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POST WEANING VARIATIONS IN BODY CONDITION AND FIRST INDEPENDENT FEEDING OF NORTHEAST ATLANTIC HARP (*PHOCA GROENLANDICA*) AND HOODED (*CYSTOPHORA CRISTATA*) SEALS

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ABSTRACT

Data were collected for harp seals *Phoca groenlandica* of the Barents Sea (or the "East Ice") stock in 1990-1995, and from harp and hooded seals *Cystophora cristata* belonging to the Greenland Sea (or "West Ice") stocks in 1995, and questions concerning various ecological aspects of the early life stages of the two species were addressed. Pups of both harp and hooded seals were able to find prey and feed independently shortly after weaning. In the East Ice the first food of harp seal pups was mainly euphausiids ("krill") *Thysanoessa* sp. and amphipods of the genus *Parathemisto*. *Parathemisto* sp., particularly *P. libellula*, dominated the diet of both harp and hooded seal pups in the West Ice, but the diet also contained sympagic amphipods of the genus *Gammarus*. Krill was of minor importance as food for seal pups in the West Ice. The change in body condition of East Ice harp seal pups from weaning (mid March) to June indicated that considerable amounts of blubber energy, deposited during suckling, were mobilized. This suggests that the early food intake was insufficient to meet the energy requirements of the weaned pups facing the transition from life on the pack ice to existence in the open water environment. The patterns of poor spring and early summer body condition, followed by a subsequent rapid improvement during late summer and autumn seemed to occur not only amongst pups-of-the-year, but also amongst harp seals in their second and third years of life.

INTRODUCTION

Three stocks of harp seals *Phoca groenlandica* inhabit the North Atlantic Ocean (Sergeant 1991). Two stocks are distributed in the northeast Atlantic, with whelping and moulting taking place off the east coast of Greenland (the Greenland Sea or West Ice stock) and in the White Sea (the Barents Sea or East Ice stock), respectively (see Fig. 1). Studies of the annual cycle of distribution, nutrition, condition and reproduction of Barents Sea harp seals were carried out in the period 1990-1994 (Haug *et al.* 1994, Nilssen 1995, Kjellqwist *et al.* 1995).

The harp seal pups of the East and West Ice commence independent feeding in habitats that differ from each other (see Sergeant 1991). The East Ice pups are usually born on the 40-90 cm thick winter ice, of the current year, and they start independent feeding in the southeastern parts of the Barents Sea in relatively shallow waters (30-100 m deep). In the West Ice, the harp seals whelp on the fringe of the winter ice (usually snow covered floes of approximately 1 m thickness) that lies seaward to the heavier multi year ice of the east Greenland pack. Most of the West Ice is located in areas where water depths range between 1000 and 3000 m. The main pupping period for harp seals of the West Ice stock is approximately one month later than that of the East Ice, most of the pups usually being born in late March (Sergeant 1991, Øritsland & Øien 1995).

The main pupping season for hooded seals in the West Ice is mid March (Rasmussen 1960, Øritsland 1964, Øritsland & Øien 1995). Since harp and hooded seals are present in the same areas of the West Ice throughout the breeding season, pups of both species may commence feeding independently in a situation that results in competition. The adult harp seals of the West Ice have a diet that differs from that of hooded seals (Potelov, Nilssen & Haug, unpublished material). It would be of interest to establish whether the same is true for the pups of these two species. If a competition exists, the size of a year-class of one species might influence year-class strength of the other.

Questions concerning ecological aspects of the early life history of phocid seals have, however, been little studied. Some information concerning energy transfer from mothers to pups during lactation, first neonatal growth, and the post weaning fast of the harp seal, and other phocid species, including hooded seals *Cystophora cristata*, is available (Stewart & Lavigne 1980, 1984, Worthy & Lavigne 1983a, b, 1987, Kovacs & Lavigne 1986, 1992, Kovacs *et al.* 1991, Nordøy *et al.* 1993), and the dietary composition of young harp seals has been examined in various areas (Lawson & Stenson 1995, Lawson *et al.* 1995, Nilssen *et al.* 1995a). Although there are some data relating to the changes of blubber thickness and weight of harp seal pups from the East Ice (Sivertsen 1941, Timoshenko 1995), the feeding habits of harp seal pups in the northeast Atlantic areas are virtually unknown. It has, however, been suggested that they feed on crustaceans and fish both in the East Ice and West Ice (Sivertsen 1941, Rasmussen 1957).

Deficiencies in knowledge about pup ecology led us to address increased attention towards this type of study. Attention was directed towards the study of Barents Sea harp seal pups, with the aim of gaining any understanding of mechanisms that may influence the survival of harp seal pups during their first year of life. Such information could be explaining the large variations in year-class strength that have been observed in this stock (see Kjellqwist et al. 1995, Timoshenko 1995).

MATERIALS AND METHODS

Sampling of seals

The sampling of Barents Sea harp seals in 1990-1994 yielded data from pups-of-the year (145 individuals), and from 1 and 2 years old animals (45 and 41 individuals, respectively), which were all included in the body condition analyses, in June, September, October and February (see Nilssen *et al.* 1994, 1995a, b). Therefore, to cover the entire year, the appropriate period for collection of supplementary seal pup data in 1995 was March-May, i.e. in the period from weaning until the pups started to feed independently.

In 1995 the collection of pups was carried out during the commercial hunting season. Permission was obtained to catch up to 1,500 harp seal pups (750 from the East Ice and 750 from the West Ice), and up to 750 hooded seal pups from the West Ice. All pups should be weaned, i.e., the harp seal pups should be ragged jackets (moulting young) and beaters (moulted young) while the hooded seal pups should all be weaned bluebacks. In order to study the development of the pups after weaning it was necessary to obtain a temporal distribution of catches, and this was achieved by setting a maximum allowable quota per week.

One vessel (M/S *Harmoni*) operated in the East Ice (Fig. 1) during the periods, 23 March - 13 April and 24 April - 10 May 1995. During the first period, 156 ragged jackets and 89 beaters were collected. When the vessel made its second trip to the East Ice there was little ice in the traditional catch areas (see Fig 1), and only 4 beaters were caught.

Two vessels (M/S *Polarfangst* and M/S *Polarstar*) operated in the West Ice (Fig. 1) from 8 April to 12 May 1995. During this period, 338 ragged jackets, 22 beaters, and 364 bluebacks were obtained.

Measurements and biological collections

Two scientists collected samples on each of the three Norwegian sealing vessels that operated during the 1995 season. All samples were collected in accordance with the guidelines established during 1990-1994. For each pup samples records were taken of species, date, time of the day, position, sex and stage of development.

All pups were weighed to the nearest kg, and standard body length was measured to the nearest cm in a straight line from the tip of the snout to the tip of the tail, with the animal laying on its back. The dorsal blubber thickness (at a knife-cut in the mid-line between the front flippers) was measured to the nearest mm.

The stomach and large intestine of each pup was removed, and frozen for subsequent analysis in the laboratory.

