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First records of *Myxine affinis* Günther, 1870 and *Myxine knappi* Wisner & McMillan, 1995 in San Jorge gulf, central Patagonia, Southwestern Atlantic

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Abstract: There are records of seven species of hagfishes in the Argentine shelf and continental slope, comprising the most diverse region for this group in the Southwestern Atlantic. Here, the authors report the occurrence of *Myxine affinis* and *Myxine knappi* in San Jorge gulf, adding two species to the ichthyofauna of central Patagonia. A specimen of *M. affinis* (447 mm TL; hermaphrodite) was incidentally caught by the Patagonian shrimp fishing fleet and collected by the Fishery Observer Program of Fisheries Secretariat of the Chubut Province, Argentina. Subsequently, the authors collected a second specimen of *M. affinis* (358 mm TL; female) and a specimen of *M. knappi* (303 mm TL) during the research cruises of the oceanographic vessel ARA Puerto Deseado, within the "Pampa Azul" initiative. The latter is the twelfth record for the species. These specimens are stored in the ichthyological collection of the Instituto de Investigación de Hidrobiología of the Universidad Nacional de la Patagonia San Juan Bosco, Trelew (UNPSJB-ICT), Argentina. These new records of *M. affinis* and *M. knappi* extended their known distribution by 850 km and 220 km northward, respectively. In addition, the authors reported morphometric, meristic and reproductive variables of the collected specimens.

Keywords: Myxinidae, new record, Pampa Azul, Argentine Sea, agnathans, cyclostomes

Resumen: Primeros registros de *Myxine affinis* Günther, 1870 y *Myxine knappi* Wisner & McMillan, 1995 en el golfo San Jorge, Patagonia central, Atlántico Sudoccidental. En aguas de la plataforma Argentina y del talud continental se tiene registro de siete especies de mixines (*hagfishes*), comprendiendo la región de mayor diversidad del Atlántico sudoccidental. A partir del Programa de Observadores a Bordo de la Secretaría de Pesca de la Provincia del Chubut, que monitorea las pesquerías industriales de la región, se capturó incidentalmente un ejemplar de *Myxine affinis* (447 mm TL; hermafrodita). Posteriormente, durante las campañas de investigación del buque oceanográfico ARA Puerto Deseado, en el marco de la iniciativa "Pampa Azul", se registró un segundo ejemplar de *M. affinis* (358 mm TL; hembra) y un ejemplar de *Myxine knappi* de 303 mm TL. Este último es el doceavo registro para la especie. Todos los ejemplares fueron capturados mediante la utilización de redes de arrastre de fondo y se encuentran depositados en la colección ictiológica del Instituto de Investigación de Hidrobiología de la Universidad Nacional de la Patagonia San Juan Bosco, sede Trelew (UNPSJB-ICT), Argentina. Estos nuevos registros amplían la distribución conocida para *M. affinis* y *M. knappi* en 850 km y 220 km respectivamente, sumando así dos especies a la ictiofauna de Patagonia central. En los ejemplares colectados, se registraron variables morfométricas, merísticas y reproductivas.

Palabras clave: Myxinidae, nuevo registro, Pampa Azul, Mar Argentino, agnatos, ciclostomados

INTRODUCTION

Hagfishes comprise a primitive group of jawless, cartilaginous and anguilliform, strictly marine, benthic fishes with a global distribution (Martini, 1998). They have important roles in the functioning of benthic ecosystems; as hagfishes are fossorial scavengers and/or detritivores, the effect of excavation and feeding is assumed to significantly impact substrate turnover and nutrient cycling (Martini, 1998; Knapp *et al*., 2011).

