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ESTUDIO DE LAS RELACIONES TRÓFICAS DE ALGUNOS PECES BENTÓNICOS DE INTERÉS COMERCIAL DEL GOLFO DE VALENCIA (MEDITERRANEO OCCIDENTAL).

MARÍA SALOMÉ MORTE SEGURA

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ESTUDIO DE LAS RELACIONES TRÓFICAS DE ALGUNOS PECES BENTÓNICOS DE INTERÉS COMERCIAL DEL GOLFO DE VALENCIA (MEDITERRÁNEO OCCIDENTAL).

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Dr. Antonio Sanz Brau
Profesor Titular de Ecología

Maria Salomé Morte Segura

CASTELLÓN, 2001

ANTONIO SANZ BRAU, Profesor titular de Ecologia de la Universitat de València,

CERTIFICA:

Que la memoria de Tesis Doctoral titulada: **Estudio de las relaciones tróficas de algunos peces bentónicos de interés comercial del Golfo de Valencia (Mediterráneo occidental)** presentada por MARIA SALOMÉ MORTE SEGURA, ha sido realizada bajo su dirección en el Laboratorio de Biología Marina del Departament de Microbiologia i Ecologia de esta Universidad.

Lo que hace constar a los efectos oportunos, en Burjassot a 22 de Mayo de 2001.

Dr. Antonio Sanz Brau

RESUMEN: En el presente estudio se han analizado los contenidos estomacales de 6370 ejemplares pertenecientes a ocho especies de peces bentónicos (*Mustelus mustelus*, *Lepidorhombus boscii*, *Lepidorhombus whiffiagonis*, *Trachinus draco*, *Scorpaena notata*, *Scorpaena porcus*, *Trisopterus minutus capelanus* y *Phycis blennoides*). En este trabajo se ha descrito de forma detallada el régimen alimentario de estas especies provenientes de capturas comerciales, analizando los cambios de las dietas respecto a la talla de los individuos estudiados y también respecto a las estaciones. Se ha evaluado la amplitud de los nichos tróficos de cada una de ellas y las interrelaciones existentes entre estos peces a partir de su competencia trófica.

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ÍNDICE

1. INTRODUCCIÓN

1. ESTUDIO DE LOS CONTENIDOS ESTOMACALES EN PECES

El análisis de los contenidos estomacales de peces ha permitido establecer claras adaptaciones anatómicas (Magnuson & Heitz, 1971; De Groot, 1969, 1971, Wheeler & Jones, 1989). Del mismo modo, cambios en la dieta del pez a lo largo de su vida pueden estar correlacionados con variaciones en la morfología del individuo (Machado-Allison & García, 1986; Stergiou & Fourtouni, 1991).

El estudio de la alimentación de las poblaciones de una biocenosis también permite conocer mejor el papel que cada especie juega en la transferencia de energía dentro del ecosistema, aportándonos información sobre el nicho trófico que esta ocupa (Berg, 1979; Macpherson, 1981; Gibson & Ezzi, 1987; Harnois, 1992; Gröhsler, 1994). Asimismo, permite determinar las relaciones tróficas del ecosistema marino, sirviendo de punto de partida en el estudio de las interacciones entre especies (predación y competencia), tanto interespecífica como intraespecífica. Por ello, se ha comprobado que, en el medio marino, el conocimiento de la organización trófica de los ecosistemas tiene gran importancia en la evaluación, regulación y producción de los recursos pesqueros (Steele, 1965; Ryther, 1969; Parsons & Le Brasseur, 1970).

En consecuencia, los datos procedentes del análisis de contenidos estomacales se consideran esenciales para determinar los efectos de la pesca en aquellas especies explotadas, en sus predadores, sus presas y sus competidores (Olaso & Rodríguez-Marín, 1995; Hall *et al.*, 1995). Esto permite desarrollar modelos multiespecíficos y conocer con menor error la mortalidad natural de algunas especies.

Además de los aspectos citados, estos trabajos desempeñan un papel complementario en los estudios faunísticos; aunque no aportan una idea demasiado fiable de la abundancia de las distintas especies del medio, debido a la acción que el predador efectúa sobre estas presas (Eleftheriou & Holme, 1984). Pero si bien no nos ofrecen una idea cuantitativa absoluta, sí que es interesante el conocimiento cualitativo de comunidades cuya metodología de muestreo seria de lo contrario, muy complicada (Rodríguez-Marín, 1993). Como prueba de esto, pueden tenerse en cuenta trabajos como el de Naganta (1959), que a partir de estudios de los contenidos estomacales de tríglidos del Mar del Japón, dió a conocer tres nuevas especies del género *Ampelisca* (Amphipoda); o el estudio realizado por Reys (1960) sobre la nutrición de peces demersales en el Golfo de León, que contribuyó a conocer mejor la población de Anfípodos, Misidáceos, Poliquetos y Equinodermos de la citada región.

Por tanto, el conocimiento de la alimentación de una especie es un aspecto básico en su biología, y determinante en sus adaptaciones tanto anatómicas, fisiológicas como etológicas. Además permite conocer la posición trófica que dicha especie ocupa en la cadena alimentaria, contribuyendo al conocimiento de las características del ecosistema en que habita.

Tampoco hay que olvidar, que con miras a la posibilidad del cultivo en cautividad, es necesario conocer los requerimientos tróficos de toda especie a lo largo de su ciclo biológico; dado que a menudo muchas especies de peces varían su dieta acorde con su crecimiento (Macpherson, 1977; Molinero *et al.*, 1991).

2. METODOLOGÍA DEL ANÁLISIS DE CONTENIDOS ESTOMACALES

Como hemos visto, el análisis del contenido estomacal puede aportar información de naturaleza muy diversa. Existen numerosos trabajos que examinan estómagos de peces, pero dependiendo del objetivo específico, la metodología y el diseño experimental varían considerablemente. Esto significa que a pesar de la gran cantidad de información que hay sobre contenidos estomacales de peces, en muchos de los casos no es utilizable por falta de una unificación en la metodología empleada, lo que limita el alcance de los trabajos a las condiciones particulares en las que se llevaron a cabo.

El método más fiable para conocer del régimen alimentario de los peces consiste en la observación directa del tipo y cantidad de alimento que ingieren, así como la frecuencia con que lo hacen en condiciones naturales. Esto tropieza en la práctica con la dificultad que encuentra el hombre de introducirse en el medio marino. Por ello en los estudios ictiológicos de alimentación, el trabajo se centra en el examen de las distintas secciones del tramo digestivo y más concretamente de la cavidad estomacal (Amezaga, 1988).

Sin embargo, esta metodología lleva inherente errores que se deben de tener en cuenta, como el hecho de que pueden aparecer restos alimenticios muy digeridos y por tanto difíciles de clasificar, o bien, puede que los peces al ser atrapados expulsen las presas de su estómago. Pero a pesar de esto, el análisis y clasificación del contenido estomacal es el método de trabajo más empleado y el que proporciona un mayor conocimiento de los hábitos alimentarios de la fauna ictiológica (Hynes, 1950; Hyslop, 1980; Amezaga, 1988; Marrero, 1994; Hall *et al.*, 1995).

2.1. Obtención del material

En las investigaciones sobre alimentación de peces, los métodos más empleados para la obtención de estómagos son las campañas oceanográficas (Kinzer, 1977; Papaconstantinou & Caragitsou, 1989; Kompowski, 1992; Robb *et al.*, 1994) y las pescas comerciales (Hamerlynck *et al.*, 1990; Golani & Galil, 1991; Redón *et al.*, 1994; Pedersen, 1995). También se recoge material, pero menos frecuentemente, con la pesca deportiva (Hayes *et al.*, 1991).

2.2. Tamaño de la muestra

El número de ejemplares estudiados es muy variable, variando desde unas pocas decenas (Mori, 1982; Matallanas *et al.*, 1993; Hernández-García, 1995), cientos (Cau *et al.*, 1986; Caragitsou & Papaconstantinou, 1988; Vivó & Sanz, 1989; Deady & Fives, 1995; Morte *et al.*, 1997) o miles (Lamas, 1979; Arias, 1980; Lyle, 1983; Hanchet, 1991; Hislop *et al.*, 1991). Algunos combinan un análisis en detalle de un número reducido de estómagos con un estudio somero de un número mayor (Konstantinov *et al.*, 1985).

Diversos autores (Simenstad & Lipovsky, 1976; Lipovsky & Simenstad, 1978; Maucheline & Gordon, 1984) han diseñado una serie de tests estadísticos para determinar el número óptimo de estómagos a recoger. Sin embargo, en la práctica la elección del tamaño de la muestra depende en cada caso de los objetivos del trabajo, de las disponibilidades económicas y de personal investigador, o de la abundancia de éstas en el medio (escasez de individuos en un área en particular o bien especies protegidas).

2.3. Extracción de los estómagos

Para obtener estómagos con contenidos en buenas condiciones se deben capturar los ejemplares, si es posible, al final de un periodo alimentario antes de que la digestión haya avanzado demasiado (Windell, 1968). Y por supuesto extraerlos, lo más pronto posible después de la captura, para evitar la digestión *post mortem.*

Uno de los métodos más frecuentes, en la extracción de los estómagos, consiste en abrir la cavidad abdominal mediante una incisión longitudinal en la zona ventral. Luego se corta el intestino a nivel del píloro y el estómago se saca cortando por el esófago. Otro método (Reintjes & King, 1953), consiste en hacer una incisión a lo largo de la membrana branquial, en la zona posterior al cuarto arco branquial, se sacan las vísceras y el estómago se extrae cortando el intestino y el esófago.

2.4. Regurgitación

Un dato importante en los trabajos es conocer el consumo de alimento de los peces estudiados, por lo que es esencial el poder diferenciar que estómagos están realmente vacíos por la no ingestión de alimento, y cuales de ellos se encuentran sin presas por haber regurgitado todo o parte de sus contenidos estomacales como consecuencia de su captura.

Diferentes formas de *stress* pueden causar la regurgitación del alimento. Bowen (1983) observa que algunas técnicas de captura, como pesca eléctrica, tresmallo y arrastre a profundidad, pueden causar este fenómeno. La regurgitación en peces fisoclistos es normalmente más frecuente y fácil de detectar (estómago evaginado) que en peces fisóstomos o que no poseen vejiga natatoria. Por ejemplo, como resultado de un izado rápido de la red de arrastre hacia la superficie, la vejiga se agranda e incluso llega a romperse, ya que el gas que contiene se expande debido a la disminución de presión en el exterior. Puesto que la vejiga esta localizada junto al estómago, el alimento puede expelerse o en caso extremo evaginarse el estómago, a causa del incremento de presión en la cavidad corporal. La forma y tamaño del tracto digestivo son probablemente importantes a este respecto, puesto que los tractos digestivos están generalmente adaptados a la dieta (Lagler et al., 1962). Se sabe que especies piscívoras, que comen grandes presas tienen un esófago grande y distensible, regurgitan más frecuentemente que los peces que se alimentan de pequeñas presas y tienen esófagos de menor tamaño (Bowen, 1983).

Debido a la regurgitación se produce una pérdida del contenido estomacal, que se puede identificar porque hay restos de comida en la boca del pez, o bien, porque el estómago está evaginado. En otras ocasiones, sólo se encuentran síntomas de regurgitación al eviscerar el pez. Realmente es a menudo difícil decir si ha tenido lugar la regurgitación o no, pero en situaciones donde el estómago se halla flácido o distendido, pero tiene poca comida, el tamaño y el color de la vesícula biliar es un indicador de la reciente historia alimentaria del pez. Así, una vesícula grande y fuertemente coloreada indica que el estómago ha estado vacío por algún tiempo y que recientemente no ha perdido su contenido por regurgitación.

2.5. Alimento ingerido en el arte de pesca

Dependiendo del arte de pesca utilizado, a veces, puede que el pez ingiera alguna presa capturada con él o que actuara como cebo. Otras veces, la predación en el interior de la red puede causar que algunas presas se hallen sobrerepresentadas (Mattson, 1981). Este tipo de presas, que serán excluidas de la muestra, también aparecerán extremadamente frescas. Por lo tanto, si los estómagos se abren inmediatamente después de la captura se puede distinguir este alimento del resto. En otros casos no se encuentra explicación de su aparición, como es el caso de escamas de peces. La aparición de escamas, en los contenidos estomacales de ejemplares capturados por artes de pesca pelágicas, sugieren que estas han sido ingeridas en el interior de la red (Collard, 1970; De Witt & Cailliet, 1972; Matallanas, 1982; Mauchline & Gordon, 1984). Estos argumentos, sin embargo, fueron rebatidos por Hopkins & Baird (1970) y Imsand (1981) que afirman que las escamas son comunes en suspensión en la columna de agua y su presencia en los estómagos no puede ser considerada como una evidencia de ingestión en el interior del copo.

2.6. Preservación del material

Los estómagos son guardados individualmente en recipientes de plástico, que contienen en su interior un líquido conservante como puede ser formol (6%) o etanol (70%).

El formol presenta el inconveniente de que con el tiempo va disolviendo estructuras calcáreas, como por ejemplo otolitos, por lo que es más recomendable el etanol. Sin embargo en etanol la digestión no se detiene de forma absoluta y además pueden precipitar las proteínas. Otro método de conservación empleado es la congelación, aunque es menos eficaz y es susceptible de perdida del material por cambio de temperatura, facilita a posteriori la clasificación de presas como los crustáceos, ya que no las endurece.

2.7. Reconstrucción de partes originales

Cuando se aplican métodos objetivos en la evaluación de los contenidos estomacales, podemos encontrar presas relativamente intactas y otras ya fragmentadas por el proceso digestivo. Por tanto, es interesante crear una colección de referencia de las categorías alimenticias. Los individuos integrantes de la colección deben ser pesados y medidos. Luego los contenidos estomacales y las distintas piezas encontradas se miden y comparan con la tabla hecha a partir de la colección de referencia. De esta forma, por inferencia, se obtienen los pesos y las tallas del material ingerido.

Puede considerarse que este método a veces sobrestimará las presas, ya que al encontrar una pieza de una especie suponemos que proviene de un individuo ingerido entero, suposición no necesariamente cierta.

3. MÉTODOS DE EVALUACIÓN DE LOS COMPONENTES ALIMENTICIOS

Existen diversos métodos para expresar los resultados obtenidos a través del examen de los contenidos estomacales. Son varios los trabajos que realizan una revisión a dichas metodologías, incidiendo sobre las ventajas y desventajas de cada uno de ellos (Hyslop, 1980; Rosecchi & Nouaze, 1987; Amezaga, 1988; Cortés, 1997).

3.1. Métodos numéricos

Pueden clasificarse en dos tipos. Uno, la frecuencia de ocurrencia (F%), expresa el porcentaje de estómagos que en una muestra examinada contienen una determinada presa. La frecuencia de ocurrencia, por lo tanto, describe la uniformidad con la que grupos de peces seleccionan sus dietas (Caillet, 1977), pero no indica la importancia de los varios tipos de alimento seleccionado.

Otro, la composición numérica (Cn%), expresa la proporción de cada tipo de presa en relación al número total de presas encontradas en toda la muestra de estómagos analizada (Ikusemijn & Olaniyan, 1977; Crisp *et al.*, 1978). Se puede calcular así el número medio de individuos por cada categoría alimenticia y por estómago (Smyly, 1952; Bulkeley, 1976). La mayor desventaja de este método reside en que se consideran por igual todas las presas sin tener en cuenta su tamaño, con lo que la importancia de cada categoría alimenticia puede quedar enmascarada por los resultados. También entraña dificultades en el estudio de aquellas especies planctófagas y herbívoras, debido a la dificultad de contar microalgas y detritus en términos de unidades (Arawomo, 1976). Sin embargo este método permite estimaciones generales de la disponibilidad de un determinado tipo de alimento y según Macdonald & Green (1983) de la selectividad de los predadores.

Si la dieta esta constituida por gran número de invertebrados que se hallan muy desarticulados por el aparato faringeo del pez, deben contarse solo los fragmentos característicos. Para minimizar el tiempo de contaje, es mejor elegir solo aquellos fragmentos que representen a la presa por aparecer una sola vez por individuo (por ejemplo, el céfalon de crustáceos o piezas mandibulares de poliquetos y cefalópodos). Detritus y grandes algas, de las que solo se ingieren fragmentos, no se encuentran en unidades discretas de tamaño uniforme, y así, el contaje de estas partículas tiene poco significado. Por último, algunos peces se alimentan de pequeños organismos, apareciendo en gran número en sus estómagos, por lo que contarlos en su totalidad resulta impracticable, por ello se hace necesario la toma de submuestras.

La utilización conjunta de ambos métodos es muy apropiada cuando el contenido estomacal está constituido por presas que pueden contarse individualmente (Hyslop, 1980).

3.2. Método volumétrico

Este método es bastante sencillo y preciso cuando aparecen grandes volúmenes de alimento y el número de categorías en que hemos clasificado los contenidos estomacales son pocas. Se dispone de varios métodos para calcularlo (Hyslop, 1980). Cuando las presas se hallan intactas, el volumen puede ser calculado directamente por desplazamiento de agua en un recipiente graduado (Wolfert & Miller, 1978) o presionando hasta un grosor dado los contenidos de la muestra en un platillo y midiendo el área (Hellawell & Abel, 1971; Capitoli, 1992). El volumen puede ser medido indirectamente a partir de las estimaciones del volumen medio de individuos de cada tipo de presa. Cuando las presas aparecen bastante digeridas y solo restan partes duras, puede calcularse el volumen usando relaciones establecidas entre el tamaño de la presa y el tamaño de la pieza hallada, teniendo la ventaja de no verse afectado el calculo por la digestión de las partes blandas. Si las presas son pequeñas se realiza una estimación indirecta del volumen (Larimore, 1957), calculando la media de las dimensiones de las diferentes presas basada en medidas individuales, que ayudarán después a determinar el volumen medio.

Al igual que los dos métodos anteriores, este subestima la importancia en la dieta de algunos organismos blandos de los que no quedan restos. Asimismo, la aparición ocasional de un alimento excepcionalmente voluminoso y las diferentes tasas de digestión de las presas son responsables de estimaciones erróneas.

3.3. Método gravimétrico

Los pesos de las presas pueden ser medidos directa o indirectamente. Las medidas directas pueden calcular el peso húmedo o seco, estando ambas medidas directamente relacionadas (Glenn & Ward, 1968). Las medidas de peso húmedo, se realizan a un grado estándar de humedad, por ejemplo cuando el ejemplar tras ser enjugado ya no se pega al papel de filtro, pero aun así, la cantidad de humedad que resta en la presa constituye una fuente de error (Parker, 1963). Además, cuando el material se halla conservado en formol se produce un incremento del peso que conduce a errores.

Generalmente, los pesos de las presas derivan indirectamente de medidas de restos duros de las presas (Prime & Hammond, 1990; Pierce *et al.*, 1991a).

Se ha discutido que las medidas del peso sobrestiman la importancia de presas de gran tamaño que no suelen aparecer frecuentemente en la dieta (Hellawell & Abel, 1971). Si bien esto puede ser cierto para estudios comportamentales de selección de alimento, para estudios sobre el impacto de los predadores sobre poblaciones presa, la biomasa de la presa es un indicador relevante de su importancia en la dieta (Hyslop, 1980). Para estudios sobre energética, sin embargo, el uso del peso de las presas pude dar más importancia a presas de baja densidad calórica.

Los resultados se expresan como porcentaje del peso de cada categoría alimenticia frente al peso total de todos los contenidos estomacales. Este método tiene las mismas ventajas y desventajas en cuanto a representatividad que el volumétrico.

3.4. Método de los puntos

Este método subjetivo fue propuesto por Swynnerton y Worthington (1940), modificado por Frost (1943) y de nuevo por Hynes (1950).

Después de la identificación de los contenidos de cada estómago a cada tipo de presa se le asigna un rango de números o puntos dependiendo del tamaño de los ejemplares o de su abundancia, se elabora una escala arbitraria definiendo los límites de cada valor, como por ejemplo, comunes, frecuentes, etc.; respecto al tamaño se suele considerar un organismo de tamaño grande equivalente a varios pequeños. Todos los puntos asignados a un tipo determinado de alimentos se suman y se calculan porcentajes respecto a todos los estómagos examinados. El método de los puntos es, en esencia, un método de volumen aproximado. La mayor limitación de este método es la dificultad de establecer criterios uniformes en los que se base la asignación de los puntos y mantenerlos a lo largo de investigaciones extensivas.

3.5. Métodos combinados

Algunos autores (Hyslop, 1980; Cortés, 1997) han discutido los méritos relativos de los métodos básicos de análisis descritos: los numéricos, el volumétrico o el gravimétrico. Así, si consideramos únicamente la presencia en número de cada presa no obtendremos una buena visión de su importancia en la dieta, debido a las grandes diferencias de ocurrencia, también cometeremos errores en favor de los organismos más pequeños. Por otro lado, las medidas de volumen favorecen a los organismos de mayor tamaño porque se digieren más lentamente y son reconocibles en el estómago durante más tiempo. Estas y otras consideraciones han dado lugar al desarrollo de diversos métodos combinados de análisis. Aunque la decisión de la utilización de un método para la determinación de la importancia relativa y dominancia de las presas es subjetiva (Hyslop, 1980), uno de los métodos más empleado en los estudios de alimentación de peces es el Indice de Importancia Relativa (IRI) (Pinkas *et al.*, 1971). Se calcula sumando los porcentajes en número y volumen y multiplicando esta suma por la frecuencia de ocurrencia en tanto por ciento para cada tipo de alimento. Hacunda (1981) lo modifico, utilizando en lugar del porcentaje en volumen, el porcentaje en peso. Esta modificación ha sido usada posteriormente en muchos trabajos (Papaconstantinou & Caragitsou, 1989; Stergiou & Fortuni, 1991; Carrason *et al.*, 1992; Matallanas et al., 1993; Casadevall et al., 1994; Sartor & de Ranieri, 1996) y también en los trabajos que constituyen esta Tesis.

4. OBJETIVOS DEL TRABAJO

En los años cincuenta los estudios sobre la biología de los teleósteos tuvieron un gran auge en las costas de la Comunidad Valenciana (Planas & Vives 1952, 1953; Planas et al., 1955; Planas & Vives 1956a,b; Suau & Vives, 1957). Sin embargo, en dichos trabajos la alimentación es tratada de una manera muy superficial, junto con otros aspectos como el crecimiento, la reproducción etc., no realizándose ningún estudio detallado de las presas encontradas en sus estómagos. Asimismo, tampoco se estudiaron las variaciones de la dieta con la talla y las estaciones, ni se aplicó ningún tratamiento estadístico.

A finales de los setenta e inicios de los ochenta, los estudios ictiológicos sobre alimentación experimentan un nuevo impulso, centrándose básicamente en esta cuestión. Sin embargo la mayoría de estos trabajos se realizan en las costas catalanas (Suau & López, 1976; Macpherson, 1977; Matallanas, 1982; Moreno & Matallanas, 1983), mientras que en las costas valencianas fueron muy puntuales (Penadés & Acuña, 1980; Ramos, 1981). Esto condujo a la realización por parte del laboratorio de Biología Marina del Departamento de Microbiología y Ecología de la Universidad de Valencia de una serie de estudios sobre los hábitos alimentarios de diversos peces bentónicos (Vivo & Sanz, 1989; Redón, 1991; Morte, 1992), que posteriormente han servido de base para el desarrollo de este trabajo. Estudios similares fueron realizados simultáneamente por otros investigadores de la Universitat de Valencia (Rodilla, 1990; Vicent, 1995, 1998).

El presente trabajo está dirigido a conseguir un mayor conocimiento de los hábitos alimenticios de ocho especies de peces de interés comercial en nuestro litoral, como son la musola (*Mustelus mustelus*), los gallos (*Lepidorhombus boscii* y *Lepidorhombus. whiffiagonis*), la araña (*Trachinus draco*), las escorpas (*Scorpaena porcus* y *Scorpaena notata*), la mollera (*Trisopterus minutus capelanus*) y la brótola (*Phycis blennoides*).

La tesis está formada por cinco capítulos. En el primero se realiza una revisión de las investigaciones sobre los contenidos estomacales de peces, centrándose en el porqué de estos estudios y las metodologías más empleadas. En el segundo capítulo se aborda ya el estudio de los hábitos alimenticios de las especies citadas anteriormente, mientras que en el tercero se evalúa la competencia interespecífica y la amplitud del nicho trófico. Finalmente, en los dos últimos capítulos se realiza un resumen global de los trabajos que comprenden esta memoria y se enumeran las conclusiones obtenidas.

Los objetivos planteados fueron los siguientes:

1. Describir de forma detallada el régimen alimenticio de estas especies a partir de un número significativo de ejemplares, provenientes de capturas comerciales.

2. Analizar las variaciones de las dietas respecto a la talla de los individuos.

3. Determinar las posibles variaciones estacionales teniendo en cuenta al menos dos ciclos anuales.

4. Estudiar las posibles interrelaciones entre las diversas especies a partir del estudio de la competencia trófica, y evaluar la amplitud de su nicho trófico.

5. Comparar los resultados con los obtenidos por otros autores en el Mediterráneo.

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2. ESTUDIO DE LA DIETA DE OCHO PECES BENTÓNICOS

2.1. *Mustelus mustelus*

Feeding habits of juvenile *Mustelus mustelus* (Carcharhiniformes, Triakidae) in the western Mediterranean

SALOME MORTE, MANUEL J. REDON and ANTONIO SANZ-BRAU

Universitat de Valencia, Facultad de Ciencias Biológicas, Ecología, Laboratorio de Biología Marina, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain

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ABSTRACT.- The stomach content of 261 juvenile smoothhounds *Mustelus mustelus* (36-75 cm total length) from the Gulf of Valencia (Spain) were studied. Samples were obtained between 1988 and 1996. Brachyura were the most important prey in terms of frequency of occurrence and numerical composition, followed by Stomatopoda, teleosts and Natantia. No significant differences were found between male and female diets. A change in food composition according to the size of fish was observed.

RÉSUMÉ.- Les contenus stomacaux de 261 juvéniles d'émissole lisse *Mustelus mustelus* (36-75 cm de longueur totale) du Golfe de Valencia (Espagne) ont été étudiés. Les échantillons ont été récoltés entre 1988 et 1996. Les Brachyoures constituent les proies les plus nombreuses et les plus fréquentes, suivis par les Stomatopodes, les poissons et les Natantia. Il n'apparaît aucune différence significative entre les mâles et les femelles. Un changement du régime alimentaire en fonction de la taille a été mis en évidence.

Keywords: *Mustelus mustelus*, feeding, Elasmobranchii, Mediterranean.

INTRODUCTION

The smoothhound, *Mustelus mustelus* (L., 1758) is a common shark occurring in the Mediterranean and in the North-eastern Atlantic, from the Baltic Sea to the coast of Morocco, including waters of the southern coast of Iceland and those of Great Britain and Ireland (Branstetter, 1986; Moreno, 1995). It is usually found in sand or mud bottoms at depths of between 50 and 100 m (Quignard & Capapé, 1971; Lloris, 1990). The sizes at first sexual maturity for males and females are respectively 96 cm and 108 cm of total length (Capapé, 1974a, b). In the Mediterranean *M. mustelus* spawns in summer and the size at birth is around 28-32 cm (Capapé, 1974a, b, 1983).

Despite its high commercial value, very little is known about the feeding ecology of the species. There are only few brief accounts describing the smoothhound diet which point out that crustaceans, fish and molluscs are the main staple diet (Wheeler, 1978; Branstetter, 1986; Moreno, 1995).

The present work was conducted within the framework of a project for the study of trophic relationships in a demersal fish community in the Gulf of Valencia. Due to the paucity of information on the feeding ecology of the smoothhound, a pilot study was carried out on the stomach content of juvenile *M. mustelus*.

MATERIALS AND METHODS

A total of 261 smoothhounds were examined for their stomach content and their sex was determined. Samples were obtained from diurnal commercial catches landed at the port of Valencia, Spain. Fish were caught between 1988 and 1996 from

May to October at varying depths from 50 to 150 metres in the Gulf of Valencia (Western Mediterranean). Fish were measured to the nearest centimetre (Fig. 1), dissected and the stomachs were removed, preserved in 6% formalin, upon opening, their contents were preserved in a 70% ethanol solution and stored for a later analysis.

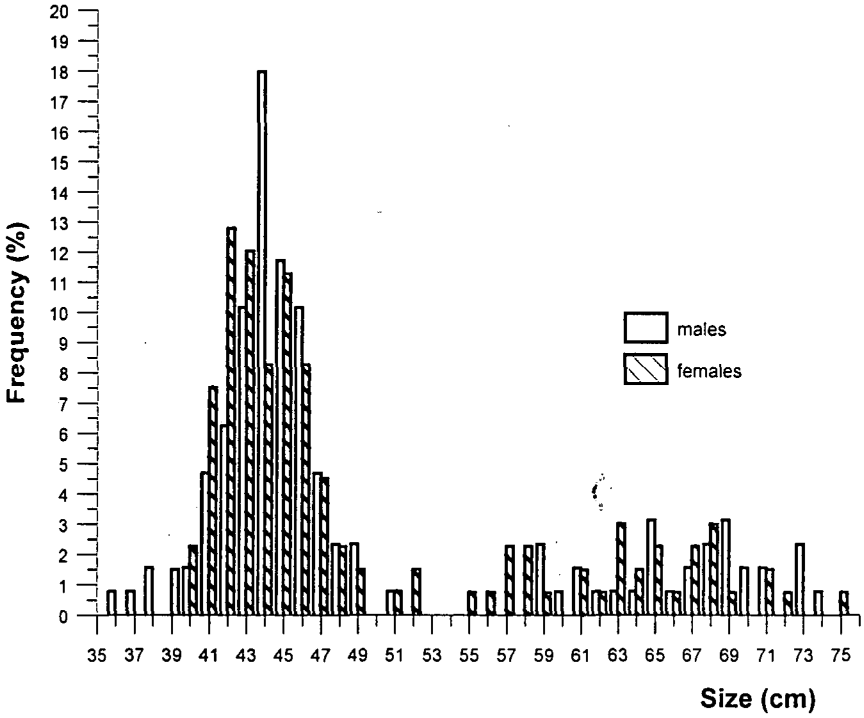

Figure 1. Length-frequency distribution of 261 juveniles of *Mustelus mustelus* caught in the Gulf of Valencia.

Figure 1. Distribution des fréquences de tailles de 261 juvéniles de *Mustelus mustelus* pêchés dans le Golfe de Valencia.

To assess for possible changes in diet with respect to the length, fish were divided into two size-classes (≤50 cm and ≥50.5 cm). In the laboratory, prey items were identified to the lowest possible taxonomic level. Hard parts such as beaks of cephalopods, chelae, telson or pereion fragments of crustaceans and fish otoliths were often significantly helpful in identifying prey items.

The contribution of each prey item to the diet was described by the percentage of frequency of occurrence (F%) and numerical composition (Cn%) (Hyslop, 1980). The percentage of empty stomachs (V) was also recorded.

Statistical differences ($P<0.05$) in basic diet composition as a function of sex and size were established by applying a Chi-square test (Sokhal & Rohlf, 1981). This was applied over the direct variables, grouping types of prey into eight categories and using contingency tables as applied by SPSS Pc software. These categories were: Brachyura, Natantia, Reptantia, Stomatopoda, other crustaceans (amphipods, mysids, isopods), Mollusca, teleosts and "others" (polychaetes, echinoids remains, algal remains). A Chi-square test was also applied to test significant differences in the number of empty stomachs.

RESULTS

General feeding trends

Out of the 261 stomachs analysed, 253 were found to contain food. The percentage of empty stomachs was 3.06% (3.90% in males and 2.25% in females); but there was not significant differences between these values.

The stomach contents of the smoothhound consisted of at least 41 different prey species (Table I), with a low average number of prey per stomach (mean 4.09). Crustaceans were the most numerous ingested preys, constituting 77.71% of the total. Among these, Decapoda Brachyura were present in the greatest number and also occurred most frequently in the stomachs. Less abundant crustaceans included stomatopods (such as *Squilla mantis*) and Decapoda Natantia.

Teleosts were less numerous than crustaceans (14.13%), while Mollusca, polychaetes, echinoderms and algal remains were only present in low numbers.

Table I. Diet composition of 253 juveniles of *M. mustelus* containing food (n number of stomachs in which relevant prey occurs; p number of individuals of relevant prey; F% frequency of occurrence; Cn% numerical composition).

Tableau I. Composition du régime alimentaire de *M. mustelus* d'aprés l'analyse de 253 juvéniles ayant ingeré des proies (n nombre d'estomacs contenant une proie; p nombre total d'individus d'une même proie; F% indice de fréquence de proie; Cn% pourcentage numérique).