Analyses of body condition

The condition was determined as index $C = \sqrt{L / W} * d$, where L is standard body length in cm, W is total body mass in kg and d is the dorsal blubber thickness in cm. This index was introduced by Ryg *et al.* (1990), and it has proved to be useful in studies of seasonal variations in body condition of adult harp seals (Chabot *et al.* 1995, Nilssen *et al.* 1995c).

Analyses of stomach and intestine contents

In the laboratory, the stomachs and intestines were thawed and then cut open. The weight of stomach contents was recorded, and the intestinal contents were flushed out using fresh water. Crustaceans were separated from fish and identified to the lowest possible taxon according to Enckell (1980). A crude estimate of the number of crustaceans was obtained by counting carapaces. Otoliths from the stomach and intestines were collected and identified to the lowest possible taxon using the keys developed by Härkönen (1986). The number of fish of each species present in the stomachs and intestines was calculated by halving the number of otoliths.

Indices commonly used in stomach analyses of top predators (Hyslop 1980, Pierce & Boyle 1991) were used to estimate the dietary contribution of different prey items: 1) the percentage of occurrence of a given dietary component, defined as the percentage of stomachs or intestines that contained one or more individuals of this component; 2) the relative frequency of occurrence of a prey species calculated as a numerical fraction of total numbers of all prey categories (% numerical frequency).

RESULTS

Body condition

East Ice - harp seals

To address the question of seasonal variation in body condition of harp seal pups from the East Ice stock, data from 231 animals (aged between 3 months and 3 years) collected in 1990-1994 was combined with that collected in 1995 (249 pups). The ragged jackets had the thickest dorsal blubber (approximately 48 mm). Blubber thickness decreased from the time of weaning in March until June, when the dorsal blubber was only about 17 mm thick (Fig. 2). The blubber increased in thickness during the course of summer, but never regained the levels observed just after weaning. A dorsal blubber thickness of 39-40 mm was maintained from October until April. Variations in the condition index C (Fig. 3) resemble those of the dorsal blubber. The patterns observed for variations in dorsal blubber thickness and condition index during the first year of life seem to be maintained also through the second and third year (Figs 2 and 3).

West Ice - harp seals

The body condition data for the 338 ragged jackets and 22 beaters collected during 1995 are shown in Fig. 4. Body condition index tended to decrease in the period 10 - 30 April.

West Ice - hooded seals

A total of 326 West Ice bluebacks were analysed with respect to condition index (Fig. 5). There was little change in mean condition index during April, but the animals taken in May exhibited significantly lower condition indices than those taken earlier.

Pup diets

East Ice - harp seals

All but one stomach of harp seal pups taken in the East Ice in March and April 1995 were empty. The stomach with content contained milk. Only few of the intestines of the pups collected during the first period (20-26 March) were empty, and this held true for both ragged jackets (9.9%) and beaters (16.5%) (Table 1). In the second period (24-30 April), only 4 beaters were caught, two of which had empty intestines. Much of the intestinal content was unidentifiable and was most probably the remains of milk. Of the 9 identifiable prey items, krill *Thysanoessa* sp. was found in the intestines of 25.2% of the ragged jackets and of nearly 50% of the beaters. Also amphipods of the genus *Parathemisto* occurred frequently, in 20.5% of the ragged jackets and in more than 50% of the beaters. In 29% of the pups, both *P. libellula* and krill occurred simultaneously, while non co-occurrent presence were observed in 7% of the pups for both prey items. Of other identified prey species, the amphipod *Gammarellus homari* occurred in c. 8% of the beaters. In terms of numerical frequency, krill contributed most (42-

67%) to the seal pup diets, followed by *Parathemisto* sp. which contributed 32-56% (Fig. 6). Other prey appeared to be of negligible importance.

West Ice - harp seals

Stomachs and intestines of harp seal pups sampled in the West Ice were examined in three periods (Table 2). Stomachs were usually empty, but the incidence of empty intestines was low (0-15.4%). Ten prey types were observed in the stomachs/intestines of the West Ice ragged jackets and beaters. Amphipods of the genus *Parathemisto* occurred in 44.4-100% of the intestines, and *P. libellula* was particularly common, occurring in 55.6-100% of the intestines. Amphipods of the genus *Gammarus* sp. weree also encountered frequently, with the species *G. wilkitzkii* being particularly abundant (found in 38.5-100% of the intestines). The prey groups designated *Parathemisto* sp. and *Gammarus* sp. may well also include remains of *P. libellula* and *G. wilkitzkii*, which could not be identified to species. Other amphipods occurred quite frequently in the intestines (*Eusirus* sp. and representatives from the family Lysianassidae) while krill was rare. Contents from stomachs resembled those observed in the intestines. *Parathemisto libellula* was the dominant prey species by numerical frequency, contributing 43-60% (Fig. 7), and amphipods of the genus *Parathemisto* had a numerical contribution of 64-92% to the diet. The contribution of the genus *Gammarus* was small (4-28%), and other food items seemed to be of minor importance.

West Ice - hooded seals

All but one hooded seal pups were examined in three periods from 10 to 30 April (Table 3). The blueback collected in the period 3-9 April had unidentifiable remains in the intestines. Most of the stomachs were empty (70.9-87.2%), but the frequency of empty intestines was much lower (0-38.5%). At least 14 different prey items were recorded. Crustaceans dominated the intestinal contents, but cephalopods and fish had also been consumed. *Parathemisto libellula* was the most frequent prey species, occurring in 10.3-25.7% of the stomachs and 46.2-86.7% of the intestines. *Gammarus wilkitzkii* was also of some importance, occurring in 5.1-8.9% of the stomachs and 15.4-33.3% of the intestines. Co-occurrence of *Parathemisto* and *Gammarus* was observed in 20% of the samples. Some prey items that were absent from early samples weer found later; e.g., the amphipods *Eusirus* sp.; krill, unidentified decapods, the cephalopod *Gonathus fabricii* and fish (in particular the polar cod, *Boreogadus saida*). In terms of numerical frequency of occurrence (Fig. 8), *Parathemisto libellula* dominated with a contribution of 78.2-92.5% to the blueback stomach and intestinal content. The total contribution of the genus *Parathemisto* was to 82.3-95.3%, whilst that of *Gammarus* sp. varied between 1.9-8.1%.

DISCUSSION

In their studies of neonatal growth in harp seals, Stewart & Lavigne (1980) observed that body weight declined considerably during the post-weaning period, and they attributed most of this weight decrease to a loss from the core of the animals. Energy loss from the blubber layer seemed to be less conspicuous, and Stewart & Lavigne (loc.cit.) attributed this to the necessity of maintenance of the blubber layer to reduce heat loss when the young began to forage in the aquatic environment. Later studies have, however, revealed that, although core reserves of energy may be of importance in the earliest phases of the postweaning fast, the weaned pups must rely on the blubber layer as the most important source of energy during fasting (Worthy & Lavigne 1983a, b, 1987). Results from recent studies on harp seal pups, indicate that catabolism of subcutaneous blubber energy represented the major energy source (ca 80%) in the post weaning period (Nordøy *et al.* 1993).