All 78 described species of hagfishes are currently grouped into a single family (Myxinidae), which is divided into three subfamilies (Rubicundinae, Eptatretinae and Myxininae), and six genera (*Rubicundus* Fernholm, 2013; *Eptatretus* Cloquet, 1819; *Myxine* Linnaeus, 1758; *Notomyxine* Nani & Gneri, 1951; *Neomyxine* Richardson, 1953; and *Nemamyxine* Richardson, 1958) (Fernholm *et al*., 2013). In the southern region of South America (Argentina and Chile), there are records of 14 species of hagfishes, comprising the second most diverse area for this group in the world. However, it is the area with the greatest gaps of biological information on these species (Knapp *et al*., 2011). The Argentine shelf and continental slope are the most diverse region of hagfishes in the southwestern Atlantic (Knapp *et al*., 2011) with seven species: *Myxine affinis* Günther, 1870; *Myxine australis* Jenyns, 1842; *Myxine debueni* Wisner & McMillan, 1995; *Myxine fernholmi* Wisner & McMillan, 1995; *Myxine knappi* Wisner & McMillan, 1995; *Nemamyxine kreffti* McMillan & Wisner, 1982; and *Notomyxine tridentiger* (Garman, 1899) (Norman, 1937; Nani & Gneri, 1951; Wisner & McMillan, 1995; Góngora *et al*., 2009; Knapp *et al*., 2011; Bovcon *et al*., 2013; Figueroa, 2019; Cousseau *et al*., 2020; Delpiani *et al*., 2020; Mabragaña & Cousseau, 2021). However, in central Patagonia, only two species have been recorded to date, *M. australis* and *N. tridentiger* (Góngora *et al*., 2009; Bovcon *et al*., 2013).

According to Mincarone (2013a), the known distribution of *M. affinis* includes the southernmost coasts of Argentina and Chile, in the Straits of Magellan, Beagle Channel and other channel systems around Tierra del Fuego, including Isla de Los Estados and Cape Horn. Catches of *M. affinis* are associated with muddy and sandy bottoms between 3 and 146 m depth (Mincarone, 2013a), and recently was recorded in Burdwood Bank (Delpiani *et al.,* 2020). Information about *M. knappi* is limited. So far, only 11 specimens are known to be preserved in collections (Mincarone, 2013b). Its distribution comprises the southern end of the Argentine continental shelf, including Cape Horn, Malvinas Islands, and Burdwood Bank, approximately between latitudes 48°S and 55°S (Mincarone, 2013b). This study aims to report two new records of *M. affinis* and one of *M. knappi* in the waters of the San Jorge gulf (central Patagonia, Argentina), extending the knowledge of their distributions northward by 850 km and 220 km, respectively.

MATERIAL AND METHODS

The records reported here come from two sources: i) The Fishery Observer Program of Fisheries Secretariat of the Chubut Province (POBCh, spanish acronyms of Programa de Observadores a Bordo de la Provincia del Chubut) for the monitoring of the fishing fleet targeting the Patagonian shrimp *Pleoticus muelleri* Bate, 1888, which in 2010 collected an incidentally caught specimen of *M. affinis* (46°52'10" S, 66°12'46" W; 58 m depth; UNPSJB-ICT-2010/33), and ii) a research cruise of the "Pampa Azul" initiative conducted by the Oceanographic vessel ARA Puerto Deseado, which in 2016 captured the second specimen of *M. affinis* (46°38'24" S, 65°47'29" W; 65 m depth; UNPSJB-ICT-2016/15; Fig. 1A) and a specimen of *M. knappi* (45°51'33" S, 65°05'27" W; 82 m depth; UNPSJB-ICT-2016/16; Fig. 1B). All catches were done with bottom trawl nets.