Prey category	n	p	F%	Cn%
Polychaeta	30	39	11.858	3.652
Sipunculida	2	2	0.791	0.187
Echinoderma				
Ophiuroidea	2	3	0.791	0.281
Mollusca				
Bivalvia	1	1	0.395	0.094
Nucula nucleus	1	1	0.395	0.094
Nucula sp.	1	1	0.395	0.094
Tellina planata	1	1	0.395	0.094
Chlamys opercularis	1	1	0.395	0.094
Mactridae	1	1	0.395	0.094
Spisula subtruncata	2	2	0.791	0.187
Gasteropoda	1	1	0.395	0.094
Cerithiidae	1	1	0.395	0.094
Donax sp.	1	1	0.395	0.094
Turritella communis	1	1	0.395	0.094
Scaphopoda				
Dentalium sp.	1	1	0.395	0.094
Cephalopoda	1	1	0.395	0.094
Sepia officinalis	2	2	0.791	0.187
Alloteuthis mediterranea	2	2	0.791	0.187
Loligo vulgaris	4	4	1.581	0.375
Crustacea				
Mysidacea				
Lophogastridae				
Lophogaster typicus	1	1	0.395	0.094
Isopoda	4	5	1.581	0.468
Amphipoda	1	2	0.395	0.187
Stomatopoda				
Squilla mantis	112	142	44.269	13.29
Parasquilla ferussaci	1	1	0.395	0.094
Platysquilla eusebia	9	9	3.557	0.843
Decapoda				
Natantia	31	36	12.253	3.371
Penaeus kerathurus	2	2	0.791	0.187
Sicyonia carinata	12	15	4.743	1.404
Caridea	3	3	1.186	0.281
Alpheus glaber	10	14	3.953	1.311

Processa parva	1	1	0.395	0.094
Processa sp.	4	4	1.581	0.375
Crangonidae	1	1	0.395	0.094
Pontocaris cathaphracta	6	13	2.372	1.217
Pontocaris sp.	2	2	0.791	0.187
Reptantia				
Scyllarus sp.	2	2	0.791	0.187
Upogebia typica	1	3	0.395	0.281
Upogebia sp.	11	11	4.348	1.03
Anomura	10	13	3.953	1.217
Paguridea	19	23	7.510	2.154
Pagurus prideauxi	1	2	0.395	0.187
Diogenes pugilator	3	3	1.186	0.281
Brachyura	26	33	10.28	3.09
Ethusa mascarone	2	3	0.791	0.281
Dorippe lanata	14	20	5.534	1.873
Calappa granulata	3	4	1.186	0.375
Ilia nucleus	1	1	0.395	0.094
Atelecyclus rotundatus	18	23	7.115	2.154
Atelecyclus sp.	1	2	0.395	0.187
Liocarcinus corrugator	1	1	0.435	0.109
Liocarcinus sp.	199	411	78.656	38.48
Portunus hastatus	2	2	0.791	0.187
Goneplax rhomboides	5	8	1.976	0.749
Brachynotus sexdentatus	1	1	0.395	0.094
Parthenope massena	3	3	1.186	0.281
Parthenope sp.	2	2	0.791	0.187
Majidae	1	3	0.395	0.281
Corystes cassivelaunus	1	1	0.395	0.094
Maja verrucosa	1	1	0.395	0.094
Macropodia sp.	3	3	1.186	0.281
Teleostei	82	98	32.411	9.176
Cupleiformes				
Sardina pilchardus	8	12	3.162	1.124
Sardinella aurita	2	3	0.791	0.281
Engraulis encrasicholus	2	5	0.791	0.468
Anguiliformes	12	16	4.743	1.498
Dalophis imberbis	1	1	0.395	0.094
Apterichthus caecus	2	3	0.791	0.281
Congridae	2	2	0.791	0.187
Conger conger	1	1	0.395	0.094
Sparidae	3	3	1.186	0.281
Pagellus erythrinus	1	1	0.395	0.094
Scombridae				
Scomber scombrus	1	1	0.395	0.094
Mugilidae	2	2	0.791	0.187
Mugil cephalus	2	2	0.791	0.187
Bothidae				
Arnoglossus sp.	1	1	0.395	0.094
Algal remains	16	16	6.324	1.498
Posidonia sp.	5	5	1.976	0.468

Diet variations as a function of smoothhound sex and size

The chi-square test revealed no significant differences in the composition of the prey ingested in relation to sex. Therefore, diet comparison between smoothhound sizes were made grouping sexes.

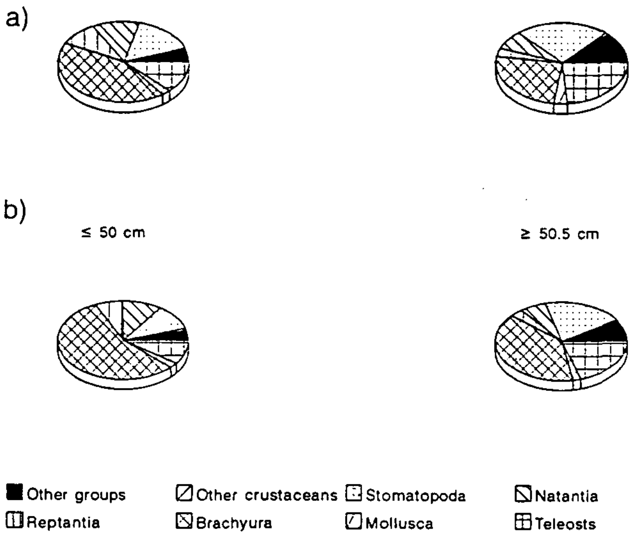

Figure 2. Changes in the main prey categories of *Mustelus mustelus* according to the length-class (cm). a)Frequency of occurrence; b) numerical composition.

Figure 2. Variations des principales catégories de proies dans le régime alimentaire de *Mustelus mustelus*, en fonction de la taille de ce dernier. a) indice de fréquence de proie; b) pourcentage numérique.

Large specimens of *Mustelus mustelus* had a higher average number of prey per stomach (6.42) than small fish (3.25). The dietary groups most occurring over each size range of *M. mustelus* are shown in Fig. 2. Brachyura dominated in number and occurrence in diet of all size classes (χ^2=1.79, df=1). Predation of Natantia (χ^2=0.007, df=1) and Reptantia (χ^2=2.76, df=1) did not vary significantly with size, but there was a tendency for Stomatopoda (χ^2=42.74, df=1, P<0.001) and teleosts (χ^2=60.07, df=1, P<0.001) to be mostly consumed by large specimens. Although there were significant differences in frequency of "others" (χ^2=33.65, df=1, P<0.001), they were not important in the diet. No significant values were found for Mollusca (χ^2=3.59, df=1) and other crustaceans (χ^2=0.41, df=1).

DISCUSSION

In the present study, frequency of occurrence and numerical composition were used to measure the relative importance of prey in the diet of smoothhound because a great number of preys were quite digested so that it was difficult to apply a gravimetric index. Many others studies on sharks diets have also used frequency of occurrence and numerical composition (Hanchet, 1991; Stillwell & Kohler, 1993; Saldanha *et al.*, 1995, Ellis *et al.*, 1996). However, the main criticism of these methods is that they give little information on the relative amount or biomass of the various items in the stomachs (Hyslop, 1980). Provided that these limitations are recognised, stomach contents analysis can supply useful information regarding the types of prey consumed, dietary breadth and the relative importance of different prey categories in the diet, thereby providing indications on the niche occupied by the predator species (Zaret & Rand, 1971; Eliassen & Jobling, 1985).

In this study a few number of stomachs has been found without food and this agrees with observations by Capapé & Quignard (1977), Euzen (1987) and Ellis *et al.* (1996) who usually found a low percentage of elasmobranchs with empty stomachs in comparison with teleost fish. This suggests that *M. mustelus* eats frequently and/or that gastric evacuation is slow relative to feeding frequency. Capapé & Quignard (1977) point that *M. punctulatus* is a voracious species which feeds abundantly over the year.

Few detailed reports about feeding habits have been carried out on the genus *Mustelus* and even fewer on the species *M. mustelus*. In the British coasts Ford (1921) examined 48 specimens of *Mustelus* spp. and reported that the diet is based on crustaceans, teleosts and polychaetes. Capapé & Quignard (1977) reported that juveniles of *M. punctulatus* from the Tunis coast fed on decapods (*Liocarcinus* sp., *Dorippe lanata* and *Alpheus* sp.), stomatopods (*Squilla mantis*), cephalopods (*Sepia* sp.) and teleosts (*Citharus macrolepidotus*). In the Mediterranean and Atlantic, both Capapé (1975) and Ellis *et al.* (1996) concluded that the diet of *M. asterias* is essentially based on cephalopods, teleosts and crustaceans. Rountree & Able (1996), in studing the diet of juvenile *M. canis* in the estuary of southern New Jersey (Atlantic Ocean), reported a food spectrum dominated by natantids (*Crangon septemspinosa* and *Palaemonetes vulgaris*) and polychaetes. Our study point out that *M. mustelus* feeds primarily on crabs, with the main prey items being *Liocarcinus* sp.. But, Stomatopoda may be more significant than Brachyura, in terms of mass or energy, because individuals of Stomatopoda are much greater in size than any Brachyura that appears in these stomach contents. Teleosts, polychaetes and Mollusca are also consumed.

In *M. mustelus* the teeth are broad and flattened, almost heart-shaped with faint ridges down the long axis. This specific type of dental morphology is thought to be adapted for the trituration of shells of molluscs and cuticle of crustaceans (Wheeler & Jones, 1989). The presence of numerous triturated preys in this study supports these views.

No differences were found in the diet of males and females of *M. mustelus*, this may indicate that there was no special food requirement and that foraging habit is similar in both sexes dued to the fact that all the specimens are juvenile. Similar results have been presented for juveniles of *M. punctulatus* (Capapé & Quignard, 1977).

Food intake varied with smoothhound size, as has been observed in others sharks (Capapé & Quignard, 1977; Macpherson, 1980; Carrassón *et al.*, 1992; Ellis *et al.*, 1996). We just found the largest preys in stomachs that belong to the biggest specimens.

The preference of *M. mustelus* for *Squilla mantis* and *Liocarcinus* sp. clearly suggests they may be important predators for these species. However, information on the abundance of *M. mustelus*, *S. mantis* and *Liocarcinus* sp. in the Gulf of Valencia is presently not sufficient to determine whether this interaction has significant effects on the dynamics of these preys.

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2.2. *Lepidorhombus boscii* y *Lepidorhombus whiffiagonis*

Feeding ecology of two megrims *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis* in the western Mediterranean (Gulf of Valencia, Spain)

SALOME MORTE, MANUEL J. REDON and ANTONIO SANZ-BRAU

Universitat de Valencia, Facultad de Ciencias Biológicas, Ecología, Laboratorio de Biología Marina, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain

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ABSTRACT.- The stomach contents of 344 four-spotted megrim, (*Lepidorhombus boscii*) and 159 megrim (*Lepidorhombus whiffiagonis*), off the eastern coast of the Gulf of Valencia (Spain), were analyzed. The two species examined appear to have not very similar diets, based on the species composition of prey. The vacuity coefficient is not high for anyone of the species, being Crustacean (Decapoda and Mysidacea) the main food. Also as components of the diet appear Amphipoda and Teleostei. Variations in the food of both fishes related to their length show few little crustaceans as prey of the major specimens. Finally, there was evidence for seasonal variation of the quality and quantity of the food consumed. There was not great dietary overlap between these two species.

INTRODUCTION

Two species of megrim, the four-spotted megrim *Lepidorhombus boscii* (Risso, 1810) and the megrim *Lepidorhombus whiffiagonis* (Walbaum, 1792), occur around the coasts of the Iberian Peninsula (Nielsen, 1986). Only the former is abundant on the soft bottoms of the Gulf of Valencia, Spain (western Mediterranean) and harvested commercially due to its economic importance.

The composition of the diet of *L. boscii* in the Mediterranean Sea has been studied by several authors (Reys, 1960; Macpherson, 1977, 1979, 1981; Mannini et al., 1990; Sartor & De Ranieri, 1996). However, feeding habits in *L. whiffiagonis*, only has been investigated in the Atlantic Ocean (Rae, 1963; Du Buit, 1984, 1992).

These two species inhabit the same fishing grounds, although *Lepidorhombus boscii* has a wider bathymetric distribution (Bauchot & Pras, 1980). As they are close in morphology and size, and important overlap may be expected in their diets. However, little has been published on the trophic relationships between these species.

In the present study, the diet of *L. boscii* and *L. whiffiagonis* in the western Mediterranean (waters of the Gulf of Valencia, Spain) is described and compared, taking into account the effect of predator size and season in the feeding habits of both species.

MATERIALS AND METHODS

A total of 344 *Lepidorhombus boscii* and 159 *Lepidorhombus whiffiagonis* were taken from diurnal commercial catches landed at the port of Valencia (Spain) (Figure 1) between October 1991 and October 1994.

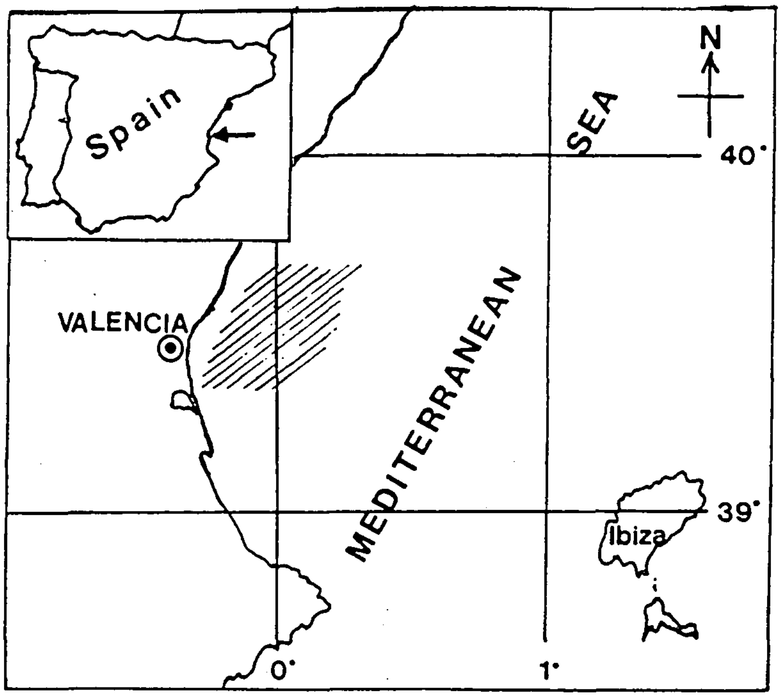

Figure 1. Map showing location of sampling area.

Specimens were caught at depths ranging from 50 to 175 m depth in the Gulf of Valencia. Total length of fish was measured, to the lower half centimetre, dissected and the stomachs were removed and preserved in 6% formalin. Upon opening, stomach contents were stored in a 70% ethanol solution. Evidence of regurgitation was never observed in any fish.

Food items were identified to the lowest taxonomic level possible and their number was recorded, and the wet weight (nearest 0.1 mg) registered. Every time Foraminifera appeared in the stomach contents were considered as only one prey item, because they were passively ingested (Lagardère, 1977).

A χ^2 test was also applied to test for differences in the number of empty stomachs (V).

The contribution of each prey in the diet was determined by the frequency of occurrence (F%), numerical composition (Cn%) and biomass composition (Cw%)

(Hyslop, 1980). The Index of Relative Importance (IRI) (Pinkas et al., 1971), as modified by Hacunda (1981), was calculated for consumed prey item:

$$IRI=F\%(Cn\%+Cw\%)$$

To asses changes in the diet with size, fish were divided into three size classes according to age (Fuertes, 1978): Group I (≤12 cm), Group II (12.5-15.5 cm) and Group III (≥16 cm).

Interspecific dietary overlap between size classes and season was calculated at level of species according to Schoener (1970):

$$a = 1 - 0.5\left(\sum_{i=1}^{n}\left|p_{xi} - p_{yi}\right|\right)$$

where n is the number of food organisms, and p_{xi} and p_{yi} are the numerical composition indexes of prey (i) in the diets of species x and y, respectively. The index has a minimum value of zero, when no overlap occurs, and a maximum value of one, when all prey are shared in equal proportions by the two species.

In order to compare the both species diet, the species constituting the diet were partitioned into eight categories: amphipods, isopods, mysids, natantids, reptands, other crustaceans (euphasiasids, copepods and stomatopods), teleosts and 'others' (molluscs, polychaetes, foraminifers, and non-identified remains).

A cluster analysis based on squared Euclidean distance (Sokal & Rohlf, 1981) was carried out on biomass composition data of their preys, in order to evaluate the pattern of the diet of each megrim species according to fish size and/or season.

Statistical differences (P<0.05) in diet composition as a function of size and season were assessed by applying a Chi-square test (Sokal & Rohlf, 1981). This was applied over the number of stomachs in which a prey occurs (n), and using contingency tables as applied by SPSS Pc software.

RESULTS

General feeding trends

The stomachs of 9.0% of the total number of 344 four-spotted megrim and 18.2% of 159 megrim were empty. These percentages did not vary significantly over the year for *Lepidorhombus whiffiagonis* (χ^2=5.00, df=3), although in *Lepidorhombus boscii* these values changed significantly (χ^2=9.62, df=3, P<0.05) increasing during spring.

Appendix 1 & 2 show the Index of Relative Importance, the frequency of occurrence, the numerical and biomass composition of all prey items found in *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis* stomach contents, respectively.

The number of prey items recorded for *L. boscii* was 38 species, with an average number of 3.9 prey per stomach. Crustaceans were the most numerous prey ingested and were dominated by mysids (*Parapseudomma calloplura* and *Leptomysis gracilis*) and natantids (*Alpheus glaber* and *Processa mediterranea*). Amphipods, isopods and reptands (*Calocaris macandreae*, *Liocarcinus depurator* and *Goneplax rhomboides*) were secondary prey, whereas teleosts, molluscs, copepods, stomatopods and polychaetes were infrequent. As for the IRI, *P. mediterranea* was the most important prey, followed *Alpheus glaber*, *Parapseudomma calloplura* and *Processa canaliculata*.

A total of 33 different prey species were identified from the stomach contents of *L. whiffiagonis*, with an average number of 3.0 prey per stomach. The diet consisted principally of mysids (*Parapseudomma calloplura*), natantids (*Processa mediterranea* and *Alpheus glaber*) and teleosts (*Lesueurigobius friesii*). Other taxa found in the stomach contents, but with less importance, were reptands, molluscs, copepods, stomatopods and polychaetes. According to the IRI, the most important prey was *L. friesii*, followed by *P. mediterranea*, *Parapseudomma calloplura* and *Alpheus glaber*.

Variation in stomach contents relative to fish length

Figure 2 shows the length-frequency distribution of the fish examined, in percentage relative to the total number.

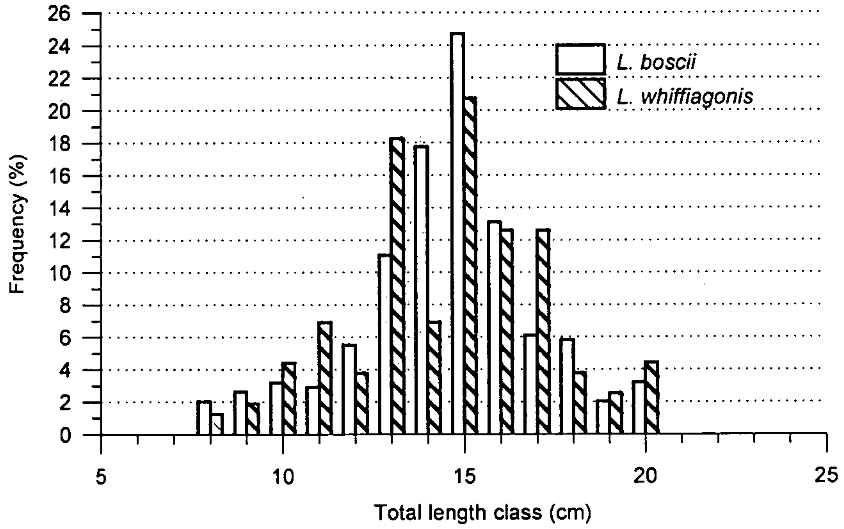

Figure 2. Length-frequency distribution of the fish examined.

In both species the average number of prey per stomach (Nm/St) decrease from the smallest individuals to the largest, whereas average prey weight per stomach (Wm/St) increase (Figure 3). The vacuity coefficient has no significant differences in the various size groups of both species.

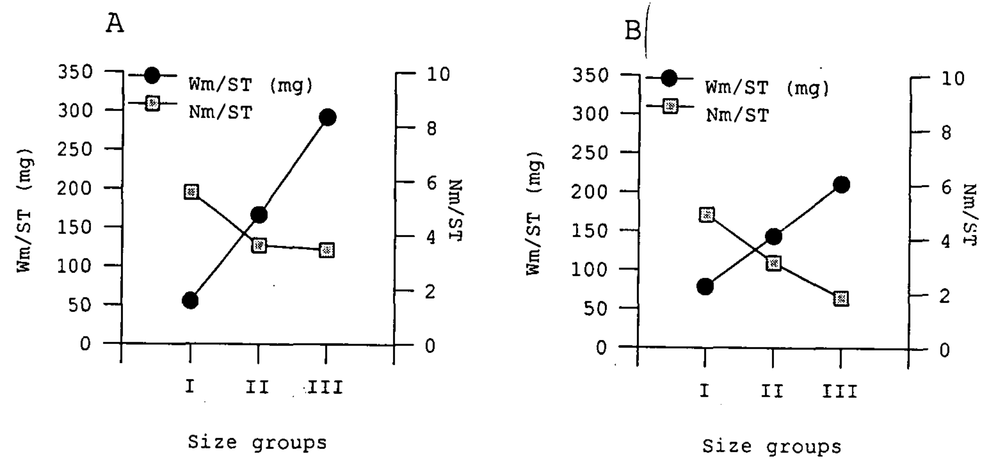

Figure 3. Average number of prey per stomach and average prey weight per stomach for the size groups A) *Lepidorhombus boscii*; B) *Lepidorhombus whiffiagonis*. (Nm= Number of preys; ST= Number of stomachs).

Table I displays the stomach contents for size groups of *Lepidorhombus boscii* with regard to IRI, the frequency of occurrence, the numerical and biomass composition of the eight main prey categories.

Table I. Dietary groups for each size range of *Lepidorhombus boscii*, with regard to the frequency of occurrence (F%), Numerical composition (Cn%), biomass composition (Cw%) and Index of Relative Importance (IRI).

	Other groups	Other crustaceans	Mysids	Natantids	Reptands	Isopods	Amphipods	Teleosts
Group I								
F (%)	3.85	3.85	82.69	50.00	9.61	23.08	50.00	0.00
Cn (%)	0.64	0.64	60.90	13.78	1.60	8.01	14.42	0.00
Cw (%)	11.58	0.00	9.70	51.24	24.70	1.10	1.69	0.00
IRI	47.03	2.47	5838.19	3250.97	252.71	210.16	805.41	0.00
Group II								
F (%)	7.36	0.61	44.79	73.62	23.93	4.91	11.66	6.75
Cn (%)	2.69	0.15	34.33	44.18	7.91	4.03	5.07	1.64
Cw (%)	2.86	0.01	2.39	47.07	27.37	0.13	0.12	20.05
IRI	40.81	0.10	1644.69	6717.91	844.14	20.43	60.54	146.42
Group III								
F (%)	4.08	2.04	26.53	80.61	34.69	8.16	4.08	7.14
Cn (%)	1.11	0.55	13.30	61.50	14.40	5.82	1.38	1.94
Cw (%)	3.30	0.62	1.19	58.61	26.38	0.23	0.02	9.65
IRI	17.98	2.39	384.39	9682.44	1414.55	49.36	5.72	82.77

Appreciable variation was found in the food composition of different size groups. An increase in length was also followed by defined changes in feeding habits: the frequency of amphipods (χ^2=58.37, df=2, P<0.001), isopods (χ^2=16.08, df=2,

$P<0.001$) and mysids ($\chi^2=43.28$, df=2, $P<0.001$), decreased with increasing four-spotted megrim size whereas the frequency of natantids ($\chi^2=16.26$, df=2, $P<0.001$) and reptands ($\chi^2=11.60$, df=2, $P<0.01$) increased. No significant values were found for other crustaceans ($\chi^2=2.80$, df=2), teleosts ($\chi^2=3.82$, df=2) and 'others' ($\chi^2=1.61$, df=2).

Table II. Dietary groups for each size range of *Lepidorhombus whiffiagonis*, with regard to the frequency of occurrence (F%), numerical composition (Cn%), biomass composition (Cw%) and Index of Relative Importance (IRI).

	Other groups	Other crustaceans	Mysids	Natantids	Reptands	Isopods	Amphipods	Teleosts
Group I								
F (%)	12.50	4.17	58.33	54.17	0.00	20.83	45.83	12.50
Cn (%)	2.11	0.70	55.63	19.72	0.00	7.75	11.97	2.11
Cw (%)	16.22	0.00	2.85	28.14	0.00	1.02	0.87	50.89
IRI	229.18	2.92	3411.19	2592.36	0.00	182.77	588.57	662.52
Group II								
F (%)	4.92	4.92	45.90	63.93	16.39	8.20	11.48	22.95
Cn (%)	2.62	1.31	33.19	39.30	6.11	3.93	7.42	6.11
Cw (%)	3.42	0.11	0.95	27.31	14.88	0.16	0.19	52.97
IRI	29.74	7.00	1566.97	4258.30	343.99	33.57	87.37	1355.93
Group III								
F (%)	0.00	0.00	11.11	37.78	15.56	4.44	8.89	51.11
Cn (%)	0.00	0.00	10.48	44.76	11.43	1.90	6.67	24.76
Cw (%)	0.00	0.00	0.08	16.95	12.11	0.12	0.04	70.71
IRI	0.00	0.00	117.28	2331.47	366.26	8.95	59.61	4879.54

The dietary groups most commonly occurring over each size range in *Lepidorhombus whiffiagonis* are shown in Table II. Mysids dominated in number and occurrence in the small size classes ($\chi^2=19.85$, df=3, $P<0.001$). Predation on natantids vary significantly due to the high number appeared in the medium size class ($\chi^2=7.13$, df=2, $P<0.05$), and there was a tendency for teleosts to be mostly consumed by the large specimens ($\chi^2=14.25$, df=2, $P<0.001$). No significative values were found for the other categories of prey.

Seasonal variations in stomach contents

In both species the average number of prey per stomach changes throughout the year (Figure 4). In the case of *L. boscii* a maximum of 5.71 prey items per stomach was recorded in autumn due to the high frequency of occurrence of little crustaceans, such as isopods and amphipods. For *L. whiffiagonis*, a minimum of 1.34 prey items per stomach was recorded in winter. On the other hand, the average prey weight for *L. whiffiagonis* was constant through the year, whereas in *L. boscii* increased from winter to autumn (Figure 4A).

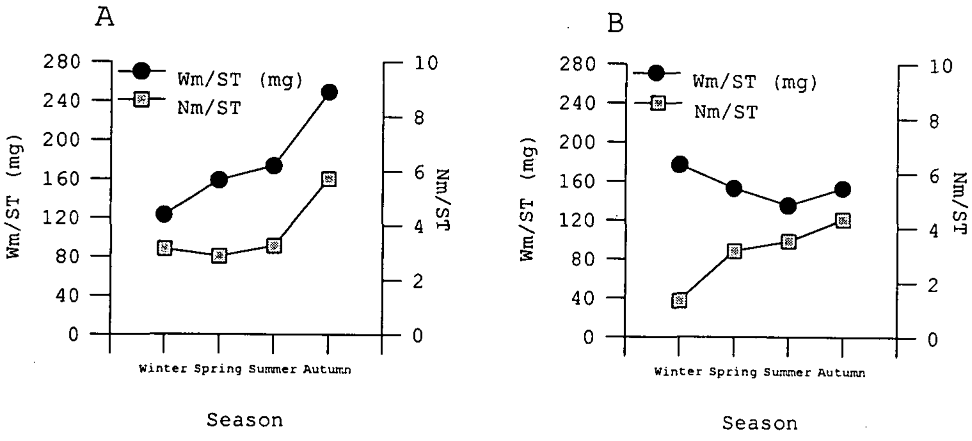

Figure 4. Average number of prey per stomach (Nm/ ST) and average prey weight per stomach (Wm/ ST) throughout the year: A) *Lepidorhombus boscii*; B) *Lepidorhombus whiffiagonis*. (Nm=Number of preys; ST=Number of stomachs).

The relative importance of the prey groups of *L. boscii* changed seasonally (Figure 5A). Natantids and mysids were the dominant food throughout the year. Isopods (χ^2=22.24, df=3, *P*<0.001) and amphipods (χ^2=22.49, df=3, *P*<0.001) occurred least frequently in the diet during spring, and were present primarily during autumn. No significative differences were found for teleosts, natantids, reptands 'others' and other crustaceans.

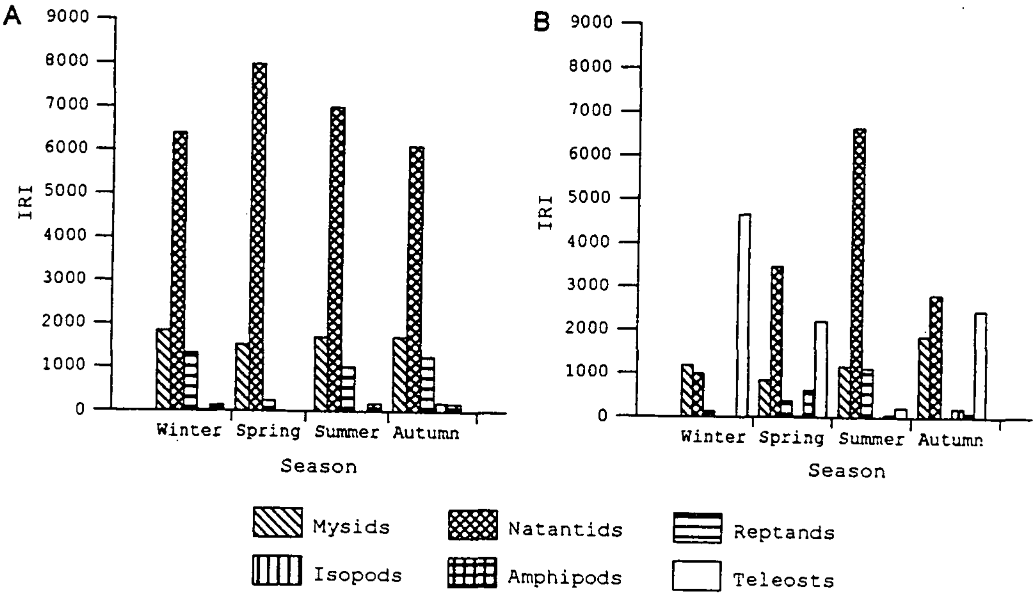

Figure 5. Seasonal changes in the Relative Importance Index of the main prey categories. A) *Lepidorhombus boscii*; B) *L. whiffiagonis*. In order to clarify the representation, "Others" and Other crustaceans have not been considered due to their low IRI values.

The seasonal importance of the different groups in *L. whiffiagonis* is indicated in Figure 5B. Teleosts were important in the stomach content of megrim throughout year, especially in winter (χ^2=10.11, df=3, P< 0.01). Amphipods (χ^2=10.42, df=3, P<0.05) were present primarily during spring. Natantids (χ^2=11.23, df=3, P<0.05) and reptands (χ^2=8.88, df=3, P<0.05) appeared most frequently in summer. 'Others' and isopods were consumed secondarily during autumn.

Diet overlap

Overlap on the basis of prey weight (Cw%) indicates small differences between the diets of four-spotted megrim and those of megrim in the same size groups and seasons (Table III). All the values obtained were higher than 0.30, an indicator of medium dietary overlap (Zaret & Rand, 1971; Langton, 1983).

Table III. Proportional food overlap coefficients of *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis* between seasons and size classes.

L. whiffiagonis	Group I	Group II	Group III	Winter	Spring	Summer	Autumn
L. boscii							
Group I	0.77						
Group II		0.72					
Group III			0.56				
Winter				0.50			
Spring					0.47		
Summer						0.66	
Autumn							0.74

The dietary overlap between the smallest size class of the two species was 0.77. Since overlap values >0.60 are considered significant (Langton, 1983; Brodeur & Pearcy, 1984), it suggests a high competition dued a predilection for mysids, natantids and amphipods. Significant overlap values were also found for the medium size class of the two megrim species, owing to the fact that both prey heavily on *Alpheus glaber* and *Processa mediterranea*. The overlap between the highest size class of the two species showed an intermediate value (0.56), because four spotted-megrim switched to small prey including natantids and reptands while megrim retained a preference for large prey including teleosts.

The two species overlapped during summer and autumn in the families of prey species eaten, owing to the fairly similar proportions by weight of mysids and decapods consumed.

The dendrogram (Figure 6) shows, below the value of 40% two clusters which identify the species of fish: group 1 which contains mainly *Lepidorhombus whiffiagonis* specimens and group 2 that contains *Lepidorhombus boscii* specimens. Group 1 can be further divided into two subgroups: specimens ≤12 cm and longer than

16 cm (subgroup A) and those with length from 12.5-15.5 cm (subgroup B). Subgroup A showed the highest similarity value with each other, and their specimens are linked because their diet is dominated by *Lesueurigobius friesii* and *Processa mediterranea.*

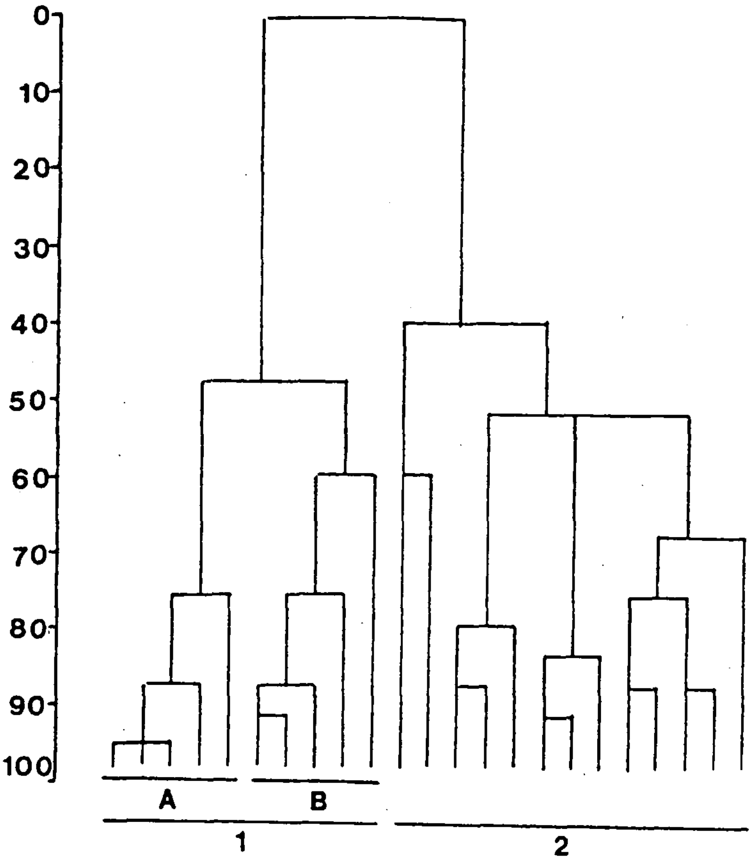

Figure 6. Dendogram of the cluster analysis.

In subgroup B the common prey type consist of *L. friesii* and *Deltentosteus quadrimaculatus*, preys with a high weight too. However, in group 2, cluster analysis did not clearly distinguish diet categories according to size and/or season.

DISCUSSION

Our study indicates the importance of crustaceans (mysids and decapods) in the diet of *Lepidorhombus boscii.* Similar results have been reported for other Western Mediterranean areas from studies in the Gulf of Lion (Reys, 1960), Catalan coast

(Macpherson, 1977, 1979, 1981), Tuscan Archipelago (Mannini et al., 1990) and Tyrrhenian Sea (Sartor & De Ranieri, 1996).

In the Gulf of Valencia, *Lepidorhombus whiffiagonis* appears to feed mainly on crustaceans and teleosts. Concerning the Mediterranean waters, no information is available about the diet of megrim. Studies in Atlantic waters have reported a diet rather similar to that of Mediterranean megrim, but with more importance taken on by the fishes as a prey (Rae, 1963; Du Buit, 1984, 1992) due to the different length range.

