MASTER THESIS IN ECOLOGY/ZOOLOGY

A survey of the riparian Coleoptera fauna along the river Altaelva after 15 years with regulation

Guro Saurdal

May 2005

The river Altaelva; Ellilaholmen and Aronnes

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Department of Biology
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EIT ORD

Eit ord – ein stein i ei kald elv.
Ein stein til –
Eg lyt ha fleire steinar for å koma yver.

Olav H. Hauge – Dropar i austavind (1966)

Takk til alle som har hjulpet meg å legge steiner i elva! Først og fremst må jeg få takk Johan Andersen min veileder for engasjerende og svært lærerike samtaler, og for å la meg få bruke noe av hans upubliserte materiale. Takk til Roger Sværd i NVE Narvik for rapporter og kommentarer angående Altavassdraget. Takk til Jonathan, Åshild, Eiliv og Kristoffer for gjennomlesning av oppgaven og verdifulle kommentarer. Sist, men ikke minst takk til familie og venner for ubetinget støtte og ei god studietid!

Tromsø (fredag) 13. mai 2005

Guro Saurdal

CONTENT

Abstract

The riparian Coleoptera fauna of the river Altaelva, Finmark County, Northern Norway, has been surveyed in summer 2002 and 2003. The river Altaelva has been regulated since 1987, and my objective was to investigate the effect of the regulation on the riparian fauna. In total, 37 localities were examined, and four methods were used: hand collecting, washing without area limitation, quadrate sampling with washing and pitfall trapping. In sum, 2949 beetles were sampled, representing 88 species among which 27 were riparian. The majority of the species recorded from before the regulation, were also found in this survey, and their habitat distribution were in accordance with the literature. The species that were not found again are lithophilous. Four species were recorded for the first time in the Alta region. The impact of flood prevention walls and the effects of tributaries are discussed. In addition, the viability of the *Cicindela maritima* population and the importance of secondary, anthropogenic habitats are also considered. It is recommended that the annual water regime remain unchanged and that building of new flood prevention walls and other constructions are avoided.

1. Introduction

The Convention on Biological Diversity (1992) strongly emphasizes the importance of protecting biodiversity. This Convention considers habitat fragmentation, degradation, and outright loss of habitats as the gravest threat to biodiversity.

In this context, damming of rivers has been identified as one of the most dramatic and widespread deliberate impact of humans on the natural environment (Dynesius and Nilsson 1994). Besides flow regulation, reduction of inundation areas by flood prevention walls constitutes a serious impact on riverine systems (Stelter et al. 1997). As a result, the terrestrial invertebrate fauna on the river banks may be threatened. Today, several Norwegian river systems have shown a clear decline regarding invertebrate populations and 44 riparian (i.e. main or exclusive occurrence on river banks with mineral soil) species are now red-listed (DN 1999). Most of these threatened invertebrates belong to the families Carabidae and Staphylinidae and represent unique elements in the Norwegian nature. Fennoscandia has 67 riparian species, among which nine species are found almost exclusively in Norway (Andersen and Hanssen 2004).

This fauna of riparian Coleoptera is highly adapted to its environment and has specific requirements regarding the substrate, moisture and more or less vegetation-free river banks (Andersen and Hanssen 1994). River banks are not static habitats and depend constantly on disturbances created by floods. Floods are responsible for the periodic creation of new habitat openings and repeated onsets of vegetation succession (Bonn and Kleinwächter 1999).

On the other hand, damming generally causes an altered flow regime in the river downstream to the dam. The alteration depends on the extent of flow regulation and the management strategy. Generally, there is a leveling in the water-flow throughout the year, with limited water discharge in the spring and a greatly increased winter flow (Sundborg 1977, Englund and Malmqvist 1996). Flood prevention walls alter the original habitats and their fauna (Andersen and Hanssen 1994), as well as influence the erosion processes and floodplain deposition

(Sundborg 1977, Poff et al. 1997). These effects combined may result in a reduced erosion of the elevated zones of the banks. Hence, the zones would be affected by enhanced vegetation succession, the banks will narrow and the riparian fauna will face competition from more widespread and opportunistic species (Berglind, Ehnström and Ljungberg 1997). Along this succession, the species confined to sand and silt areas are thought to be the most vulnerable to the effects of regulation as this habitat is the first to be overgrown by vegetation (Andersen and Hanssen 1994). In contrast, the group consisting of lithophilous species is supposed to be the least vulnerable to the effects of regulations.

The river Altaelva in Finmark County has been regulated since 1987. However, the banks along the river were well surveyed before the regulations took place. From several surveys between 1821 and 1953 (Strand 1946, 1953) it is known that the river had the highest number of riparian species of all the rivers in Finmark County (Andersen and Hanssen 2004), with 34 riparian and 10 not strictly riparian species recorded from Alta (Strand 1946, 1953).

My thesis is focusing on the status of the riparian fauna 15 years after this regulation started. I have compared the diversity of species with the diversity before the regulation took place. The status of the riparian fauna is evaluated in relation to the frequency and extent of the different habitats and the occurrence of habitats is seen in the light of sedimentation- and inundation conditions. It is accounted for the possibility that species have changed microhabitat because of altered habitat availability. Special attention was given to the psammophilous (i.e. species restricted to areas with pure sand without or with sparse vegetation) tiger beetle *Cicindela maritima* Latreille & Dejean which was recorded from Elvestrand, Alta (Strand 1946).

2. Materials and methods

2.1 Description of the Altavassdraget river system

The Altavassdraget river system is located in the western part of Finnmark County, with its outlet in the Altafjord. The catchment area is located in the northern boreal and alpine zone and the river valley in the middle-boreal zone (Moen 1998). The survey was conducted along the main channel from the outlet and 26 km upstream to Bollo (Figure 1). Table 1 gives the main characteristics of the river system and the regulations in question.