Specimens were identified to the specific level according to the characters proposed by Wisner & McMillan (1995) and Figueroa (2019), and they were deposited in the ichthyological collection of the Instituto de Investigación de Hidrobiología of the Facultad de Ciencias Naturales y Ciencias de la Salud of the Universidad Nacional de la Patagonia San Juan Bosco in Trelew city (UNPSJB-ICT). As diagnostic characteristics of the species *M. affinis*, the following were considered: multicusps of two cusps on anterior and posterior rows, a total of cusps ranging between 38 and 46, absence of gill pores, and a narrow whitish band ventrally limited to below lateral slime pores. As diagnostic characteristics of the species *M. knappi*, the following were considered: multicusps of two cusps on anterior and posterior rows, a total of cusps ranging between 34 and 40, absence of gill pores, absence of the ventral whitish band, and a tail length between 12 and 13 percentage of total length. The measurement of the morphometric and meristic variables fol-

Fig. 1. Specimens deposited in the UNPSJB-ICT collection: (A) *Myxine affinis* UNPJSB-ICT 2016/15, 358 mm and (B) *Myxine knappi* UNPSJB-ICT 2016/16, 303 mm. Scales = 20 mm.

lowed Fernholm & Hubbs (1981), McMillan & Wisner (1984), and Wisner & McMillan (1995). Morphometric variables and weights were recorded with a caliper of 0.02 mm and a digital scale of 0.01 g accuracy, respectively.

RESULTS

Both specimens of *M. affinis* identified presented 42 dental cusps and narrow whitish band ventrally limited to below the line of lateral