The diet of the two megrim species examined is based on benthic species (*Alpheus glaber*, *Goneplax rhomboides*, *Lesueurigobius friesii*, *Calocaris macandreae*, *Liocarcinus depurator*, *Solenocera membranacea*) or species which live just above the bottom (*Processa mediterranea*, *Parapseudomma calloplura*, *Leptomysis gracilis*). Most of these preys, such as *Alpheus glaber*, *Goneplax rhomboides*, *Calocaris macandreae* and *Lesueurigobius friesii*, live buried in the substratum. Therefore prey-catching must be active, as the fish has to dig in the bottom in search of food.

Studies carried out in the feeding habits of various flat fishes in relation to their alimentary tract morphology (De Groot, 1971) have revealed that *L. boscii* and *L. whiffiagonis*, as the other Scolphtalmids, have a large esophagus and stomach, while the intestinal loop is simple. The gill rakers, however, and the mouth are large. These characteristics allow it feed large preys (*A. glaber*, *G. rhomboides*, etc.), being very well adapted to feed on larger, quick moving prey as can be the fish.

An increase in *Lepidorhombus boscii* length was also followed by defined changes in feeding habits: the frequency of amphipods, isopods and mysids decreased with increasing four-spotted megrim size whereas the frequency of natantia and reptands increased. These results agrees with the findings of previous investigators for other areas (Macpherson, 1977, 1979; Sartor & De Ranieri, 1996).

The results indicate that the diet of *L. whiffiagonis* changed with growth: small prey was caught by smaller specimens and, as specimen size increased, prey also became bigger, firstly mysids, secondly decapods and then teleosts. Du Buit (1984, 1992) report similar results, but they find a higher occurrence of teleosts in the stomachs of larger specimens.

In *L. boscii*, the low percentage of empty stomachs agrees with observations of previous investigators for other areas (Macpherson, 1977; Sartor & De Ranieri, 1996). However, this percentage was not constant throughout the year. A maximum of empty stomachs was recorded in the reproductive period, which it is consistent with Macpherson's (1977) findings in the Catalan Sea, who found the highest vacuity in spring. No changes were observed in the vacuity index with growth. Opposite results have been presented in the Tyrrhenian Sea, whereas *L. boscii* increases its food ingestion with the increase of size (Sartor & De Ranieri, 1996).

In *L. whiffiagonis* the percentage of empty stomachs was higher than in *L. boscii*, although did not varied with the season and size.

Overlap values indicates competition between the two species in the same size groups and in the same season. However, the cluster analysis shows an evident segregation between the two species according to their size in each season. This reinforced the fact that, in an ecological sense, high overlap values did not provide sufficient evidence of competition unless resources are in short supply (Pianka, 1976) and no data is available to assess whether food supply is scarce or abundant.

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Appendix 1. Prey registered in the stomach of *Lepidorhombus boscii.*

Food items	n	p	F%	Cn%	Cw%	IRI
Foraminifera	2	8	0.639	0.596	*	0.381
Polychaeta	2	2	0.639	0.149	1.089	0.791
Mollusca						
Bivalvia	2	2	0.639	0.149	0.032	0.116
Leda commutata	1	1	0.319	0.074	0.937	0.323
Venus verrucosa	2	2	0.639	0.149	0.032	0.116
Cephalopoda	1	1	0.319	0.074	0.937	0.323
Sepiola rondeleti	1	1	0.319	0.074	0.937	0.323
Crustacea						
Mysidacea						
Lophogastridae						
Lophogaster typicus	22	33	7.029	2.457	1.191	25.642
Mysidae	6	7	1.917	0.521	0.018	1.034
Boreomysis arctica	2	6	0.639	0.447	0.013	0.294
Boreomysis megalops	9	13	2.875	0.968	0.025	2.855
Siriella sp.	1	1	0.319	0.074	*	0.025
Gastrosaccus normani	12	23	3.834	1.713	0.052	6.765
Anchialina agilis	10	14	3.195	1.042	0.032	3.431
Erythrops sp.	12	13	3.834	0.968	0.029	3.824
Erythrops erythrophthalma	2	4	0.639	0.298	*	0.196
Erythrops elegans	28	52	8.946	3.872	0.117	35.687
Parapseudomma affine	3	4	0.958	0.298	*	0.294
Parapseudomma calloplura	41	177	13.099	13.179	0.397	177.840
Amblyops sp.	2	3	0.639	0.223	*	0.147
Leptomysis gracilis	26	108	8.307	8.042	0.251	68.883
Mysideis parva	10	10	3.195	0.745	0.023	2.451
Isopoda	7	10	2.236	0.745	0.064	1.808
Gnathiidae	17	58	5.431	4.319	0.055	23.756
Cirolanidae	4	5	1.278	0.372	0.105	0.610
Copepoda						
Calanoida	3	3	0.958	0.223	*	0.214
Amphipoda	11	13	3.514	0.968	0.020	3.473
Gammaroidea	5	8	1.597	0.596	0.012	0.971
Rhachotropis grimaldi	23	41	7.348	3.053	0.082	23.033
Rhachotropis rostrata	10	18	3.195	1.340	0.036	4.397
Caprellidea						
Pseudolirius kroyerii	3	4	0.958	0.298	*	0.286
Stomatopoda						
Rissoides desmaresti	1	1	0.319	0.074	0.294	0.118
Euphausiacea	1	1	0.319	0.074	*	0.026
Decapoda						
Natantia	21	28	6.709	2.085	2.995	34.081
Solenocera membranacea	29	39	9.265	2.904	2.640	51.367

Sergestes arcticus	4	5	1.278	0.372	0.792	1.488
Caridea	2	2	0.639	0.149	0.087	0.150
Plesionika sp.	4	4	1.278	0.298	3.397	4.721
Pandalina brevirostris	19	28	6.070	2.085	0.750	17.209
Alpheus glaber	67	93	21.406	6.925	15.867	487.878
Processa sp.	8	15	2.556	1.117	1.063	5.573
Processa macrophthalma	11	15	3.514	1.117	1.063	7.662
Processa canaliculata	35	80	11.182	5.957	5.768	131.104
Processa mediterranea	79	209	25.240	15.562	15.255	777.812
Crangonidae	4	5	1.278	0.372	0.026	0.509
Pontocaris lacazei	5	5	1.597	0.372	1.680	3.278
Pontophilus spinosus	5	6	1.597	0.447	0.569	1.622
Philocheras echinulatus	8	8	2.556	0.596	0.682	3.265
Philocheras bispinosus	13	16	4.153	1.191	0.092	5.328
Philocheras monacanthus	3	3	0.958	0.223	0.016	0.230
Reptantia						
Scyllarus pygmaeus	1	1	0.319	0.074	0.080	0.049
Calocaris macandreae	23	28	7.348	2.085	7.549	70.790
Munida iris	9	10	2.875	0.745	0.353	3.156
Munida intermedia	3	3	0.958	0.223	0.340	0.540
Brachyura	5	5	1.597	0.372	1.387	2.810
Portunidae	1	1	0.319	0.074	0.277	0.112
Liocarcinus sp.	3	5	0.958	0.372	1.387	1.686
Liocarcinus depurator	16	27	5.112	2.010	7.488	48.557
Pilumnus sp.	1	1	0.319	0.074	0.181	0.082
Goneplax rhomboides	20	29	6.390	2.159	7.725	63.159
Teleostei	4	4	1.278	0.298	2.569	3.663
Lotinae	1	1	0.319	0.074	0.719	0.254
Deltentosteus quadrimaculatus	4	4	1.278	0.298	3.221	4.497
Lesueurigobius friesii	9	9	2.875	0.670	7.645	23.910
Unidentified remains	7	7	2.236	0.521	0.442	2.155

n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F%, frequency of occurrence; Cn%, numerical composition; Cw%, biomass composition; IRI, Index of Relative Importance. * = <0.01

Appendix 2. Prey registered in the stomach of *Lepidorhombus whiffiagonis*.

Food items	n	p	F%	Cn%	Cw%	IRI
Foraminifera	1	4	0.769	0.840	*	0.647
Polychaeta	2	2	1.538	0.420	2.818	4.982
Mollusca						
Bivalvia	1	1	0.769	0.210	0.041	0.194
Venus verucosa	2	2	1.538	0.420	0.083	0.774
Crustacea						
Copepoda						
Calanoida	1	1	0.769	0.210	*	0.162
Isopoda	2	5	1.538	1.050	0.083	1.743
Gnathiidae	8	15	6.154	3.151	0.029	19.571
Cirolanidae	2	2	1.538	0.420	0.109	0.814
Amphipoda	6	8	4.615	1.681	0.032	7.906
Gammaroidea	3	3	2.308	0.630	0.012	1.482
Rhachotropis sp.	5	11	3.846	2.311	0.057	9.106
Rhachotropis grimaldi	6	11	4.615	2.311	0.057	10.927
Rhachotropis rostrata	2	4	1.538	0.840	0.021	1.325
Caprellidea	1	1	0.769	0.210	*	0.162
Phthisica marina	3	3	2.308	0.630	*	1.455
Mysidacea						
Lophogastridae						
Lophogaster typicus	3	3	2.308	0.630	0.338	2.235
Mysidae	1	2	0.769	0.420	*	0.326
Boreomysis megalops	8	13	6.154	2.731	0.050	17.110
Gastrosaccus normani	8	14	6.154	2.941	0.025	18.256
Anchialina agilis	3	3	2.308	0.630	*	1.467
Erythrops erythrophthalma	2	5	1.538	1.050	*	1.630
Erythrops elegans	7	13	5.385	2.731	0.024	14.833
Parapseudomma affine	2	2	1.538	0.420	*	0.652
Parapseudomma calloplura	18	98	13.846	20.588	0.177	287.526
Amblyops sp.	3	3	2.308	0.630	*	1.467
Leptomysis gracilis	1	2	0.769	0.420	0.012	0.333
Mysideis parva	8	8	6.154	1.681	0.047	10.630
Euphausiacea	3	3	2.308	0.630	0.048	1.565
Decapoda						
Natantia	9	9	6.923	1.891	1.275	21.915
Solenocera membranacea	3	3	2.308	0.630	0.344	2.249
Sergestes arcticus	2	3	1.538	0.630	0.982	2.480
Pandalina brevirostris	9	9	6.923	1.891	0.407	15.904
Parapandalus narval	3	9	2.308	1.891	0.407	5.301
Alpheus glaber	17	22	13.077	4.622	4.371	117.606
Processa sp.	9	16	6.923	3.361	1.752	35.401
Processa mediterranea	27	78	20.769	16.387	8.714	521.317
Crangonidae						

Pontocaris lacazei	2	2	1.538	0.420	2.164	3.976
Pontophilus spinosus	3	4	2.308	0.840	1.098	4.472
Philocheras echinulatus	4	4	3.077	0.840	0.765	4.939
Philocheras bispinosus	5	6	3.846	1.261	0.090	5.194
Reptantia						
Calocaris macandreae	9	11	6.923	2.311	7.671	69.105
Munida iris	1	1	0.769	0.210	0.069	0.215
Brachyura	1	1	0.769	0.210	0.150	0.277
Liocarcinus sp.	1	2	0.769	0.420	0.772	0.917
Liocarcinus depurator	4	7	3.077	1.471	1.999	10.674
Pilumnus sp.	1	1	0.769	0.210	0.298	0.390
Goneplax rhomboides	2	3	1.538	0.630	1.211	2.832
Teleostei	4	4	3.077	0.840	3.516	13.403
Deltentosteus quadrimaculatus	5	5	3.846	1.050	9.360	40.041
Gobius auratus	2	2	1.538	0.420	2.419	4.368
Lesueurigobius friesii	24	27	18.462	5.672	43.193	902.127
Callionymus rissoi	4	4	3.077	0.840	2.027	8.824
Sardina pilchardus	1	1	0.769	0.210	0.859	0.822

n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F%, frequency of occurrence; Cn%, numerical composition; Cw%, biomass composition; IRI, Index of Relative Importance. * = <0.01

2.3. *Trachinus draco*

Feeding habits of *Trachinus draco* off the eastern coast of Spain (Western Mediterranean)

SALOME MORTE, MANUEL J. REDON and ANTONIO SANZ-BRAU

Universitat de Valencia, Facultad de Ciencias Biológicas, Ecología, Laboratorio de Biología Marina, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain

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Fish, *Trachinus draco*, Trachinidae, feeding, Mediterranean.

ABSTRACT.- The stomach contents of 893 specimens of *Trachinus draco* (taken at monthly intervals) off the eastern coast of the Gulf of Valencia (Spain), were analyzed to determine diet according to fish size and season. Crustaceans (Mysidacea and Decapoda) and teleosts constituted the main prey. Feeding habits varied with predator size; small specimens contained a greater number of mysids in their stomachs, while decapods and fishes were more abundant in the stomachs of larger specimens. Little seasonal variation in food habits was noticed.

Poisson, *Trachinus draco*,Trachinidae, nutrition, Méditerranée

RÉSUMÉ.- Les contenus stomacaux de 893 individuees de la Grande Vive *Trachinus draco* (capturés avec une périodicité mensuelle) du Golfe de Valencia (Espagne), ont été analysés en une de détermination le regime alimentaire en fonction de la taille des Poissons et de la saison. Crustacés (Mysidacés et Décapodes) et Téléostéens constituent les proies préférentielles. Le régime alimentaire varie avec la taille du prédateur; les estomacs des petits spécimens contiennent un grand nombre de Mysidacés, tandés que ceux des exemplaires de grande taill les Décapodes et les Poissons furent les plus abondants. Un léger changement du régime alimentaire en fonction de la saison a été mis en évidence.

INTRODUCTION

The weever, *Trachinus draco* Linnaeus, 1758 is a common trachinid found in the Mediterranean, Black Sea and North-eastern Atlantic, from Norway to Morocco and Madeira (Tortonese, 1975). It lives in relatively deep water of 30-100 m, but may be taken on occasions as shallow as 5 m (Férnandez *et al.*, 1990).

Published information on the diet of the weever only points out that its main diet comprises of crustaceans and fish (Muus & Dahlstrom, 1971; Wheeler, 1978). Only Vivó & Sanz (1989) studied its diet more thoroughly in the Western Mediterranean, applying a numerical method which over-rates the importance of small but numerous preys and no statistical significance of the variations is discussed.

This paper describes the feeding habits of *T. draco* in the Gulf of Valencia (Western Mediterranean), including the influence of predator size and seasonal variations in the stomach contents.

MATERIALS AND METHODS

Monthly samples of *Trachinus draco* were taken from diurnal commercial catches landed at the port of Valencia (Spain) taken at 50 to 175 m depth in the Gulf of Valencia (Western Mediterranean), between October 1991 and October 1994. A total of 893 specimens were measured with a total length between 10 and 30 cm (Figure 1), to the lower half centimeter, dissected and the stomachs were removed and preserved in 6% formalin. Upon opening, stomach contents were preserved in a 70% ethanol solution. Evidence of regurgitation was never observed in any fish.

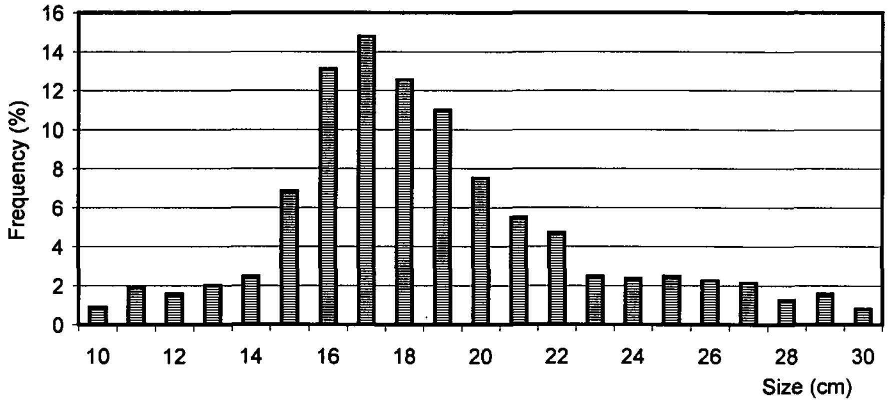

Figure 1. Length-frequency distribution of 893 individuals of *Trachinus draco* caught in the Gulf of Valencia.

In the laboratory, identification of prey was carried out to species level whenever possible. We registered their number and wet weight of the food items, after removal of surface water by blotting on tissue paper.

The contribution of each prey to the diet of this species was determined by the frequency of occurrence (F%), numerical composition (Cn%) and biomass composition (Cw%) (Hyslop, 1980). Percentage of empty stomachs (V) was also recorded. The Index of Relative Importance (IRI) (Pinkas *et al.*, 1971), as modified by Hacunda (1981), was calculated for consumed prey item:

$$IRI = F\% \, (Cn\% + Cw\%)$$

To assess for possible changes in diet with respect to size, fish were divided into three size-classes: small (≤15 cm), medium (15.5 to 19.5 cm) and large (≥20 cm).

Statistical differences ($P<0.05$) in diet composition as a function of size and season were assessed by applying a chi-square test (Sokal & Rohlf, 1981). This was applied over the number of individuals of a specific prey. To avoid small expected frequencies for chi-square test, numbers of prey items were pooled into seven categories using contingency tables as applied by SPSS Inc. Pc. These categories were: mysids, natantids, reptands, other crustaceans (copepods, isopods, amphipods and euphausiids), molluscs, teleosts and "others" (polychaetes, algal remains and non-identified remains).

The variation of index of emptiness was also tested by a chi-square test over a contingency table of number of empty stomachs.

The significance of variation of mean number of prey and weight per stomach was tested by analysis of variance (ANOVA), after checking the normality of each variable and the homogeneity of variances (Sokal & Rohlf, 1981).

RESULTS

Emptiness index

Of the 893 stomachs of *Trachinus draco* examined, 394 were empty (44.12%). This percentage varied significantly over the year (χ^2=12.20, df=3, P<0.01), with a maximum of 52.61% during summer.

The percentage with empty stomachs increased significantly (χ^2=17.77, df=2, P<0.01) with decreasing weever size from 34.35% in large size class to about 53% in small specimens.

Overall composition of the diet

Table I shows the frequency of occurrence, numerical composition, biomass composition and the Index of Relative Importance, of all prey items found in *Trachinus draco*.

Table I. Diet composition of 499 *T. draco* containing food (F% frequency of occurrence; Cn% numerical composition; Cw%, biomass composition; IRI, Index of Relative Importance).* = <0.01

Food items	F %	Cn %	Cw %	IRI
Algal remains	1.80	0.48	0.16	1.16
POLYCHAETA	1.60	0.54	3.03	5.71
MOLLUSCA				
Bivalvia	3.21	0.86	0.14	3.21
Chlamys sp.	0.40	0.11	0.02	0.05
Cavolinia sp.	0.20	0.11	0.02	0.03
Gasteropoda	0.20	0.05	0.01	0.01
Turritella communis	0.80	0.21	0.10	0.25
Cephalopoda	0.40	0.11	1.04	0.46
Teithoidea				
Alloteuthis media	0.80	0.21	1.17	1.11
Illex coindeti	0.60	0.16	2.46	1.57
Decapoda				
Sepioidea	1.20	0.32	3.12	4.14
Sepiola rondeletti	3.01	0.86	8.33	27.63
CRUSTACEA				
Copepoda	0.80	0.32	*	0.26
Caligus sp.	0.20	0.05	*	0.01
Isopoda	0.60	0.16	0.01	0.10
Amphipoda	0.40	0.11	*	0.04
Gammaridae	1.00	0.32	0.01	0.33
Eusirus longicornis	0.20	0.05	*	0.01
Vibilia armata	0.20	0.21	0.01	0.04
Phytisica marina	0.40	0.11	*	0.04
Mysidacea				
Lophogaster typicus	1.00	0.32	0.14	0.46
Mysidae	2.00	0.54	0.01	1.10
Siriella sp.	2.00	1.50	0.04	3.10
Siriella jaltensis	0.80	0.21	0.01	0.18
Gastrosaccus normani	3.61	1.61	0.04	5.94
Anchialina agilis	6.41	3.81	0.09	25.01
Amblyops sp.	0.60	0.21	0.01	0.13
Leptomysis gracilis	33.06	61.62	1.45	2085.35
Leptomysis mediterranea	2.20	0.81	0.02	1.82
Stomatopoda				
Risoides desmaresti	0.80	0.21	0.66	0.71
Euphausiacea	0.40	0.20	0.01	0.10
Decapoda				
Natantia	1.60	0.43	0.63	1.71
Solenocera membranacea	1.60	0.43	0.20	1.01
Sicyonia carinata	0.60	1.16	0.18	0.21
Caridea	0.20	0.05	0.02	0.02
Chlorotocus crassicornis	0.40	0.11	0.79	0.36
Alpheus glaber	14.83	6.87	22.74	439.15
Processa sp.	0.80	0.27	0.20	0.37
Processa mediterranea	1.80	0.48	0.35	1.51
Crangonidae	0.20	0.05	*	0.01
Philocheras sculptus	0.40	0.16	0.05	0.09

Philocheras bispinosus	0.60	0.21	0.01	0.14
Reptantia				
Calocaris macandreae	0.60	0.21	0.60	0.49
Upogebia sp.	0.80	0.21	0.07	0.23
Galathea intermedia	0.40	0.11	0.02	0.05
Pisidia longimana	0.60	0.16	0.06	0.13
Brachyura	1.20	0.32	0.92	1.50
Liocarcinus sp.	1.00	0.38	1.08	1.46
Liocarcinus corrugatus	1.80	0.54	1.39	3.48
Liocarcinus pusillus	1.60	0.48	1.39	3.00
Liocarcinus arcuatus	1.20	0.86	2.23	3.71
Liocarcinus depurator	4.81	1.77	5.16	33.36
Goneplax rhomboides	12.02	3.76	10.90	176.19
TELEOSTEI	1.60	0.43	2.85	5.27
Anguilliformes	0.20	0.05	0.11	0.03
Conger conger	1.40	0.38	0.74	1.56
Gadidae	1.00	0.27	1.98	2.26
Gobiidae	0.60	0.16	1.08	0.74
Lesueurigobius friesii	3.21	0.86	5.75	21.18
Cepola rubescens	1.40	0.38	2.50	4.03
Capros aper	1.20	0.32	1.74	2.48
Sardina pilchardus	0.40	0.16	0.67	0.33
Engraulis encrasicolus	0.40	0.11	0.44	0.22
Pleuronectiformes	0.20	0.05	0.22	0.06
Arnoglossus laterna	1.20	0.32	1.33	1.99
Citharus linguatula	0.40	0.11	0.44	0.22
Callionimydae	0.60	0.16	0.85	0.61
Callionymus lyra	1.60	0.43	2.27	4.34
Callionymus maculatus	3.61	0.97	5.12	21.95
Callionymus rissoi	0.40	0.11	0.57	0.27
Non-identified remains	1.20	0.32	0.21	0.64

The stomach contents of the weever consisted of at least 40 different prey species, with a low average number of prey per stomach (2.09). Crustaceans were the most numerous ingested preys, constituting 90.39% of the total. Among these, mysids were present in the greatest number and also occurred most frequently in the stomachs. Despite the great variety of crustacean species in the stomachs, the most frequent prey was the mysid *Leptomysis gracilis*. Less abundant crustaceans included natantids (*Alpheus glaber*) and reptands (*Goneplax rhomboides* and *Liocarcinus depurator*).

Gobiids and callionimids were the dominant teleosts, although these were less numerous than crustaceans (5.26%).

Other taxa found in the stomach contents, but of lesser importance, were molluscs (*Sepiola rondeletti*), amphipods, isopods, copepods, euphausiids and polychaetes.

According to the IRI, the most important prey was *L. gracilis*, followed by *A. glaber* and *G. rhomboides*.

Variation in stomach contents relative to fish length

The average number of prey and weight per stomach increase from the smallest individuals to the largest (ANOVA, P<0.05) (Figure 2A).

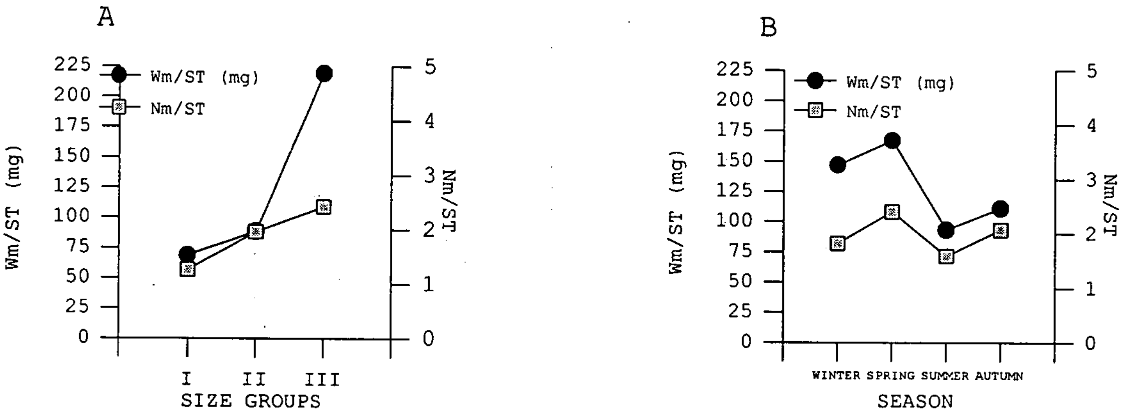

Figure 2. Average number of prey per stomach (Nm/ST) and average prey weight per stomach (Wm/ST) of *Trachinus draco*. A) by size; B) through the year.

Table II displays the stomach contents for size groups of *Trachinus draco* with regard to frequency of occurrence, numerical composition, biomass composition and Index of Relative Importance of the seven main prey categories. Frequency of occurrence of the various prey types varied with weever size: the frequency of molluscs, natantids, reptands and teleosts increase with increasing weever size whereas the frequency of "others" and other crustaceans decreased. The numerical composition index indicates that mysids were the most numerous prey ingested in all size classes, even the large size class. By weight, however, teleosts and decapods were more important than mysids.

Table II. Dietary groups for each size range of *T. draco*, with regard to the frequency of occurrence (F%), numerical composition (Cn%), biomass composition (Cw%) and Index of Relative Importance (IRI).

	≤ 15 cm				15.5 - 19.5 cm				≥ 20 cm			
	F (%)	*Cn (%)*	*Cw (%)*	*IRI*	*F (%)*	*Cn (%)*	*Cw (%)*	*IRI*	*F (%)*	*Cn (%)*	*Cw (%)*	*IRI*
Others	12.50	6.20	21.67	348.4	4.65	1.23	2.99	19.63	2.59	0.66	1.69	6.09
Other crustaceans	6.25	3.10	0.09	19.92	5.81	2.15	0.52	15.52	3.63	0.92	0.90	6.60
Molluscs	6.25	2.33	17.28	122.55	9.69	2.77	21.81	238.15	13.47	3.43	12.65	216.5
Mysids	54.17	70.54	1.93	3925.36	61.24	77.23	2.79	4900.22	22.80	62.19	1.10	1442.80
Natantids	16.67	7.75	5.78	225.49	17.83	5.95	22.11	500.20	27.46	13.70	29.42	1184.20
Reptands	8.33	3.10	9.70	106.64	22.87	8.31	32.44	931.72	29.02	10.41	19.49	867.54
Teleosts	6.2	6.98	43.56	947.64	8.53	2.36	17.36	168.15	34.20	8.70	34.76	1485.90

A chi-square test revealed significant differences between ingestion by weever size of natantids (χ^2=6.79, df=2, P<0.05), reptands (χ^2=9.34, df=2, P<0.01) and teleosts (χ^2=46.47, df=2, P<0.01) due to the low number which appeared in the small size class. There was a tendency for mysids to be mostly consumed by the small and medium specimens (χ^2=67.29, df=2, P<0.01). No significant values were found for other crustaceans (χ^2=1.28, df=2), molluscs (χ^2=2.31, df=2) and "others" (χ^2=3.41, df=2).

Based on IRI, mysids were the most important prey group in all size groups, although teleosts were also important.

Seasonal variation in the diet

Average prey per stomach values decrease significantly from spring to summer (ANOVA, P<0.05), whereas mean weight of stomach contents decrease significantly from spring to autumn (ANOVA, P<0.05) (Figure 2B).

Little seasonal variation in food habits of *Trachinus draco* within the studied area was noticed (Figure 3).

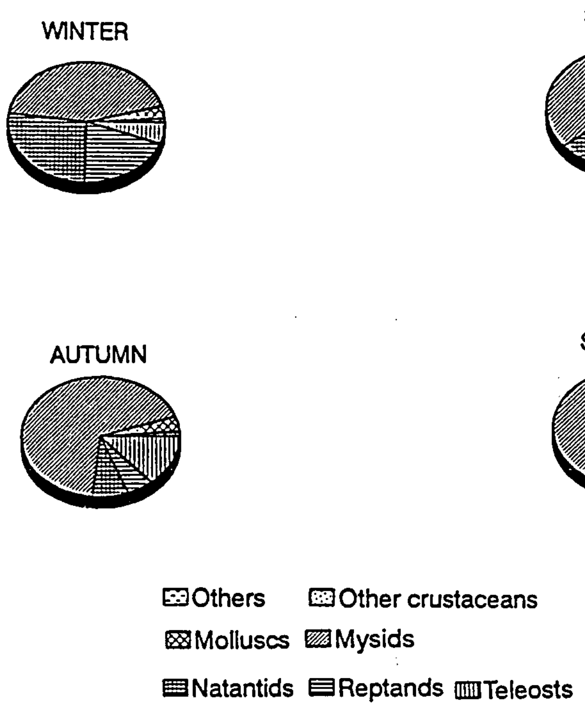

Figure 3. Seasonal variation of the Index of Relative Importance (IRI) in the main prey categories of *Trachinus draco*.

Figure 3. Fluctuations saisonnières de Indice d'Importance Relative (IRI) des principales catégories de proies dans le régime alimentaire de *Trachinus draco*.

Mysids were the dominant food during all the seasons. Decapod crustaceans and teleosts were common throughout the year. However, during winter the IRI of natantids increased with respect to the other seasons, whereas reptands were present primarily during spring (IRI=1694). Teleosts were less common in winter (IRI=295). Statistical analysis only revealed significant differences for reptands (χ^2=28.17, df=3, P<0.01) because they appeared most frequently in spring.

DISCUSSION

Few detailed reports are available for *Trachinus draco* feeding habits in the Mediterranean Sea. Our study indicates that, like for other species of the family Trachinidae (Muus & Dahlstrom, 1971; Wheeler, 1978), crustaceans (mysids and decapods) and teleosts are the main identifiable prey. Vivó & Sanz (1989) in another area of the Gulf of Valencia, confirm the overall dominance of mysids in the diet of weever, and in addition supply detailed information on the specific composition of this taxon. These authors reported that decapods (*Alpheus glaber* and *Goneplax rhomboides*) were also important, whereas fishes (*Callionymus maculatus*) constituted a secondary group.

Like all members of the family, *T. draco* is a bottom-living fish which lies buried in the sandy sea-bed during daylight and emerges to forage at night (Wheeler, 1978). The diet examined is basically composed of benthic species (*Alpheus glaber*, *Goneplax rhomboides*, *Liocarcinus depurator*, *Lesueurigobius friesii*, *Callionymus maculatus*) or species which live just above the bottom (*Leptomysis gracilis*). Most of these prey, such as *A. glaber*, *G. rhomboides*, *C. macandreae* and *L. friesii*, are able to bury themselves. Therefore capturing prey must be active, as the fish has to dig in the bottom in search of food.

The high percentage of empty stomachs (44.12%) obtained from this study agrees with observation of Vivó & Sanz (1989). Stomach fullness showed a seasonal cycle with a minimum in summer, the reproductive period (Muus & Dahlstrom, 1971; Nichols & Miller, 1981). However, reproduction seems to have little effect on feeding intensity since the highest vacuity was found in the small size class. In the work of Vivó & Sanz (1989), the highest vacuity for *T. draco* was found in winter.

Our results indicate that the diet of *T. draco* changed with growth: small prey were caught by smaller specimens and, as specimen size increased, prey also became bigger, in the first place mysids, secondly decapods and then teleosts. Vivó & Sanz (1989) report similar results.

Maximum occurrence of a specific prey species often coincided with the breeding period of that species. For example, *L. gracilis* and *L. friesii* are more abundant in autumn, coinciding with the breeding period (Macquart-Moulin, 1965; Casadevall *et al.*, 1994). *A. glaber* breeds between March and August (Casadevall *et al.*, 1994) and maximum occurrence was found in May. Breeding in *L. depurator* begin in November and lasted until January (Abelló, 1989) when its occurrence coefficient increases. This indicates that observed seasonal variations in food ingestion may be related to fluctuations of the prey in the environment. Although no data are available in the study area in relation to the availability of the food supply, previous studies in the Gulf of Valencia on the feeding habits of several fish point out that several prey species, such us *L. gracilis*, *A. glaber*, *L. depurator*, *G. rhomboides* and *L. friesii*, occurred more frequently in the stomach contents (Vivó & Sanz, 1989; Redón *et al.*, 1994; Morte *et al.*, 1997; Morte *et al.*, 1999).

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2.4. *Scorpaena notata* y *Scorpaena porcus*

Diet of *Scorpaena porcus* and *Scorpaena notata* (Pisces: Scorpaenidae) in the western Mediterranean.

SALOME MORTE, MANUEL J. REDON and ANTONIO SANZ-BRAU

Universitat de Valencia, Facultad de Ciencias Biológicas, Ecología, Laboratorio de Biología Marina, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain

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ABSTRACT.- Food preferences of 230 *Scorpaena porcus* and 576 *S. notata* (Pisces: Scorpaenidae) were investigated from the stomach contents of fish caught in the Gulf of Valencia (Spain), between October 1991 and October 1994.

Our aim was to study the effects of predator size and season on the feeding habits of both species, the existence of a possible ditary overlap between species, and to compare the results with those of other studies in the Mediterranean.

Crustacea Decapoda constituted the preferential prey of both fish species, whereas Amphipoda were secondary prey. However, these two scorpaenids had different diets, shown by the prey species composition of the stomach contents. *Scorpaena notata* had a more diverse diet (67 different types of prey) than *S. porcus* (44 different species). The vacuity index was low for both species, although it varied significantly over the year, with a maximum during the reproductive period. Little variation was found in the food composition of different *S. porcus* size groups: brachyura dominated in number and occurrence in the diet of all size classes. A variation was found in the food composition of different *S. notata* size groups: the frequency of occurrence of reptantia and brachyura increased with increasing *S. notata* size, whereas the frequency of amphipods, mysids, isopods, and copepods decreased. In both species, seasonal dietary changes were also recorded. There was a moderate dietary overlap between these two species.