The present observations on changes in condition index and dorsal blubber thickness of harp seal pups from the East Ice are in agreement with previous field and laboratory observations, and indicate that substantial amounts of stored blubber are mobilized in the period from weaning (mid March) to mid June. Thus, although the pups may be able to find prey and feed independently shortly after weaning, it appears that food intake is insufficient to meet the energy requirements needed in the transition from the pack ice to a life in more open water.

Pooling of material collected in 1990-1995 may give a false picture of seasonal changes in body condition if substantial year-to-year variations occur, but the patterns we observed are similar to those obtained for East Ice harp seals by Siversten (1941). A pattern of poor spring and early summer condition followed by an improvement during late summer and autumn seems to occur not only in young-of-the-year, but also in harp seals in their second and third year of life. Similar observations have been made on adult East Ice harp seals (Nilssen *et al.* 1995c), and seasonal variation in body mass, blubber thickness, condition index and energy intake have also been observed in captive subadult and adult harp seals (Renouf *et al.* 1993; Lager *et al.* 1994).

The significance of early independent feeding as an energetic supplement is not known. It is, for example, uncertain whether survival of the pups is completely dependent upon the blubber stores established during suckling or whether they are able to compensate for an unsuccesful suckling period by increasing feeding soon after weaning. The energy deficit imposed by excessive depletion of the blubber layer would presumably be exacerbated by increased heat loss, necessitating an elevation in metabolic rate to maintain thermal homeostasis in the cold aquatic environment (Brodie & Paasche 1982, Worthy & Lavigne 1987). Mobilisation of energy reserves stored in the body core may reduce this effect (Nordøy *et al.* 1993), but the period from weaning until mid June seems to be critical for the pups. Their ability to perform intensive feeding sufficient to deposit energy stores appear to be good after June.

The trend towards decreased condition in West Ice harp seal pups in the post weaning period is generally consistent with the observations made in the East Ice, but it is difficult to attach any significance to the apparantly lower condition indices of ragged jackets in the West Ice as compared with the East Ice on the basis of data from a single year.

As has been observed previously (Sivertsen 1941, Nilssen *et al.* 1995b), most of the stomachs examined in March-April were empty. This could be indicative of rapid digestion by harp seal pups, and may also reflect a moderate feeding intensity during this period. Examination of intestinal contents revealed that the first food of harp seal pups was restricted almost exclusively to crustaceans, although there was considerable species variation between the two areas investigated.

The early post-weaning diet of East Ice harp seal pups was dominated by two types of prey: euphausiids (krill) and amphipods of the genus *Parathemisto.* The importance of crustaceans, and krill in particular, as first food for East Ice harp seals was emphasized by Siversten (1941).

While krill seems to be an important prey for the youngest animals, particularly during the first period after weaning, *Parathemisto* sp. has proven to be a prey of major importance for both pups and older harp seals of the East Ice stock during the intensive feeding period in late summer and autumn (Nilssen *et al.* 1995a).

The post-weaning diet of West Ice harp seal pups was also characterized by a dominance of amphipods of the genus *Parathemisto.* Unlike in the East Ice, krill appeared to be unimportant, but amphipods of the genus *Gammarus*, in particular *G. wilkitzkii*, contributed significantly to the diet of the harp seal pups in the West Ice. Information about the feeding habits of ragged jackets and beaters from the West Ice is extremely scarce, although Rasmussen (1957) reported to have observed beaters returning from dives with polar cod in their mouths in April. No fish species were recorded in the diet of harp seal pups in our study.

Gammarus wilkitzkii is an autochthonous sympagic amphipod of Arctic areas (see Gulliksen & Lønne 1991), and its frequent occurrence in the diet of West Ice harp seal pups suggest that the pups may perform their first feeding excursions beneath ice floes. According to Gulliksen & Lønne (loc.cit.), *G. wilkitzkii* is prevalent in the perennial sea ice zone, and this may explain why the species was present in the diets of the harp seal pups sampled in the multi year sea ice areas of the West Ice but was absent from the diets of pups sampled in the seasonal sea ice areas of the East Ice. Given its high degree of co-occurrence with *G. wilkitzkii* in harp seal stomachs/intestines, and its frequent occurrence close to the surface of sea ice, *Parathemisto libellula* may also have been taken by the seal pups as they foraged underneath the ice floes. However, *P. libellula* is classified as belonging to the sub ice fauna, due both to its lack of physical association with the lower layers of sea ice and to its frequent pelagic occurrence in cold water areas (Gulliksen & Lønne 1991, Lønne & Gulliksen 1991). This prey could, therefore, have been consumed by seals foraging in open waters.

The results of the present investigation confirm previous findings that crustaceans, *P. libellula* in particular, are of major importance as food for harp seals at certain times of the year (Sivertsen 1941, Sergeant 1973, Nilssen 1995, Nilssen *et al.* 1995a, Lindstrøm *et al.* 1996). The composition of the diet of the harp seal pups of the East Ice stock remains unknown for the period June to September, in September the diet is a mixture of *P. libellula*, krill, capelin and polar cod, and in October the diet mainly comprises capelin and polar cod (Nilssen *et al.* 1995a, Lindstrøm *et al.* 1996). Mårtensson *et al.* (1994) have shown that captive harp seal pups were unable to maintain body mass when fed a crustacean diet *ad libitum*, and they suggested that the seals would have to supplement the diet with fish in order to maintain growth. Our observations indicate that pups feeding on crustaceans in the post-weaning period lose condition from March to June. An increase in the contribution of fish to the diet in summer and autumn may have led to the increased body condition observed from June onwards. Also, the substantial increase in energy density that occurs both in crustaceans and in planktivorous fish during the summer and autumn may have been a contributory factor (see Percy 1993, Mårtensson *et al.* 1996).

As was observed for the harp seal pups, the bluebacks also started to feed independently soon after weaning. The blueback diet appeared to be very similar to that of the West Ice harp seal pups: a dominance of *Parathemisto* (almost exclusively *P. libellula*), with some contribution from *Gammarus* sp. (mainly *G. wilkitzkii*). This may indicate that the feeding behaviour of the harp and hooded seal pups is similar, and the possibility of interspecific competition can not be excluded may be inferred. In the last part of the investigation period there is some weak evidence that non-crustacean prey items (polar cod and the cephalopod *Gonatus fabricii*) may increase in abundance on the diet.

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Table 1. Frequencies of empty intestines and identified species of prey in intestines of East Ice harp seal pups (ragged jackets and beaters) captured in 1995 during the two periods 20-26 March and 24-30 April, respectively. N = number of intestines examined. "Others" include remains such as molluscs, hair and algae.