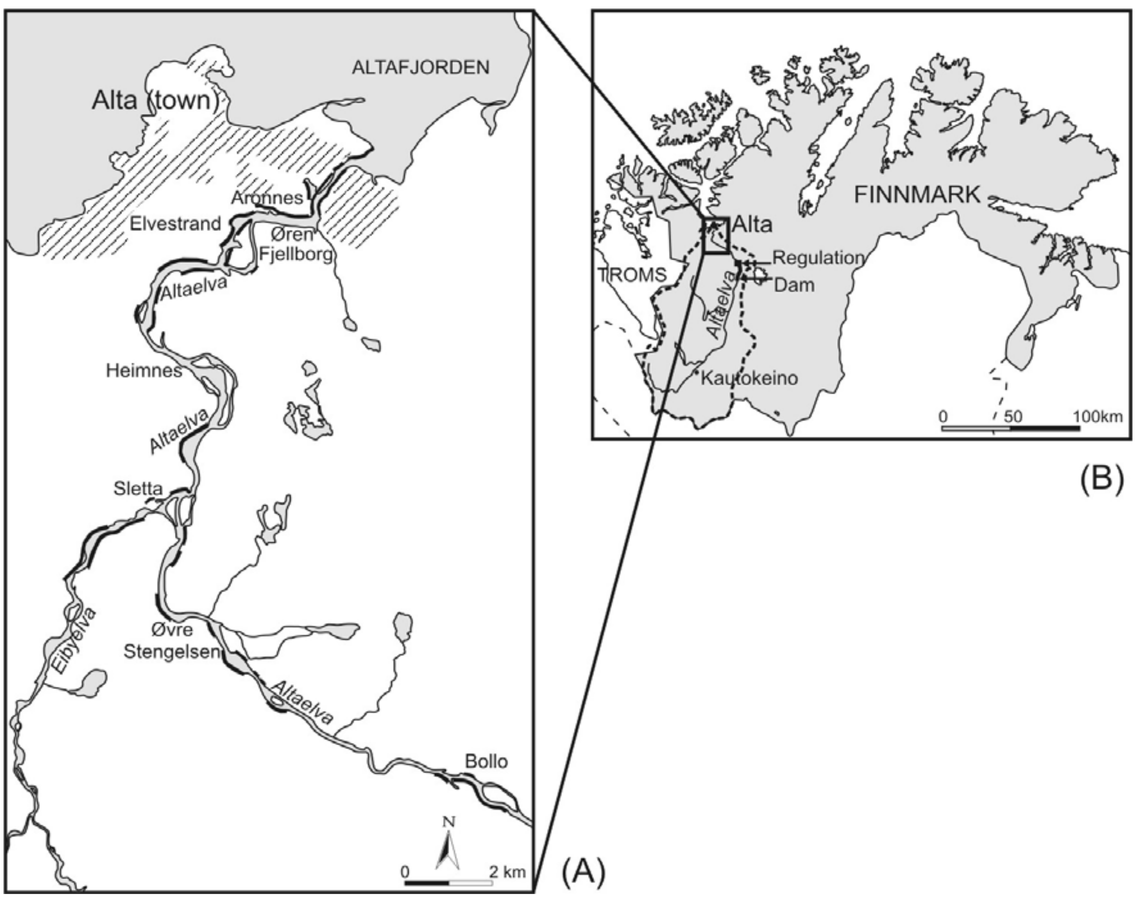

Figure 1. (A) Study sites along the river Altaelva. The catchment area in Finnmark County (B). Bold lines along the river indicate flood prevention walls.

Table 1. The main characteristics of the river system and the regulations.

Main characteristics	Source
Catchment area: 8961 km^2	NVE Atlas
Average annual discharge: 84 m^3/s	Dynesius 1994
Main river channel length: 170 km	Sværd 2003
Distance from the outlet to the dam: 40 km	Sværd 2003
Flow regulation: 5%	Dynesius 1994
Flood-prevention walls, downstream to the dam: 16.5 km	NVE Atlas
Bottom encroachments, downstream to the dam: 3.9 km	NVE Atlas

Dynesius (1994) states the Altavassdraget river system to be a moderately affected, medium sized river. Figure 2 shows the average annual flow in the river before and after the regulation started, measured by Stengelsen water gauging station. The Figure shows that there are only moderate alterations in the water flow throughout the year after the regulation took place. The most important being a somewhat higher winter flow and a slightly lesser average flood. There may also be a small displacement in time for the flood peaks, especially for the small floods (Figure 3,4). Figure 5 shows the extent of floods in a historic view (Sværd 2003).

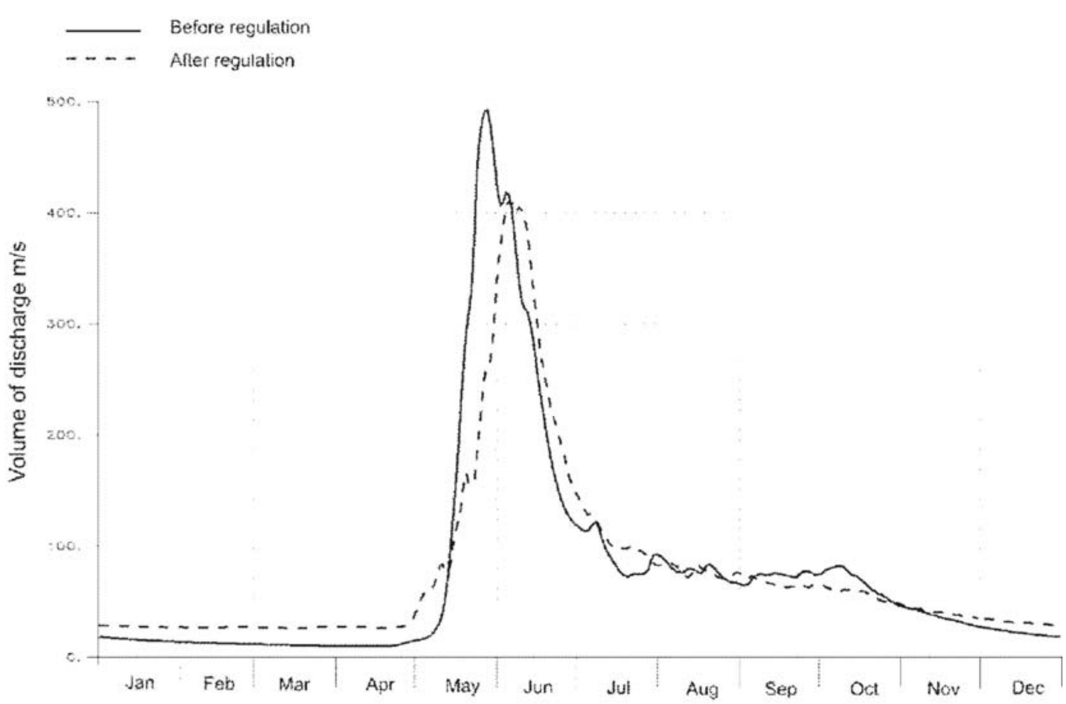

Figure 2. Average middle annual flow in the river Altaelva, before and after the regulation took place in 1986. Average 24 hours values; data from Kista water gauging station, 1972 to 1986 and 1987 to 2002.