RÉSUMÉ.- *Régime alimentaire de* Scorpaena porcus *et* Scorpaena notata (Pisces: Scorpaenidae) *en Méditerranée occidentale.*

Les préférences alimentaires de 230 *Scorpaena porcus* et 575 *S. notata* capturés dans le Golfe de Valence (Espagne), entre octobre 1991 et octobre 1994 ont été étudiées d'après leurs contenus stomacaux. Notre but était d'étudier les variations dans l'alimentation des deux espèces selon les saisons et les individus et the comparer ces résultats avec ceux d'autres études faites en Méditerranée.

Les crustacés Décapodes constituent les proies préférentielles des deux espèces examinées, tandis que les Amphipodes sont des proies secondaires. Cependant, ces deux rascasses ont des régimes alimentaires différents, comme le montre la composition spécifique des contenus stomacaux. *S. notata* a un régime alimentaire plus diversifié (67 types de proies) que *S. porcus* (44 types de proies). L'indice de vacuité est faible pour les deux espèces, bien qu'il ait varié significativement durant l'année, atteignant un maximum pendant la période de reproduction. Peu de changements sont observés dans le régime alimentaire de différents groupes de taille de *S. porcus* et les Brachyoures dominent en nombre et en fréquence d'occurrence dans toutes les classes de taille. Une variation a été observée dans le régime alimentaire des différentes classes de taille de *S. notata*: la fréquence d'occurrence des Reptantia et des Brachyoures augmente avec l'augmentation de la taille, tandis que la fréquence d'occurrence des Amphipodes, Mysidacés, Isopodes et Copépodes diminue. Chez les deux espèces on observe un changement de régime alimentaire avec la saison. Les deux espèces présentent un chevauchement alimentaire modéré.

Keywords: Scorpaenidae, *Scorpaena porcus*, *S. notata*, diet overlap, Mediterranean

INTRODUCTION

Scorpaena porcus Linnaeus, 1758 and *S. notata* Rafinesque, 1810 are two common marine demersal fishes in Spanish Mediterranean waters. Both scorpaenids inhabit the same grounds (rocky areas and *Posidonia* beds), although *S. notata* has a wider bathymetric distribution (Harmelin-Vivien et al., 1989).

Diet analysis is necessary to demonstrate the trophic overlap among species within a community. This parameter is essential in determining the intensity of the interspecific interactions in marine fish communities (Macpherson, 1981). Although the feeding habits of scorpaenid fishes in the Mediterranean were studied during the last decades (Dieuzeide et al., 1955; Bell & Harmelin-Vivien, 1983; Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990; Pallaoro & Jardas, 1991; Arculeo et al., 1993), no statistical significance of the diet variations is discussed in these studies. Furthermore, very little is known about the trophic relationships between these species, except in the work of Harmelin-Vivien et al. (1989) referring to the Gulf of Marseille.

The present work was conducted within the framework of a project for the study of trophic relationships in a demersal fish community in the Gulf of Valencia. The aim of this paper was to examine the diet and dietary overlap of two scorpaenid species in the western Mediterranean, taking into account the effect of predator size and season on the feeding habits of both species, and also to compare our results with those of other studies in the Mediterranean.

MATERIALS AND METHODS

A total of 230 *Scorpaena porcus* and 576 *S. notata* were taken at depths from 50 to 175 m, in the fishing grounds of the Gulf of Valencia (39°25' N - 39°35' N, 0°17' W - 0°15' W), between October 1991 and October 1994 (Table I). Fish were caught from diurnal commercial trawl catches landed at the port of Valencia (Spain).

Table I. Classification of the *Scorpaena porcus* and *S. notata* stomachs considered in this study, by year and season.

Tableau I. Nombre total des estomacs et nombre des estomacs vides chez les deux espèces de *Scorpaena* considérées dans cette étude, par année et par saison.

	Scorpaena porcus							
year	winter		spring		summer		autumn	
	total	empt	total	empt	total	empt	total	empt
oct '91 - sep '92	24	2	14	6	21	10	13	4
oct '92 - sep '93	19	5	42	6	19	7	16	3
oct '93 - sep '94	21	2	12	2	17	7	12	0
	Scorpaena notata							
oct '91 - sep '92	43	4	42	12	43	20	66	15
oct '92 - sep '93	25	5	77	15	47	21	70	24
oct '93 - sep '94	34	2	35	7	46	15	48	14

Monthly samples, stored in ice boxes, were quickly transferred to the laboratory. There, they were measured (total length), to the lower half centimetre, immediately dissected and the stomachs were removed and preserved in 6% formalin. Upon opening, stomach contents were stored in a 70% ethanol solution. Evidence of regurgitation was never observed in any fish.

Percentage of empty stomachs (vacuity index, V%) was also recorded. A χ^2 test was applied to test differences in the number of empty stomachs.

In the laboratory, identification of prey was carried out at specific level whenever possible. We registered number and wet weight (nearest 0.1 mg) of the food items, after wiping of the surface water..

The contribution of each prey to the diets of both species was determined by the frequency of occurrence (F%), numerical composition (Cn%) and biomass composition (Cw%) (Hyslop, 1980). The Index of Relative Importance (IRI) (Pinkas et al., 1971), as modified by Hacunda (1981), was calculated for consumed prey items:

$$IRI=F\%(Cn\% + Cw\%)$$

To asses changes in the diet with size, fish were divided into three size classes according to age (Siblot-Boutéflika, 1976): Group I (<11 cm) maximum 2 years, Group II (11-15 cm) between 2 and 4 years old, and Group III (>15 cm) the oldest ones.

Interspecific dietary overlap between size classes and seasons was calculated at level of species according to Schoener (1970):

$$a = 1 - 0.5\left(\sum_{i=1}^{n} \left|p_{xi} - p_{yi}\right|\right)$$

where n is the number of food organisms, p_{xi} and p_{yi} are the numerical composition index of prey (i) in the diets of species x and y, respectively. The index has a minimum value of zero, when no overlap occurs, and a maximum value of one, when all prey are shared in equal proportions by the two species. The convention established by Langton (1983) and Brodeur and Pearcy (1984) was invoked. Overlap index values of 0.00-

0.29 were considered low, values of 0.30-0.60 were considered medium, and values >0.60 were considered high.

In order to compare both species' diets, prey items were partitioned into six categories: natantia, brachyura, reptantia, amphipods, other crustaceans (mysids, isopods, copepods and stomatopods), and "other groups" (polychaetes, molluscs, ascidians, teleosts and vegetal remains).

A cluster analysis based on squared Euclidean distance (Sokal & Rohlf, 1981) was carried out on biomass composition data of their preys, to evaluate the pattern of the diet of each scorpaenid species according to fish size in each season.

Statistical differences ($P<0.05$) in diet composition as a function of size and season were assessed by applying a χ^2- test (Sokal & Rohlf, 1981). This was applied over the number of stomachs in which a prey occurs (n).

The significance of variation of mean number of prey and weight per stomach was tested by analysis of variance (ANOVA). The normality of the data was verified using the Kolmogorov-Smirnov test and the homogeneity of variances using the Bartlett's test ($P<0.05$). When data do not satisfy the assumptions of parametric tests, several transformations were applied (logarithmic, arcsine and square root transformations). If this condition remains, a nonparametric one-way ANOVA (Kruskal-Wallis test) was applied (Sokal & Rohlf, 1981).

RESULTS

General feeding trends

Of the 230 stomachs of *S. porcus* examined, 54 were found to be empty (23.5%). The vacuity index varied significantly over the year (χ^2=15.41, df=3, *P*<0.01), with a maximum in summer (42.1%) and a minimum in winter (14.1%) (Figure 1).

The stomachs of 26.7% *S. notata* were empty. Like in *S. porcus*, the vacuity index varied significantly over the year (χ^2=29.83, df=3, *P*<0.001), with a maximum in summer (41.2%) and a minimun in winter (10.8%).

The proportion of empty stomachs examined did not varied significantly among the size classes of *S. notata* (χ^2=3.17, df=2, *P*>0.05) and *S. porcus* (χ^2=5.47, df=2, *P*>0.05).

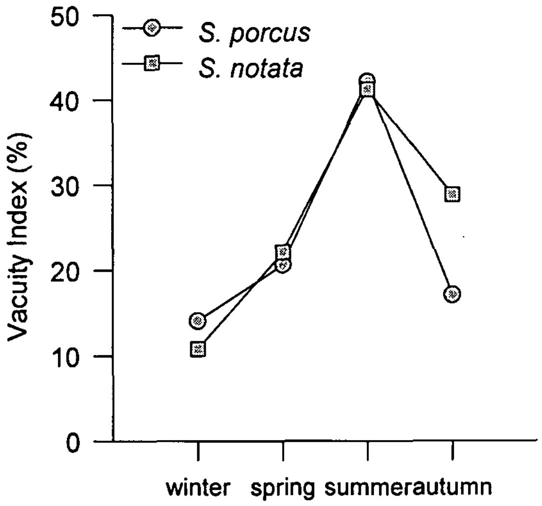

Figure 1. Seasonal variation of the vacuity index (V%)

Figure 1. Variation saisonnière de l'indice de vacuité (V%).

Data on the frequency of occurrence (F%), the numerical composition (Cn%), biomass composition (Cw%) and the Index of Relative Importance (IRI) of the main prey species consumed by this scorpaenids, in the study area, are given in Tables II and III. Further details, of the prey items found in *S. porcus* and *S. notata* stomach contents, are given in appendix 1 and 2, respectively.

The stomach contents of *S. porcus* contained 44 different prey species, with a low average number of prey per stomach (mean 1.87). Crustaceans were the most numerous prey ingested, dominated by brachyura (*Pilumnus hirtellus*, *Liocarcinus corrugatus* and *Goneplax rhomboides*) and reptantia (*Pisidia longimana* and *Upogebia deltaura*). Less abundant crustaceans included natantia (*Processa mediterranea* and *Philocheras monacanthus*) and amphipods. Less important taxa found in the stomach contents were molluscs, copepods, isopods, mysids, stomatopods, polychaetes and

Table II. Main preys registered in the stomach of *Scorpaena porcus*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F%, frequency of occurrence; Cn%, numerical composition; Cw%, biomass composition; IRI, Index of Relative Importance; only appears those species for which IRI> 25.

Tableau II. Proies préférentielles observées dans les estomacs de *Scorpaena porcus*. n, nombre d'estomacs où apparaissent les proies; p, nombre d'individus d'un type de proie; F%, indice de fréquence d'occurrence; Cn%, pourcentage numérique; Cw%, pourcentage en poids; IRI, Index d'Importance Relative; apparaissent uniquement les espèces pour lesquelles IRI> 25.

Food items	n	p	F (%)	Cn (%)	Cw (%)	IRI
Bathinectes	5	6	2.84	1.39	11.50	36.64
Goneplax	14	14	7.95	3.26	5.15	66.88
Ilia nucleus	8	9	4.54	2.09	3.51	25.49
Liocarcinus	17	19	9.66	4.42	6.08	101.43
Liocarcinus	10	13	5.68	3.02	4.16	40.82
Pilumnus hirtellus	26	33	14.77	7.67	16.71	360.27
Pisidia longimana	33	45	18.75	10.46	2.09	235.39
Processa	13	15	7.39	3.49	1.23	34.83

Table III. Main preys registered in the stomach of *Scorpaena notata*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F%, frequency of occurrence; Cn%, numerical composition; Cw%, biomass composition; IRI, Index of Relative Importance; only appears those species for which IRI> 25.

Tableau III. Proies préférentielles observées dans les estomacs de *Scorpaena notata*. n, nombre d'estomacs où apparaissent les proies; p, nombre d'individus d'un type de proie; F%, indice de fréquence d'occurrence; Cn%, pourcentage numérique; Cw%, pourcentage en poids; IRI, Index d'Importance Relative; apparaissent uniquement les espèces pour lesquelles le IRI> 25.

Food items	n	p	F (%)	Cn (%)	Cw (%)	IRI
Polychaeta	24	28	5.69	2.29	11.36	77.65
Alpheus glaber	36	37	8.53	3.03	2.16	44.30
Macropodia rostrata	23	35	5.45	2.87	2.27	28.02
Pilumnus hirtellus	43	53	10.19	4.34	14.16	188.47
Pisidia longimana	91	217	21.56	17.77	6.01	512.92
Processa	34	97	8.06	7.94	5.28	106.52
Thoralus cranchii	37	61	8.78	5.00	0.15	45.10

teleosts. According to the IRI, the most important prey was *Pilumnus hirtellus*, followed by *Pisidia longimana* and *Liocarcinus corrugatus*.

The number of prey species recorded for *S. notata* was 67, with an average number of 2.11 preys per stomach, comprising almost exclusively crustaceans. Among these crustaceans, natantia (*Processa mediterranea*, *Alpheus glaber* and *Thoralus cranchii*), reptantia (*Pisidia longimana*) and brachyura (*Pilumnus hirtellus*) made up the greatest number and also occurred most frequently in stomachs. Polychaetes and amphipods were secondary preys, whereas isopods, copepods, mysids, stomatopods, molluscs and teleosts were infrequent. For the IRI, *P. longimana* was by far the most important prey, followed by *P. hirtellus* and *P. mediterranea*.

Variation in stomach contents relative to fish length

In both species, there were no significant differences in the average number of prey per stomach between the different size classes (Figure 2).

The average prey weight per stomach changed with the different *Scorpaena notata* size groups (F=3.369, df=573, P<0.05), although in *Scorpaena porcus* no significative changes were found (F=0.94, df=227, P>0.05). The vacuity coefficient had no significant differences in the various size groups of both species.

Little variation was found in the food composition of different *S. porcus* size groups (Table IV). Brachyura dominated in number and occurrence in the diet of all size classes (χ^2=2.43, df=2, *P*>0.05). Predation on natantia did not vary significantly with the size of *S. porcus* (χ^2= 3.78, df= 2, *P*> 0.05), but there was a trend for reptantia to be less consumed by the large specimens (χ^2=6.62, df=2, *P*<0.05). Amphipods were consumed primarily by small specimens (χ^2=6.11, df=2, *P*<0.05), whereas "other groups" were present primarily in large specimens. No significant values were found for other crustaceans (χ^2=3.45, df=2, *P*>0.05).

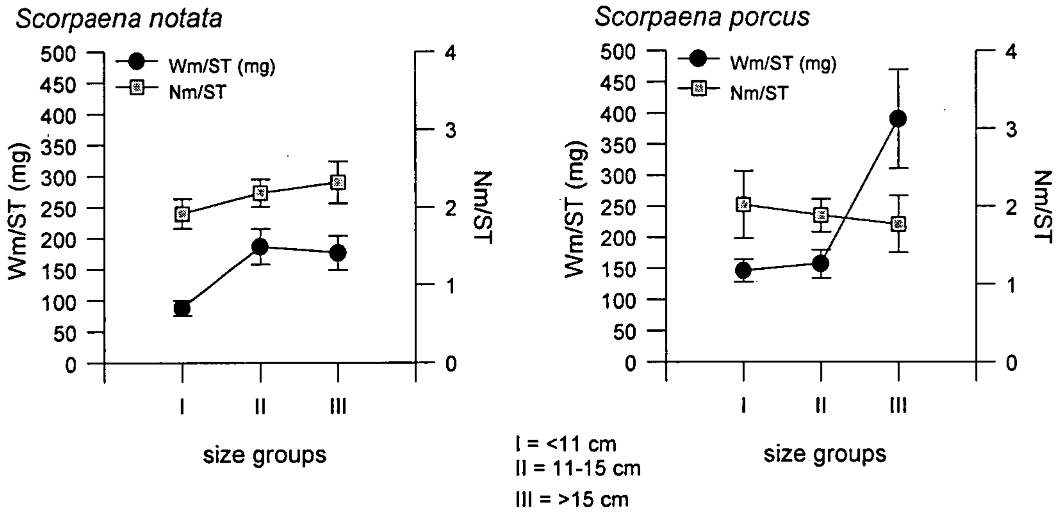

Figure 2. Average number of prey per stomach (Nm/ ST) and average prey weight per stomach (Wm/ ST) for the size groups. Nm= Number of preys; Wm= Weight of preys; ST= Number of stomachs.

Figure 2. Nombre moyen de proies par estomac (Nm/ ST) et poids moyen des proies par estomac (Wm/ ST) pour chaque groupe de taille. Nm= Nombre de proies; Wm= Poids des proies; ST= Nombre d'estomacs.

Appreciable variation was found in the food composition of different *S. notata* size groups (Table V). An increase in length was also followed by defined changes in feeding habits: the frequency of occurrence of reptantia (χ^2=13.99, df=2, P<0.001), brachyura (χ^2= 18.09, df= 2, P< 0.001) and other groups (χ^2= 8.52, df= 2, P< 0.05) increased with increasing *S. notata* size whereas the frequency of amphipods (χ^2=2.75, df=2, P>0.05) and other crustaceans (χ^2=23.90, df=2, P<0.001) decreased. Natantia were important in all size classes (χ^2=0.91, df=2, P>0.05). The numerical composition index indicates that natantia were the most numerous prey ingested in the small and medium size classes, whereas reptantia were important in the large size class.

Table IV. Diet of each size group of *Scorpaena porcus*, with regard to the frequency of occurrence (F%), numerical composition (Cn%), biomass composition (Cw%) and Index of Relative Importance (IRI). Group I <11 cm; Group II 11-15 cm; Group III >15 cm.

Tableau IV. Alimentation de chaque classe de taille de *Scorpaena porcus*, selon l'indice de fréquence d'occurrence (F%), le pourcentage numérique (Cn%), le pourcentage en poids (Cw%) et l'Index d'Importance Relative (IRI). Groupe I <11 cm; Groupe II 11-15 cm; Groupe III >15 cm.

	Natantia	Reptantia	Brachyura	Amphipods	Other groups	Other crustaceans
Group I						
F (%)	22.22	17.79	82.22	17.78	2.22	2.22
Cn (%)	29.13	7.77	50.48	9.71	0.97	1.94
Cw (%)	4.96	2.23	87.94	0.13	4.69	0.04
IRI	757.51	177.73	11381.83	174.98	12.58	4.40
Group II						
F (%)	38.57	8.57	74.29	11.43	11.43	11.43
Cn (%)	28.57	3.43	53.14	5.14	4.57	5.14
Cw (%)	7.99	11.88	61.55	0.06	17.95	0.56
IRI	1410.32	131.23	8519.99	59.48	257.39	65.23
Group III						
F (%)	27.87	3.28	68.85	3.28	26.23	11.47
Cn (%)	18.42	1.32	42.10	1.97	10.53	25.66
Cw (%)	6.72	11.78	151.61	0.17	36.75	16.44
IRI	700.80	42.92	13337.64	7.03	1240.07	483.14

Table V. Diet of each size group of *Scorpaena notata*, with regard to the frequency of occurrence (F%), numerical composition (Cn%), biomass composition (Cw%) and Index of Relative Importance (IRI). Group I <11 cm; Group II 11-15 cm; Group III >15 cm.

Tableau V. Alimentation de chaque classe de taille de *Scorpaena notata*, selon l'indice de fréquence d'occurrence (F%), le pourcentage numérique (Cn%), le pourcentage en poids (Cw%) et l'Index d'Importance Relative (IRI). Groupe I <11 cm; Groupe II 11-15 cm; Groupe III >15 cm.

	Natantia	Reptantia	Brachyura	Amphipods	Other groups	Other crustaceans
Group I						
F (%)	50.00	15.79	32.89	23.03	10.53	25.66
Cn (%)	37.08	11.49	18.02	12.53	4.96	15.93
Cw (%)	28.54	5.58	32.79	0.26	30.47	2.37
IRI	3280.63	269.51	1671.12	294.46	373.00	469.36
Group II						
F (%)	55.25	24.31	52.49	18.23	18.23	12.15
Cn (%)	40.79	12.41	26.13	8.08	6.95	5.64
Cw (%)	18.63	5.15	36.58	0.10	28.47	11.08
IRI	3282.95	426.80	3291.09	149.10	645.89	203.16
Group III						
F (%)	52.81	37.08	57.30	14.61	24.72	3.37
Cn (%)	21.57	39.22	24.51	5.88	7.84	0.98
Cw (%)	9.79	12.42	51.01	0.08	26.64	0.07
IRI	1656.10	1914.43	4327.53	87.08	852.29	3.53

Seasonal variations in stomach contents

In *Scorpaena porcus*, the average number of prey (F=26.86, df=226, P>0.05) and weight (F=0.95, df=226, P>0.05) per stomach changes throughout the year (Figure 3). In this case, a minimum of 0.91 prey items per stomach was recorded in summer whereas the average prey weight was maximum in this season. On the other hand, for *S. notata*, the average number of prey (F=52.76, df=572, P<0.01) and weight per stomach (F=9.90, df=572, P<0.01) in winter and spring were higher than in summer and autumn.

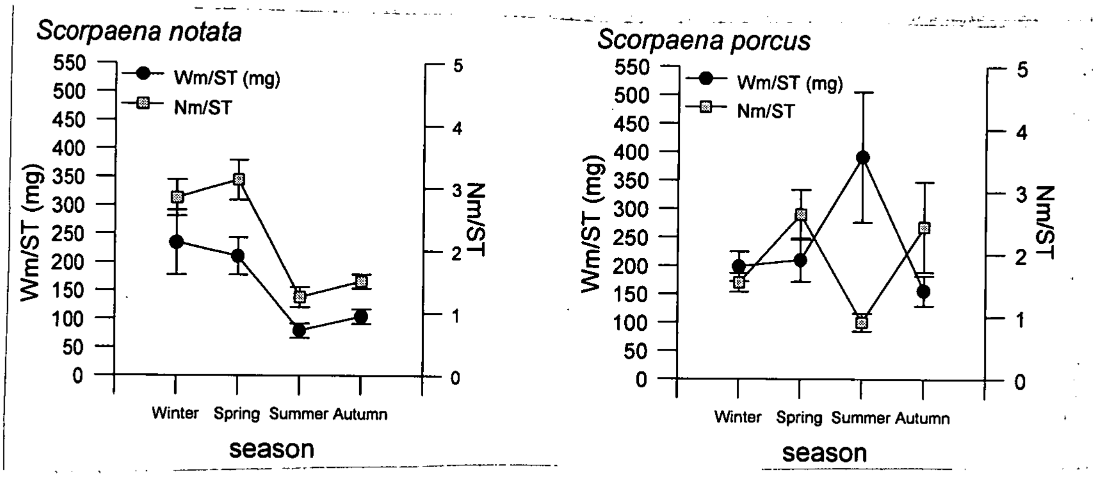

Figure 3. Average number of prey per stomach (Nm/ ST) and average prey weight per stomach (Wm/ ST) throughout the year. Nm= Number of preys; Wm= Weight of preys; ST= Number of stomachs.

Figure 3. Nombre moyen de proies par estomac (Nm/ ST) et poids moyen des proies par estomac (Wm/ ST) tout au long de l'année. Nm= Nombre de proies; Wm= Poids des proies; ST= Nombre d'estomacs.

The relative importance of the prey groups of *S. porcus* changed seasonally (Figure 4). Brachyura were the most important prey in all seasons, although occurred less frequently in summer (χ^2=10.23, df=3, *P*<0.05). Natantia (χ^2=19.63, df=3, *P*<0.001), reptantia (χ^2=22.24, df=3, *P*<0.001) and amphipods (χ^2=9.13, df=3, *P*<0.05) were present primarily during spring. No significative differences were found for other crustaceans and other groups.

Brachyura were important in the stomach contents of *S. notata* throughout the year (χ^2=6.87, df=3, *P*>0.05), whereas natantia were present primarily during spring and summer (χ^2=11.62, df=3, *P*<0.01) (Figure 4). Reptantia occurred less frequently in the diet during summer and autumn (χ^2=57.63, df=3, *P*<0.01). Amphipods (χ^2=19.17, df=3, *P*<0.001) appeared most frequently during winter and spring. No significant differences were found for other groups (χ^2=3.40, df=3, *P*>0.05) and other crustaceans (χ^2=1.27, df=3, *P*>0.05). According to the IRI, reptantia were the most important prey group in winter, natantia showed the higher values in spring and summer, whereas brachyura constituted the main prey items in autumn.

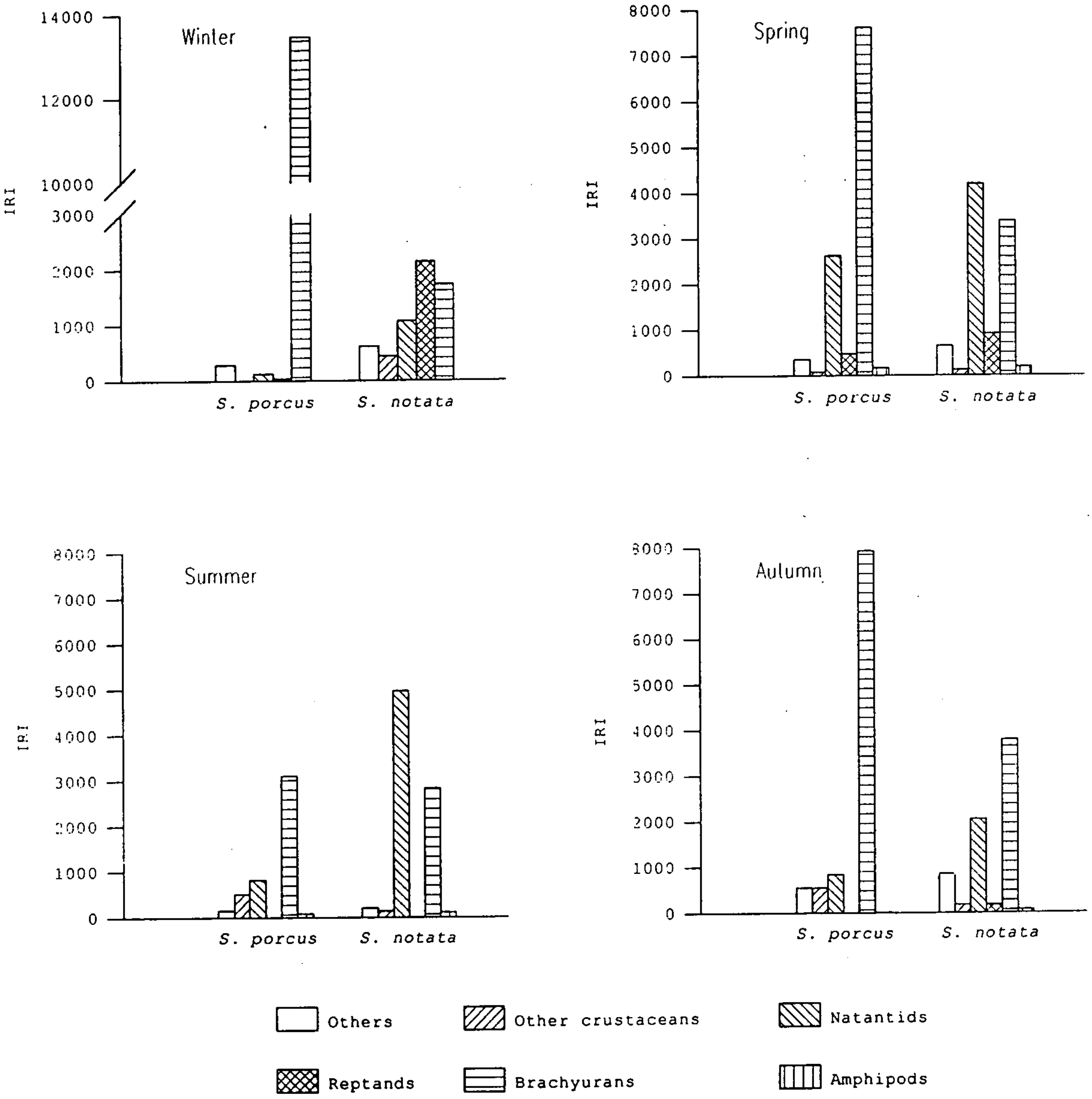

Figure 4. Seasonal changes in the Relative Importance Index (IRI) of the main prey categories for *Scorpaena porcus* and *S. notata*.

Figure 4. Changements saisonniers de l'Index d'Importance Relative (IRI) des principales catégories de proies chez *Scorpaena porcus* et *S. notata*.

Diet overlap

Of the 79 different species found in the stomachs, 31 occurred in the diet of both scorpaenid. The extent of interspecific dietary similarity was quantified by comparing dietary overlaps among all possible pairs of groups size within each season (Table VI).

In winter, the dietary overlap between Group III of *S. porcus* and Group II of *S. notata* was 0.63. It reflects here a predilection of these predators for the same decapod (*Pisidia longimana, Pilumnus hirtellus*, *Thoralus cranchii* and *Processa mediterranea*) and amphipod species (*Dexamine spiniventris*). Medium dietary overlap was also evidenced among Group II of *S. porcus* and Group I and Group III of *S. notata*, owing to the fact that they prey heavily on *Pisidia longimana*.

In spring, Schoener's index between Group II of both species showed a high dietary overlap. Similar results were found when we compared the diet of Group II of *S. porcus* and Group III of *S. notata*. In both cases they mainly overlaped for brachyura (*Pilumnus hirtellus*, *Macropodia rostrata*), Reptantia (*Pisidia longimana*) and Natantia (*Philocheras monacanthus*, *Processa mediterranea*, *Hippolite longirostris*).

During summer months, interspecific diet overlap of the different size classes was not important, because both species have a very varied diet. In this season, the Group I of *S. porcus* did not ingested any food and so no comparison was done with this class.

In autumn, the dietary overlap between Group II of *Scorpaena porcus* and Group I of *S. notata* was high (0.62), owing to the fairly similar proportions of brachyuran species such as *Pilumnus hirtellus*, *Inachus thoracicus* and *Achaeus* *gracilis*. An interspecific diet overlap among Group II of *S. porcus* and Groups II and III of *S. notata* was also important, due to a predilection for the same decapod species (*Pisidia longimana* and *Achaeus gracilis*). No *S. porcus* smaller or equal to 10.5 cm were obtained in this study, for this reason their feeding could not be compared with the size classes of *S. notata*.

Table 6. Interspecific food overlap of the different size classes as a function of season. Index calculated according to Schoener (1970) see Material and methods.

Tableau 6. Chevauchement dans l'alimentation des deux espèces, pour les différentes classes de taille et selon les saisons. Valeurs calculées d'après Schoener (1970), voir Matériel et méthodes.

	Winter		
S. porcus	Group I	Group II	Group III
S. notata			
Group I	0.14	0.61	0.53
Group II	0.08	0.57	0.63
Group III	0.07	0.61	0.50

	Spring		
S. porcus	Group I	Group II	Group III
S. notata			
Group I	0.42	0.52	0.50
Group II	0.47	0.62	0.54
Group III	0.37	0.64	0.54

	Summer		
S. porcus	Group I	Group II	Group III
S. notata			
Group I	-----	0.46	0.32
Group II	-----	0.33	0.29
Group III	-----	0.21	0.30

	Autumn		
S. porcus	Group I	Group II	Group III
S. notata			
Group I	-----	0.62	0.53
Group II	-----	0.58	0.41
Group III	-----	0.42	0.37

Cluster analysis of dietary data (Figure 5) produced, below the value of 70%, two major fish groups. The first (group A) includes mainly large *Scorpaena porcus* specimens and shows the highest similarity value which each other; their specimens are linked because their diet is dominated by *Pilumnus hirtellus* and *Pisidia longimana*. The second group (B) contains mainly *Scorpaena notata* specimens and can be further divided into two subgroups, 1 and 2. Cluster analysis did not clearly distinguish diet categories according to size and/or season neither in subgroup 1, nor in 2 although this one was composed, with others, of the autumn *S. notata* specimens.

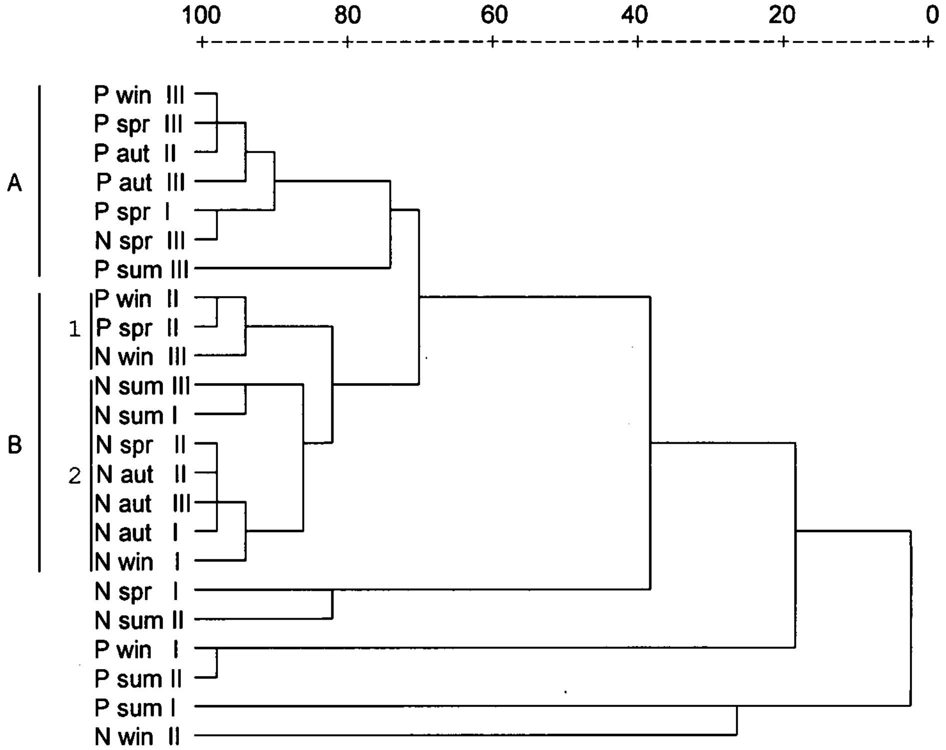

Figure 5. Dendrogram of the cluster analysis of trophic similarity of *Scorpaena porcus* and *Scorpaena notata* based on size and season. P (*Scorpaena porcus*), N (*S. notata*), win (winter), spr (spring), sum (summer), aut (autumn), I (Group I <11 cm), II (Group II 11-15 cm), III (Group III >15 cm).

Figure 5. Dendrogramme de l'analyse des similarités trophiques de *Scorpaena porcus* et *S. notata* en fonction de la taille et de la saison. P (*Scorpaena porcus*), N (*S. notata*), win (hiver), spr (printemps), sum (eté), aut (automne), I (Groupe I <11 cm), II (Groupe II 11-15 cm), III (Groupe III >15 cm).