	20-26 March		24-30 April
	ragged jackets	beaters	beaters
N	151	85	4
Empty	9.9	16.5	50
Crustaceans			
Amphipoda			
Parathemisto libellula	6.0	8.2	0
Parathemisto sp.	20.5	54.1	50
Gammarellus homari	0.7	8.2	0
Lysianassidae indet.	6.6	4.7	0
Amphipoda indet.	0.7	3.5	0
Euphausiacea			
Thysanoessa sp.	25.2	49.4	50
Decapoda			
Decapoda indet.	0.7	3.5	50
Unidentified crustacea	1.3	7.1	0
Pisces			
Unidentified fish remains	0	1.2	0
Others	6.0	15.3	0
Digested remains	59.6	23.5	0

Table 2. Frequencies of empty stomachs and intestines and identified species of prey in stomachs/intestines of West Ice harp seal pups (ragged jackets and beaters) captured in 1995 during the periods 10-16 April, 17-23 April and 24-30 April, respectively. N = number of intestines examined. "Others" include remains such as hair and algae.

	10-16 April			17-23 April		24-30 April
	ragged jackets		beaters	rag.jack.	beaters	rag.jack.
	stom.	intest.	intestines	intestines		intestines
N	73	73	1	26	6	9
Empty	87.7	2.7	0	15.4	0	0
Crustaceans						
Copepoda						
Copepoda indet.	0	0	0	11.5	16.7	11.1
Amphipoda						
Parathemisto libellula	5.5	52.1	100	57.7	100	55.6
Parathemisto sp.	4.1	47.9	100	57.7	100	44.4
Gammarus wilkitzkii	5.5	43.8	100	38.5	66.7	44.4
Gammarus sp.	2.7	26.0	0	26.9	33.3	33.3
Eusirus sp.	0	6.8	0	11.5	16.7	11.1
Lysianassidae indet.	1.4	27.4	0	26.9	50.0	33.3
Amphipoda indet.	1.4	8.2	0	7.7	16.7	0
Euphausiacea						
Thysanoessa sp.	0	0	0	7.7	16.7	0
Unidentified crustacea	0	0	0	11.5	0	0
Others	1.4	2.7	0	3.8	0	11.1
Digested remains	1.4	32.9	0	11.5	0	22.2

Table 3. Frequencies of empty stomachs and intestines and of stomachs/intestines containing identified groups of prey of West Ice hooded seal pups (bluebacks) captured in 1995 during the periods 3-9 April, 10-16 April, 17-23 April and 24-30 April, respectively. N = number of stomachs/intestines examined. "Others" include remains such as hair and algae.

	3-9 April		10-16 April		17-23 April		24-30 April	
	stom.	intest.	stom.	intest.	stom.	intest.	stom.	intest.
N	1		39		181		15	
Empty	100	0	87.2	38.5	70.9	19.6	80.0	0
Crustacea								
Copepoda								
Copepoda indet.	0	0	0	2.5	0	0.6	0	0
Amphipoda								
Parathemisto libellula	0	0	10.3	46.2	25.7	67.0	20.0	86.7
Parathemisto sp.	0	0	2.6	25.6	10.1	33.0	6.7	66.7
Gammarus wilkitzkii	0	0	5.1	15.4	8.9	16.8	6.7	33.3
Gammarus sp.	0	0	0	5.1	1.7	3.4	0	13.3
Eusirus sp.	0	0	2.6	0	4.5	14.0	0	26.7
Lysianassidae indet.	0	0	0	2.6	0.6	2.8	0	0
Amphipoda indet.	0	0	0	0	0	0.6	0	6.7
Euphausiacea								
Thysanoessa sp.	0	0	0	0	0	0.6	0	6.7
Decapoda								
Decapoda indet.	0	0	0	0	2.2	6.7	0	13.3
Unidentified crustacea	0	0	0	2.6	1.7	6.1	0	6.7
Cephalopods								
Gonathus fabricii	0	0	0	0	1.7	2.8	6.7	13.3
Pisces								
Boreogadus saida	0	0	0	2.6	1.7	6.1	0	6.7
Gadoidea indet.	0	0	0	0	0	0.6	0	6.7
Unidentified fish	0	0	0	0	0	0.6	0	0
Others	0	0	1.9	2.6	16.2	2.2	13.3	6.7
Digested remains	0	100	0	5.1	0	5.0	0	0

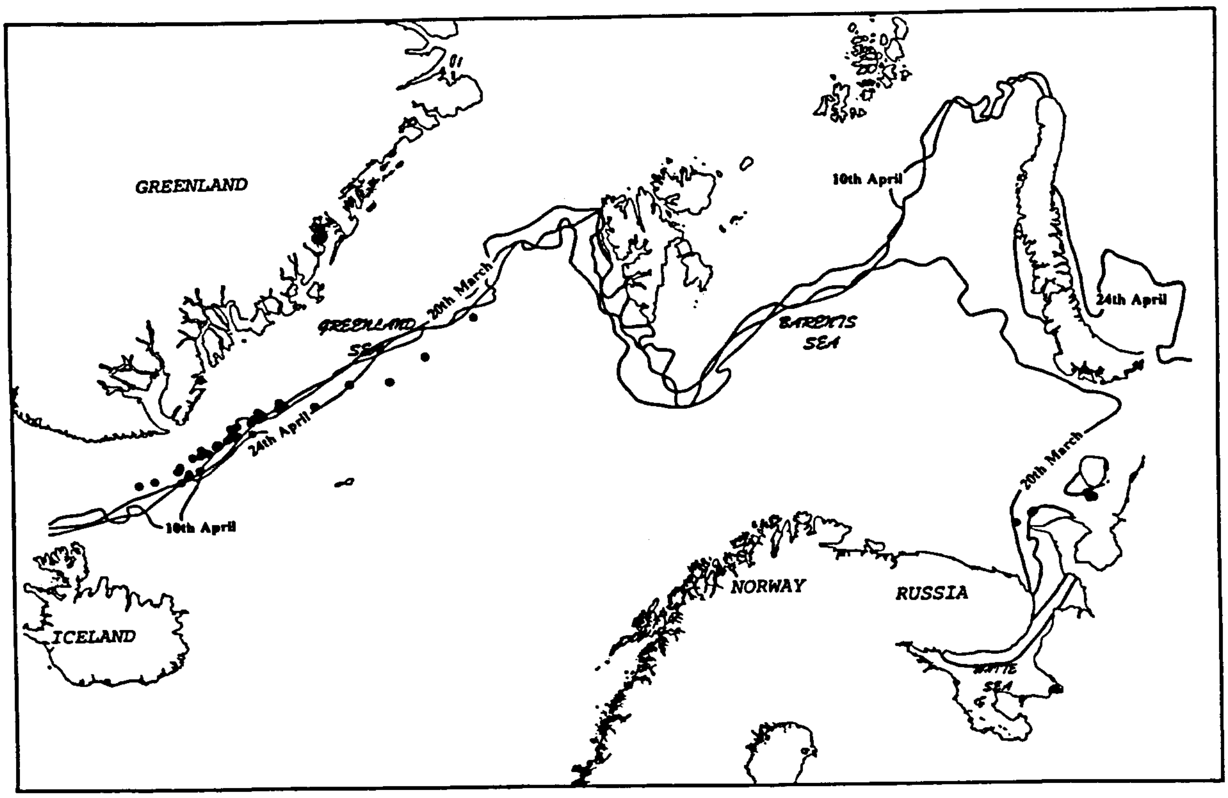

Fig. 1. Map showing the 1995 catch positions of the seal pups (filled circles) in the southeastern Barents Sea (the "East Ice") and in the Greenland Sea (the "West Ice"). Approximate localisations of the ice edge at the beginning, in the middle and by the end of the period of investigation are indicated (Source: The Norwegian Meteorological Institute, PO Box 43 Blindern, N-0313 Oslo, Norway).