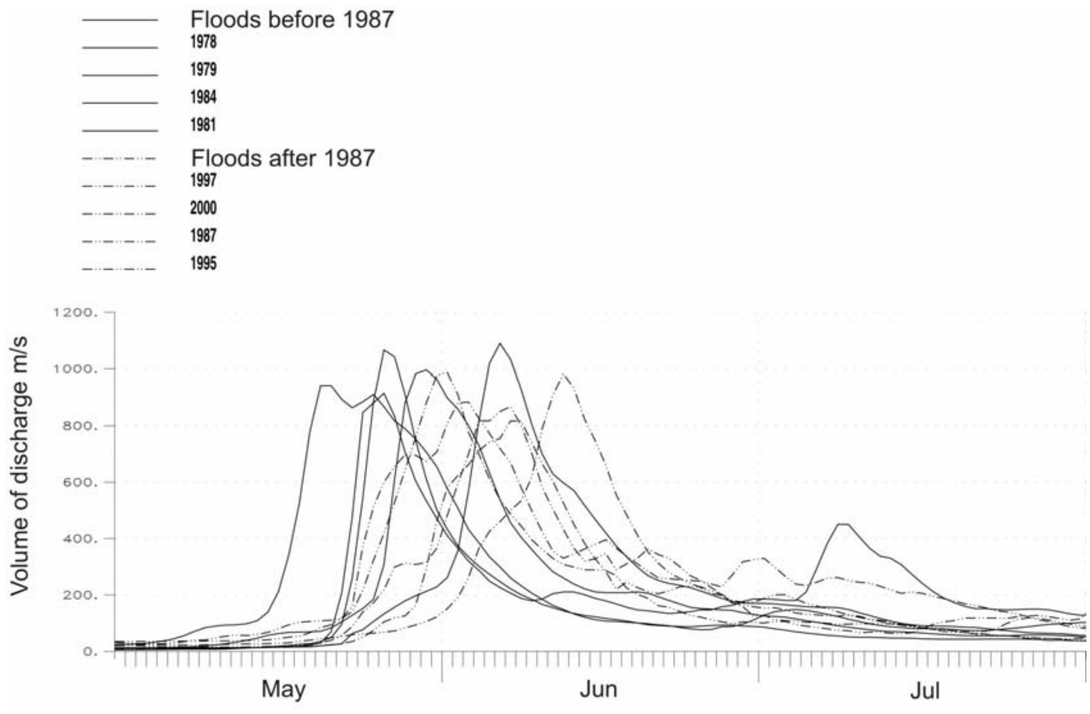

Figure 3. Placement in time of the five largest floods both before and after the regulation took place in 1986. Data from Kista water gauging station.

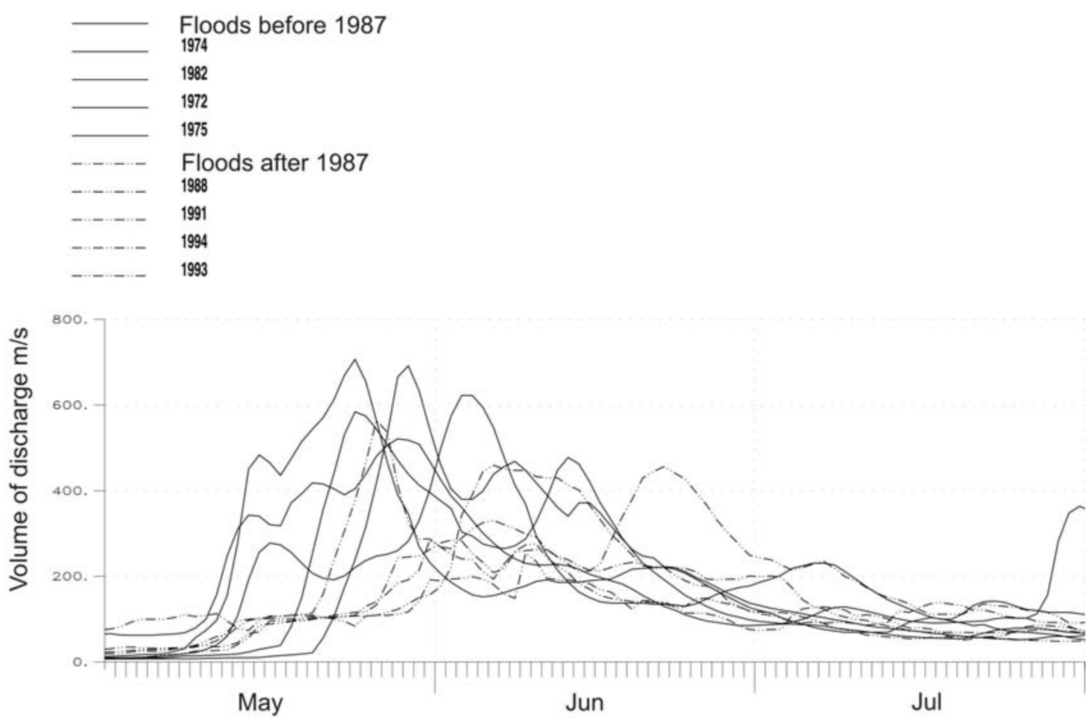

Figure 4. Placement in time of the five smallest floods both before and after the regulation took place in 1986. Data from Kista water gauging station.