DISCUSSION

Crustacean decapods are the main dietary components of *Scorpaena porcus* and *S. notata*. These are typical scorpaenids prey items, irrespective of species, biotope or geographic zone considered (Harmelin-Vivien et al., 1989).

In Spanish Mediterranean waters, as the Tyrrhenian Sea (Arculeo et al., 1993), *S. porcus* appears to feed mainly on decapods. Similar results have been reported for other Mediterranean areas. But, in stomach contents from French and Tunisian Mediterranean waters (Bell & Harmelin-Vivien, 1983; Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990) and Adriatic coast (Pallaoro & Jardas, 1991), teleosts were frequent.

The dominant part played by crustaceans in the diet of *S. notata* is also noted by Harmelin-Vivien et al. (1989). Nevertheless, these authors found some different natantia (*Hippolite inermis*), brachyura (*Macropipus arcuatus*, *Maia squinado*, *Pisa armata* and *Xantho incisus*) and amphipoda species (*Dexamine spinosa*, *Maera knudseni* and *Apherusa bispinosa*) due to the fact that they sampled fish at depths from 16 to 20 m in *Posidonia oceanica* seagrass beds. Furthermore, the lower frequency of amphipods in our study compared with that of Harmelin-Vivien et al. (1989) was probably due to the absence of specimens smaller than 8 cm in our samples. In fact, these authors observed a rather abrupt decrease in the percentage of amphipods in the stomachs of specimens with an average length of more than 6 cm.

In both species, the percentage of empty stomachs was lower than the values found by previous investigators for other areas (Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990; Pallaoro & Jardas, 1991). However, these percentages were not constant throughout the year. Several investigators pointed out in different fish species that a maximum of empty stomachs was recorded in the reproductive period in relation to a significant decrease in food intake during reproduction (Macpherson, 1978; Sanz, 1985; Redón et al., 1994; Morte et al., 1999). Spawning for both scorpaenids occurs in summer (Siblot-Bouteflika, 1976), which corresponds to the maximum vacuity-index values recorded during the present study.

No changes were observed in the vacuity index with scorpaenid size classes, while opposite results have been presented for *S. porcus* in the Adriatic coast (Pallaoro & Jardas, 1991).

In the present study, *S. porcus* showed little variation in the food composition of different size groups. However, a relative increase of fish and brachyuran ingestion, with a decrease of natantia, has been observed in relation to growth in other areas (Harmelin-Vivien et al., 1989; Bradai & Bouain, 1990; Pallaoro & Jardas, 1991). However comparison between areas is often difficult due to variations in the length of the sampled specimens and the small size of the samples. Fish diets also change according to the abundance of different prey in the environment, provided that these prey are within the selected size range and have similar ecological characteristics (Macpherson, 1978; Froglia, 1988; Redón et al., 1994). Furthermore, the importance of different food items may change as the predator grows.

It was observed that the diet of *S. notata* also changed with size classes. This change was due to the decrease of the frequency of occurence of amphipods and other crustaceans with increasing predator size whereas the frequency of occurence of reptantia, brachyura and other groups increased. Harmelin-Vivien et al. (1989) reported similar results, but they found a higher occurrence of teleosts in the stomachs of larger specimens.

Cannibalism was rarely observed, and only in *S. porcus*, in our study. In contrast, Harmelin-Vivien et al. (1989) reported frequent cannibalism in both scorpaenid species.

In both species feeding habits changed seasonally and these changes, besides variations of diet according to fish size, could be due to depth of sampling sites. This is difficult to control when samples are caught by professional fisherman. However, in this study fish were collected over a relatively narrow depth range (50 to 175 m) where structure of bottom communities are probably similar.

Although the high taxonomic groups of the major preys of *S. porcus* and *S. notata* were very similar, both *Scorpaena* species preyed on different species or genera of the same family, so that food overlap and probably competition is low. Overlap values calculated may be helpful in comparing how close the feeding habits of these two species are, but they may be of limited use when examined from an ecological point of view. High overlap values did not provide sufficient evidence of competition unless resources are in short supply (Pianka, 1976) and no data is available to assess whether food supply is scarce or abundant. Nevertheless, studies along the eastern coast of Spain, showed that the main preys identified in both scorpaenid diet are common in the benthos (Zariquiey-Alvarez, 1968; Fusté, 1982, 1989; Abelló, 1986; García-Raso, 1987; Abelló et al., 1988). Several studies into demersal fish communities have revealed an increase of food overlap due the opportunistic utilization of superabundant food resources by fishes (Macpherson, 1981; Targett, 1981; Delbeck & Williams, 1987; Morte et al., 1997, 1999). On the other hand, cluster analysis in the present study shows a certain segregation between the two scorpaenid species.

In conclusion, the two species examined in this study appear to have similar diets (mainly reptantia and brachyurans), but not all the species are eaten by both of them, and this fact produces a medium dietary overlap.

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Appendix 1. Prey registered in the stomach of *Scorpaena porcus*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F(%), frequency of occurrence; Cn(%), numerical composition; Cw(%), biomass composition; IRI, Index of Relative Importance; * = values < 0.01.

Annexe 1. Proies observées dans les estomacs de *Scorpaena porcus*. n, nombre d'estomacs où apparaissent les proies; p, nombre d'individus d'un type de proie; F(%), indice de fréquence d'occurrence; Cn(%), pourcentage numérique; Cw(%), pourcentage en poids; IRI, Index d'Importance Relative; * = valeurs < 0.01.

Food items	n	p	F(%)	Cn(%)	Cw(%	
Polychaeta	6	6	3.409	1.395	3.773	17.618
Mollusca						
Bivalvia	2	2	1.136	0.465	0.037	0.571
Gastropoda	2	2	1.136	0.465	0.037	0.571
Cephalopoda	1	1	0.568	0.233	1.823	1.168
Sepiola sp.	2	2	1.136	0.465	3.564	4.578
Crustacea						
Copepoda	1	20	0.568	4.651	*	2.643
Isopoda						
Cirolana cranchii Leach (Hansen, 1905)	1	1	0.568	0.233	0.024	0.146
Cymodoce truncata	2	2	1.136	0.465	0.124	0.669
Eurydice affinis Hansen, 1905	1	1	0.568	0.233	0.075	0.175
Sphaeroma sp.	2	2	1.136	0.465	0.010	0.540
Amphipoda	1	1	0.568	0.233	*	0.133
Gammaridea	11	12	6.250	2.791	0.022	17.577
Ampelisca sp.	1	3	0.568	0.698	*	0.399
Dexamine spiniventris (A. Costa, 1853)	5	6	2.841	1.395	0.011	3.995
Mysidacea	1	1	0.568	0.233	*	0.134
Siriella sp.	1	2	0.568	0.465	*	0.268
Anchialina agilis (G.O. Sars), 1877	4	16	2.273	3.721	0.040	8.547
Leptomysis mediterranea G.O. Sars, 1877	1	2	0.568	0.465	*	0.267
Stomatopoda						
Pseudoesquillopsis ceresii (Roux, 1828)	1	1	0.568	0.233	8.766	5.113
Rissoides desmaresti (Risso, 1816)	2	2	1.136	0.465	0.691	1.313
Decapoda						
Natantia	2	2	1.136	0.465	0.228	0.788
Alpheus dentipes Guérin, 1832	8	11	4.545	2.558	0.976	16.064
Alpheus glaber (Olivi, 1792)	1	1	0.568	0.233	0.382	0.349
Athanas nitescens (Leach, 1814)	5	7	2.841	1.628	0.242	5.311
Hippolyte sp.	2	2	1.136	0.465	0.011	0.541
Hippolyte longirostris (Czerniavsky, 1868)	4	6	2.273	1.395	0.045	3.274
Processa sp.	2	3	1.136	0.698	0.245	1.072
Processa canaliculata Leach, 1815	6	8	3.409	1.860	0.710	8.764
Processa mediterranea (Parisi, 1915)	13	15	7.386	3.488	1.227	34.833
Sicyonia carinata (Brünnich, 1768)	7	8	3.977	1.860	2.394	16.923
Thoralus cranchii (Leach, 1817)	3	13	1.705	3.023	0.107	5.335
Thoralus sollaudi (Zariquiey Cenarro, 1935)	3	12	1.705	2.791	0.123	4.966
Crangonidae	2	2	1.136	0.465	0.013	0.544

Philocheras monacanthus (Holthuis, 1961)	8	18	4.545	4.186	0.118	19.564
Reptantia	2	2	1.136	0.465	0.622	1.236
Calcinus ornatus (Roux, 1828)	1	1	0.568	0.233	0.167	0.227
Pisidia sp.	2	2	1.136	0.465	0.419	1.004
Pisidia longimana (Risso, 1816)	33	45	18.750	10.465	2.086	235.338
Scyllarus sp.	1	1	0.568	0.233	1.642	1.065
Upogebia sp.	1	1	0.568	0.233	0.037	0.153
Upogebia deltaura (Leach, 1815)	10	10	5.682	2.326	0.992	18.849
Anomura						
Paguridea	1	1	0.568	0.233	0.166	0.226
Brachyura	1	1	0.568	0.233	0.320	0.314
Achaeus gracilis (O. Costa, 1839)	2	3	1.136	0.698	0.648	1.530
Bathinectes longipes (Risso, 1816)	5	6	2.841	1.395	11.502	36.641
Ethusa mascarone (Herbst, 1785)	3	3	1.705	0.698	0.762	2.489
Eurynome aspera (Pennant, 1777)	2	2	1.136	0.465	0.132	0.679
Goneplax rhomboides (Linnaeus, 1758)	14	14	7.955	3.256	5.152	66.883
Ilia nucleus (Linnaeus, 1758)	8	9	4.545	2.093	3.514	25.489
Inachus dorhynchus Miranda & Rivera, 1940	9	9	5.114	2.093	0.731	14.440
Inachus phalangium (Fabricius, 1775)	2	2	1.136	0.465	0.175	0.727
Inachus thoracicus Roux, 1830	1	1	0.568	0.233	0.018	0.143
Liocarcinus sp.	2	3	1.136	0.698	0.960	1.884
Liocarcinus corrugatus (Pennant, 1777)	17	19	9.659	4.419	6.082	101.431
Liocarcinus depurator (Linnaeus, 1758)	10	13	5.682	3.023	4.162	40.824
Liocarcinus pusillus (Leach, 1815)	2	2	1.136	0.465	2.317	3.161
Majidae	2	2	1.136	0.465	0.640	1.256
Macropodia sp.	5	6	2.841	1.395	0.538	5.493
Macropodia deflexa Forest, 1978	2	2	1.136	0.465	0.149	0.698
Macropodia linaresi Forest & Zariquiey Alvarez, 1964	1	1	0.568	0.233	0.074	0.174
Macropodia rostrata (Linnaeus, 1761)	10	11	5.682	2.558	0.750	18.799
Pachygrapsus sp.	1	1	0.568	0.233	0.171	0.229
Pachygrapsus marmoratus (Fabricius, 1787)	8	8	4.545	1.860	1.368	14.676
Parthenope massena (Roux, 1830)	3	3	1.705	0.698	0.281	1.668
Pilumnus sp.	2	2	1.136	0.465	0.898	1.549
Pilumnus hirtellus (Linnaeus, 1761)	26	33	14.773	7.674	16.713	360.272
Pilumnus spinifer H. Milne Edwards, 1834	3	3	1.705	0.698	1.818	4.289
Xantho pilipes A. Milne Edwards, 1867	2	2	1.136	0.465	0.444	1.033
Xantho poressa (Olivi, 1792)	1	1	0.568	0.233	0.184	0.237
Teleostei	3	3	1.705	0.698	2.224	4.979
Scorpaena notata Rafinesque, 1810	1	1	0.568	0.233	0.705	0.533
Pleuronectiformes	1	1	0.568	0.233	0.461	0.394
Lesueurigobius friesii (Malm, 1874)	6	6	3.409	1.395	4.093	18.711
Vegetal remains	1	1	0.568	0.233	0.038	0.153

Appendix 2. Prey registered in the stomach of *Scorpaena notata*. n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F(%), frequency of occurrence; Cn(%), numerical composition; Cw(%), biomass composition; IRI, Index of Relative Importance; * = values < 0.01.

Annexe 2. Proies observées dans les estomacs de *Scorpaena notata*. n, nombre d'estomacs où apparaissent les proies; p, nombre d'individus d'un type de proie; F(%), indice de fréquence d'occurrence; Cn(%), pourcentage numérique; Cw(%), pourcentage en poids; IRI, Index d'Importance Relative; * = valeurs < 0.01.

Food items	n	p	F(%)	Cn(%	Cw(	IRI
Polychaeta	24	28	5.687	2.293	11.361	77.655
Mollusca						
Bivalvia	5	5	1.185	0.410	0.060	0.556
Gastropoda	8	8	1.896	0.655	0.096	1.423
Turritella communis Risso, 1826	6	6	1.422	0.491	0.116	0.864
Cephalopoda	5	5	1.185	0.410	5.881	7.453
Rossia sp.	1	1	0.237	0.082	0.698	0.185
Sepioidea	1	1	0.237	0.082	1.150	0.292
Sepiola sp.	4	5	0.948	0.410	5.014	5.141
Crustacea						
Copepoda	3	12	0.711	0.983	*	0.699
Isopoda	2	2	0.474	0.164	0.010	0.082
Cirolanidae	2	2	0.474	0.164	0.031	0.092
Cirolana cranchii	3	3	0.711	0.246	0.036	0.200
Cymodoce truncata (Leach, 1814)	14	14	3.318	1.147	0.318	4.859
Idotea chelipes (Pallas, 1766)	1	1	0.237	0.082	*	0.021
Sphaeromatidae	1	1	0.237	0.082	*	0.020
Sphaeroma sp.	1	1	0.237	0.082	*	0.020
Amphipoda	14	15	3.318	1.229	0.017	4.133
Gammaridea	18	24	4.265	1.966	0.028	8.503
Ampelisca sp.	7	9	1.659	0.737	0.010	1.240
Dexamine sp.	1	1	0.237	0.082	*	0.020
Dexamine spiniventris	21	26	4.976	2.129	0.030	10.747
Iphimedia vicina Ruffo & Schiecke, 1979	2	3	0.474	0.246	*	0.118
Lembos sp.	2	2	0.474	0.164	*	0.079
Leucothoe sp.	9	9	2.133	0.737	0.012	1.598
Caprellidae						
Phytisica marina Slabber, 1769	4	4	0.948	0.328	*	0.311
Mysidacea	5	6	1.185	0.491	*	0.586
Anchialina agilis	5	5	1.185	0.410	*	0.488
Gastrosaccus normani	13	16	3.081	1.310	*	4.062
Leptomysis gracilis (G.O. Sars), 1864	6	9	1.422	0.737	0.012	1.065
Leptomysis lingvura (G.O. Sars), 1866	1	1	0.237	0.082	*	0.020
Leptomysis mediterranea	7	10	1.659	0.819	0.014	1.381
Parapseudomma calloplura (Holt & Tattersall, 1905)	1	1	0.237	0.082	*	0.020
Siriella sp.	5	6	1.185	0.491	0.012	0.596
Siriella clausii G.O. Sars, 1876	1	2	0.237	0.164	*	0.040
Stomatopoda						
Pseudosquillopsis ceresii	2	2	0.474	0.164	5.876	2.863
Decapoda						

Natantia	8	8	1.896	0.655	0.326	1.861
Alpheus dentipes	10	11	2.370	0.901	0.661	3.700
Alpheus glaber	36	37	8.531	3.030	2.162	44.296
Alpheus macrocheles (Hailstone, 1835)	2	2	0.474	0.164	0.120	0.135
Athanas nitescens	18	19	4.265	1.556	0.207	7.519
Chlorotocus crassicornis (Costa, 1871)	3	3	0.711	0.246	0.844	0.774
Hippolyte sp.	7	10	1.659	0.819	0.032	1.412
Pandalina brevirostris (Rathke, 1843)	1	1	0.237	0.082	0.013	0.022
Processa sp.	22	28	5.213	2.293	1.403	19.267
Processa canaliculata	18	24	4.265	1.966	1.267	13.790
Processa edulis (Risso, 1816)	10	12	2.370	0.983	0.582	3.709
Processa mediterranea	34	97	8.057	7.944	5.277	106.52
Processa parva Holthuis, 1951	20	34	4.739	2.785	1.737	21.4285
Sicyonia carinata	20	21	4.739	1.720	1.154	13.620
Thoralus cranchii	37	61	8.768	4.996	0.148	45.098
Thoralus sollaudi	7	13	1.659	1.065	0.082	1.903
Crangonidae	1	1	0.237	0.082	*	0.020
Philocheras bispinosus (Hailstone, 1835)	3	3	0.711	0.246	0.013	0.184
Philocheras monacanthus	15	29	3.555	2.375	0.123	8.880
Pontocaris cataphracta (Olivi, 1792)	2	2	0.474	0.164	0.105	0.128
Pontocaris lacazei (Gourret, 1887)	7	9	1.659	0.737	2.000	4.540
Reptantia	1	1	0.237	0.082	0.201	0.067
Dardanus arrosor (Herbst, 1796)	1	1	0.237	0.082	0.098	0.043
Galathea intermedia Lilljeborg, 1851	4	4	0.948	0.328	0.110	0.415
Pisidia longimana	91	217	21.564	17.772	6.014	512.92
Scyllarus pygmaeus (Bate, 1888)	2	2	0.474	0.164	0.388	0.2610
Upogebia deltaura	4	4	0.948	0.328	0.266	0.562
Upogebia littoralis (Risso, 1816)	1	1	0.237	0.082	0.120	0.048
Brachyura	7	7	1.659	0.573	1.446	3.350
Acanthonyx lunulatus (Risso, 1816)	2	2	0.474	0.164	0.136	0.142
Achaeus cranchii Leach, 1817	3	6	0.711	0.491	0.033	0.373
Achaeus gracilis	19	22	4.502	1.802	0.129	8.694
Atelecyclus rotundatus (Olivi, 1792)	2	2	0.474	0.164	0.121	0.135
Ebalia sp.	5	5	1.185	0.410	0.203	0.725
Eurynome aspera	7	11	1.659	0.901	0.013	1.516
Eurynome spinosa Hailstone, 1835	5	5	1.185	0.410	0.375	0.743
Ethusa mascarone	5	6	1.185	0.491	0.348	0.994
Goneplax rhomboides	10	10	2.370	0.819	2.215	7.189
Ilia nucleus	19	19	4.502	1.556	3.585	23.146
Inachus communissimus Rizza, 1839	4	5	0.948	0.410	0.273	0.647
Inachus dorsettensis (Pennant, 1777)	4	5	0.948	0.410	0.282	0.656
Inachus phalangium	8	10	1.896	0.819	0.780	3.032
Inachus thoracicus	2	3	0.474	0.246	0.169	0.197
Liocarcinus sp.	5	7	1.185	0.573	1.301	2.221
Liocarcinus arcuatus (Leach, 1814)	3	5	0.711	0.410	0.801	0.861
Liocarcinus corrugatus	2	2	0.474	0.164	0.413	0.273
Liocarcinus depurator	12	16	2.844	1.310	3.070	12.456
Liocarcinus zariquieyi (Gordon, 1968)	3	3	0.711	0.246	0.527	0.549
Macropodia deflexa	1	1	0.237	0.082	*	0.021

Macropodia longipes (A. Milne Edwards & Bouvier, 1899)	9	10	2.133	0.819	0.487	2.786
Macropodia longirostris (Fabricius, 1775)	3	4	0.711	0.328	0.232	0.398
Macropodia rostrata	23	35	5.450	2.867	2.274	28.017
Parthenope massena	11	11	2.607	0.901	0.837	4.529
Pirimela denticulata (Montagu, 1808)	4	4	0.948	0.328	0.634	0.911
Xanthidae						
Pilumnus sp.	3	3	0.711	0.246	1.169	1.005
Pilumnus hirtellus	43	53	10.190	4.341	14.156	188.47
Pilumnus spinifer	15	15	3.555	1.229	1.496	9.683
Xantho pilipes	5	5	1.185	0.410	1.584	2.362
Xantho poressa	2	2	0.474	0.164	0.618	0.370
Ascidacea						
Styelidae	1	1	0.237	0.082	1.037	0.265
Teleostei	13	13	3.081	1.065	1.081	6.609
Gobiidae	2	2	0.474	0.164	1.221	0.657
Gobius niger Linnaeus, 1758	1	1	0.237	0.082	0.571	0.155
Vegetal remains	4	4	0.948	0.328	0.097	0.402

2.5. *Trisopterus minutus capelanus*

Feeding habits of *Trisopterus minutus capelanus* (Gadidae) off the eastern coast of Spain (western Mediterranean)

SALOME MORTE, MANUEL J. REDON and ANTONIO SANZ-BRAU

Universitat de Valencia, Facultad de Ciencias Biológicas, Ecología, Laboratorio de Biología Marina, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain

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Key words: Food, poor cod, *Trisopterus minutus capelanus*, Gadidae, western Mediterranean.

ABSTRACT.- The stomach contents of poor cod, *Trisopterus minutus capelanus* (Lacepède), were taken at monthly intervals off the eastern coast of the Gulf of Valencia (Spain). A total of 1276 were analyzed to determine diet according to fish size and season. The basic food consists of crustaceans (Mysidacea and Decapoda) and teleosts. Feeding habits varied with size: decapods and fishes were more abundant in the stomachs of larger specimens. Little seasonal variation in food habits was recorded.

PROBLEM

Two subspecies of the poor cod *Trisopterus minutus*, separated on the basis of morpho-anatomical features, exist in the European Sea waters: the Mediterranean poor cod, *T. m. capelanus* (Lacepède), and the Atlantic poor cod, *T. m. minutus* (L.) (Svetovidov, 1948). *T. m. capelanus* is a common gadoid found in the western Mediterranean and eastern Atlantic Ocean off the coast of Morocco, whereas *T. m. minutus* occurs from Trondheim Fjord to Gibraltar (Whitehead *et al.*, 1989). However, recent genetic analyses (Tirard *et al.*, 1992; Mattiangeli *et al.*, 2000) support the classification of Atlantic and Mediterranean poor cod as distinct taxa and the close relationship between the Mediterranean poor cod and bib *Trisopterus luscus* (Linnaeus, 1758).

The feeding habits of *T. m. minutus* have been studied by various authors (Menon, 1950; Nagabhushanam, 1965; Labarta, 1976; Armstrong, 1982; Dauvin, 1988; Mattson, 1990; Albert, 1993), but there have been few investigations on the feeding habits of *T. m. capelanus*. Politou *et al.* (1989) and Politou & Papaconstantinou (1994) provide detailed information on the feeding ecology of *T. m. capelanus* off the eastern coast of Greece, whereas Biagi *et al.* (1992) and Gramitto (1999) made some limited observations in the northern Tyrrhenian Sea and Adriatic Sea, respectively. Only Planas & Vives (1952) studied its diet more thoroughly in the western Mediterranean, but they did not undertake a systematic study of its food intake and no statistical significance of the variations was discussed.

The present work was conducted within the framework of a project on the trophic relationships in a demersal fish community in the Gulf of Valencia (Redón *et al.* 1994; Morte *et al.*, 1997a,b; Morte, 1999a,b). Due to the paucity of information about the feeding ecology of *T. m. capelanus* along the western Mediterranean, we decided to carry out a systematic and detailed study of its prey, including the influence of predator size and seasonal variations in the stomach contents.

MATERIALS AND METHODS

Monthly samples of *T. m. capelanus* were collected from diurnal commercial catches landed at the port of Valencia (Spain); the catches were taken at 50 to 175 m depth in the Gulf of Valencia between October 1991 and October 1994.

A total of 1276 specimens with a total length between 8.5 and 23 cm were measured to the closest half centimeter (Figure 1), dissected and the stomachs were removed and preserved in 6% formalin. Upon opening, stomach contents were preserved in a 70% ethanol solution. A few fish showing evidence of regurgitation were excluded from the study.

In the laboratory, identification of prey was carried out to specific level whenever possible. We registered the number and wet weight of the food items after removal of surface water by blotting on tissue paper.

The contribution of each feeding item to the diet was determined by the frequency of occurrence (F%), numerical composition (Cn%) and biomass composition (Cw%) (Hyslop, 1980). The percentage of empty stomachs (V) was also recorded (Table I). The Index of Relative Importance (IRI) (Pinkas *et al.*, 1971), as modified by Hacunda (1981), was calculated for each consumed prey item:

$$IRI = F\%.(Cn\% + Cw\%)$$

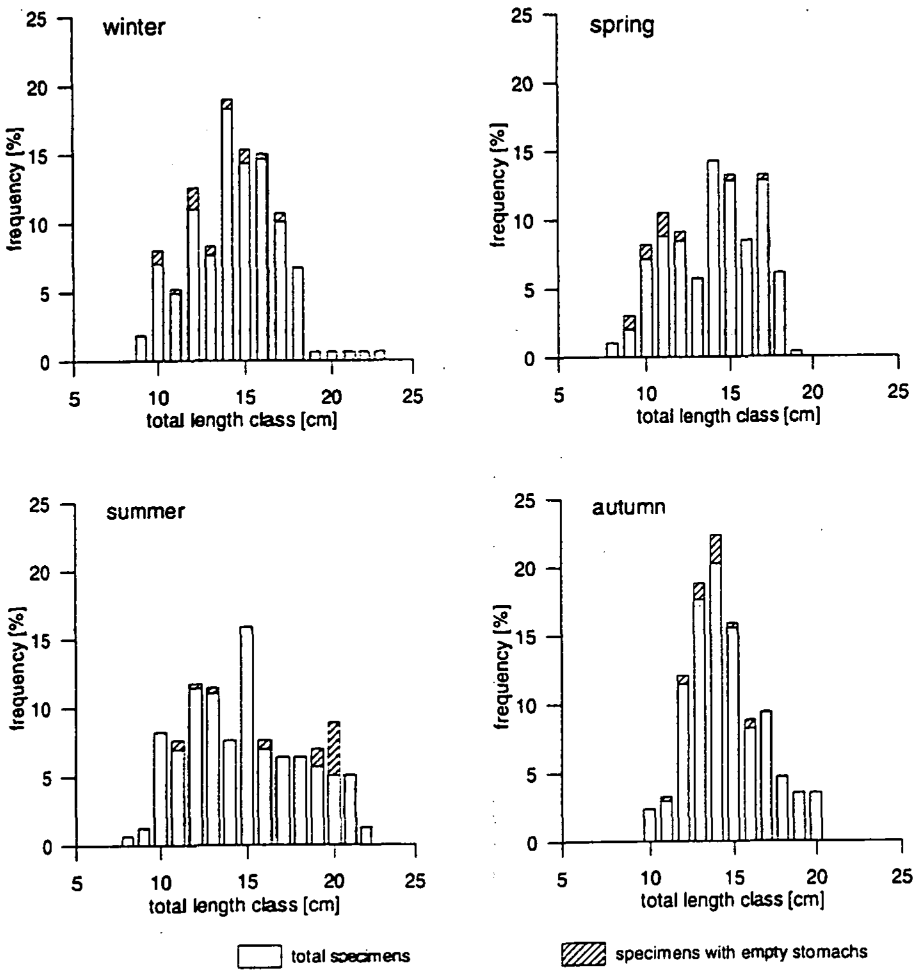

Figure 1. Length-frequency distribution of the *Trisopterus minutus capelanus* specimens analysed in each season.

Table I. Classification of poor cod stomachs by size class and season.

	seasons							
size classes	winter		spring		summer		autumn	
	total	empty	total	empty	total	empty	total	empty
≤ 14 cm	134	11	143	15	125	4	156	11
14.5-17 cm	146	8	104	2	112	2	136	6
≥ 17.5 cm	46	0	48	0	78	16	48	0

To assess potential diet changes with respect to size, fish were divided into three size classes according to age classes (Tangerini & Arneri, 1984): small (≤14 cm), medium (14.5 to 17 cm) and large (≥17.5 cm).

The proportional food overlap between the size classes and seasons was calculated using the overlap index of Schoener (1970):

$$a = 1 - 0.5\left(\sum_{i=1}^{n} \left|p_{xi} - p_{yi}\right|\right)$$

where n is the number of food organisms, and p_{xi} and p_{yi} are the biomass composition indices of prey (i) in the diets of size classes x and y, respectively. The index has a minimum value of zero when no overlap occurs and a maximum value of one when all prey are shared in equal proportions by the two size classes.

A cluster analysis based on squared Euclidean distance (Sokal & Rohlf, 1981) was carried out on prey biomass composition data in order to evaluate the diet pattern according to fish size and/or season.

Statistical differences in diet composition as a function of size and season were assessed using a chi-square test (Sokal & Rohlf, 1981). This was applied for the number of stomachs containing at least one of prey types listed below. To avoid small expected frequencies for the chi-square test, numbers of prey items were pooled into five categories using contingency tables. These categories were: mysids, decapods, other crustaceans (ostracods, cumaceans, copepods, isopods, amphipods, euphausiids and stomatopods), teleosts and "other groups" (polychaetes, echinoderms, algal remains and molluscs).

A chi-square test was also used to test for differences in the number of empty stomachs.

The significance of variation of mean number of prey and weight per stomach was tested by analysis of variance (ANOVA). The normality of the data was verified using the Kolmogorov-Smirnov test and the homogeneity of variances using Bartlett's test ($P<0.05$). When the data did not satisfy the assumptions of parametric tests, several transformations were applied (logarithmic, arcsine, square root transformations). If this condition remained, a nonparametric one-way ANOVA (Kruskal-Wallis test) was applied (Sokal & Rohlf, 1981).

RESULTS

Emptiness index

Of the 1276 stomachs of *T. m. capelanus* examined, 75 were empty (5.87%). This percentage did not vary significantly over the year ($\chi^2=1.17$, df=3, $P>0.05$). However, the emptiness index varied significantly with poor cod size ($\chi^2=7.56$, df=2, $P<0.05$). The highest values of this index were obtained in the smallest specimens and in the biggest ones.

Overall composition of the diet

Table II shows the frequency of occurrence, numerical composition, biomass composition and the Index of Relative Importance of all prey items found in *T. m. capelanus*.

Table II. Prey registered in the stomach of *Trisopterus minutus capelanus.*

food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Foraminifera	23	56	1.915	0.843	*	1.615
Polychaeta	94	106	7.827	1.596	10.750	96.632
Echinodermata						
Asteroidea	1	1	0.083	0.015	*	*
Ophiuroidea	1	1	0.083	0.015	*	*
Mollusca						
Veliger larvae	1	1	0.083	0.015	*	*
Bivalvia	38	42	3.164	0.633	0.125	2.398
Chlamys sp.	4	4	0.333	0.060	0.012	0.024
Gastropoda	14	14	1.166	0.211	0.042	0.294
Turritella communis	5	5	0.416	0.075	0.043	0.049
Cephalopoda	12	12	0.999	0.181	3.528	3.705
Teuthoidea	1	1	0.083	0.015	0.414	0.036
Alloteuthis media	1	1	0.083	0.015	0.098	*
Sepiola sp.	22	23	1.832	0.346	6.610	12.743
Crustacea						
Ostracoda	5	6	0.416	0.090	*	0.038
Cumacea	1	1	0.083	0.015	*	*
Copepoda	28	49	2.331	0.738	*	1.721
Isopoda	12	14	0.999	0.211	*	0.220
Cirolana cranchii	1	1	0.083	0.015	*	*
Amphipoda	63	78	5.246	1.175	0.023	6.281
Lysianassidae	7	8	0.583	0.120	*	0.072
Gammaridea	52	69	4.330	1.039	0.020	4.586
Ampelisca sp.	35	46	2.914	0.693	0.013	2.058
Eusirus longipes	1	1	0.083	0.015	*	*
Epimeria cornigera	8	13	0.666	0.196	*	0.133
Hippomedon massiliensis	1	2	0.083	0.030	*	*
Monoculodes sp.	15	25	1.249	0.377	*	0.480
Oedicerotidae	4	8	0.333	0.120	*	0.041
Corophium sp.	1	1	0.083	0.015	*	*
Phrosina semilunata	3	3	0.250	0.045	0.031	0.019
Vibilia armata	6	11	0.500	0.166	*	0.086
Phoxocephalidae	5	5	0.416	0.075	*	0.032
Caprellidea	23	43	1.915	0.648	*	1.240
Caprella sp.	1	1	0.083	0.015	*	*
Phtisica marina	7	23	0.583	0.346	*	0.202
Pseudolirius kroyerii	2	3	0.167	0.045	*	*
Mysidacea						
Lophogastridae						
Lophogaster typicus	62	85	5.162	1.280	0.693	10.187
Mysidae	77	157	6.411	2.364	0.066	15.582
Siriella sp.	9	9	0.749	0.136	*	0.105
Siriella armata	23	53	1.915	0.798	0.026	1.579
Siriella clausii	33	126	2.748	1.898	0.063	5.387
Siriella jaltensis	36	142	2.998	2.139	0.071	6.622
Gastrosaccus sp.	1	1	0.083	0.015	*	*
Gastrosaccus normani	115	408	9.575	6.145	0.171	60.478
Gastrosaccus spinifer	1	2	0.083	0.030	*	*
Anchialina agilis	176	704	14.654	10.602	0.296	159.707

Erythrops sp.	10	10	0.833	0.151	*	0.129
Erythrops elegans	13	21	1.082	0.316	*	0.352
Parapseudomma calloplura	1	1	0.083	0.015	*	*
Leptomysis sp.	2	3	0.167	0.045	*	*
Leptomysis gracilis	166	1576	13.822	23.735	0.685	337.528
Leptomysis mediterranea	3	6	0.250	0.090	*	0.023
Mysideis parva	1	1	0.083	0.015	*	*
Mysidopsis angusta	1	1	0.083	0.015	*	*
Stomatopoda						
Nannosquilloides occulta	1	1	0.083	0.015	0.055	*
Rissoides desmaresti	3	3	0.250	0.045	0.167	0.053
Euphausiacea	1	1	0.083	0.015	*	*
Euphausia krohnii	3	7	0.250	0.105	*	0.028
Decapoda						
Natantia	69	104	5.745	1.566	1.486	17.535
Solenocera membranacea	18	29	1.499	0.437	0.244	1.021
Sicyonia carinata	3	6	0.250	0.090	0.068	0.040
Caridea	1	1	0.083	0.015	*	*
Chlorotocus crassicornis	4	4	0.333	0.060	0.530	0.197
Plesionika sp.	2	2	0.167	0.030	0.316	0.058
Pandalina brevirostris	16	34	1.332	0.512	0.111	0.829
Hippolyte sp.	1	1	0.083	0.015	*	*
Thoralus sp.	5	10	0.416	0.151	*	0.065
Eualus sp.	1	1	0.083	0.015	*	*
Alpheus glaber	671	1139	55.870	17.154	37.913	3076.600
Processa sp.	170	388	14.155	5.843	5.136	155.407
Processa canaliculata	20	31	1.665	0.467	0.409	1.459
Processa macrophthalma	13	23	1.082	0.346	0.304	0.704
Processa mediterranea	12	19	0.999	0.286	0.251	0.536
Crangonidae	40	54	3.331	0.813	0.053	2.884
Pontocaris lacazei	12	13	0.999	0.196	0.244	0.439
Pontophilus spinosus	4	6	0.333	0.090	0.031	0.040
Philocheras sp.	8	9	0.666	0.136	*	0.097
Philocheras bispinosus	188	314	15.654	4.729	0.337	79.293
Philocheras echinulatus	4	5	0.333	0.075	0.022	0.032
Philocheras monacanthus	11	14	0.916	0.211	0.014	0.206
Philocheras sculptus	20	32	1.665	0.482	0.082	0.940
Reptantia	2	2	0.167	0.030	0.043	0.012
Scyllarus pygmaeus	1	1	0.083	0.015	0.015	*
Calocaris macandreae	12	12	0.999	0.181	0.545	0.725
Jaxea nocturna	3	3	0.250	0.045	0.013	0.014
Upogebia sp.	3	3	0.250	0.045	0.018	0.016
Upogebia deltaura	2	2	0.167	0.030	0.012	*
Upogebia tipica	8	9	0.666	0.136	0.120	0.170
Anapagurus laevis	4	4	0.333	0.060	0.029	0.030
Galathea intermedia	13	21	1.082	0.316	0.101	0.452
Brachyura	11	11	0.916	0.166	0.568	0.672
Megalopa	15	16	1.249	0.241	*	0.311
Liocarcinus sp.	9	11	0.749	0.166	0.568	0.550
Liocarcinus corrugatus	4	4	0.333	0.060	0.207	0.089
Liocarcinus depurator	22	22	1.832	0.331	1.123	2.664
Liocarcinus pusillus	12	12	0.999	0.181	0.565	0.745
Liocarcinus zariquieyi	12	13	0.999	0.196	0.222	0.418
Goneplax rhomboides	51	52	4.246	0.783	2.589	14.319
Teleostei	6	6	0.500	0.090	0.723	0.406

Gadidae	5	6	0.416	0.090	0.770	0.358
Gadiculus argenteus	11	11	0.916	0.166	1.929	1.918
Gobiidae	8	8	0.666	0.120	1.280	0.933
Gobius auratus	4	4	0.333	0.060	0.640	0.233
Lesueurigobius friesii	46	49	3.830	0.738	7.472	31.445
Deltentosteus quadrimaculatus	15	15	1.249	0.226	2.354	3.223
Scorpaena notata	1	1	0.083	0.015	0.114	0.011
Engraulis encrasicolus	10	10	0.833	0.151	1.112	1.051
Pleuronectiformes	1	1	0.083	0.015	0.074	*
Callionymus maculatus	40	48	3.331	0.723	3.352	13.573
Callionymus rissoi	35	35	2.914	0.527	1.199	5.030
Synchiropus phaeton	4	4	0.333	0.060	0.137	0.066
Maurolicus muelleri	2	2	0.167	0.030	0.245	0.046
Hygophum benoitii	1	2	0.083	0.030	0.170	0.017
Algal remains	5	5	0.416	0.075	0.030	0.044

n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F(%), frequency of occurrence; Cn(%), numerical composition; Cw(%), biomass composition; IRI, Index of Relative Importance. * indicates values ≤0.01.