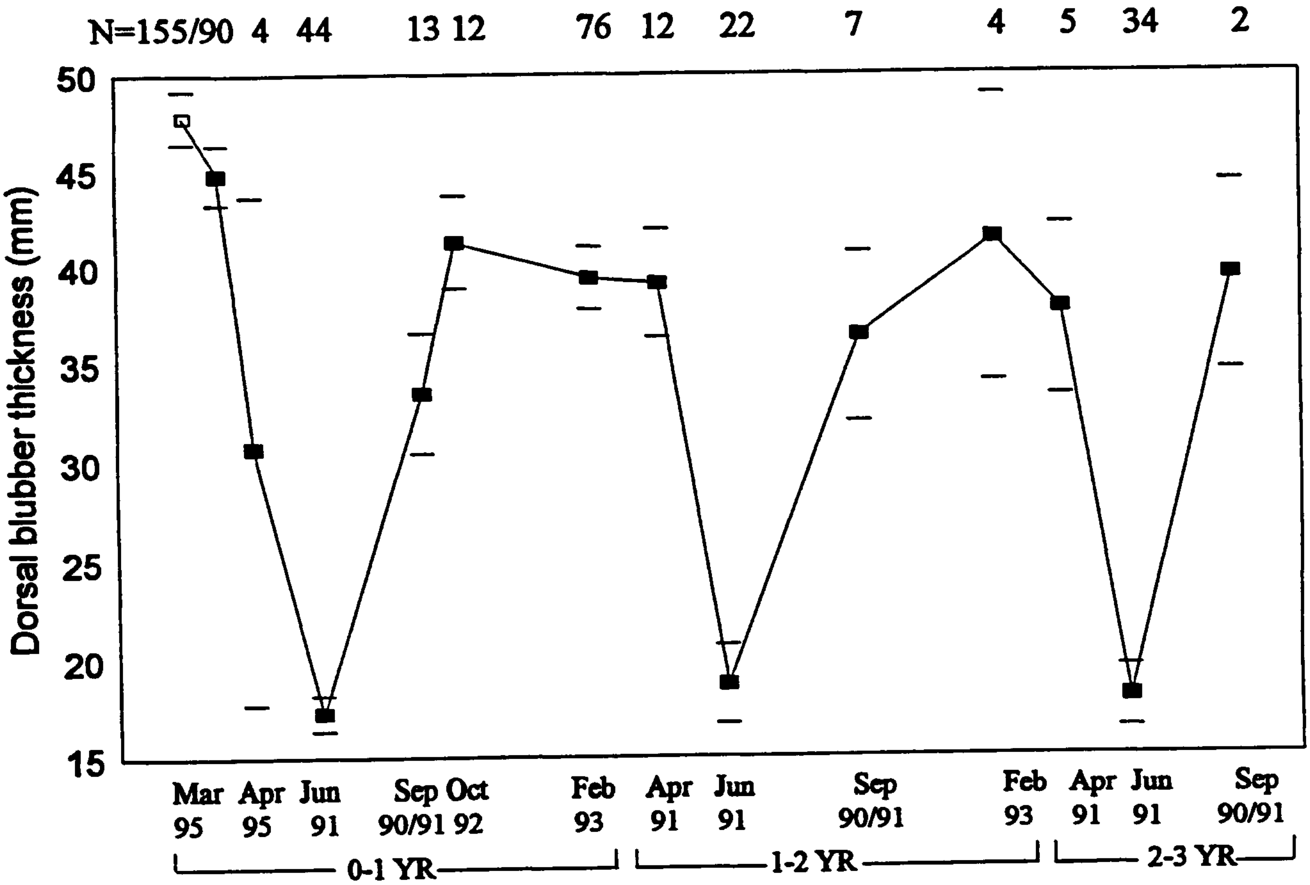

Fig. 2. Seasonal variation in dorsal blubber thickness (mean ± 95% CI) of young harp seals during their first three years of life in the East Ice and Barents Sea. Data collected during different years are pooled. Open squares = ragged jackets; filled squares = beaters; N = number of pups.