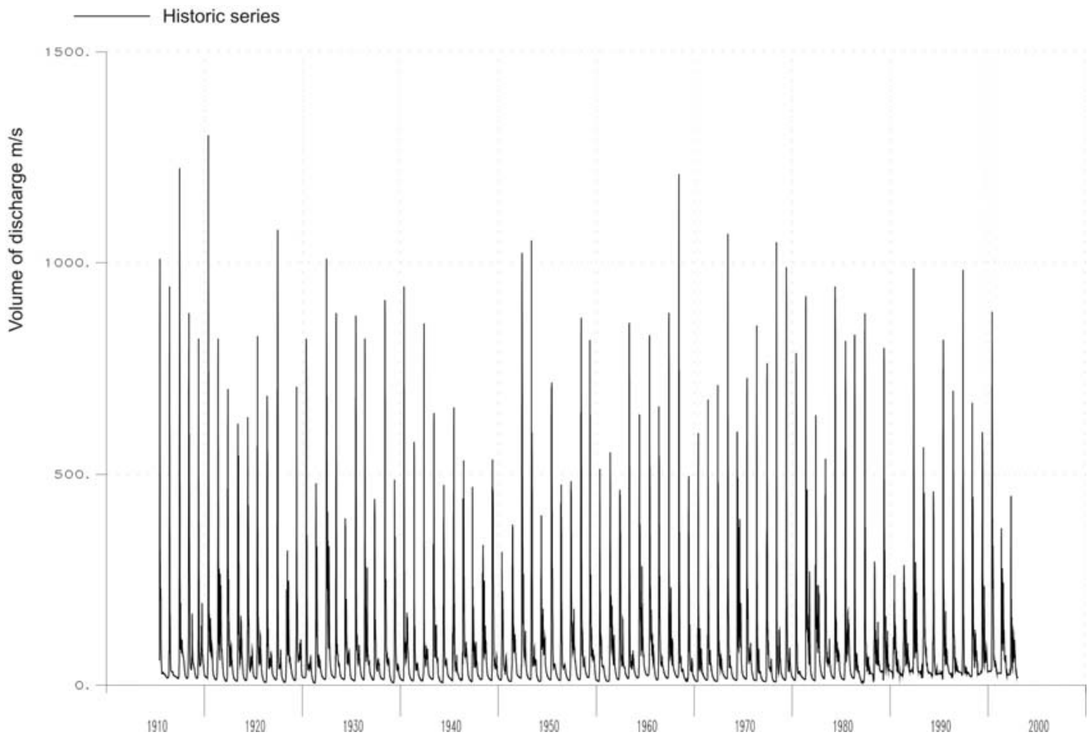

Figure 5. Historic series of floods from 1910 to 2003. Data are from Stengelsen water gauging station 1910 to 1990 and from Kista water gauging station from 1991 to 2003.

The flood prevention walls are mainly located in the lower 10 km of the main channel, i.e. close to the town of Alta and agricultural land (Figure 1). In accordance with the EU-Water Framework Directive (2000), the amount/dimensions of constructions should not be classified as moderate or worse (Størset et. al 2004).

The spring and summer in Alta were warm in 2002 and 2003. The average middle temperature for the months of April throughout June was 2.6°C and 1.2°C in 2002 and 2003, respectively, which was warmer than the normal period during 1961-1990. The weather conditions during the investigation have generally been favorable (above 9°C, no rain, KDVH 2005) to secure a high chance of discovery of the beetles.

2.2 Sampling methods

The sampling was carried out during three days in June 2002 and two one-week periods during July and August 2003. Pitfall traps were open for nine weeks in 2002 and 2 weeks in 2003. Three localities (i.e. Øren, Elvestrand, and Øvre Stengelsen, Figure 1) with a large diversity in microhabitats were investigated during each period. In addition to these three areas, and in order to have a greater coverage from different habitats, 34 other locations along the river were investigated.

Four sampling methods were used; A) hand collecting, B) washing without area limitation, C) quadrate sampling with washing, and D) pitfall trapping. These four methods are well suited to sample the Coleoptera species on river banks (Hammond 1998). The transition zone between the river banks and the fluvial forest was not included in this study.

A) Most of the investigations were based on timed hand collecting. This method allows sampling a wide diversity of epigeic species. In addition, this method was used for the purpose of habitat distribution of the species. This method gives a good indication on the relative abundance of the different species within microhabitats. When the investigation time is taken into consideration, timed hand collecting also gives indication on the relative abundance of the different species between microhabitats (see discussion) (Andersen 1983a). The beetles were picked by hand and the time used in the investigation was noted. Places with no or sparse vegetation were investigated by moving slowly and with continuous monitoring. Loose material, gravel and vegetation were systematically removed (Andersen 1970a).

B) The method involving washing without area limitation samples the diversity of the hypogeal fauna, and gives good estimates of the relative abundance of the different species within the microhabitat. This method was performed in fine sand and silt habitats in areas with an anticipated high abundance of *Bledius* sp., i.e. in areas with a high abundance of surface castings. The beetles were collected by removing the uppermost 15 cm soil layer. The block of soil was then thoroughly washed in a bucket filled with freshwater. The beetles were collected as they floated to the surface (Evans 1971). Beetles found at the surface belonging to the soil block were included in the sample (Andersen 1968).

C) Quadrate sampling is a reliable method to determine the absolute abundance of species in a microhabitat (Andersen 1995), and was used to determine the absolute maximum abundance of the hypogeal fauna. In areas with a very high density of surface casting, quadrate sampling of areas of 0.125 m^2 were undertaken, following the same procedure as for washing (see section B).

D) The pitfall trapping method gives good qualitative data (Lövei and Sunderland 1996), and was used to sample a wide diversity of species. However, there are several biases hampering the method (vide Spence and Niemelä 1994, Lange 2000). Changing river level may have affected some capture results (Andersen 1983b). Pitfall traps also overestimate the number of large and mobile species (Andersen 1995, Standen 2000), and have a tendency of overestimating species in sub-optimal microhabitats (Andersen 1995). Hence, the method does not give a correct relative abundance of the species, and the data was not used for the purpose of habitat distribution (Arneberg and Andersen 2003). The trap lines were set in fine sand and silt habitats within the localities Øren, Elvestrand and Øvre Stengelse. In 2002, plastic jars were set 1 m apart following a pattern consisting of five traps in one line, and in 2003, they were changed to ten traps in one line. Totally, there were eight and nine trap lines in 2002 and 2003, respectively, and this gave a total of 6700 trap days. The plastic cups were filled with a salt solution and a drop of detergent, and a cover was suspended a few centimeters above the trap.

The following information was consistently recorded for each sample and trap line:
Type of substrate was classified as clay, fine sand with silt, sand or gravel. Moisture content was ranked as saturated, moist or dry, and light intensity as exposed, semi-exposed or shaded. Coverage by herbaceous vegetation was judged according to the scale of Hult - Sernander (Nordhagen 1943): 1 (sparse vegetation) to 5 (more or less dense vegetation). Weather condition and time of sampling was noted. In addition, the size of the stone, gravel, silt, and sand areas were estimated.

