present study has confirmed the observed direct relationship between dietary protein level and FCR. Van der Meer et al. (1996) also reported that low dietary protein levels of 22% caused growth reduction in Colossoma macropomum, compared with fish fed a 42% protein diet.

During the present study, none of the different dietary protein sources tested showed any negative effect on fish growth or feed efficiency. For example, fish fed 15% cottonseed meal showed no reduction in growth or feed performance. These results are in agreement with those of Lee et al. (2002) with rainbow trout juveniles fed a diet containing 15% cottonseed meal.

Similarly, no growth restrictions due to antinutritional factors were evident within fish fed diets containing up to 50% soybean meal. This is in agreement with the study of Van der Meer (1996) with Colossoma macropomum who found that diets with 43 % of soybean meal resulted in better growth (although not statistically significant) than diets containing higher dietary fish meal inclusion levels.

The low percentage of blood meal used within the feather and cottonseed diets (7 and 5%) had no apparent deleterious effect on feed or fish performance. Eckman (1987) reported reduced growth in juvenile Colossoma fed diets with blood meal as the main protein source compared with fish fed diets composed of mixtures of fish meal (10-20 %) and blood meal (5-15%). This growth reduction may have been due to the poor amino acid balance of blood meal when used as the sole source of dietary protein and/or due to the thermal degradation of the protein during the blood

drying process. Finally, fish fed the hydrolized feather meal diet displayed the lowest FCR, indicating a high digestibility.

Conclusion

Pacu showed great versatility and adaptability to the diets fed during the present study with no loss in growth or feed efficiency. This may have been due to the herbivorous/omnivorous feeding habit of this species.

The encouraging results obtained with fish silage and the other dietary proteins tested hold great promise to further reduce feed costs for this species and ensure the continued development of cost-effective semi-intensive production technologies.

Acknowledgments

The authors wish to thank Ing. Emilio Manca and J. Carlos Carrizo, National Institute for Fishery Research and Development (INIDEP) for their help and suggestions concerning silage formula elaboration, the Consejo Federal de Inversiones (CFI) and Ministry of Economy and Production (Secretaría de Agricultura, Ganadería, Pesca y Alimentos - SAGPyA) for financial support; and the staff of CENADAC, and especially to Technician F. Rossi for his work.

References

Bernardino, G. Peret, A.C. Ferrari, V.H., Verani, J.R., 1998. Biomassa sustentavel do Pacu, Piaractus mesopotamicus (Holmberg,1887) criados em viveros com baixa renovacao de agua. Resumos do Acuicultura, pp. 261. Recife, Brasil.

Bernardino, G., Ferrari, V.A., 1989. Efeito do uso de racao comercial no desempenho do pacu, Piaractus mesopotamicus (Holmberg,1887) em cativeiro. Bol.Tec.CEPTA, 2, 19-33. Brasil.

Cantelmo, O.A., 1993. Níveis de proteína e energia em dietas para o crescimento do pacu, Piaractus mesopotamicus (Holmberg,1887). Dissertacao apresentada para obtencao do título de Mestre em Acuicultura. 55 pp. UFSC, Brasil.

Eckman, R., 1987. Growth and body composition of juvenile Colossoma macropomum Cuvier,1818 (Characoidei) Feeding on artificial diets. Aquaculture, 64, 293-303.

Ferraz de Lima, J.A., Bustamante, A., Chablin, E., Pallarhes, F.J., Souza, J.H., Gaspar, L.A., 1992. Utilizacao de resíduos de produtos hortifruto-granjeiros para o criacao do pacu, Piaractus mesopotamicus (Holmberg, 1887) em gaiolas. Bol.Tec.CEPTA, 5 (1), 1-9. Brasil.

Jacobo, W. Martinez, M.C., Revidatti, F., 1992. Cultivo experimental de pacú, Piaractus mesopotamicus (Holmberg, 1887) en el noreste de la provincia de Corrientes, Argentina. Rev.de Ictiología, 1, 93-98. Argentina.

Lee, K.J., Dabrowski, K. Blom, J. H., Bai, S.C.,

Nutrition & Feeding

Stromberg, P.C., 2000. A mixture of cottonseed meal, soybean meal and animal by product mixture as a fish meal substitute: growth and tissue gossypol isomers in juvenile rainbow trout (Oncorhynchus mykiss). J.Anim.Physiol.Anim.Nutr., 86,1-13.

Machado-Allison,A., 1980. Estudios sobre las subfamilias Serrasalmidae (Teleostei, Characidae). Parte 1. Estudio comparado de los juveniles de cachamas de Venezuela (Géneros Colossoma y Piaractus). Acta Biológica Venezuélica, 11 (3),1-101. Venezuela.

Manca, E., Carrizo, J.C.,2002. Informe final de producción y utilización de ensilados en la formulación de dietas. Proyecto DNA/INIDEP. Expte 4961. 8 pp. Argentina.

Mendonca, J.O., Ferrari, V.A., Gaspar, L.A., Camargo, M.B., 1988. monocultivo de Pacú (Colossoma mitrei) en una propiedade particular. Bol.Tec.CEPTA, 1 (1),29-35. Brasil.

Pereyra de Godoy, M.,1975. Peixes do Brasil. Subordem Characoidei.Volumen II.Ed. Franciscana, 217-397. Brasil.

Quiros, R. 2003. The La Plata river basin: Internacional basin development and riverine fisheries. Paper presented at Second International Symposium on the Management of Large river for Fisheries (LARS2). Phnom Penh, Kingdom of Cambodia, 11th -14th February 2003.First Draft.

Ringuelet, R.A., Aramburu, R.H., Alonso de Aramburu,A., 1967. Los peces argentinos de agua dulce. CIC., 248 pp. Argentina.

Roux, J.P., Bechara, J.A., 1998. Engorde de pacú (Piaractus mesopotamicus) en sistema semi intensivo en el Norte de la provincia de Santa Fe – Argentina. Rev. Ictiología,6 (1-2), 65-72. Argentina.

Van der Meer, M.B., Huisman,E.A., Verdegem, M.C.J., 1996. Feed composition, growth and protein utilization of Colossoma macropomum (Cuvier) at different dietary fish meal/soya meal rations. Aquaculture Research, 27, 531-538.

Wicki, G., Luchini,L., Kohan,G.,Petriatto, H. 2001. Programa de reconversión de pescadores artesanales a piscicultura de pacú. Informe final (Parte II y III). Consejo Federal de Inversiones (CFI). 228 pp. Argentina. (in Spanish).

Wicki, G., 2003. Cultivo y producción de pacú (Piaractus mesopotamicus): Incidencia de dos dietas de diferente composición y de la densidad de siembra en sistemas de cultivo semi intensivo. Tesis de Maestría en Acuicultura (in Spanish with english abstract). Escuela de Graduados, Fac. Agronomía, Univ. Buenos Aires. 81 pp. Argentina.

Wicki, G., Witchtenski, E., Luchini, L., 2002. Producción de pacú (Piaractus mesopotamicus) en el subtrópico argentino con diferentes densidades de siembra. Resúmenes X Congreso Latinoam. Acuicult. (ALA). 38 pp. Chile. (in Spanish with English abstract).