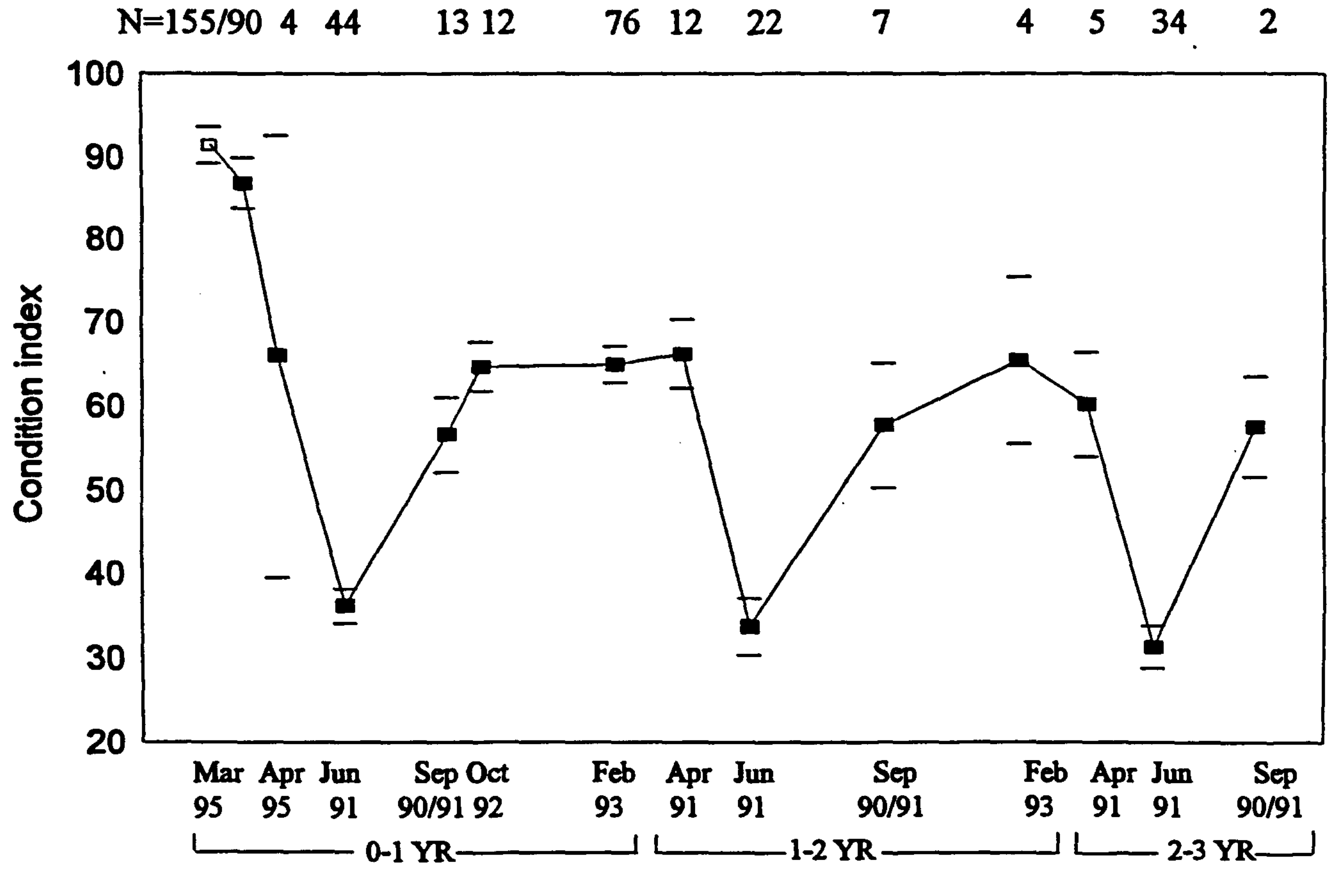

Fig. 3. Seasonal variation in body condition index (mean ± 95% CI, see text for definition of the index) of young harp seals during their first three years of life in the East Ice and Barents Sea. Data from different years are pooled. Open squares = ragged jackets; filled squares = beaters; N = number of pups.

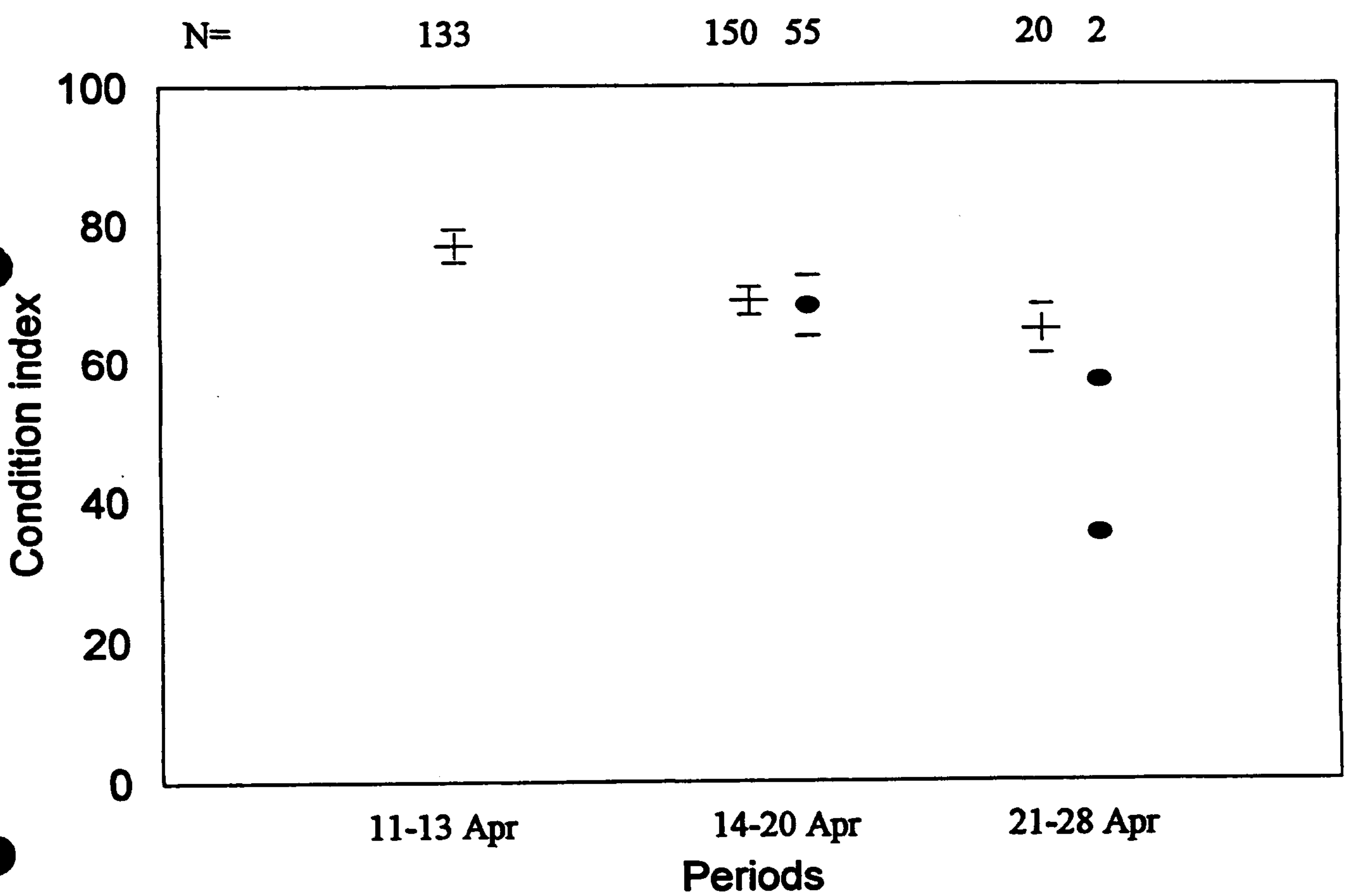

Fig. 4. Weekly variation in body condition index (mean ± 95% CI, see text for definition of the index) of harp seal pups in the West Ice during April 1995. Crosses = ragged jackets; filled circles = beaters; N = number of pups.