The size of the *Cicindela maritima* populations was estimated by counting the number of larval holes (Gärdenfors 2002, Berglind 2004). These burrows were distinguished from those made by other species because of the perfect circularity of the holes, the lack of surface castings, and the constant diameter of the holes of each larval stage (Gärdenfors 2002). To collect a proof of the existence of the species an attempt was made to hand collect imagines.

2.3 Analysis and treatment of the material

Information on the presence of the species studied at Alta prior to 1987 was obtained from data by Strand (1946, 1953). The autecology of the riparian and non riparian species was taken from works by Lindroth (1945), Palm (1948, 1961, 1963, 1968, 1972), Hansen (1954a,b,c, 1966, 1968a,b, 1973), Andersen (1970a, 1970b, 1980, 1982, 1983a, 1997, unpubl. data), Andersen and Hanssen (1994, 2004), Eyre, Lott and Luff (2001) and Eyre, Luff and Phillips (2001). A species was classified as euryoecious if it was recorded according to the literature from several habitats, both within and outside the riverbank (Lott 2003).

Relative abundance of the species in the different microhabitats was estimated as the number of hand-collected specimens per 10 min interval. The microhabitats of stone, gravel and sand were separated according to the moisture content (Eyre, Luff and Phillips 2001). The microhabitats of silt and fine sand were separated using the following variables: exposure from the sun, vegetation cover and moisture (see ref. above). The same procedure was applied for species collected by washing.

Chi-square tests were used to test whether there were significant differences in the microhabitat distribution of the species. Using the hand collected data there was only enough data to test five species from the stone and gravel microhabitats. The data from moist and dry sites were pooled together and tested against the saturated site.

The nomenclature follows Silfverberg (2004), with the exception of the species *Hypnoidus consobrinus* (Mulsant & Guillebeau) and *H. rivularius* (Gyllenhal). Silvferberg (2004) synonymies this species, whereas in this thesis, they have been treated as separate species according to Freude et al. (1979) and Andersen (2005).

3. Results

3.1 Size of the material

In the present survey, 2949 specimens were sampled. These were comprised of 88 species and 12 families. The material consisted of 27 riparian species and 8 not strictly riparian species (Table 2). The list of non-riparian species is given in Appendix 1.

Table 2. Riparian species recorded at Alta before and after the regulation started. x = recorded from Alta before 1986, digits indicate total number of specimens collected, [x], [1] = see text for comment.

Species	Red-listed species	**Riparian species Alta before 1987**	Not-strictly riparian species Alta before 1987	**Riparian species Alta 2002/03**	Not-strictly riparian species Alta 2002/03
CARABIDAE					
Cicindela maritima	*	**x**		**1**	
Dyschirius angustatus	*	**x**		**4**	
Dyschirius septentrionum		**x**		**11**	
Asaphidion pallipes		**x**		**14**	
Bembidion lapponicum	*	**x**		**3**	
Bembidion difficile			x		4
Bembidion prasinum		**x**		**273**	
Bembidion hyperboraeorum		**x**		**5**	
Bembidion hastii		**x**		**73**	
Bembidion mckinleyi scandicum	*			**1**	
Bembidion petrosum siebkei		**x**		**96**	
Bembidion schueppelii		**x**		**218**	
Agonum dolens					[1]
LEIODIDAE					
Sogda ciliaris	*			**5**	
STAPHYLINIDAE					
Geodromicus plagiatus			x		1
Geodromicus longipes			x		11
Coryphiomorphus hyperboreus		**x**			
Aleochara suffusa		**x**		**37**	
Devia prospera			x		
Parocyusa rubicunda		**x**		**143**	
Gnypeta coerulea			x		13
Brachyusa concolor		**x**		**1**	
Hydrosmecta subtilissima		**x**			
Aloconota eichoffi	*	**x**			
Aloconota strandi		**x**			

Table 2 Continued

Species	Red-listed species	**Riparian species Alta before 1987**	Not-strictly riparian species Alta before 1987	**Riparian species Alta 2002/03**	Not-strictly riparian species Alta 2002/03
Aloconota currax		**x**		**8**	
Philhygra britteni			x		
Philhygra ripicola			x		
Ochthephilus omalinus		**[x]**		**2**	
Ochthephilus strandi				**1**	
Thinobius brundini	*	**x**		**0**	
Thinobius munsteri	*	**x**		**0**	
Thinobius crinifer strandi		**x**		**0**	
Bledius arcticus		**x**		**7**	
Bledius poppiusi		**x**			
Bledius longulus		**x**		**29**	
Bledius erraticus		**x**		**558**	
Stenus ruralis		**x**		**23**	
Stenus strandi			x		2
Stenus subarcticus		**x**			
Philonthus subvirescens	*	**x**		**102**	
BYRRHIDAE					
Arctobyrrhus dovrensis	*	**x**		**2**	
Curimopsis paleata	*	**x**		**17**	
Curimopsis cyclolepidia			x		
ELATERIDAE					
Hypnoidus consobrinus	*	**x**		**1**	
Negastrius arenicola			x		162
Fleutiauxellus maritimus	*	**x**		**9**	
CURCULIONIDAE					
Pelenomus velaris		**x**		**8**	
Total individuals				1650	193

The pitfall trapping method sampled most specimens, with a total number of 1548 specimens from 6499 trap days. From fifteen washing samples and three quadrate samples it was collected 390 and 175 specimens, respectively. Hand collecting sampled 836 specimens in a total time of 30h 27min.

On two sites the populations were so large that not all the beetles could be put in glasses. This situation occurred in microhabitats close to the water edge in August 2003.

3.2 New faunistic records

Four new species were recorded in the Alta region:

Bembidion mckinelyi scandicum Lindroth

Sletta, 3 July 2003. One specimen was sampled on dry, stone and gravel riverbank.

Bembidion quadrimaculatum (Linnaeus)

Elvestrand, 20 June 2002. One specimen was found in fine sand and silt habitat with sparse vegetation.

Agonum dolens (Sahlberg)

Elvestrand, 21 June 2002. One specimen sampled in a backwater, in a site of fine sand and silts with saturated water.

Sogda ciliaris (Thomson)

Five individuals were sampled in pitfall traps at Elvestrand, in a site with mesic, fine sand and a top layer of silt and some vegetation.