The stomach contents of the poor cod consisted of at least 63 different prey species, with a low average number of prey per stomach (5.20). The food was made up almost exclusively of crustaceans and fish, the former constituting a much greater part than the latter. The crustaceans were mainly mysids (*Anchialina agilis*, *Gastrosaccus normani* and *Leptomysis gracilis*) and decapods (*Alpheus glaber*, *Processa* sp., *Philocheras bispinosus*). The fish were gobiids and callionymids. Less abundant crustaceans included ostracods, cumaceans, copepods, isopods, amphipods, euphausiasiids and stomatopods. Other taxa found in the stomach contents, but of lesser importance, were foraminifers, polychaetes, echinoderms, molluscs and algal remains.

According to the IRI, decapods represented the highest portion (70.56%). Of those identified at the specific level, *A. glaber* was most important, followed by *Processa* sp.. Decapods were followed by mysids, which represent 20.19%.

Variation in stomach contents relative to fish length

Although the average number of prey per stomach decreased from the smallest individuals to the largest, no significant differences were found (F=5.85, df=1273, P>0.05). The average prey weight per stomach, however, increased significantly (F=243.33, df=1273, P<0.001) from the smallest to the largest size class (Figure 2A).

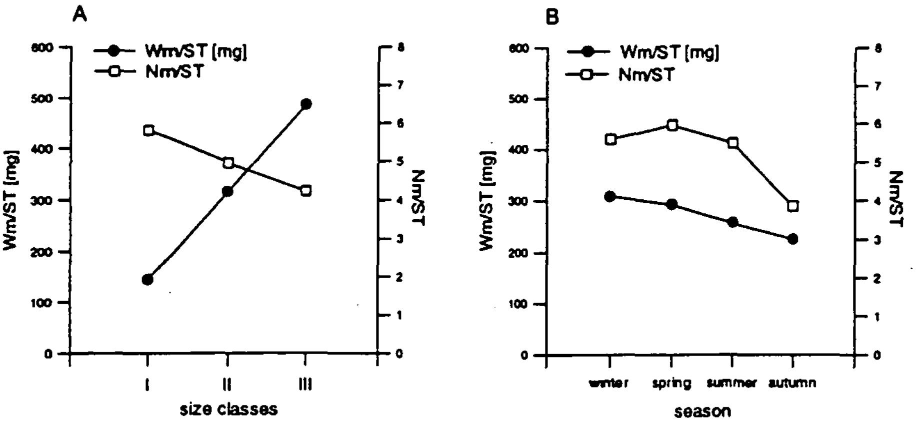

Figure 2. Average number of prey per stomach (Nm/ST) and average prey weight per stomach (Wm/ST) of *Trisopterus minutus capelanus*. A) Different size classes; B) Different seasons.

Figure 3 displays the frequency of occurrence and Index of Relative Importance of the five main prey categories for *T. m. capelanus*. The values of the various prey types varied with poor cod size: in decapods and teleosts the indices increased with increasing poor cod size whereas they decreased in mysids and other crustaceans. A chi-square test revealed significant differences among poor cod size classes with respect to decapods (χ^2=95.43, df=2, P<0.001) and teleosts (χ^2=96.29, P<0.001) due to the low number of these prey in the small size class. There was a clear tendency for mysids (χ^2=124.81, P<0.001) and "other crustaceans" (χ^2=38.51, P<0.001) to be mostly consumed by the small specimens. No significant values were found for "other groups" (χ^2=1.89, P>0.05).

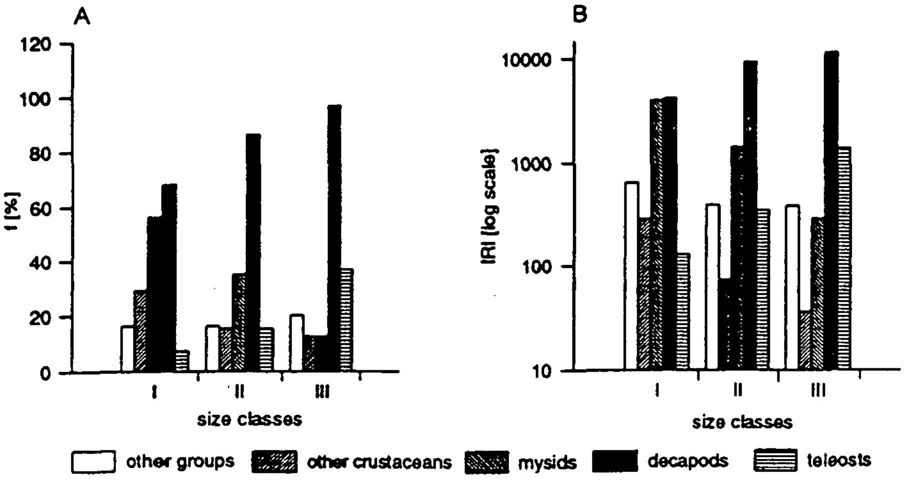

Figure 3. Changes in diet of the main prey categories as a function of *Trisopterus minutus capelanus* size classes. A) Frequency of occurrence (F%); B) Index of Relative Importance (IRI).

Figure 4 shows the most important prey species for the three poor cod size groups based on IRI. The importance of mysid species (*G. normani*, *A. agilis* and *L. gracilis*) decreased as predator size increased. An opposite trend was evident for the main decapod and teleost species, whose IRI values increased considerebly as the predator grew.

Seasonal variation in the diet

The average number of prey per stomach was significantly lower in autumn (F=65.68, df=1272, P<0.001), whereas the mean weight of the stomach was constant through the year (F=4.25, df=1272, P>0.05) (Figure 2B). The relative importance of the prey groups of *T. m. capelanus* changed seasonally (Figure 5), although decapod crustaceans were the dominant food in every season. Mysids were present in the stomach contents of poor cod throughout year, especially in winter (χ^2=19.33, df=3,

$P<0.001$). Teleosts appeared most frequently in spring ($\chi^2=12.57$, $P<0.01$). Other crustaceans ($\chi^2=88.63$, $P<0.0001$) and “other groups” ($\chi^2=14.19$, $P<0.005$) were less frequent in the diet during autumn.

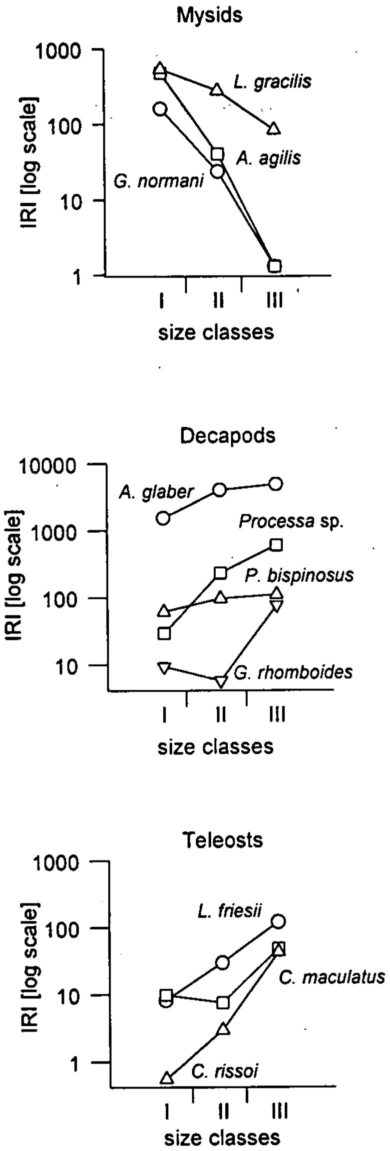

Figure 4. Index of Relative Importance (IRI) variation of the more important prey species in relation to *Trisopterus minutus capelanus* size classes.

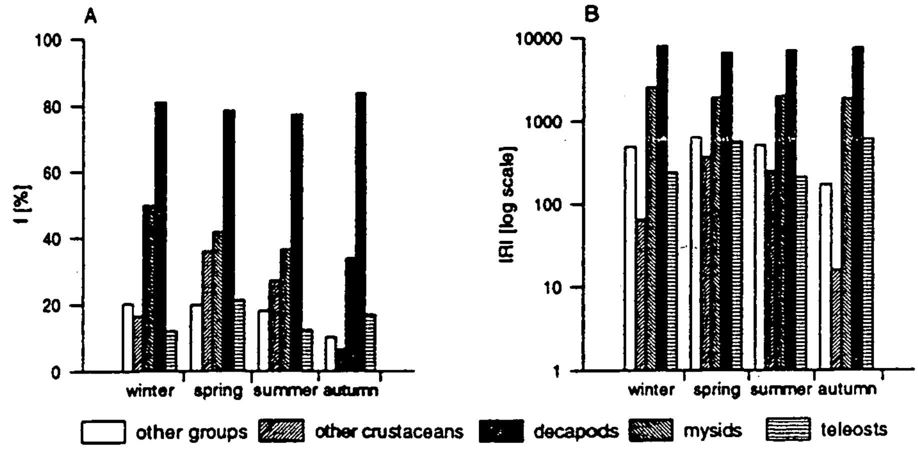

Figure 5. Seasonal variation in the main prey categories of *Trisopterus minutus capelanus*. A) Frequency of occurrence (F%); B) Index of Relative Importance (IRI).

Diet overlap

The diet overlap, calculated on the basis of prey weight (Cw%), among fishes of different length groups in each season was relatively small (Table III). Only in spring, was a moderate dietary overlap (0.68) indicated between the small and medium size classes (Zaret & Rand, 1971; Langton, 1983; Brodeur & Pearcy, 1984).

Table III. Proportional food overlap coefficients of *Trisopterus minutus capelanus* between seasons and size classes.

	≤ 14 cm	14.5-17 cm
winter		
14.5-17 cm	0.52	
≥ 17.5 cm	0.20	0.47
spring		
14.5-17 cm	0.68	
≥ 17.5 cm	0.13	0.3
summer		
14.5-17 cm	0.47	
≥ 17.5 cm	0.05	0.23
autumn		
14.5-17 cm	0.51	
≥ 17.5 cm	0.19	0.29

The dendrogram (Figure 6) shows two clusters: group 1 containing mainly large and medium poor cod specimens and group 2 containing small specimens captured in summer and autumn. The separation between groups 1 and 2 was primarily due to the high frequency of mysids (mainly *L. gracilis* and *A. agilis*) in the second group. Group 1 can be further divided in two subgroups: medium specimens captured in summer and autumn along with large specimens (subgroup A), and those small and medium specimens captured in winter and spring (subgroup B). Members of subgroup A showed the highest similarity value with each other, and their specimens were linked because their diet is dominated by *A. glaber*. In subgroup B the common prey consists of mysids and small natantids (mainly crangonids and small *A. glaber*).

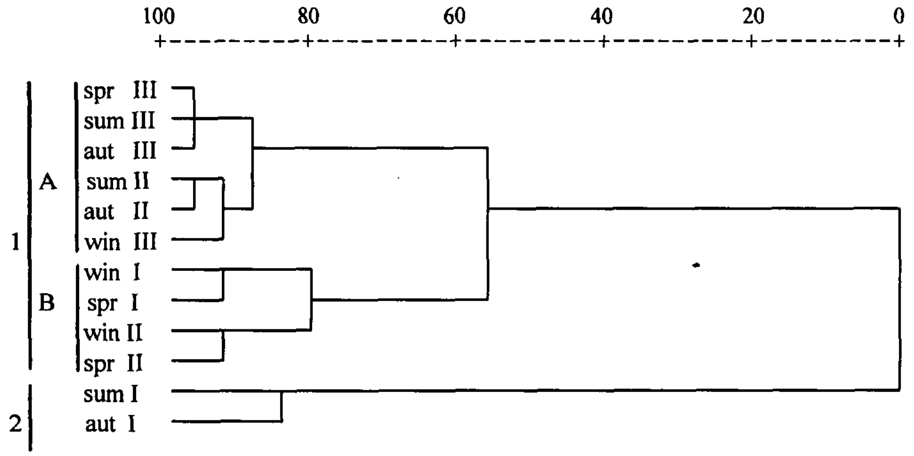

Figure 6. Dendogram of the cluster analysis of diet composition in the different seasons and size classes of *Trisopterus minutus capelanus*.

DISCUSSION

Our study of *T. m. capelanus* feeding habits in the western Mediterranean shows that decapods (mostly shrimps such as *A. glaber*, Crangonidae and Processidae) are the main identifiable prey. Mysids, although dominant in number, represented only a small percentage by weight. Teleosts such as gobiids and callionymids were also important, but only in the largest size classes.

In general, our results agree with previous studies in this region (Planas & Vives, 1952) and other Mediterranean areas (Politou & Papaconstantinou, 1994; Biagi *et al.*, 1992; Gramitto, 1999). Observations made by Planas & Vives (1952) in the Gulf of Valencia confirm the overall predominance of crustaceans in the diet, although no information was given for mysids. One peculiarity of the diet of *T. m. capelanus* here is the importance of the mysid *L. gracilis*, which is absent in the other areas investigated so far. Moreover, previous feeding studies in the Gulf of Valencia reveal that this mysid also occurs frequently in the stomachs of other demersal fishes such as *Citharus linguatula* (Redón *et al.*, 1994), *Aspitrigla obscura* (Morte *et al.*, 1997a), *Lepidorhombus boscii* (Morte *et al.*, 1999a) and *Trachinus draco* (Morte *et al.*, 1999b), indicating a high abundance of this prey in the region.

The abundance of *L. gracilis* in the stomachs of *T. m. capelanus* suggests that this fish feeds during the day: the crustacean is found on the bottom during the day and at night pelagically (Russell, 1925).

The poor cod has a well-developed barbel and long soft pelvic rays, which indicate that it is adapted to feed mainly near the bottom. Moreover, its mouth is designed for quick suction of prey above the bottom (Mattson, 1990). The diet consists of benthic species (*A. glaber*, *L. friesii*, *G. rhomboides*) or species which live just above the bottom (*Processa mediterranea*, *L. gracilis*). Most of these prey, such as *A. glaber*, *Lesueurigobius friesii*, *Calocaris macandreae* and *G. rhomboides*, live buried in the substratum. Prey-search must therefore be active, and the fish has to sweep its pelvic fins over the bottom to locate prey (Mattson, 1990), as do other members of the family Gadidae (Brawn, 1969; Marshall & Cohen, 1973).

With increasing *T. m. capelanus* length, feeding habits changed. The smaller fish consumed mainly mysids, amphipods, copepods and small natantids (principally crangonids and small *A. glaber*). In large specimens the frequency of mysids decreased whereas the frequency of decapods (mainly large *A. glaber*, *Solenocera membranacea* and *G. rhomboides*) and teleosts (gobiids and callionymids) increased. These findings were corroborated by the cluster analysis, which shows an evident segregation between size classes. Similar results have been reported for other Mediterranean areas (Politou & Papaconstantinou, 1994; Gramitto, 1999), although the prey species differ.

The low percentage of empty stomachs agrees with observations of previous investigators for other areas (Politou & Papaconstantinou, 1994; Biagi *et al.*, 1992, Gramitto, 1999). Reproduction, which takes places in winter and early spring, seems to have little effect on vacuity because this was constant throughout the year. Similar findings are reported by Gramitto (1999) in the Adriatic Sea, whereas Politou & Papaconstantinou (1994) off the eastern coast of Greece found a seasonal cycle with a maximum vacuity in winter.

On the other hand, many demersal fishes lower their feeding activity as the temperature drops (Tyler, 1971; Caragitsou & Papaconstantinou, 1988). In the study area, however, the bottom temperature varies little (Canales, 1999), which is reflected in a constant percentage of empty stomachs throughout the year. Therefore, the seasonal variation in diet selection is not directly influenced by water temperature.

Poor cod feeding habits changed seasonally. These changes could be due to different depths of sampling sites, which is difficult to evaluate when samples are provided by professional fishermen. In this study, however, fish were collected over narrow depth range (50 to 175 m), where structure of bottom communities is probably quite similar. Other factors should be considered, among them temporal variation in abundance and/or availability of prey. A number of authors have shown that, as the density of a particular prey type declines, a predator may switch to another, more abundant prey (Murdoch, 1969; Cornell, 1976; Hume & Northcote, 1985; Davidson, 1986). Unfortunately, no data on distribution and abundance of crustaceans are currently available to determine the food web in the Gulf of Valencia. Nevertheless, studies along the eastern coast of Spain and in the Gulf of Valencia pointed out that the main prey identified in the poor cood diet are common in the benthos (Zariquiey-Alvarez, 1968; Fusté, 1982, 1989; Abelló, 1986; García-Raso, 1987; Abelló *et al.*, 1988).

Summary

This study describes the feeding habits of *Trisopterus minutus capelanus* in the Gulf of Valencia (western Mediterranean), including the influence of predator size and the seasonal variations in the stomach contents.

The low vacuity coefficient and the high number of different prey species eaten suggest that *T. m. capelanus* is an important euryphagous species in the benthic communities of Spanish Mediterranean waters, feeding mainly on crustaceans (decapods and mysids) and teleosts (almost exclusively gobiids and callionymids). The emptiness index did not fluctuate significantly in relation to season of capture,

whereas significant differences were found between size classes. Differences with regard to size were highlighted: mysids are the main prey of small specimens; decapods and fishes take on greater importance as the predator grows, becoming the main prey of large specimens. Little seasonal variation in food habits was recorded. Decapods and mysids were the dominant food during all seasons, whereas teleosts appeared most frequently in spring.

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2.6. *Phycis blennoides*

Diet of *Phycis blennoides* (Gadidae) in relation to fish size and season in the western Mediterranean (Spain).

SALOME MORTE, MANUEL J. REDON and ANTONIO SANZ-BRAU

Universitat de Valencia, Facultad de Ciencias Biológicas, Ecología, Laboratorio de Biología Marina, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain

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Key words: Food, greater forkbeard, *Phycis blennoides*, Gadidae, crustaceans, western Mediterranean.

ABSTRACT.- Despite its commercial value, little is known about the feeding ecology of greater forkbeard, *Phycis blennoides* (Brünnich 1768). The stomach contents of 2631 greater forkbeard, were taken at monthly intervals off the coast of the Gulf of Valencia (western Mediterranean). They were examined in order to assess diet and to determine fish size and season related dietary variation of the species. Prey items were identified to the lowest taxonomic level possible. The basic food consists of epibenthic species, mostly Decapoda, Mysidacea and Teleostei, as highlighted by the analysis. A change in food composition based on fish size was observed and seasonal variation in diet was also noticed. The food overlap analysis indicated a high convergence in diet among similar size groups.

INTRODUCTION

The greater forkbeard, *Phycis blennoides* (Brünnich 1768) is a common gadoid occurring in the Mediterranean and in the North-eastern Atlantic, from Iceland to Morocco (Tortonese, 1975; Fisher *et al.*, 1987; Davis & Edwards, 1988; Whitehead *et al.*, 1989). It is usually found on muddy or sand bottoms in depths of 100-650 m, but occasionally is captured in shallower depths, close to shore (18 m) (Bello & Rizzi, 1988). The total length at first sexual maturity for males and females are 18-20 cm and 22-23 cm respectively (Gallardo-Cabello & Gual-Frau, 1984). In the Mediterranean, *P. blennoides* spawns from June to August (Gallardo-Cabello & Gual-Frau, 1984).

Despite its commercial value, little is known about the feeding ecology of greater forkbeard. Published information on the diet of the greater forkbeard states that its diet is comprised of crustaceans and teleosts (Muus & Dahlstrom, 1971; Tortonese, 1975; Wheeler, 1978; Whitehead *et al.*, 1989). Only Macpherson (1978) and Sorbe (1977) in the western Mediterranean and Gulf of Gascogne, respectively, conducted a thorough study of its diet. However, these works did not study the seasonal variation.

The present work was conducted within the framework of a project on the study of trophic relationships in a demersal fish community in the Gulf of Valencia. The objective of the research in this paper was to examine the diet and intraespecific dietary overlap of *P. blennoides* in the western Mediterranean, including the influence of predator size and seasonal variations in the stomach contents.

MATERIAL AND METHODS

A total of 3514 *Phycis blennoides* were taken from diurnal commercial catches landed at the port of Valencia (Spain) between October 1991 and October 1994. Monthly samples were caught at depths ranging from 50 to 175 m depth in the Gulf of Valencia.

Evidence of regurgitation was observed. Everted stomachs (25.13%) is a common characteristic in phisoclistous fishes, particularly the gadiforms (Bowman, 1986). Everted stomachs were not considered in this study. Each specimen was measured (total length) to the closest half centimetre (Table I), dissected and the whole stomach was removed and preserved in 6% formalin. Upon opening, stomach contents were stored in a 70% ethanol solution.

Table I. Classification of the *Phycis blennoides* stomachs considered in this study, by size group and season.

	seasons							
size groups	winter		spring		summer		autumn	
	total	empty	total	empty	total	empty	total	empty
≤ 12.5 cm	141	24	168	6	176	17	162	18
13 - 17 cm	254	31	238	17	286	15	296	9
17.5 - 21 cm	158	12	144	15	131	8	226	14
≥ 21.5 cm	62	6	66	3	72	7	51	3

Food items were sorted under a binocular microscope into taxonomic groups at species level whenever it was possible, the number recorded, and the wet weight (nearest 0.1 mg) registered, after removal of surface water by blotting on tissue paper. Foraminifera were considered as one prey item, because they were passively ingested (Lagardère, 1977).

The percentage of empty stomachs (vacuity index, V%) was recorded. A χ^2 test was applied to test differences in the number of empty stomachs.

The importance of the different prey types was calculated using the following indices (Hyslop, 1980): frequency of occurrence (F%), numerical composition (Cn%) and biomass composition (Cw%). The Index of Relative Importance (IRI) (Pinkas *et al.*, 1971), as modified by Hacunda (1981), was calculated for consumed prey items:

$$\text{IRI} = F\% \, (Cn\% + Cw\%)$$

Size-related dietary variations were investigated by dividing the fish collected into four length-classes according to age classes Gallardo-Cabello, 1986: Group I (≤ 12.5 cm), Group II (13-17 cm), Group III (17.5-21 cm) and Group IV (≥21.5 cm).

Proportional food overlap between size classes and seasons was calculated using the overlap coefficient of Schoener (1970):

$$a = 1 - 0.5\left(\sum_{i=1}^{n} \left| p_{xi} - p_{yi} \right| \right)$$

where n is the number of food organisms, and p_{xi} and p_{yi} are the numerical composition indexes of prey (i) in the diets of species x and y, respectively. The index has a minimum value of zero, when no overlap occurs, and a maximum value of one, when all prey are shared in equal proportions by the two species. The convention established by Langton (1983) and Brodeur & Pearcy (1984) was invoked. Overlap index values have been grouped into three categories representing low (0.00 to 0.29), medium (0.30 to 0.60), and high (>0.60) levels of dietary overlap.

A cluster analysis based on squared Euclidean distance (Sokal & Rohlf, 1981) was carried out on biomass composition data of their preys, in order to evaluate the pattern of the diet of each megrim species according to fish size and/or season.

Statistical differences in diet composition as a function of size and season were assessed using a chi-square test (Sokal & Rohlf, 1981). This was applied for the number of stomachs containing one specific prey. To avoid small expected frequencies for chi-square test, numbers of prey items were pooled into eight categories using contingency tables. These categories were: amphipods, isopods, mysids, natantids, reptands, other crustaceans (euphasiasids, copepods, cumaceans, ostracods and stomatopods), teleosts and 'others' (molluscs, polychaetes, foraminifers, algal remains, echinoids and non-identified remains).

The significance of variation in the mean number of prey and weight per stomach was tested by analysis of variance (ANOVA). The normality of the data was verified using the Kolmogorov-Smirnov test and the homogeneity of variances using the Bartlett's test ($P<0.05$). When data did not satisfy the assumptions of the parametric tests, several transformations were applied (logarithmic, arcsine and square root transformations). If normality was not achieved, a non-parametric one-way ANOVA (Kruskal-Wallis test) was applied (Sokal & Rohlf, 1981).

RESULTS

Emptiness index

Of the 2631 stomachs of *P. blennoides* examined, 205 were empty (7.79%). This percentage varied significantly over the year ($\chi^2=19.16$, df=3, $P<0,01$), with a maximum of 11.87% during winter. However, emptiness index did not vary significantly with greater forkbeard size ($\chi^2=6.48$, df=3, $P>0.05$).

Overall composition of the diet

In the analysis of stomach contents from *P. blennoides* ranging between 9.5 and 33.5 cm, at least 112 different prey species were identified (Table II), with a low average number of prey per stomach (4.37).

Table II. Prey registered in the stomach of *Phycis blennoides*.

food items	n	p	F(%)	Cn(%)	Cw(%)	IRI
Vegetal remains	10	10	0.412	0.087	0.031	0.048
Foraminifera	10	10	0.412	0.087	*	0.036
Polychaeta	26	28	1.072	0.243	1.196	1.543
Serpulidea	3	3	0.124	0.026	0.045	*
Echinodermata						
Crinoidea	1	1	0.041	*	*	*
Ophiuroidea	1	1	0.041	*	*	*
Mollusca						
Bivalvia	8	16	0.330	0.139	0.016	0.051
Leda commutata	1	1	0.041	*	*	*
Gastropoda	7	12	0.289	0.104	0.014	0.034
Turritella sp.	1	1	0.041	*	*	*
Turritella communis	14	15	0.577	0.130	0.049	0.104
Cephalopoda	5	5	0.206	0.043	0.619	0.137
Teuthoidea	6	6	0.247	0.052	1.561	0.399
Alloteuthis media	1	1	0.041	*	0.313	0.013
Illex coindeti	2	2	0.082	0.017	0.268	0.024
Decapoda	1	1	0.041	*	0.074	*
Sepioidea	3	6	0.124	0.052	0.726	0.096
Sepia sp.	1	1	0.041	*	0.121	*
Sepiola sp.	18	27	0.742	0.235	3.269	2.600
Crustacea						
Ostracoda	1	1	0.041	*	*	*
Cumacea	11	14	0.453	0.122	*	0.055
Copepoda	38	43	1.566	0.374	*	0.586
Calanoida sp.	58	88	2.391	0.765	*	1.830
Isopoda	46	52	1.896	0.452	0.026	0.907
praniza	182	235	7.502	2.043	*	15.332
Gnathiidea	39	255	1.608	2.217	0.016	3.590
Gnathia sp.	2	3	0.082	0.026	*	*
Gnathia maxillaris	22	38	0.907	0.330	*	0.302
Gnathia dentata	5	5	0.206	0.043	*	*
Cirolanidae	21	55	0.866	0.478	0.048	0.455
Eurydice sp.	7	11	0.289	0.096	0.028	0.036
Eurydice affinis	2	2	0.082	0.017	*	*
Eurydice spinigera	1	1	0.041	*	*	*

Cirolana sp.	8	11	0.330	0.096	0.018	0.038
Cirolana cranchii	11	14	0.453	0.122	0.023	0.066
Jaeropsidae	1	3	0.041	0.026	*	*
Amphipoda	94	117	3.875	1.017	0.014	3.997
Amphilochidae	2	7	0.082	0.061	*	*
Lysianassidae	17	29	0.701	0.252	*	0.179
Hyperidae	2	4	0.082	0.035	*	*
Aeoridae	2	2	0.082	0.017	*	*
Gammaridea	135	187	5.565	1.626	0.023	9.176
Ampelisca sp.	25	34	1.031	0.296	*	0.309
Rhachotropis rostrata	2	5	0.082	0.043	*	*
Apherusa sp.	1	3	0.041	0.026	*	*
Dexamine sp.	1	1	0.041	*	*	*
Dexamine spiniventris	8	10	0.330	0.087	*	0.029
Eusiridae	1	2	0.041	0.017	*	*
Eusirus longipes	7	9	0.289	0.078	*	0.023
Maera schmidtii	1	1	0.041	*	*	*
Monoculodes sp.	10	27	0.412	0.235	*	0.098
Monoculodes gracilis	29	66	1.195	0.574	*	0.696
Oedicerosidae	1	1	0.041	*	*	*
Phrosina sp.	1	1	0.041	*	*	*
Phrosina semilunata	1	1	0.041	*	*	*
Rhacotropsis sp.	3	4	0.124	0.035	*	*
Rhacotropsis grimaldi	8	11	0.330	0.096	*	0.032
Westwoodilla rectirostris	22	46	0.907	0.400	*	0.369
Vibilia armata	3	4	0.124	0.035	*	*
Corophiidae	1	1	0.041	*	*	*
Pseudoprotella phasma	2	2	0.082	0.017	*	*
Phtisica marina	9	9	0.371	0.078	*	0.029
Mysidacea						
Lophogaster typicus	323	627	13.314	5.452	2.129	100.933
Mysida	36	64	1.484	0.557	0.011	0.843
Boreomysis sp.	13	16	0.536	0.139	*	0.076
Boreomysis arctica	1	2	0.041	0.017	*	*
Boreomysis megalops	12	14	0.495	0.122	*	0.061
Siriella sp.	5	20	0.206	0.174	*	0.037
Siriella clausii	6	11	0.247	0.096	*	0.024
Siriella jaltensis	1	2	0.041	0.017	*	*
Gastrosaccus spinifer	1	1	0.041	*	*	*
Gastrosaccus normani	76	118	3.133	1.026	0.021	3.280
Anchialina agilis	257	2182	10.594	18.974	0.396	205.200
Erythrops sp.	91	161	3.751	1.400	0.028	5.358
Erythrops erythrophthalma	10	34	0.412	0.296	*	0.124
Erythrops elegans	35	72	1.443	0.626	0.013	0.922
Parapseudomma sp.	3	15	0.124	0.130	*	0.016
Parapseudomma calloplura	80	151	3.298	1.313	0.027	4.418
Amblyops sp.	4	4	0.165	0.035	*	*
Leptomysis gracilis	71	150	2.927	1.304	0.027	3.898
Leptomysis mediterranea	9	13	0.371	0.113	*	0.043
Mysideis parva	26	35	1.072	0.304	*	0.333
Stomatopoda	1	1	0.041	*	0.023	*
Allomedia sp.	1	1	0.041	*	0.023	*