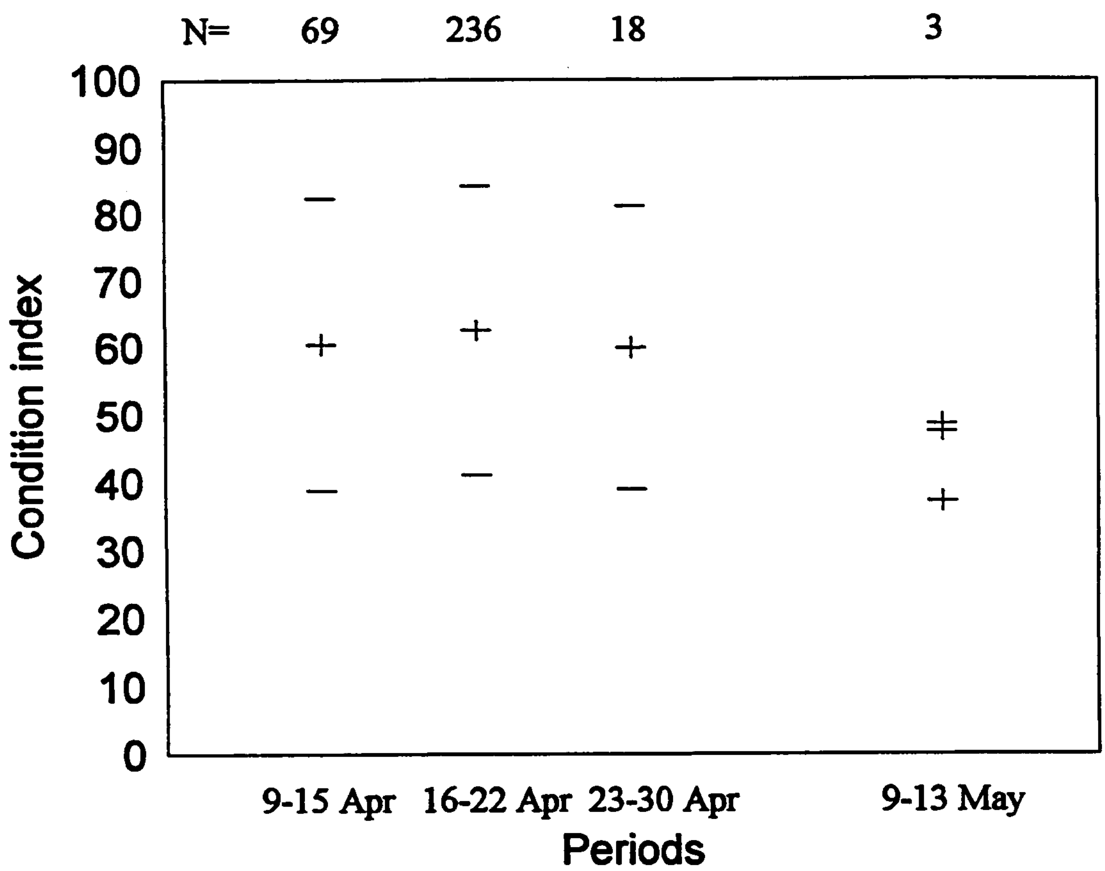

Fig. 5. Weekly variation in body condition index (mean ± 95% CI, see text for definition of the index) of hooded seal pups in the West Ice during April and May 1995. N = number of pups.

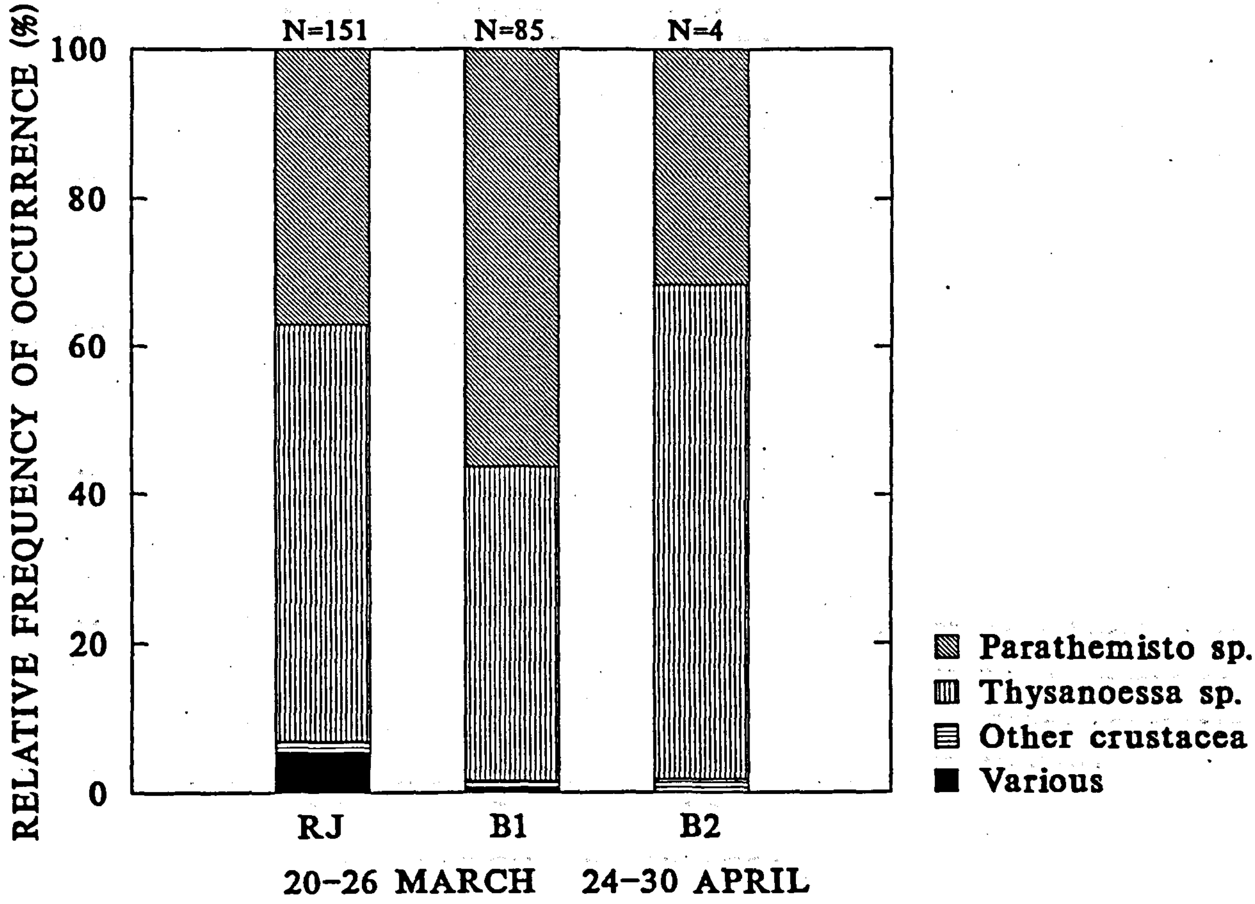

Fig. 6. Relative numerical frequency of occurrence of prey species in intestines of East Ice harp seal pups (ragged jackets: RJ; beaters: B) during two periods (1 = 20-26 March; 2 = 24-30 April) in 1995. N = number of intestines examined.