3.3 Areal estimation of the stone and gravel, and silt and sand habitats

The total area of the 37 localities investigated was estimated to 1.43 km^2. The stone and gravel bars were continuous along the river. The silt areas investigated were scattered over nine localities along the stretch from the sea to Øvre Stengelsen and were estimated to 6900 m^2. Five sand bars were present along the river and the total area of these bars was roughly 7400m^2, with the following distribution: Øren 4500 m^2; Heimnes 1400 m^2; Fjellborg 800 m^2; Aronnes 600 m^2 and Øvre Stengelsen 50 m^2.

3.4 Habitat selection and abundance of the species

The habitat distribution of the species in the various microhabitats of the hand-collected species is shown in Table 3, while Table 4 gives result from the washing method.

Table 4. Distribution of species from washing without area limitation, digits represents the number of specimens collected.

		FINE SAND AND SILT SITES					
		Exposed				Semi-exposed	
		Veg. cover 1-3		Veg. cover 4-5		Veg. cover 1-3	
Species	Ecological group	Moist	Dry	Moist	Dry	Moist	Dry
CARABIDAE							
Bembidion schueppelii	Si/Sa	3			6		
STAPHYLINIDAE							
Bledius arcticus	Si/Sa		1			2	
Bledius longulus	Si/Sa, Sa	1					
Bledius erraticus	Si/Sa	101	59			126	90
ELATERIDAE							
Negastrius arenicola	Sa	1			2		
BYRRHIDAE							
Arctobyrrhus dovrensis	Si/Sa				1		
CURCULIONIDAE							
Pelenomus velaris	Si/Sa	1					

Results from chi-square tests revealed the distribution of *Bembidion prasinum* (Duftschmid) was significantly different from that of *B. hastii* Sahlberg*, B. virens* Gyllenhal*, B. petrosum siebkei* Sparre Schneider and *B. saxatile* Gyllenhal ($X^2 = \geq 3.97$; $p < 0.05$). In other words, *B. prasinum* was more dominating in saturated, stone and gravel habitats compared to the other species in that particular microhabitat (table 5).

Table 5. Abundance of species in stone and gravel microhabitats. Density represents the number of specimens in the microhabitat divided by total time collected in the microhabitat, per 10 min.

	Microhabitat	
Species	Saturated	Moist -dry
Bembidion prasinum	3.39	0.56
Bembidion hastii	0.59	0.44
Bembidion virens	0.14	0.28
Bembidion petrosum siebkei	0.63	0.45
Bembidion saxatile	0.26	0.37

In the quadrate sampling *Bledius erraticus* Erichson was collected with an average abundance of 684 specimens per m^2. *Bledius arcticus* J.Sahlberg, *Bembidion schueppelii* Dejean and *Dyschirius angustatus* (Ahrens) had abundance of 8, 8 and 16 specimens per m^2, respectively.

3.5 Larval burrows of Cicindela maritima

An imago of *Cicindela maritima* was observed by J. Andersen and G. Saurdal at Øren in June 2002. At the same site, one third-stage larva was collected 18th of August 2003 as a proof of the existence of the species. The population size on the 18th of August 2003 was approximated to a total of 176 larval holes at Øren and was distributed as follows: 44 first-stage larval holes (diameter 2.0mm); 46 second-stage larval holes (diameter 3.0 mm) and 86 third-stage larval holes (diameter 4.5 mm).

At Øren, the larval holes were found in two separated areas covering 25 m^2. The holes were located in the transition zone bordering more vegetated areas and in a slight incline of the terrain. The sand was relatively moist, fine and tightly packed with a thin top layer of silt.

There were also found burrows at Fjellborg and Aronnes. At these localities, it was recorded eight and 31 larval holes, respectively, and these larval areas had areas of 10 to 15 m^2. Attempts were made to dig and find larvae although no one was found. No larval hole was seen at the localities of Heimnes and Øvre Stengelsen.

4. Discussion

4.1 The present fauna of the river banks

Generally, the expected riparian species were found in the areas investigated, and only four species were recorded for the first time in the Alta region. All previously recorded riparian species in sand and silt habitats were collected in the present study with the exception of *Bledius poppiusi* Bernhauer and *Stenus subarcticus* Poppius. *B. poppiusi* is confine to small rivers and brooks (Andersen 1982). In Alta, Strand (1946) likely sampled the species in flotsam, and the species may thus have populations in the tributaries. The nearest known *B. poppiusi* - locality is by the river Skibotnelva (Andersen unpubl. data). *S. subarcticus* is a rare species. In fact, in recent years only one specimen has been sampled in northern Norway. This specimen was sampled by J. Andersen at the river Reisaelva in 2002.

The other riparian species that have not been found in this survey are lithophilous. The following species were not collected in 2002/03: *Coryphiomorphus hyperboreus* (Mäklin), *Hydrosmecta subtilissima* (Kraatz), *Aloconota eichoffi* (Scriba), *A. strandi* (Benick), *Thinobius brundini* Scheerpeltz, *T. munsteri* Scheerpeltz, and *T. crinifer strandi* Smetana.

Regarding the lithophilous species, there are several explanations for why some expected species were not found. These species are generally rare with low population densities, although some species may from time to time have high local abundance (*Thinobius* spp., *H. subtilissima*). Five of the species are small, with sizes ranging from 1.0 mm to 2.6 mm, and were thus difficult to detect. The time of the day (light condition), year/season (imago vs. larvae) and the weather condition (degree of activity and light condition) are important factors when the specimens are searched using hand colleting. The species were previously found in the lowest zone of stone and gravel, although *Thinobius spp*. and *H. subtilissima* may also occur in dryer zones. In this lower zone it is difficult to operate with pitfall trapping due to the influence from waves (Andersen 1995) and it is therefore not possible to rely on this method to sample these species. *C. hyperboreus* is mostly collected in small cold-water rivers and tributaries (Andersen unpubl. data).

Only four species were recorded as new in the Alta region. This was the following species:

Bembidion mckinelyi scandicum

The species was probably overlooked in earlier investigations. The species is mainly composed of a majority of adults only in June – July and this demands a well-planned collection. The locality Sletta is situated at the outlet of Eibyelva. The species is reported with preference to smaller rivers (Andersen 1970b) and the species may have populations at the banks of Eibyelva. One callow was taken at the main river by J. Andersen in July 2004 and this indicates that the species has a viable population at this river. The species has a distribution in Fennoscandia in Troms and Finmark (Andersen and Hanssen 2004) with the nearest locality at Kvænangselva (Andersen 1970b).