Squilla mantis	2	2	0.082	0.017	0.046	*
Rissoides desmaresti	22	24	0.907	0.209	0.602	0.735
Euphausicea						
Euphausia khronii	2	2	0.082	0.017	*	*
Decapoda						
Natantia	138	230	5.688	2.000	1.509	19.962
zoea	3	4	0.124	0.035	*	*
Penaeidea	1	1	0.041	*	*	*
Gennadas elegans	3	3	0.124	0.026	0.020	*
Solenocera membranacea	202	314	8.326	2.730	1.122	32.081
Sicyonia carinata	25	50	1.031	0.435	0.567	1.032
Sergestes sp.	3	3	0.124	0.026	0.037	*
Sergestes arcticus	3	6	0.124	0.052	0.071	0.015
Caridea	29	30	1.195	0.261	0.102	0.434
Pasiphaea sivado	7	7	0.289	0.061	0.689	0.216
Acanthephyra sp.	2	3	0.082	0.026	0.014	*
Pandalidae	5	5	0.206	0.043	*	*
Chlorotocus crassicornis	32	33	1.319	0.287	1.611	2.504
Plesionika sp.	17	17	0.701	0.148	1.108	0.880
Plesionika heterocarpus	9	14	0.371	0.122	1.207	0.493
Plesionika antigai	7	10	0.289	0.087	0.542	0.182
Parapandalus sp.	2	2	0.082	0.017	*	*
Pandalina brevirostris	61	109	2.514	0.948	0.154	2.771
Hippolyte longirostris	2	3	0.082	0.026	*	*
Thoralus cranchii	2	3	0.082	0.026	*	*
Eualus sp.	1	2	0.041	0.017	*	*
Athanas nitescens	2	2	0.082	0.017	*	*
Alpheus dentipes	4	5	0.165	0.043	0.025	0.011
Alpheus glaber	1084	1533	44.683	13.330	27.903	1842.411
Processa sp.	239	413	9.852	3.591	2.298	58.016
Processa edulis	19	31	0.783	0.270	0.172	0.346
Processa macrophthalma	20	27	0.824	0.235	0.146	0.314
Processa parva	14	18	0.577	0.157	0.106	0.151
Processa canaliculata	98	183	4.040	1.591	1.017	10.536
Processa mediterranea	273	667	11.253	5.800	3.760	107.575
Periclimenes sp.	6	11	0.247	0.096	0.546	0.159
Crangonidae	18	19	0.742	0.165	*	0.128
Pontocaris cataphracta	6	6	0.247	0.052	0.100	0.038
Pontocaris lacazei	40	45	1.649	0.391	0.760	1.898
Pontophilus spinosus	26	28	1.072	0.243	0.352	0.639
Philocheras sp.	8	9	0.330	0.078	*	0.027
Philocheras echinulatus	31	47	1.278	0.409	0.200	0.777
Philocheras sculptus	9	10	0.371	0.087	0.018	0.039
Philocheras bispinosus	213	454	8.780	3.948	0.214	36.537
Philocheras monacanthus	30	57	1.237	0.496	0.024	0.642
Philocheras trispinosus	13	26	0.536	0.226	0.011	0.127
Reptantia						
filosoma	1	1	0.041	*	*	*
Nephrops norvegicus	1	1	0.041	*	0.021	*
Scyllarus sp.	1	2	0.041	0.017	0.013	*
Scyllarus pygmaeus	7	7	0.289	0.061	0.045	0.031
Scyllarus arctus	7	7	0.289	0.061	0.044	0.030

Calocaris macandreae	222	252	9.151	2.191	5.365	69.148
Jaxea nocturna	7	7	0.289	0.061	0.020	0.023
Upogebia sp.	7	8	0.289	0.070	0.083	0.044
Upogebia deltaura	6	12	0.247	0.104	0.130	0.058
Upogebia tipica	3	3	0.124	0.026	0.021	*
Upogebia littoralis	1	1	0.041	*	*	*
Upogebia stellata	1	2	0.041	0.017	0.021	*
Anomura						
Diogenidae	1	1	0.041	*	*	*
Diogenes sp.	4	4	0.165	0.035	0.041	0.013
Paguridae	3	3	0.124	0.026	0.042	*
Galathea squamifera	1	11	0.041	0.096	0.227	0.013
Galathea bolivari	1	1	0.041	*	0.021	*
Munida sp.	33	58	1.360	0.504	0.516	1.387
Munida iris	133	223	5.482	1.939	0.811	15.077
Munida intermedia	79	193	3.256	1.678	1.674	10.916
Pisidia longimana	10	16	0.412	0.139	0.068	0.086
Brachyura	75	86	3.092	0.748	1.871	8.095
megalopa	43	91	1.772	0.791	0.018	1.435
Portunidae	1	1	0.041	*	0.022	*
Liocarcinus sp.	21	23	0.866	0.200	0.500	0.606
Liocarcinus arcuatus	5	6	0.206	0.052	0.131	0.038
Liocarcinus corrugatus	4	6	0.165	0.052	0.191	0.040
Liocarcinus pusillus	20	24	0.824	0.209	0.494	0.579
Liocarcinus zariquieyi	10	10	0.412	0.087	0.218	0.126
Liocarcinus tuberculatus	4	4	0.165	0.035	0.138	0.028
Liocarcinus bolivari	1	1	0.041	*	0.051	*
Liocarcinus depurator	60	74	2.473	0.643	1.596	5.539
Xanthidae	1	1	0.041	*	0.025	*
Pilumnus spinifer	2	6	0.082	0.052	0.045	*
Pilumnus hirtellus	9	10	0.371	0.087	0.155	0.090
Xantho pilipes	3	4	0.124	0.035	0.102	0.017
Medaeus couchi	14	24	0.577	0.209	0.341	0.317
Goneplax rhomboides	90	98	3.710	0.852	1.949	10.393
Planes minutus	5	6	0.206	0.052	0.116	0.035
Teleostei	23	28	0.948	0.243	1.410	1.568
Anguiliformes	10	11	0.412	0.096	0.272	0.152
Conger conger	9	9	0.371	0.078	0.311	0.145
Sparidae	2	3	0.082	0.026	0.146	0.014
Pagellus sp.	2	2	0.082	0.017	0.096	*
Gadidae	8	8	0.330	0.070	0.448	0.171
Gadiculus argenteus	18	18	0.742	0.157	1.276	1.063
Merluccius merluccius	2	2	0.082	0.017	0.112	0.011
Micromesistius poutassou	2	2	0.082	0.017	0.112	0.011
Phycis blennoides	19	20	0.783	0.174	0.499	0.527
Lotinae	37	46	1.525	0.400	1.507	2.909
Gobidae	18	24	0.742	0.209	1.584	1.330
Gobius auratus	34	37	1.401	0.322	2.409	3.828
Lesueurigobius friesii	75	83	3.092	0.722	5.922	20.538
Lesueurigobius sueri	6	6	0.247	0.052	0.336	0.096
Deltentosteus quadrimaculatus	32	35	1.319	0.304	2.223	3.334
Cepola rubescens	10	10	0.412	0.087	0.326	0.170

Scorpaenidae	1	1	0.041	*	0.048	*
Helicodenus dactylopterus	8	19	0.330	0.165	2.322	0.820
Sardina pilchardus	2	3	0.082	0.026	0.132	0.013
Pleuronectiformes	3	3	0.124	0.026	0.094	0.015
Arnoglossus sp.	3	3	0.124	0.026	0.094	0.015
Lepidorhombus boscii	5	7	0.206	0.061	0.219	0.058
Symphorus sp.	2	2	0.082	0.017	0.063	*
Symphorus nigrescens	2	2	0.082	0.017	0.063	*
Callionymidae	3	3	0.124	0.026	0.043	*
Callionymus maculatus	14	16	0.577	0.139	0.694	0.481
Callionymus rissoi	10	10	0.412	0.087	0.288	0.155
Synchiropus phaeton	8	9	0.330	0.078	0.310	0.128
Maurolicus muelleri	4	4	0.165	0.035	0.204	0.039
Myctophidae	1	1	0.041	*	0.072	*
Mictophum punctatum	9	9	0.371	0.078	0.603	0.253
unidentified remains	47	47	1.937	0.409	0.233	1.243

n, number of stomachs in which prey occurs; p, number of individuals of a specific prey; F(%), frequency of occurrence; Cn(%), numerical composition; Cw(%), biomass composition; IRI, Index of Relative Importance. * indicates values ≤0.01.

Greater forkbeard preyed heavily on crustaceans, constituting 94.48% of the total. Among these, natantids (Penaeidea, Alpheidae, Crangonidae and Processidae) were present in the greatest number and also occurred most frequently in the stomachs. Reptands (*Calocaris macandreae* and *Munida iris*) and mysids (*Anchialina agilis* and *Lophogaster typicus*) were secondary preys. Less abundant crustaceans included amphipods and isopods whereas, other crustaceans (such as euphasiasids, copepods, cumaceans, ostracods and stomatopods) and 'others' (like molluscs, polychaetes, foraminifers, algal remains, and echinoids) were accidental preys.

In spite of the numerous teleosts species ingested, they only represent 3.79% of the total number of prey, but their biomass composition ranked second. Gobiids and callionimids were the dominant teleosts. A small amount of cannibalism was recorded, representing a 0.53 of the total IRI and 0.78 of F(%).

Despite the importance of natantids in the diet, the most numerous prey was the mysid *Anchialina agilis*. According to the IRI, the most important prey was *Alpheus glaber*, followed by *A. agilis*, *Processa mediterranea* and *Lophogaster typicus*.

Diet variations with fish size

The average prey weight per stomach increased from the smallest individuals to the largest (F=93.22, df=2627, P<0.001), whereas average number of prey per stomach remained constant (F=0.05, df=2627, P>0.05) (Figure 1A).

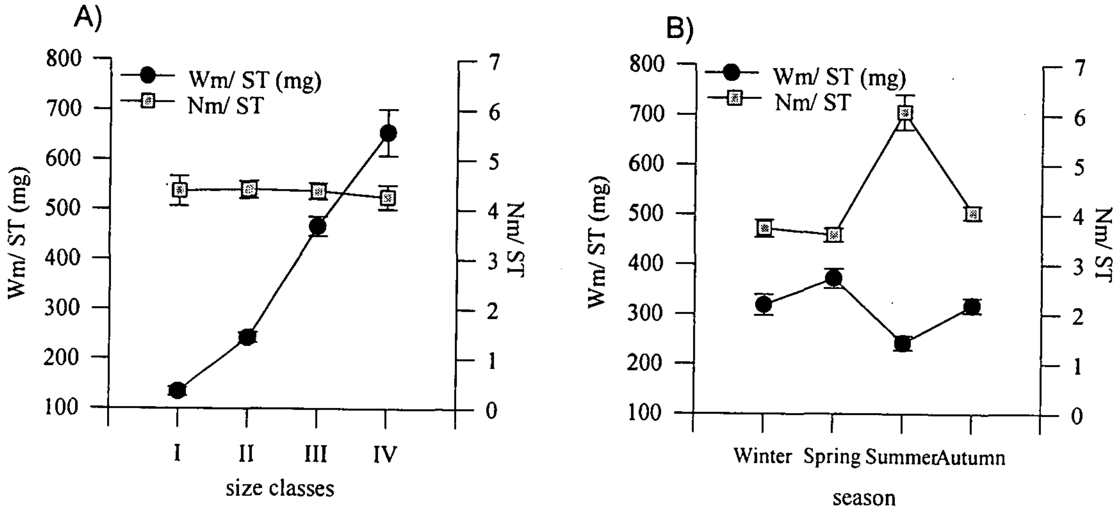

Figure 1. Average number of prey per stomach (Nm/ST) and average prey weight per stomach (Wm/ST) of *Phycis blennoides*. A) Different size groups; B) Different seasons.Vertical bars represent standar desviation from the mean.

Appreciable variation was found in the food composition of different size groups (Figure 2). Frequency of occurrence of mysids, amphipods and isopods were higher in size groups I and II, whereas the values of this index for natantids and teleosts were higher in size groups III and IV. Cannibalism was low in all size groups with values lower than 1 F(%). The IRI of mysids decreased with increasing greater forkbeard size whereas the IRI of natantids and teleosts increased.

A chi-square test revealed significant differences among greater forkbeard size groups with respect to natantids (χ^2=93.34, df=3, P<0.01), teleosts (χ^2=137.54, df=3, P<0,01) and "others" (χ^2=11.26, df=3, P<0.05) due to the high number which appeared in the III and IV size groups. Mysids (χ^2=120.31, df=3, P<0.01), amphipods (χ^2=50.53, df=3, P<0.01) and other crustaceans (χ^2=27.00, df=3, P<0.01) were consumed primarily by size groups I and II. There was a trend for reptantia to be less consumed by the small sized forkbeards (χ^2=13.50, df=3, P<0.05). Isopods (χ^2=41.97, df=3, P<0.01) were less frequent in the diet of IV size group.

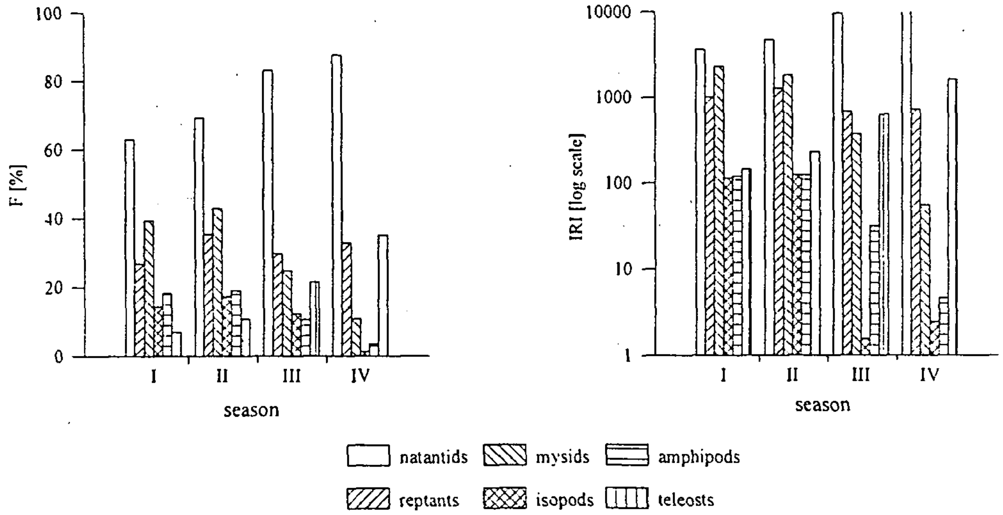

Figure 2. Changes in diet of the main prey categories as a function of *Phycis blennoides* size. A) frequency of occurrence (F%); B) Index of Relative Importance (IRI). In order to clarify the representation, "others" and other crustaceans have not been considered due to their low F% and IRI values.

Seasonal variation in the diet

Average prey per stomach values were higher in summer and autumn than in winter and spring (F=29.40, df=2627, P<0.001), whereas mean weight of stomach contents showed the highest value in spring (F=33.07, df=2627, P<0.001) (Fig. 1B).

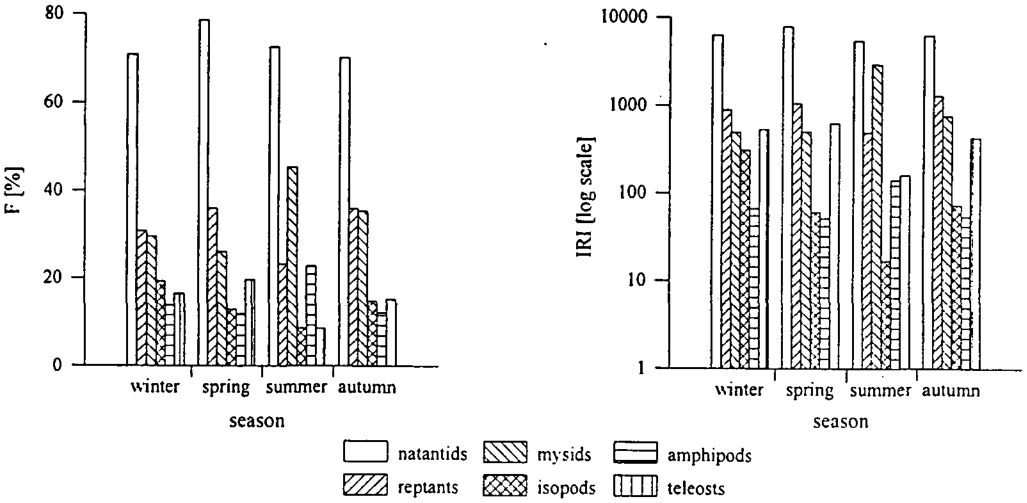

Figure 3. Seasonal variation in the main prey categories *Phycis blennoides*. A) frequency of occurrence (F%); B) Index of Relative Importance (IRI). In order to clarify the representation, "others" and other crustaceans have not been considered due to their low F and IRI values.

The relative importance of the prey groups of *P. blennoides* changed seasonally (Figure 3). Natantids were the most important prey in all seasons, although they occurred more frequently in spring (χ^2=13.84, df=3, P<0.005). Mysids (χ^2=56.18, df=3, P<0.001), amphipods (χ^2=38.70, df=3, P<0.001) and other crustaceans (χ^2=43.12, df=3, P<0.001) were present primarily during summer. Reptands (χ^2=30.89, df=3, P<0.001), isopods (χ^2=29.34, df=3, P<0.001) and teleosts (χ^2=30.86, df=3, P<0.001) occurred less frequently in the diet during summer. No significative differences were found for "others" (χ^2=1.59, df=3, P>0.05). According to the IRI, natantids were the dominant food during all the seasons. Reptands were the second group in importance, although in summer, mysids took this position. Cannibalism reached its highest value in winter (1.84 F%).

Dietary Overlap

The extent of intraspecific dietary similarity was quantified by comparing dietary overlaps among all possible pairs of size groups within each season. Generally, close size groups had higher dietary overlap than size groups which are not consecutive (Table 3). The similarity values ranged from 0.31 to a maximum of 0.84. Almost all the values obtained were more than 0.60, an indicator of high dietary overlap (Zaret & Rand, 1971; Langton, 1983).

Table III. Intraspecific food overlap of the different size groups as a function of season.

Winter	Group I	Group II	Group III
Group II	0.84		
Group III	0.70	0.76	
Group IV	0.61	0.61	0.62

Spring	Group I	Group II	Group III
Group II	0.75		
Group III	0.74	0.82	
Group IV	0.73	0.68	0.74

Summer	Group I	Group II	Group III
Group II	0.80		
Group III	0.43	0.58	
Group IV	0.31	0.40	0.56

Autumn	Group I	Group II	Group III
Group II	0.78		
Group III	0.49	0.63	
Group IV	0.40	0.52	0.71

During winter and spring intraspecific dietary overlap was high. In summer, intraspecific dietary overlap was medium, as diet was highly variable. Overlap was high between Group I and II, as they mainly consumed natantids (*Alpheus glaber*, *Philocheras bispinosus*, *Processa mediterranea*), reptands (*Calocaris* macandreae), mysids (*Anchialina agilis*, *Lophogaster typicus*, *Gastrosaccus normani*), amphipods

(*Monoculodes gracilis*, *Westwoodilla rectirostris*). In autumn, dietary overlap showed medium and high values.

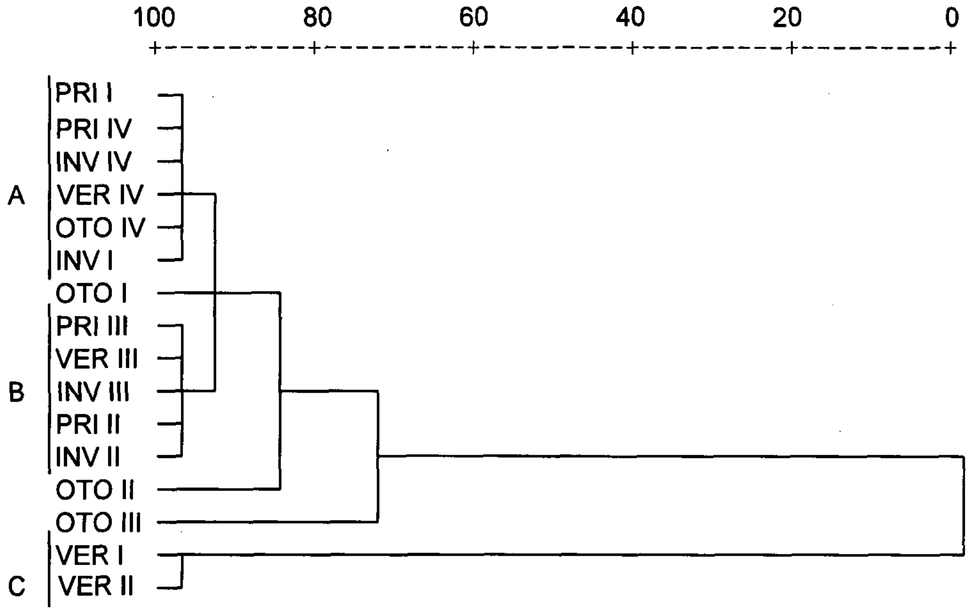

Figure 4. Dendogram of the cluster analysis of diet composition in the different seasons and size groups of *Phycis blennoides.*

Cluster analysis of dietary data (Figure 4) produced, below the value of 90%, three major fish groups. The first, group A, mainly includes large *P. blennoides* specimens and they are linked because their diet is dominated by great natantids (*Alpheus glaber*, *Processa mediterranea*, *Solenocera membranacea*) and fishes (Gobidae, Callionymidae, Scorpaenidae). Group B contains specimens of size groups II and III that consumed small decapods like natantids (Alpheidae, Crangonidae, Processidae) and reptands, and small fishes (*Deltentosteus quadrimaculatus*, *Lesueurigobius friesii*). Cluster analysis clearly distinguish diet categories according to size in group A and B, whereas group C was composed by summer specimens of *P. blennoides* pertaining to the first and second size groups.

DISCUSSION

Phycis blennoides is a demersal active predator with a diet that consists primarily of benthic crustacean decapods. Mysids, although dominant in number, represented a small percentage by weight. Teleosts were less numerous than crustaceans, being secondary prey.

Macpherson (1978), on the east coast of Spain, confirms the overall dominance of crustaceans in the diet of greater forkbeard. This author reported that decapods (*Alpheus glaber* and *Calocaris macandreae*) and mysids (*Pseudomma* sp.) were the main prey, whereas teleosts were only important in large specimens. Studies in Atlantic waters have reported a diet rather similar to that of Mediterranean greater forkbeard (Scott, 1911; Sorbe, 1977; Du Buit, 1978; Mauchline & Gordon, 1984).

The low percentage of empty stomachs (7.79%) obtained from this study does not agree with observation of Sorbe (1977), who found a higher vacuity index (20.4%). Reproduction, which takes place in summer (Gallardo-Cabello & Gual-Frau, 1984), seems to have little effect on vacuity as in our study the maximum value occurred in winter.

A gradual change in diet is observed with size: the mean weight of stomach contents increased with an increase in fish size. Also, it was observed that mysids, amphipods, isopods decreased in importance with increasing greater forkbeard size, whereas the importance of larger prey, such as natantids, reptands and teleosts increased. These findings were corroborated by the cluster analysis which shows segregation between size classes.

Cannibalism has been confirmed to be of slight importance, as other authors in the Mediterranean (Macpherson, 1978; Gallardo-Cabello & Gual-Frau, 1984) have pointed out. This phenomenon was more relevant in winter, whereas spring was observed as season of greatest cannibalism by Macpherson (1978). Cannibalism may be a population survival mechanism when resources are scarce in the environment, and also serves as an important recruitment control factor (Sale, 1982).

Maximum frequency of occurrence of a specific prey species often coincided with the breeding period for that species. For example, *L. gracilis* and *L. friesii* are more abundant in autumn, coinciding with the breeding period (Macquart-Moulin, 1965; Casadevall *et al.*, 1994). *A. glaber* breeds between March and August (Casadevall *et al.*, 1994) and maximum frequency of occurrence was found in June. Breeding in *L. depurator* begins in November and lasts until January (Abelló, 1986) when its occurrence coefficient increases, being more important in April. This indicates that observed seasonal variations in food ingestion may be related to fluctuations of the prey in the environment. Although no data are available for the study area in relation to the availability of prey, previous studies in the Gulf of Valencia on the feeding habits of several fish point out that several prey species, such as *L. gracilis*, *A. glaber*, *L. depurator*, *G. rhomboides* and *L. friesii*, occurred more frequently in the stomach contents of benthic fishes (Vivó & Sanz, 1989; Redón *et al.*, 1994; Morte *et al.*, 1997a,b, 1999a,b). The observed seasonal change, besides the diet variations due to fish size, could be also due to the depth of sampling. Also it might be caused because fishes of different size classes live in separate range depth communities or that fishes change their range depth depending of seasons. This is difficult to control when samples are provided from fisherman and unfortunately in the study area there are not any data about greater forkbeard depth distribution. However, in this study, fish were collected over narrow depth range (50 to 175 m) where the structure of the bottom communities is probably quite similar (Zariquiey, 1968).

On the other hand, many of the demersal fishes show a decrease in feeding activity as the temperature drops (Tyler, 1971; Caragitsou & Papaconstantinou, 1988). Nevertheless, in the study area, seasonal variation in bottom temperature is low (Canales, 1999). Hence seasonal variation in diet selection is not directly influenced by water temperature.

The food overlap analysis indicated a high convergence in diet among close size groups. According to Collwell & Futuyma (1971), high niche overlap can be interpreted as evidence both for and against competition. Investigation into demersal fish communities showed an increase of food overlap due to the opportunistic utilisation of superabundant food resources by individuals (Macpherson, 1981; Targett, 1981; Delbeck & Williams, 1987; Morte *et al.*, 1999a). Macpherson (1981) observed that among some Mediterranean demersal fish, the benthic predators feed upon prey items undergoing abundant seasonal availability.

Summary

This study was designed to examine the feeding habits of *Phycis blennoides* in the Gulf of Valencia (western Mediterranean), taking into account the effects of predator size and season.

The low vacuity coefficient and the high number of different prey species eaten, suggest that *P. blennoides* is an important euryphagous species in the benthic communities of Spanish Mediterranean waters. Crustaceans (decapods and mysids) and teleosts constituted the main prey. The emptiness index did not vary significantly with increasing greater forkbeard size. However, significant differences were found in emptiness in relation to season, with a maximum number of empty stomachs during winter. Variation was also found in the food composition of different size groups: mysids, amphipods and isopods were mainly fund in small specimens; large decapods and fishes take on greater importance as *P. blennoides* increase in size, becoming the main prey of large specimens. Little seasonal variation in food habits was observed. Natantids were the dominant food during all seasons. Reptands were the second group in importance, although in summer, mysids were second. Intraspecific dietary overlap analysis indicated a high convergence in diet among close size groups.

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3. ESTUDIO DE LAS RELACIONES TRÓFICAS

Feeding relationships of seven benthic fish in the Gulf of Valencia

SALOME MORTE, MANUEL J. REDON and ANTONIO SANZ-BRAU

Universitat de Valencia, Facultad de Ciencias Biológicas, Ecología, Laboratorio de Biología Marina, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain

ABSTRACT.- The stomach contents of seven species of benthic fishes from the Gulf of Valencia (Western Mediterranean) indicate that most are generalist predators, eating a variety of crustaceans and teleosts. Measures for both dietary breadth and dietary overlap are given. Our analyses point out that all of them are crustacean feeders. Nevertheless, most diet overlap values for the species examined were medium (between 0.28 and 0.55) suggesting that competition for food is not high.

INTRODUCTION

Diet analysis is of importance in studies of predation, competition, trophodynamics and food webs. In field studies, analysis of stomach contents is often the only available means of accessing information of feeding ecology.

Analysis of interaction among coexisting species, using a niche overlap index, is useful in revealing the importance of different niche parameters in community organisation and how these niche dimensions are used by fishes to reduce competition and allow species to coexist (Macpherson, 1981). There is still, however, considerable uncertainty about the role fish play in the community and about the importance of competitive interactions between species. One approach towards answering such questions is to examine feeding patterns and to use diet statistics to formally describe diet breadth and diet overlap between size classes and/or species of fish (Blaber & Bulman, 1987; Harmelin-Vivien et al., 1989; Hall et al., 1990). For Western Mediterranean coastal waters there have been relatively few attempts at a formal analysis of the feeding relationships within benthic fish assemblages. The most important works are those of Macpherson (1977, 1981) who studied, in the Catalan Western Mediterranean, the food partitioning among demersal fishes of soft-bottoms between 150 - 650 metres and 200 - 800 metres, respectively.

Recently, any study had been made in the fishing grounds of the Gulf of Valencia, and for this reason we decide to carry out this work, as a continuation of others that we made in the same area (Redón et al., 1994; Morte at al., 1997a, 1997b, 1999a, 1999b, 2001). The present paper describes the competence and diet breadth of seven benthic teleosts as determined from the stomach contents of samples collected from commercial trawl surveys in the Gulf of Valencia.

MATERIALS AND METHODS

Monthly samples of *Trachinus draco*, *Lepidorhombus boscii*, *Lepidorhombus whiffiagonis*, *Scorpaena notata*, *Scorpaena porcus*, *Trisopterus minutus capelanus* and *Phycis blennoides* were taken from diurnal commercial catches landed at the port of Valencia (Spain) taken at 50 to 175 m depth in the Gulf of Valencia, between October 1991 and October 1994.

A total of 6109 specimens with a total length between 6.5 and 33.5 cm were measured to the closest half centimetre, dissected and the stomachs were removed and preserved in 6% formalin. Upon opening, stomach contents were preserved in a 70% ethanol solution. Fish showing evidence of regurgitation were excluded from the study.

In the laboratory, identification of prey was carried out to specific level whenever possible. We registered number and wet weight of the food items, after removal of surface water by blotting on tissue paper.

Proportional food overlap between the species was calculated using the overlap index of Schoener (1970):

$$a = 1 - 0.5\left(\sum_{i=1}^{n} \left|p_{xi} - p_{yi}\right|\right)$$

where *n* is the number of food organisms, and p_{xi} and p_{yi} are the biomass composition indexes of prey (*i*) in the diets of species *x* and *y*, respectively. The index has a minimum value of zero, when no overlap occurs, and a maximum value of one, when all prey are shared in equal proportions by the two species. The convention established by Langton (1983) and Brodeur & Pearcy (1984) was invoked. Overlap index values have been grouped into three categories representing low (0.00 to 0.29), medium (0.30 to 0.60), and high (>0.60) levels of dietary overlap. The overlap index of Schoener has also been calculated for each fish in the four seasons.

Comparisons of the relative diversity of prey items ingested by different fish species were facilitated by reducing the multidimensionality and complexity of the diet to a single figure, an index of diet diversity or breadth. Dietary breadth was calculated using Levins' standarized index (Hulbert, 1978; Krebs, 1989):

$$B_i = (1/\mathrm{n}-1)[(\Sigma p_i^2)^{-1} - 1]$$

where p_i is the proportion of the ith prey item in the diet, and n is the number of prey items. This index ranges from 0 to 1, with low values indicating diets dominated by a few prey items (specialist predators) and higher values indicating generalist diets (Gibson & Ezzi, 1987; Krebs, 1989).

RESULTS

Dietary overlap

The percentage similarity values (figure 1) range from 0.25 to a maximum of 0.74. Accordingly, it is obvious that the greatest similarity in diet exists between *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis* (0.74), *Scorpaena notata* and *Scorpaena porcus* (0.64), and *Trisopterus minutus capelanus* and *Phycis blennoides* (0.61).

Figure 1. Dietary overlap between the diet of seven species of benthic fishes from the western Mediterranean. Open boxes = 0 to 0.29; ruled boxes = 0.30 to 0.60; solid boxes >0.60.

TOTAL	*T. draco*	*L. boscii*	*L. whiffiagonis*	*S. notata*	*S. porcus*	*T. m. capelanus*	*P. blennoides*
T. draco		▨				▨	▨
L. boscii	0.36		■	▨	▨	▨	▨
L. whiffiagonis	0.26	0.74		▨		▨	▨
S. notata	0.25	0.36	0.36		■	▨	▨
S. porcus	0.28	0.30	0.28	0.64			▨
T. m. capelanus	0.57	0.44	0.36	0.30	0.29		■
P. blennoides	0.35	0.55	0.47	0.40	0.35	0.61	

WINTER	*T. draco*	*L. boscii*	*L. whiffiagonis*	*S. notata*	*S. porcus*	*T. m. capelanus*	*P. blennoides*
T. draco		▨	▨			▨	▨
L. boscii	0.60		▨		▨	■	■
L. whiffiagonis	0.35	0.50			▨	▨	▨
S. notata	0.17	0.24	0.23		▨		▨
S. porcus	0.25	0.31	0.31	0.53			▨
T. m. capelanus	0.60	0.63	0.42	0.21	0.23		▨
P. blennoides	0.52	0.66	0.49	0.34	0.33	0.59	

SPRING	*T. draco*	*L. boscii*	*L. whiffiagonis*	*S. notata*	*S. porcus*	*T. m. capelanus*	*P. blennoides*
T. draco		▨				▨	▨
L. boscii	0.50		▨	▨		■	▨
L. whiffiagonis	0.17	0.48		▨		▨	▨
S. notata	0.22	0.38	0.35		■	▨	▨
S. porcus	0.17	0.26	0.23	0.64			▨
T. m. capelanus	0.56	0.65	0.35	0.33	0.27		▨
P. blennoides	0.30	0.55	0.45	0.42	0.32	0.49	

SUMMER	*T. draco*	*L. boscii*	*L. whiffiagonis*	*S. notata*	*S. porcus*	*T. m. capelanus*	*P. blennoides*
T. draco		▨				▨	
L. boscii	0.33		■	▨	▨	▨	▨
L. whiffiagonis	0.23	0.66		▨		▨	▨
S. notata	0.23	0.55	0.42		▨	▨	▨
S. porcus	0.19	0.40	0.27	0.40			
T. m. capelanus	0.47	0.48	0.33	0.33	0.22		▨
P. blennoides	0.19	0.52	0.32	0.30	0.22	0.57	

AUTUMN	*T. draco*	*L. boscii*	*L. whiffiagonis*	*S. notata*	*S. porcus*	*T. m. capelanus*	*P. blennoides*
T. draco						■	▨
L. boscii	0.20		■	▨	▨		▨
L. whiffiagonis	0.25	0.74		▨	▨	▨	▨
S. notata	0.25	0.33	0.32		■		▨
S. porcus	0.26	0.31	0.32	0.66		▨	▨
T. m. capelanus	0.64	0.26	0.30	0.29	0.36		▨
P. blennoides	0.35	0.50	0.49	0.41	0.44	0.53	

In the case of *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis*, this higher value is chiefly attributable to the fact that both species feed basically on mysids

(*Erythrops elegans*, *Parapseudomma calloplura*) and decapods (*Processa mediterranea*, *Calocaris macandreae*). Of the 43 different species found in the stomachs, 28 occurred in the diet of both megrims. It was found that overlap values between them were only high during summer and autumn, owing to the fairly similar proportions by number of mysids (*Gastrosaccus normani*, *Erythrops elegans*), decapods (*Alpheus glaber*, *Processa mediterranea*, *Philocheras echinulatus*, *Philocheras bispinosus*) and the teleost *Deltentosteus quadrimaculatus* consumed.