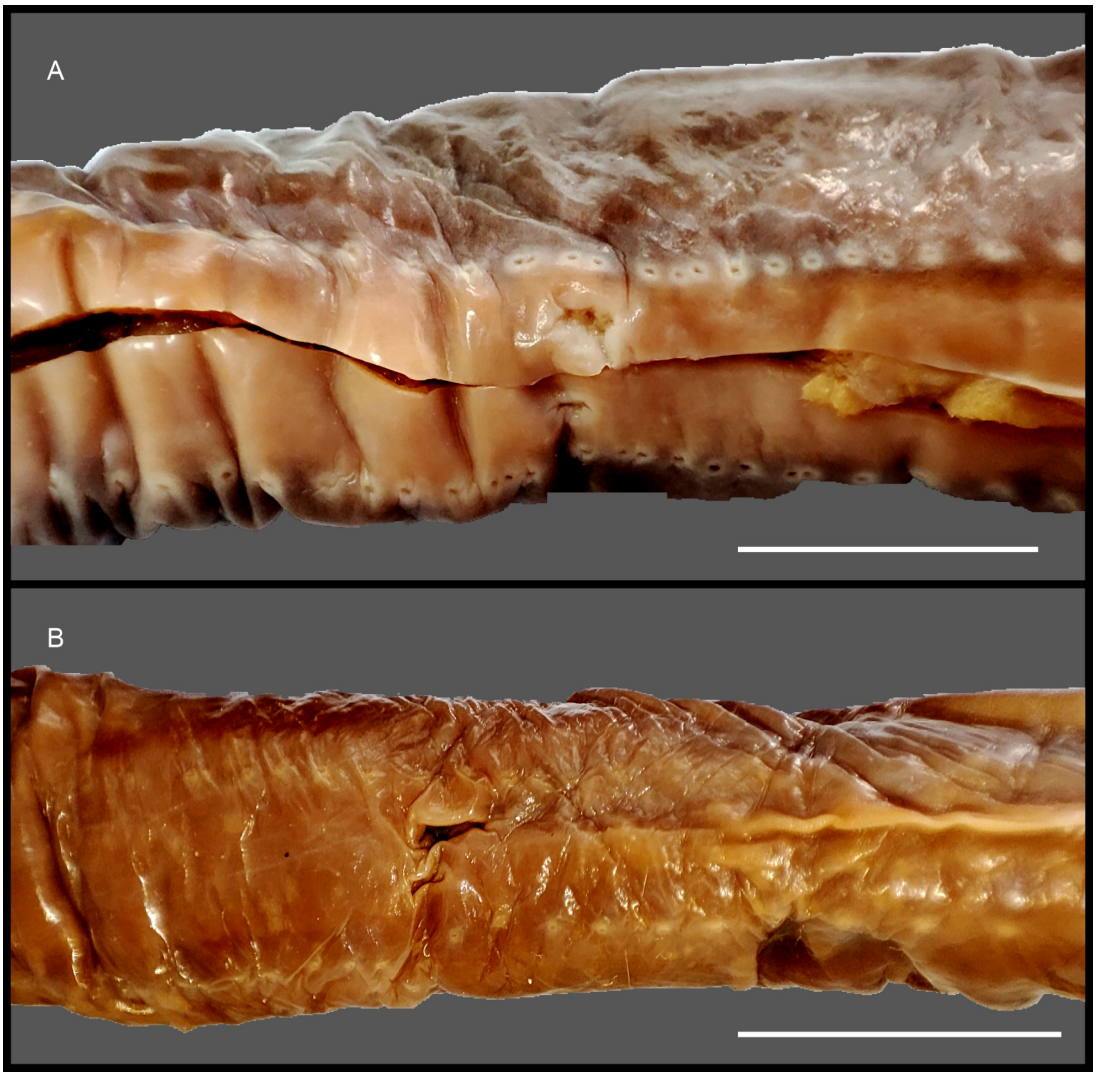

Fig. 2. Ventral view (A) *Myxine affinis* UNPJSB-ICT 2016/15, narrow whitish band ventrally limited to below the lateral pore line, and (B) *Myxine knappi* UNPSJB-ICT 2016/16, absence of the ventral whitish band. Scales = 20 mm.

pores (Fig. 2A). The first specimen of *M. affinis,* collected in 2010, a hermaphrodite with 190 oocytes (size < 1 mm), 61.22 mm long testis and the height of the ventral finfold was 2.12 mm (see Tab. 1). The second specimen of *M. affinis* was a female, collected in 2016, with 12 oocytes (size < 0.5 mm) (see Tab. 1), and the ventral finfold height was 0.67 mm. The unique specimen of *M. knappi* collected in 2016 had 35 total dental cusps, absence of the ventral whitish band (Fig. 2B), and a tail length of 13.2% of TL (see Tab. 1). The ventral finfold height was 2.54 mm. Sex was not determined in this specimen because it was deposited intact in the UNPSJB-ICT collection. The morphometric and meristic variables recorded for *M. affinis* and *M. knappi* (Tab. 1), are within the ranges reported by Mincarone (2007) for the species.

DISCUSSION

In recent decades, the known distribution of some species of hagfishes have expanded northward in the Southwestern Atlantic, as is the case of *M. australis* in the southern Brazilian waters (Mincarone & Soto, 2001) and *N. tridentiger* in waters of Uruguay (Racz Lorenz *et al.,* 2014). These records may be attributed to two factors:

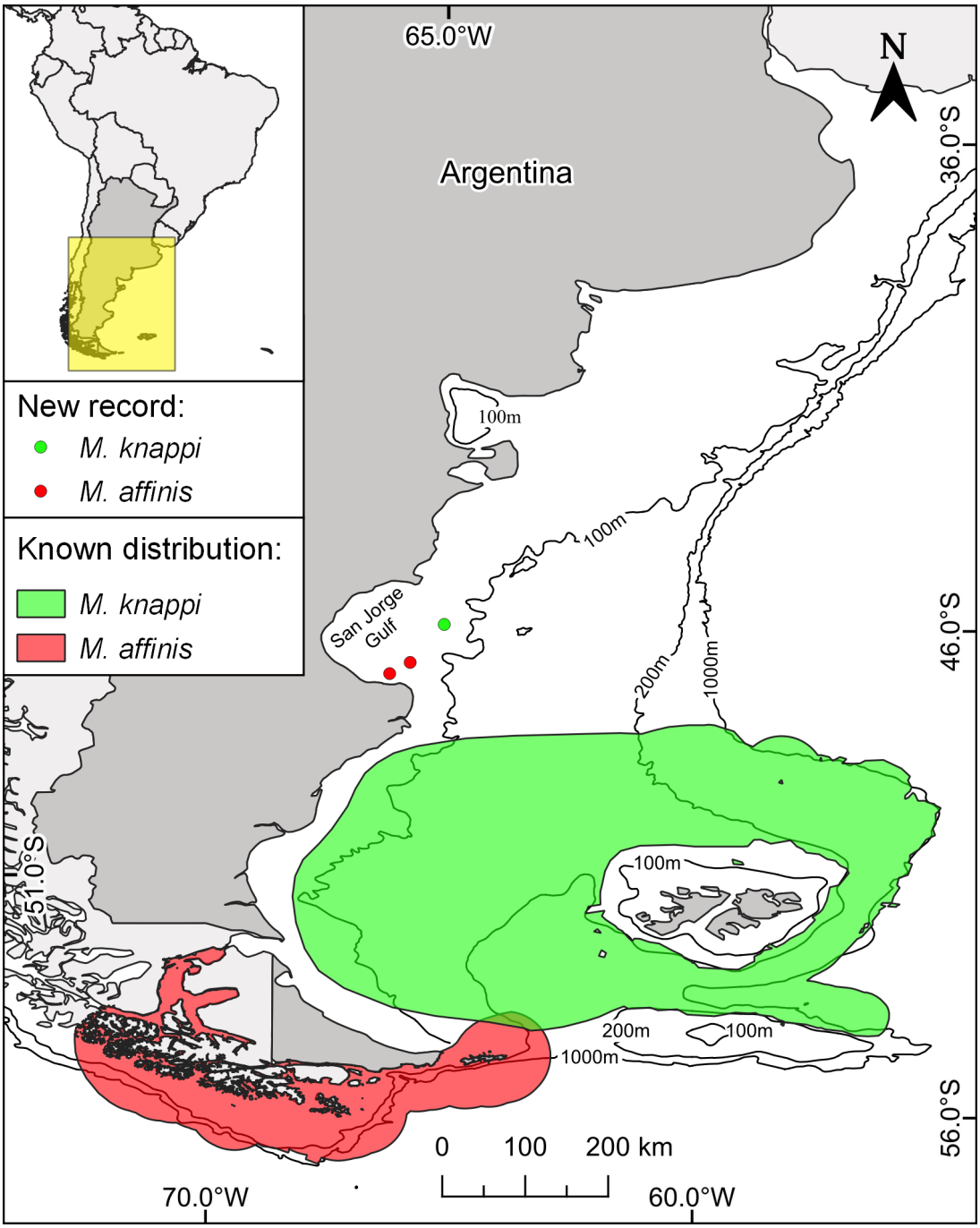

Fig. 3. Known distribution for *Myxine affinis* (red area) and *Myxine knappi* (green area) according to Mincarone (2013a,b). New records of *M. affinis* (red point) and *M. knappi* (green point).

(i) an expansion of this cold-water group northward; or (ii) an increase in the scientific interest in this group, which made possible the detection of specimens in sites where the species are rare because they are at the limit of their distribution.

In this paper we report new records of *M. affinis* and *M. knappi* in waters of the San Jorge gulf, between Dos Bahías cape (44°55' S, 65°32' W) and Tres Puntas cape (47°06' S, 65°52' W), in central Patagonia, Argentina (Fig. 3). This extends the

Table 1. Morphometric and meristic measurements of the specimens of *Myxine affinis* and *Myxine knappi*.