Bembidion quadrimaculatum

This species is not regarded as riparian, but belongs to the fauna of open, dry, and commonly anthropogenic habitats. This ecological group benefits from anthropogenic activities (Andersen 2000, Olberg and Andersen 2003) and *B. quadrimaculatum* may be in expansion in Northern Norway. The species has been found in inner parts of Finmark (Karasjokka, Anarjokka) and Reisadalen (Andersen 1980), and thereafter by S. Olberg and J. Andersen in Pasvik in 1999, and by J. Andersen on fallow fields at Moen and Olsborg in Målselvdalen in 1989-2004 (Andersen unpubl. data).

Agonum dolens

This species is probably rare at the river and is for that reason not collected earlier. The species is found on muddy freshwater fringes, but may also be confined to river banks in its northern distribution area (Andersen, unpubl. data).

Sogda ciliaris

The species has earlier been found in dry, anthropogenic habitats, e.g., fallow fields and sandpits, but are also sampled in flotsam and on dry sand along the river Gaula. This rare species is suggested to be primarily riparian.

Thus, the new species recorded are probably rare or were previously overlooked. The riparian species is a group with restricted habitat requirements, and inhabit isolated macrohabitats as large rivers that are sparsely distributed in northern Norway. Dispersal and colonization between rivers are thus unlikely, and the species are not thought to be in expansion (Andersen and Hanssen 2004).

Regarding *Ochthephilus strandi* (Scheerpeltz), this species has not been recorded from the Alta region before. However, it can not be confirmed that this is a new species in the region. Strand (1946) recorded *Ochthephilus omalinus* (Erichson) from Bossekop, Alta. In 1950, *O. omalinus* was divided into two species: *O. omalinus* and *O. strandi*, thus it can not be stated which Strand found, one of them or both.

4.2 Habitat distribution

The species were generally distributed according to results reported elsewhere (see ref. above). The density estimates gives an indication of habitat distribution. The investigation time per unit area is changing in a certain way; for example, it increases progressively from places with dense vegetation to places without vegetation. When the investigation time was taken into consideration, *Bembidion prasinum, B. hastii* and *B. petrosum siebkei* had a real optimum in the habitat as noted in the table, as they were sampled with a higher abundance in a habitat with more impediments i.e. stones, and thus within a smaller area (Andersen 1983a). As for the *B. schueppelii* and *Aleochara suffusa* (Casey) it can not be stated with assurance if they had a higher abundance in silt or sand, respectively. In fact, the literature shows that *B. schueppelii* has a preference for silt with rather dense vegetation. *Gnypeta coerulea* Sahlberg seems to be a rather euryoecious species (Andersen pers. comm.). The remaining species were sampled from one type of habitat or in small numbers.

The species also seem to have its distribution in microhabitats, which is in accordance with literature. Although, besides *Bembidion prasinum,* there are only indicia to this statement. In comparison of the density estimates, the investigation time per unit area is roughly equal within microhabitats of stone and gravel. Within microhabitats of silt and fine sand, the varying vegetation coverage has to be accounted for.

The results from the quadrate sampling were also consistent with those of unregulated rivers like, e.g., Gaula and Målselva. This gave indication of viable populations of the hypogeic fauna of fine sand and silt microhabitats. Andersen (unpubl. data) gave records from the river Gaula at 704 *Bledius erraticus* and 48 *Dyschirius angustatus* per m^2, from the river Målselv it is recorded 344 *Bledius arcticus* per m^2. Despite a small sample size, *Dyschirius angustatus* is assumed to have an acceptable population size as the main prey item are present in, what seems to be, normal densities. In addition, this species was also sampled at the river by J. Andersen in 2003 and 2004 (Andersen unpubl. data).

An unforeseen large percentage of the epigeal carabids were found at larval stage in both 2002 and 2003 because of a warm spring. However, these were not collected. In 2002, hypogeic imagines stayed most likely deep in the soil due to the extremely dry weather. Therefore, the sample size was not as large as the ideal situation but the general picture should provide useful information.

The stone, gravel and silt habitats were clearly present in sufficient areas and abundance as they were able to sustain viable populations of the species investigated.

The area of the sand bars at Altaelva is small compared with that of Karasjokka. From aerial pictures, the estimated length of the sand bars at Karasjokka was five km (NIJOS 1974). Nevertheless, Altaelva have viable populations of *Cicindela maritima*. The situation at Altaelva also gives an indication to the size sufficient to sustain a population.

According to Omland (2002), a North-American *Cicindela* - species is capable of moving one to three km along a river. If similar conditions are true for the *C. maritima* populations, of which the populations in Alta are located within 1 km, this could be considered as a metapopulation (Thomas 1994). A picture of these three populations as a metapopulation makes the populations more viable in Alta. Heimnes and Øvre Stengelsen are located six and 14 km apart, respectively, from the *C. maritima* localities. This may be too far for the species to colonize these areas. This species is a good flyer (Lindroth 1945) as it can actively direct its flight and therefore less subject of drifting by the wind (den Boer 1990). In August, the riverbank at Heimnes was heavily crowded with fishermen, cars and caravans, which may hamper a possible colonization (Berglind 2004).

The availability of habitats depends on several factors. As Figure 2-4 illustrate, the regulation has no large effect on the flow regime in general, i.e. the fluctuation in the water level, and the frequency and magnitude of floods. As a result, the flow regime maintains the river banks and habitats. In addition, an unregulated tributary, Eibyelva, contributes with extra volume of water (Figure 6, (Sværd 2003)) in the lower parts of the main channel. This outlet is located 15 km upstream from the sea. The tributary is assumed to be especially important during the floods as the rivers culminate the same day, or, with Altaelva one day after Eibyelva (Sværd 2003), which means that the main channel receives additional influence from the erosion processes. The tributary may also be essential in contributing with input of sand and silt to the main channel.