Scorpaena notata and *Scorpaena porcus*, also show a high value attributable to the fact that both of them feed basically on natantia (*Processa mediterranea*, *Alpheus glaber*, *Philocheras monacanthus*, *Thoralus cranchii*), reptantia (*Pisidia longimana*) and brachyura (*Pilumnus hirtellus*, *Liocarcinus* sp., *Macropodia rostrata*). Although, natantia were less abundant in *S. porcus* than in the diet of *S. notata*. Seventy nine different species were found in the stomachs, and 31 of them occurred in the diet of both scorpaenid. Only in spring and autumn the overlapping is high, because during this seasons they shared preys in quite similar proportions. Thus, in spring both ate mainly natants while in autumn they ate chiefly reptants and brachyurans and in quite similar proportions.

The diets of *Trisopterus minutus capelanus* and *Phycis blennoides* are reasonably similar, which accounts for the observed intermediate levels of dietary overlap during the year. They shared 51 preys, of the 122 different species found in their stomachs. Generally, it can be seen that mysids as *Anchialina agilis* or *Lophogaster typicus* and decapods (*Alpheus glaber*, *Philocheras bispinosus*, *Goneplax rhomboides*) were the most important prey categories in the diet of both species. Also can be found that they present diets based on benthic species (*A. glaber*, *G.*

rhomboides, *Lesueurigobius friesii*, *Deltentosteus quadrimaculatus*) or species which live just above the bottom (*Processa mediterranea*, *Leptomysis gracilis*).

Thirteen cases of medium interspecific dietary overlap were recorded: the diet of *Trachinus draco* was overlapped by *Lepidorhombus boscii*, *Trisopterus minutus capelanus* and *Phycis blennoides* (0.36, 0.57 and 0.35, respectively), with the four species having *Anchialina agilis*, *Leptomysis gracilis*, *Processa mediterranea*, *Alpheus glaber* and *Goneplax rhomboides* as important dietary components. In the case of *Trachinus draco*, overlap remains medium during the year except in summer, with *P. blennoides* (0.19) and in autumn, with *L. boscii* (0.20). Respect to *P. blennoides*, always was medium or even high overlapped by the other teleosts studied. The same tendency was found during each season.

The diets of both megrims showed medium overlap values with all the other species studied, except in the case of *Lepidorhombus whiffiagonis* and *Scorpaena porcus* (0.28). *S. porcus* was few overlapped by *Trachinus draco*, *L. whiffiagonis* or *Trisopterus minutus capelanus*.

Diet breadth

Diet breadth (B_i) is a quantitative measure of the specificity of a species' diet (Krebs, 1989). The values of B_i for the seven teleosts species considered in the present study (Table I) indicate a wide variability in their feeding ecologies (B_i = 0.04 - 0.61). Diet breadths varied widely from 0.04 in *Trachinus draco* to 0.61 in *Scorpaena porcus* (Table I).

Among the crustaceans feeders, *Trachinus draco*, *Phycis blennoides*, *Trisopterus m. capelanus* have very specialised diets (B_i = 0.04, 0.13 and 0.14, respectively). Although a considerable number of different prey species take part of their diet, only a few of them appear into the stomach contents in high proportion, or in other words, the preys that appear in so low proportion are accidentals and for this reason the diet are only based on few species.

Table I. Relative diversity of prey items (Levins standarized index) ingested by seven species of benthic fishes from the western Mediterranean.

Species	Number of specimens	Total length (cm)	Number of prey species	Levins standarized index
Trachinus draco	893	10.0 - 30.0	40	0.04
Lepidorhombus boscii	344	8.0 - 20.0	38	0.40
Lepidorhombus	159	8.0 - 20.5	33	0.36
Scorpaena notata	576	6.5 - 22.0	67	0.29
Scorpaena porcus	230	8.5 - 28.5	45	0.61
Trisopterus m. capelanus	1276	8.5 - 23.0	63	0.14
Phycis blennoides	2631	9.5 - 33.5	110	0.13

The narrowest diet correspond to *Trachinus draco*, *Phycis blennoides* and *Trisopterus minutus capelanus*. *T. draco* fed mainly on *Leptomysis gracilis*, *Gastrosaccus normani*, *Alpheus glaber*, *Goneplax rhomboides*, *Liocarcinus depurator*, *Sepiola rondeletti*, *Lesueurigobius friesii* or *Vibilia armata*. Whereas, *P. blennoides* have a numerous number of prey identified since specific level, it did not show a wide breadth diet index maybe because most of this items appears in low number and only occasionally in its diet. The food of *T. m. capelanus* was made up almost exclusively of mysids, decapods and teleosts as gobiids and callionymids; the other prey items appeared in low numbers.

Scorpaena porcus was found to have the widest dietary ranges, taking only the preys that could be classified to specific level (Appendix I). For this reason, it could be said that it represents a generalist specie.

The second and third widest niche were possessed by *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis*, with a total of 38 and 33 prey species, respectively. The diet of *L .boscii* consists of mysids (*Parapseudomma calloplura*, *Leptomysis gracilis*) and decapods (*Alpheus glaber*, *Processa mediterranea*, *Calocaris macandreae*, *Liocarcinus depurator* and *Goneplax rhomboides*), amphipods (*Rhachotropis grimaldi*), teleosts (*Lesueurigobius friesii*), molluscs (*Venus verrucosa*) and stomatopods (*Rissoides desmaresti*). The diet of *L. whiffiagonis* consisted principally of mysids (*P. calloplura*), natantids (*P. mediterranea*, *A. glaber*), teleosts (*L. friesii*), other taxa found in the diet were reptants, molluscs and stomatopods.

DISCUSSION

It is difficult to make firm conclusions regarding resource limitation without an extensive knowledge of the benthic community available for exploitation. Studies conducted by Arntz (1973, 1974) which combine food habits investigations, feeding chronology experiments, and a quantitative evaluation of the macrobenthos are needed before we can quantitatively determine the degree to which food resource competition actually exists. However, there is not any similar work in the studied area.

A number of non biological factors may also influence the calculation of dietary overlap and these must be accounted for when interpreting overlap data. The level of identification of the prey will affect the overlap calculations since broader taxonomic groupings actually increase the observed degree of overlap. Moyle (1977) gave an example if this when comparing the diet of sculpins and some salmonids, nothing that the greatest overlap occurred when the prey was only identified to the order level. In the present study identification of prey was carried out to specific level, whenever was possible, trying to avoid this problem.

Some species pairs show high overlap values (for example: *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis*, *Scorpaena notata* and *Scorpaena porcus*, *Phycis blennoides* and *Trisopterus minutus capelanus*). However, as several authors have pointed out (Keasts, 1978b; Macpherson, 1977, 1979), some of this values may be overestimated, because there are other factors which are likely to exert an influence on the overlap, as could be feeding at different heights in the water column, seasonal fluctuations in diets, etc. Respect to this late factor, the overlap in each season have been calculated and this three pairs remain with these overlap values.

On the other hand, overlap values increase when a resource peaks in abundance and several species are attracted to it; overlaps tend to be smallest when food is relatively scarce (Zaret & Rand, 1971; Lowe-McConnel, 1975; Macpherson, 1977; Keast, 1978a). These high overlap values are not sufficient evidence of competition, for, as Pianka (1976) has pointed out, “overlap need not necessarily lead to competition unless resources are in short supply”.

Seasonal variations in diet are on considerable importance in the estimation of real overlap (Macpherson, 1981). For instance, the overlap values of *Phycis blennoides* on the other teleosts studied are generally medium, except in summer between *P. blennoides* and *Trachinus draco* or *P. blennoides* and *Scorpaena porcus*. In that season, all of them prey over some species, but in quite different proportions, and this fact reduce the overlap index among them.

Macpherson (1981) states that generalists can exploit many different food resources and can cope with fluctuating and ecologically marginal environments. By contrast, specialised feeders occupy narrow trophic niches and are immediately impacted by perturbations or community stress. Generally, species with high overlap had a wide diet breadth and were therefore generalists. Major part of the fishes studied here show a great diversity in their diet (*Scorpaena porcus, Lepidorhombus boscii*, *Lepidorhombus whiffiagonis* or *Scorpaena notata*) and are likely to be versatile in switching between predominant food items. This is the case, here, with *L. boscii* which has a wide diet and a highest total diet overlap with all the other species. But others as *Trachinus draco*, *Phycis blennoides* or *Trisopterus minutus capelanus* have low Levins' index values. Most of these fish are primarily decapods feeders, which accounts for the observed intermediate and high levels of dietary overlap. Scorpaenids (*S. notata* and *S. porcus*) showed a preferential utilization of crustacean, chiefly brachyurans.

It is interesting to note that species from the same genus such as *Lepidorhombus boscii* and *Lepidorhombus whiffiagonis*, *Scorpaena notata* and *Scorpaena porcus* showed a higher overlap between them. Maybe due to the fact that species belong to the same genus have similar morphological trents, they prey over similar species.

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Appendix I. Proportion of preys (Cn%) that was classified to specific level.

	Trachinus draco	*Lepidorhombus boscii*	*Lepidorhombus whiffiagonis*	*Mustelus mustelus*	*Scorpaena notata*	*Scorpaena porcus*	*Trisopterus m. capelanus*	*Phycis blennoides*
PREYS	Cn%							
Posidonia	-	-	-	0.47	-	-	-	-
MOLLUSCA								
Leda commutata	-	0.07	-	-	-	-	-	0.01
Venus verucosa	-	0.15	0.42	-	-	-	-	-
Nucula nucleus	-	-	-	0.09	-	-	-	-
Tellina planata	-	-	-	0.09	-	-	-	-
Chlamys opercularis	-	-	-	0.09	-	-	-	-
Spisula subtruncata	-	-	-	0.19	-	-	-	-
Turritella communis	0.21	-	-	0.09	0.49	-	0.08	0.13
Alloteutis media	0.21	-	-	-	-	-	0.02	0.01
Alloteuthis mediterranea	-	-	-	0.19	-	-	-	-
Illex coindeti	0.16	-	-	-	-	-	-	0.02
Loligo vulgaris	-	-	-	0.38	-	-	-	-
Sepia officinalis	-	-	-	0.19	-	-	-	-
Sepiola rondeletti	0.86	0.07	-	-	-	-	-	-
CRUSTACEA								
ISOPODA								
Gnathia maxillaris	-	-	-	-	-	-	-	0.33
Gnathia dentata	-	-	-	-	-	-	-	0.04
Eurydice affinis	-	-	-	-	-	0.23	-	0.02
Eurydice spinigera	-	-	-	-	-	-	-	0.01
Cirolana cranchii	-	-	-	-	0.25	0.23	0.02	0.12
Cymodoce truncata	-	-	-	-	1.15	0.47	-	-
Idotea chelipes	-	-	-	-	0.08	-	-	-
AMPHIPODA								
Rhachotropis grimaldi	-	-	2.31	-	-	-	-	0.10
Rhachotropis rostrata	-	-	0.84	-	-	-	-	-
Dexamine spiniventris	-	-	-	-	2.13	1.40	-	0.09
Eusirus longipes	0.05	-	-	-	-	-	0.02	0.08
Epimeria cornigera	-	-	-	-	-	-	0.20	-
Hippomedon massiliensis	-	-	-	-	-	-	0.03	-
Monoculodes gracilis	-	-	-	-	-	-	-	0.57
Phrosina semilunata	-	-	-	-	-	-	0.05	0.01
Westwoodilla rectirostris	-	-	-	-	-	-	-	0.40
Vibilia armata	0.21	-	-	-	-	-	0.17	0.04
Maera schmidtii	-	-	-	-	-	-	-	0.01
Aeoridae	-	-	-	-	-	-	-	0.04
Iphimedia vicina	-	-	-	-	0.25	-	-	-
Phytisica marina	0.11	-	0.63	-	0.33	-	0.35	0.08
Pseudolirius kroyerii	-	0.30	-	-	-	-	0.05	-
Psedoprotella phasma	-	-	-	-	-	-	-	0.02
MYSIDACEA								

Lophogaster typicus	0.32	2.46	0.63	0.09	-	-	1.28	5.45
Boreomysis arctica	-	0.45	-	-	-	-	-	0.02
Boreomysis megalops	-	0.97	2.73	-	-	-	-	0.12
Siriella armata	-	-	-	-	-	-	0.80	-
Siriella clausii	-	-	-	-	0.16	-	1.90	0.10
Siriella jaltensis	0.21	-	-	-	-	-	2.14	0.02
Gastrosaccus normani	1.61	1.71	2.94	-	1.31	-	6.14	1.03
Gastrosaccus spinifer	-	-	-	-	-	-	0.03	0.01
Anchialina agilis	3.81	1.04	0.63	-	0.41	3.72	10.60	18.97
Leptomysis gracilis	61.62	8.04	0.42	-	0.74	-	23.73	1.30
Leptomysis mediterranea	0.81	-	-	-	0.82	0.47	0.09	0.11
Leptomysis lingvura	-	-	-	-	0.08	-	-	-
Erythrops elegans	-	3.87	2.73	-	-	-	0.32	0.63
Erythrops erythrophthalma	-	0.30	1.05	-	-	-	-	0.30
Pseudomma affine	-	0.30	0.42	-	-	-	-	-
Parapseudomma calloplura	-	13.18	20.59	-	0.08	-	0.02	1.31
Mysideis parva	-	0.74	1.68	-	-	-	0.02	0.30
Mysidopsis angusta	-	-	-	-	-	-	0.02	-
STOMATOPODA								
Allomedia sp.	-	-	-	-	-	-	-	0.01
Nannosquilloides occulta	-	-	-	-	-	-	0.02	-
Risoides desmaresti	0.21	0.07	-	-	-	0.47	0.05	0.21
Pseudoesquilla ceresii	-	-	-	-	0.16	0.23	-	-
Parasquilla ferussaci	-	-	-	0.09	-	-	-	-
Platysquilla eusebia	-	-	-	0.84	-	-	-	-
Squilla mantis	-	-	-	13.30	-	-	-	0.02
EUPHAUSIACEA								
Euphausia krohnii	-	-	-	-	-	-	0.11	0.02
DECAPODA								
Penaeus kerathurus	-	-	-	0.19	-	-	-	-
Gennadas elegans	-	-	-	-	-	-	-	0.03
Solenocera membranacea	0.43	2.90	0.63	-	-	-	0.44	2.73
Sicyonia carinata	1.16	-	-	1.40	1.72	1.86	0.09	0.44
Sergestes arcticus	-	0.37	0.63	-	-	-	-	0.05
Pasiphaea sivado	-	-	-	-	-	-	-	0.06
Chlorotocus crassicornis	0.11	-	-	-	0.25	-	0.06	0.29
Plesionika heterocarpus	-	-	-	-	-	-	-	0.12
Plesionika antigai	-	-	-	-	-	-	-	0.09
Parapandalus narval	-	-	1.89	-	-	-	-	-
Pandalina brevirostris	-	2.08	1.89	-	0.08	-	0.51	0.95
Hippolyte longirostris	-	-	-	-	-	1.40	-	0.03
Thoralus cranchii	-	-	-	-	5.00	3.02	-	0.03
Thoralus sollaudi	-	-	-	-	1.06	2.79	-	-
Athanas nitescens	-	-	-	-	1.56	1.63	-	0.02
Alpheus dentipes	-	-	-	-	0.90	2.56	-	0.04
Alpheus glaber	6.87	6.92	4.62	1.31	3.03	0.23	17.15	13.33
Alpheus macrocheles	-	-	-	-	0.16	-	-	-
Processa edulis	-	-	-	-	0.98	-	-	0.27
Processa macrophthalma	-	1.12	-	-	-	-	0.35	0.24
Processa parva	-	-	-	0.09	2.78	-	-	0.16
Processa canaliculata	-	5.96	-	-	1.97	1.86	0.47	1.59

Processa mediterranea	0.48	15.56	16.39	-	7.94	3.49	0.29	5.80
Pontocaris cataphracta	-	-	-	1.22	0.16	-	-	0.05
Pontocaris lacazei	-	0.37	0.42	-	0.74	-	0.20	0.39
Pontophilus spinosus	-	0.45	0.84	-	-	-	0.09	0.24
Philocheras echinulatus	-	0.60	0.84	-	-	-	0.08	0.41
Philocheras sculptus	0.16	-	-	-	-	-	0.48	0.09
Philocheras bispinosus	0.21	1.19	1.26	-	0.25	-	4.73	3.95
Philocheras monacanthus	-	0.22	-	-	2.38	4.19	0.21	0.50
Philocheras trispinosus	-	-	-	-	-	-	-	0.23
Nephrops norvegicus	-	-	-	-	-	-	-	0.01
Scyllarus pygmaeus	-	0.07	-	-	0.16	-	0.02	0.06
Scyllarus arctus	-	-	-	-	-	-	-	0.06
Calocaris macandreae	0.21	2.08	2.31	-	-	-	0.18	2.19
Jaxea nocturna	-	-	-	-	-	-	0.05	0.06
Upogebia deltaura	-	-	-	-	0.33	2.33	0.03	0.10
Upogebia tipica	-	-	-	0.28	-	-	0.14	0.03
Upogebia littoralis	-	-	-	-	0.08	-	-	0.01
Upogebia stellata	-	-	-	-	-	-	-	0.02
Pagurus prideauxi	-	-	-	0.19	-	-	-	-
Diogenes pugilator	-	-	-	0.28	-	-	-	-
Anapagurus laevis	-	-	-	-	-	-	0.06	-
Dardanus arrosor	-	-	-	-	0.08	-	-	-
Galathea squamifera	-	-	-	-	-	-	-	0.10
Galathea bolivari	-	-	-	-	-	-	-	0.01
Galathea intermedia	0.11	-	-	-	0.33	-	0.32	-
Munida iris	-	0.74	0.21	-	-	-	-	1.94
Munida intermedia	-	0.22	-	-	-	-	-	1.68
Calcinus ornatus	-	-	-	-	-	0.23	-	-
Pisidia longimana	0.16	-	-	-	17.77	10.47	-	0.14
Portunus hastatus	-	-	-	0.19	-	-	-	-
Liocarcinus arcuatus	0.86	-	-	-	0.41	-	-	0.05
Liocarcinus corrugatus	0.54	-	-	0.11	0.16	4.42	0.06	0.05
Liocarcinus pusillus	0.48	-	-	-	-	0.47	0.18	0.21
Liocarcinus zariquieyi	-	-	-	-	0.25	-	0.20	-
Liocarcinus tuberculatus	-	-	-	-	-	-	-	0.04
Liocarcinus bolivari	-	-	-	-	-	-	-	0.01
Liocarcinus depurator	1.77	2.01	1.47	-	1.31	3.02	0.33	0.64
Pilumnus spinifer	-	-	-	-	1.23	0.70	-	0.05
Pilumnus hirtellus	-	-	-	-	4.34	7.67	-	0.09
Xantho pilipes	-	-	-	-	0.41	0.47	-	0.04
Xantho poressa	-	-	-	-	0.16	0.23	-	-
Medaeus couchi	-	-	-	-	-	-	-	0.21
Goneplax rhomboides	3.76	2.16	0.63	0.75	0.82	3.26	0.78	0.85
Planes minutus	-	-	-	-	-	-	-	0.05
Acanthonyx lunulatus	-	-	-	-	0.16	-	-	-
Atelecyclus rotundatus	-	-	-	-	0.16	-	-	-
Pirimela denticulata	-	-	-	-	0.33	-	-	-
Parthenope massena	-	-	-	0.28	0.90	0.70	-	-
Eurynome aspera	-	-	-	-	0.90	0.47	-	-
Eurynome spinosa	-	-	-	-	0.41	-	-	-
Achaeus cranchii	-	-	-	-	0.49	-	-	-

Achaeus gracilis	-	-	-	-	1.80	0.70	-	-
Dorippe lanata	-	-	-	1.87	-	-	-	-
Calappa granulata	-	-	-	0.38	-	-	-	-
Atelecyclus rotundatus	-	-	-	2.15	-	-	-	-
Brachynotus sexdentatus	-	-	-	0.09	-	-	-	-
Inachus dorhynchus	-	-	-	-	-	2.09	-	-
Inachus phalangium	-	-	-	-	0.82	0.47	-	-
Inachus thoracicus	-	-	-	-	0.25	0.23	-	-
Inachus communissimus	-	-	-	-	0.41	-	-	-
Inachus dorsettensis	-	-	-	-	0.41	-	-	-
Macropodia rostrata	-	-	-	-	2.87	2.56	-	-
Macropodia linaresi	-	-	-	-	-	0.23	-	-
Macropodia deflexa	-	-	-	-	-	0.47	-	-
Macropodia longipes	-	-	-	-	0.82	-	-	-
Macropodia longirostris	-	-	-	-	0.33	-	-	-
Ethusa mascarone	-	-	-	0.28	0.49	0.70	-	-
Ilia nucleus	-	-	-	0.09	1.56	2.09	-	-
Bathinectes longipes	-	-	-	-	-	1.40	-	-
Pachygrapsus marmoreus	-	-	-	-	-	1.86	-	-
Corystes cassivelaunus	-	-	-	0.09	-	-	-	-
Maja verrucosa	-	-	-	0.09	-	-	-	-
TELEOSTEI								
Conger conger	0.38	-	-	0.09	-	-	-	0.08
Dalophis imberbis	-	-	-	0.09	-	-	-	-
Mugil cephalus	-	-	-	0.19	-	-	-	-
Pagellus erythrinus	-	-	-	0.09	-	-	-	-
Scomber scombrus	-	-	-	0.09	-	-	-	-
Gadiculus argenteus	-	-	-	-	-	-	0.17	0.16
Merluccius merluccius	-	-	-	-	-	-	-	0.02
Micromesistius poutassou	-	-	-	-	-	-	-	0.02
Phycis blennoides	-	-	-	-	-	-	-	0.17
Apterichthus caecus	-	-	-	0.28	-	-	-	-
Gobius auratus	-	-	0.42	-	-	-	0.06	0.32
Gobius niger	-	-	-	-	0.08	-	-	-
Lesueurigobius friesii	0.86	0.67	5.67	-	-	1.40	0.74	0.72
Lesueurigobius sueri	-	-	-	-	-	-	-	0.05
Deltentosteus quadrimaculatus	-	0.30	1.05	-	-	-	0.23	0.30
Scorpaena notata	-	-	-	-	-	0.23	0.02	-
Helicodenus dactylopterus	-	-	-	-	-	-	-	0.17
Sardina pilchardus	0.16	-	0.21	1.12	-	-	-	0.03
Sardinela aurita	-	-	-	0.28	-	-	-	-
Engraulis encrasichoulus	0.11	-	-	0.47	-	-	0.15	-
Cepola rubescens	0.38	-	-	-	-	-	-	0.09
Capros aper	0.32	-	-	-	-	-	-	-
Arnoglossus laterna	0.32	-	-	-	-	-	-	-
Lepidorhombus boscii	-	-	-	-	-	-	-	0.06
Symphorus nigrescens	-	-	-	-	-	-	-	0.02
Citharus linguatula	0.11	-	-	-	-	-	-	-
Callionymus maculatus	0.97	-	-	-	-	-	0.72	0.14
Callionymus rissoi	0.11	-	0.84	-	-	-	0.53	0.09
Callionymus lyra	0.43	-	-	-	-	-	-	-

Synchiropus phaeton	-	-	-	-	-	-	0.06	0.08
Maurolicus muelleri	-	-	-	-	-	-	0.03	0.04
Mictophum punctatum	-	-	-	-	-	-	-	0.08
Hygophum benoitii	-	-	-	-	-	-	0.03	-

4. RESUMEN GLOBAL

En este trabajo se ha estudiado la dieta de un total de 6370 individuos pertenecientes a ocho especies de peces bénticos de interés comercial del Golfo de Valencia, en profundidades que oscilan entre 50 y 175 metros.

Durante el estudio de sus dietas se han determinado 190 especies diferentes de presas.

Los crustáceos han sido el grupo de presas más importantes. Entre ellos, los misidáceos fueron generalmente las presas más numerosas y con una mayor frecuencia de aparición. Estos suelen predominar en los contenidos estomacales de los individuos de menor tamaño, de modo que, a medida que aumenta la talla del predador son sustituidos por crustáceos de mayor tamaño. Así, por ejemplo, su presencia en *Mustelus mustelus*, la espécie que presenta las mayores tallas, es testimonial. Los misidáceos más importantes han sido *Anchialina agilis*, *Gastrossacus normani*, *Leptomysis gracilis* y *Lophogaster typicus*, que se han hallado en los contenidos estomacales de casi todas las especies.

Los crustáceos decápodos, aunque menos numerosos que los misidáceos, tienen mayor importancia por su peso. Asimismo, también engloban el mayor número de especies diferentes identificadas. Sólo dos especies de decápodos, *Alpheus glaber* y *Goneplax rhomboides*, han aparecido en la dieta de todas las especies de peces, aquí estudiadas, de forma importante.

El resto de crustáceos identificados, como isópodos, anfípodos, eufasiáceos o estomatópodos tienen menor trascendencia, siendo sólo puntualmente notorios en los individuos de menor talla de algunas especies como *Phycis blennoides*.

Los peces han sido el siguiente grupo en importancia después de los crustáceos. Al contrario que los pequeños crustáceos (misidáceos, anfípodos, isópodos y eufasiáceos) su presencia aumenta generalmente con la talla del predador. Entre los más importantes podemos destacar los góbidos y callionímidos.

Otras presas que han aparecido en las dietas de los ejemplares estudiados, pero de modo ocasional, han sido moluscos, poliquetos, equinodermos, foraminíferos y restos de algas.

El estudio de la vacuidad ha revelado que en algunas especies es baja (<10%) como en *Mustelus mustelus*, *Lepidorhombus boscii*, *Trisopterus minutus capelanus*, *Phycis blennoides*, en otras media (10-30%) como en *Lepidorhombus whiffiagonis*, *Scorpaena notata*, *Scorpaena porcus* y elevada (>30%) en *Trachinus draco*. Señalar también, que el indice de vacuidad, en *Lepidorhombus boscii*, *Lepidorhombus whiffiagonis*, *Scorpaena notata*, *Scorpaena porcus* y *Phycis blennoides* no presenta diferencias significativas entre las diferentes clases de tallas. Sin embargo en otros, como *Trachinus draco* y *Trisopterus minutus capelanus* dicho índice, varía significativamente. *Trisopterus minutus capelanus* y *Lepidorhombus whiffiagonis* no muestran variaciones de vacuidad a lo largo del año. Durante el ciclo anual la vacuidad varia significativamente en el caso de *Trachinus draco*, *Scorpaena notata* y *Scorpaena porcus* mostrando un máximo de vacuidad en verano. En *Lepidorhombus boscii* el máximo se alcanza en primavera. En estas cuatro especies el máximo de vacuidad coincide con el periodo reproductor. *Phycis blennoides* presenta el máximo en invierno, pero en este caso su periodo de freza no se encuentra relacionado con el máximo de vacuidad.

Como se ha citado anteriormente, las especies estudiadas muestran un cambio en la dieta con el aumento de la talla: en los ejemplares más pequeños la dieta está constituida por crustáceos pequeños como misidáceos, anfípodos, isópodos o pequeños decápodos, mientras que los ejemplares grandes ingieren peces (góbidos y callionímidos) y crustáceos de mayor tamaño (*Alpheus glaber*, *Processa mediterranea*, *Goneplax rhomboides*, *Squilla mantis*).

Todas las especies estudiadas muestran variaciones estacionales, tanto cualitativas como cuantitativas, en su alimentación. Sin embargo, estos cambios son más acusados en unas especies que en otras. La dieta de *Trachinus draco* esta dominada durante todo el año por la presencia de misidáceos, mientras que los otros grupos de presas importantes como los decápodos Natantia, Reptantia y teleósteos fluctúan con las estaciones. En *Lepidorhombus boscii* y *Phycis blennoides* tampoco se aprecian grandes cambios en la dieta, siendo los Natantia las principales presas durante todo el año. Sin embargo, en *Lepidorhombus whiffiagonis* encontramos variaciones importantes: en invierno, las principales presas son los teleósteos; en primavera la dieta esta dominada por Natantia y teleósteos; en verano, las presas mayoritarias corresponden a los Natantia; mientras que en otoño, la alimentación es más diversificada y se compone de misidáceos, Natantia y teleósteos. *Trisopterus minutus capelanus* presenta una dieta constituida durante todo el año básicamente por decápodos. La alimentación de *Scorpaena porcus* muestra pocas variaciones estacionales, siendo siempre los decápodos Brachyura las presas mayoritarias. *Scorpaena notata* se alimenta principalmente de decápodos, aunque los diferentes grupos varían a lo largo del año.

En cuanto al solapamiento de las dietas y amplitud del nicho ha de puntualizarse que debido a las particularidades que presenta el elasmobranquio *Mustelus mustelus* (alto grado de digestión de las presas, dificultat de conseguir ejemplares durante todas las estaciones) se hacia difícil la comparación y el calculo del solapamiento con el resto de especies estudiadas. Por lo tanto, únicamente se analizó el solapamiento de las dietas y la amplitud del nicho entre los teleósteos integrantes del estudio.

La mayor parte de las especies estudiadas son predadores generalistas, alimentándose de diversas especies de crustáceos y teleósteos. Casi todos los valores de solapamiento de la dieta obtenidos son medios, lo cual sugiere que la competencia por el alimento no es alta.

Los valores más elevados de similaridad de las dietas se encuentran entre las especies *Lepidorhombus boscii* y *Lepidorhombus whiffiagonis* (0.74), *Scorpaena notata* y *Scorpaena porcus* (0.64), y entre *Trisopterus minutus capelanus* y *Phycis blennoides* (0.61). Es interesante destacar que especies del mismo género, tales como *Lepidorhombus boscii* y *Lepidorhombus whiffiagonis*, *Scorpaena notata* y *Scorpaena porcus*, muestran un elevado solapamiento de sus dietas, quizás debido al hecho de tener similares rasgos morfológicos y predar sobre las mismas especies o similares.

La amplitud de nicho varia ampliamente desde 0.04 en el caso de *Trachinus draco* (especialista) a 0.61 para *Scorpaena porcus* (generalista).

5. CONCLUSIONES

Mustelus mustelus

Muestra una dieta constituida mayoritariamente por Brachyura (*Liocarcinus* sp.). Sin embargo los stomatópodos (*Squilla mantis*) son más importantes en términos de biomasa o energía obtenida, ya que son mayores que los cangrejos que aparecen en los estómagos de este elasmobranquio. También forman parte de su alimentación los teleósteos, poliquetos y moluscos. No se observan diferencias entre las dietas de machos y hembras. Pero, los estomatópodos y teleósteos son consumidos con mayor frecuencia por individuos de mayor tamaño.

Lepidorhombus boscii

Se alimenta fundamentalmente de Mysidacea y Decapoda. Muchas de sus presas, como *Alpheus glaber*, *Goneplax rhomboides*, *Calocaris macandreae* o *Lesueurigobius friesii* viven enterradas en el substrato. La importancia de los crustáceos pequeños (anfípodos, isópodos y misidáceos) en la dieta disminuye con el aumento de la talla del depredador, mientras que la importancia de los crustáceos de gran tamaño (Natantia y Reptantia) es directamente proporcional a la talla de este teleosteo.

Lepidorhombus whiffiagonis

Las principales presas que componen su dieta son bentónicas o viven cerca del fondo y coinciden en muchos casos con las consumidas por *Lepidorhombus boscii*. Ingiere sobre todo Mysidacea (*Parapseudomma calloplura*), Natantia (*Processa mediterranea*, *Alpheus glaber*) y teleósteos (*Lesueurigobius friesii*). Se observa una selección de las presas con respecto a la talla del depredador y a lo largo del año.

Trachynus draco

Presenta una dieta muy especializada integrada básicamente por especies bentónicas (*Alpheus glaber*, *Goneplax rhomboides*, *Liocarcinus depurator*, *Lesueurigobius friesii*, *Callionymus maculatus*) o que viven cerca del fondo (*Leptomysis gracilis*). Algunas de estas presas son capaces de enterrarse, por ello, su captura debe ser activa. Se constata una clara selección de las presas con respecto a la talla del predador: los misidáceos disminuyen en importancia con el aumento de la talla, mientras que la importancia de los decápodos y peces aumenta.

Scorpaena notata

Se nutre principalmente de Brachyura (*Pilumnus hirtellus*), Reptantia (*Pisidia longimana*) y Natantia (*Processa mediterranea*, *A. glaber*, *Thoralus cranchii*). Poliquetos y Amphipoda son presas secundarias, mientras que isópodos, copépodos, misidáceos, estomatópodos, moluscos y teleósteos, son poco frecuentes. La frecuencia de ocurrencia de reptantia y Brachyura se incrementa con el aumento de la talla de esta escorpa, mientras que la frecuencia de anfípodos, misidáceos, isópodos y copépodos decrece. Los Natantia forman parte de su dieta, sobre todo en primavera y verano. Los anfípodos aparecen con mayor frecuencia en invierno y primavera.

Scorpaena porcus

Posee la dieta más amplia, y por esta razón puede decirse que representa a una especie generalista a la hora de alimentarse. Los crustáceos son sus principales presas, dominadas por los Brachyura (*Pilumnus hirtellus*, *Liocarcinus corrugatus*, *Goneplax rhomboides*) y Reptantia (*Pisidia longimana*, *Upogebia deltaura*). En menor abundancia aparecen Natantia tales como *Processa mediterranea*, *Philocheras monacanthus*, y anfípodos. Estos últimos son consumidos con mayor frecuencia por ejemplares pequeños. Los Brachyura son importantes durante todo el año, mientras que Natantia, Reptantia y Amphipoda aparecen principalmente durante la primavera. Se ha observado algún caso esporádico de canibalismo.

Trisopterus minutus capelanus

Su dieta es especializada, basada esencialmente en decápodos, tales como *A. glaber*, Cangronidae y Processidae. Los Mysidacea, aunque dominan en número, representan solo un pequeño porcentaje en peso, apareciendo principalmente en los ejemplares pequeños. Las preferencias alimentarias varían con la talla de las mólleras. Decápodos y teleósteos, principalmente góbidos y callionímidos, son más abundantes en los estómagos de los especímenes de mayor talla. Se aprecian pequeñas variaciones estacionales en la dieta.

Phycis blennoides

Los Natantia (Penaeidea, Alpheidae, Crangonidae y Processidae) aparecen en gran número y frecuencia en sus estómagos. Reptantia (*Calocaris macandreae*, *Munida iris*) y Mysidacea (*Anchialina agilis*, *Lophogaster typicus*) son presas secundarias. En menor abundancia aparecen anfípodos e isópodos, mientras que eufausiáceos, copépodos, ostrácodos y stomatópodos, así como moluscos, poliquetos, foraminíferos, restos vegetales y equinoideos, son presas accidentales. A pesar del gran número de especies diferentes de teleósteos ingeridos, estos sólo representan una pequeña proporción del número total de presas. Se han observado unos pocos casos de canibalismo.