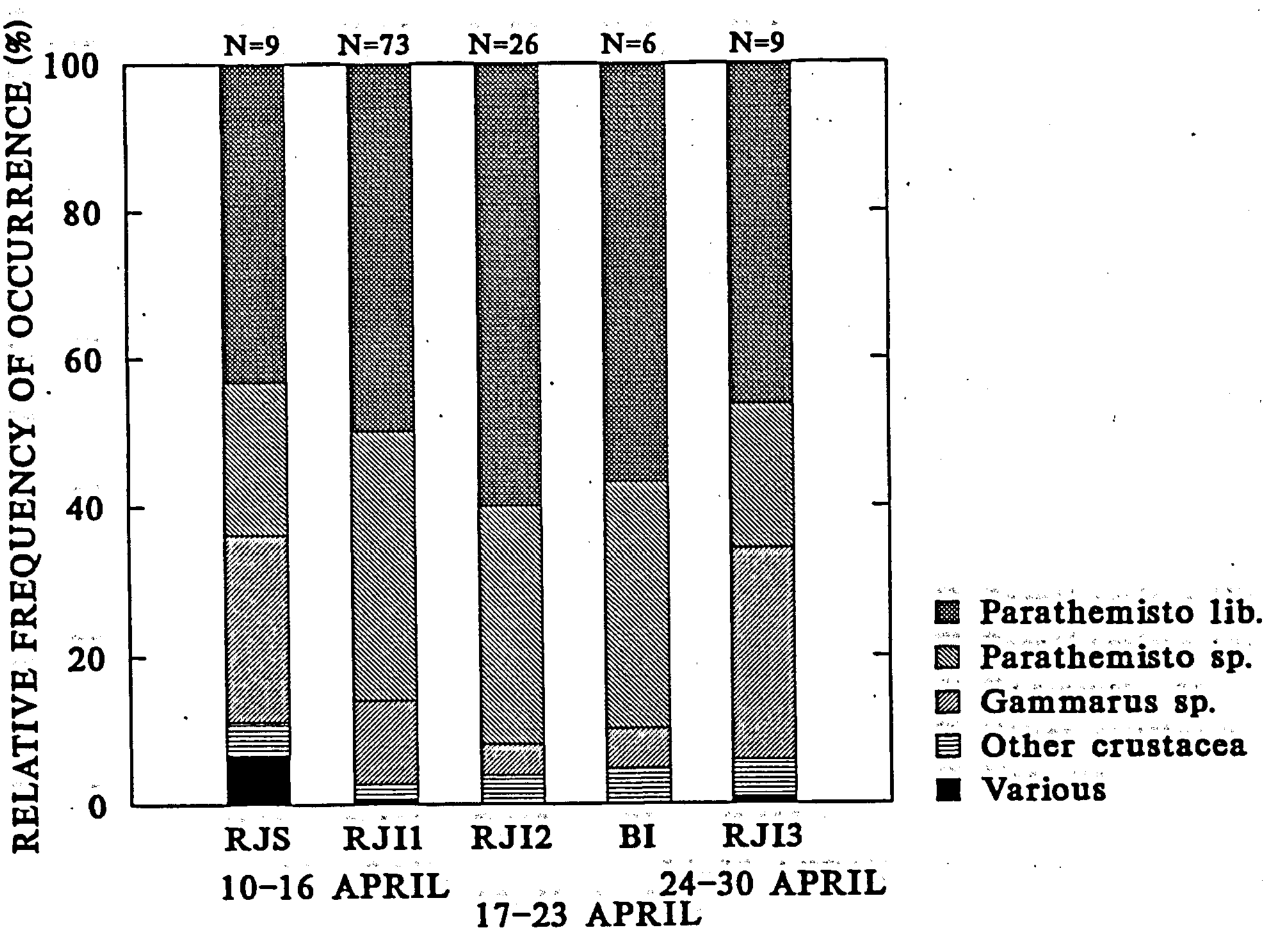

Fig. 7. Relative numerical frequency of occurrence of prey species in stomachs (S) and intestines (I) of West Ice harp seal pups (ragged jackets: RJ; beaters: B) during three periods (1 = 10-16 April; 2 = 17-23 April; 3 = 24-30 April) in 1995. N = number of stomachs/intestines examined.

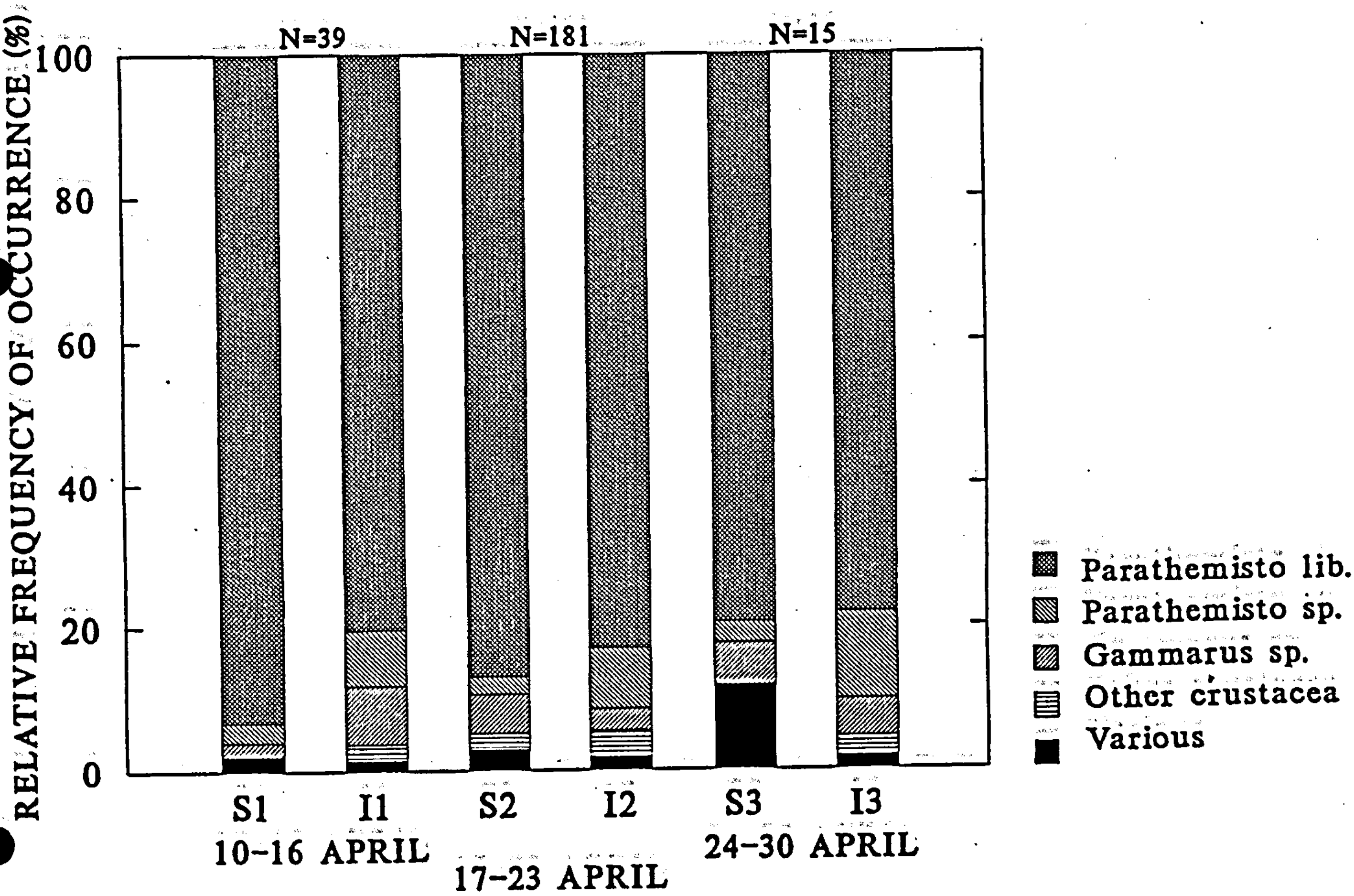

Fig. 8. Relative numerical frequency of occurrence of prey species in stomachs (S) and intestines (I) of West Ice hooded seal pups during three periods (1 = 10-16 April; 2 = 17-23 April; 3 = 24-30 April) in 1995. N = number of stomachs/intestines examined.