	M. affinis	***M. affinis***	***M. knappi***
UNPSJB-ICT	2010/33	2016/15	2016/16
Year	2010	2016	2016
Total length TL (mm)	447	358	303
Weight (g)	121	45.1	19.9
Sex	Hermaphrodite	Female	–
Measurements in % of TL			
Prefinfold length	33.3	32.9	31.0
Prebranchial length	30.2	29.0	28.7
Trunk length	59.2	60.0	60.0
Tail length	11.4	12.0	13.2
Body width	4.4	3.6	3.5
Body depth	6.8	5.0	5.1
Depth at cloaca	5.0	3.9	3.2
Tail depth	4.8	4.0	4.3
Counts			
Cusps:			
Multicusps (ant. /post.)	2/2	2/2	2/2
Anterior unicusps	8/8	8/8	7/6
Posterior unicusps	9/9	9/9	7/7
Total cusps	42	42	35
Slime pores:			
Prebranchial	31	33	35
Trunk	66	68	63
Tail	12	12	11
Total pores	109	113	109

knowledge of the distribution of *M. affinis* from its known distribution in the Straits of Magellan to the waters of San Jorge gulf, approximately 850 km and 7° northward. Similarly, the distribution of *M. knappi*, is extended by approximately 220 km and 2° in the same direction, from 48° S to the mouth of the San Jorge gulf. The present study added two new species to the fish diversity in the waters of central Patagonia. It is important to note that the finding of *M. knappi* is the twelfth historical record for the species.

The records presented here are located in the San Jorge gulf, a semi-enclosed basin of approximately 230 km latitudinal opening and 150 km longitudinal width, with an area of 40000 km^2, being the largest gulf of the Argentinean coast (Dans *et al*., 2021). The gulf is influenced by the presence of two frontal systems, the Northern Patagonian Frontal System seasonally influences the northern region, whilst the southern region is characterized by the permanent presence of the Southern Patagonian Frontal System (Sabatini & Martos, 2002; Bogazzi *et al*., 2005). Both frontal systems are areas of high primary productivity, constituting sites with high concentration of marine organisms (Yorio, 2009). One of the main environmental factors limiting the distribution of hagfish species is the low temperature (Martini, 1998). The records of the presence of *M. affinis* and *M. knappi* in the waters of San Jorge gulf may be associated with the permanent occurrence of the Southern Patagonia Frontal System, which extends from south to north from the Strait of Magellan, with the influence of cold water masses, to the southern end of the San Jorge gulf and the central outer area of its mouth (Bogazzi *et al*., 2005).

Studies of hagfishes in Argentinean waters are scarce; there are only two published works, Nani & Gneri (1951) and Wisner & McMillan (1995), both of great relevance for the study of these fishes at the global level. Despite the scarce scientific interest in the group, in northern and central Patagonia, hagfishes are part of the diet of top predators, like the sea lion *Otaria flavescens* Shaw, 1800 (Koen Alonso *et al*., 2000), and the shark *Notorynchus cepedianus* (Péron, 1807) (Crespi-Abril *et al*., 2003). In this same area, *N.*

tridentiger and *M. australis* are identified in the bycatch of the Patagonian shrimp *P. muelleri* and common hake *Merluccius hubbsi* Marini, 1933 fisheries (Góngora *et al*., 2009; Bovcon *et al*., 2013), with mean Frequencies of Occurrence (FO) of 0.06% and 0.28%, respectively (Góngora *et al*., 2009). The low FO in the San Jorge gulf could be due to the low vulnerability of these species to the bottom trawl nets. According to Martini (1998), hagfishes have a fossorial lifestyle, so the use of bottom trawls could generate underestimates of abundance. In addition, Gorbman *et al.,* (1990) point out that identifying hagfishes at the specific level is a challenging task. Similarly, the observers of the POBCh, expressed this difficulty in identifying species due to the great mobility they have and the mucus they secrete when handled. In addition, as the presence of *M. affinis* and *M. knappi* in central Patagonia was unknown until now, observers were not instructed in their identification and distinguishing features. Based on the aforementioned: i) underestimates of abundance by gear selectivity, ii) difficulty in identification on board and iii) unknown presence of the species in the area, it is likely that *M. affinis* and *M. knappi* could have a higher abundance and are not species of exceptional occurrence in the area.

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