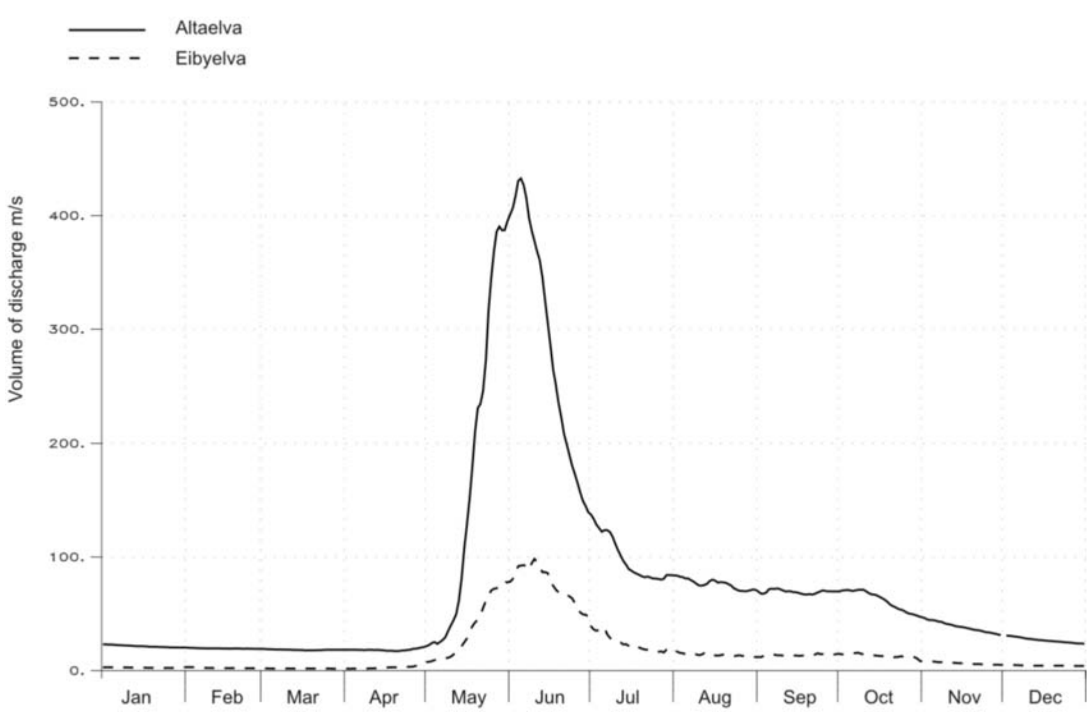

Figure 6. Average annual flow of water in the river Altaelva, represented by Kista water gauging station and the river Eibyelva. Middle values from the years 1972 to 2000.

The effects of the flood prevention walls were not extensive as several of the walls were located behind the river banks. Consequently, the exposed riverine sediments were preserved, including the hibernation sites. This positioning is important as most of the riparian species hibernate as adults in elevated parts of the riverbank or closer to the fluvial forest (Andersen 1968). However, some species hibernate, at least partly, as larvae on the river banks. Such species are *B. fellmanni* (Mannerheim), *Bembidion hastii*, *B. mckinleyi scandicum* Lindroth, *Arctobyrrhus dovrensis* Münster and *Fleutiauxellus maritimus* (Curtis) (Andersen 1982, 1983b). Larvae of these species were, a priori expected to be more vulnerable to a higher flow and inundation during the winter than imagines (Murdoch 1967). Nevertheless, despite a somewhat higher winter flow, the mentioned species had populations at Alta. This means that the winter flow and flood prevention walls did not disturb the fauna.

4.3 Estimation of the population size and life cycle of **Cicindela maritima**

In estimation of the population size, an even distribution of males/females in the population is assumed. Therefore, from a total of 86 third-stage larvae, it is estimated that 43 reproducing females will be found the following spring if all females survived the winter. Together with the smaller populations at Fjellborg and Aronnes, a metapopulation size of circa 100-150 individuals has to be considered as small and possibly vulnerable.

Furthermore, it is noteworthy that, because all three larval stages were found in August, this species may have a three-year lifecycle in Alta. In this scenario, it is first instar from spring to the first fall, second instar to fall the second year and then third instar the third fall, hibernate as imago and reproduce the fourth spring. If first instar holes are found in early spring, it would probably indicate that the species has a three-year lifecycle. By comparison, *C. campestris* Linnaeus is reported to have a three-year life cycle at Laukslett, Troms County. This locality has a similar climate as Alta; the mean air temperature during the months of April to September is 7.6°C at Laukslett (an average of Tromsø, Holt and Storsteinnes) and 7.8°C at Alta Airport (Aune 1993). Although Laukslett probably has an earlier spring and Øren a warmer summer, the population at Øren may have a three-year lifecycle.

The fact that this species may need three years to complete its life cycle renders it vulnerable to biotic and abiotic conditions for a longer period, e.g., predation by birds (Krogerus 1932) and trampling from humans (Willis 1967, Hyman and Parsons 1994, Berglind 2004) and cattle (Gärdenfors 2002). Positively the situation is acceptable at present, but due to a small population size, the population is vulnerable to alteration in the environment and the population must be monitored.

4.4 Secondary, anthropogenic habitats

In the context of conservation, it is noteworthy to mention that a number of riparian species are able to establish in secondary, anthropogenic habitats (Plachter 1986, Andersen 2000), and that secondary, anthropogenic habitats may function as source habitat for some species.

In southern Norway and up to the border of Troms, eighteen riparian species occur regularly in secondary, anthropogenic habitats. It has been recorded 14 species in secondary habitats with silt in Troms. Among these, *Bledius arcticus* and *Dyschirius septentrionum* Munster are particularly common. By comparison, five fine sand/silt species are found in secondary habitats in Finmark: *Dyschirius angustatus, Asaphidion pallipes* (Duftschmid)*, Parocyusa rubicunda* (Erichson), *Bledius arcticus,* and *B. longulus* Erichson (Andersen unpubl. data). Regarding the lithophilous species, *Thinobius ciliatus* Kiesenwetter is the only one that has been recorded from secondary habitats in Norway (O. Hanssen, pers. comm.). Psammophilous species have not been found in secondary habitats.

The only riparian species that seem to be capable of establishing successfully in secondary habitats in Finmark are *Bledius arcticus*, and possibly also *Dyschirius angustatus* and *Asaphidion pallipes* (Andersen unpubl. data). The remaining species depend on river banks for sustaining their populations in the Alta area over time. Secondary habitats can not serve as source habitats and substitute river banks in Finmark.

In conclusion, the riparian fauna along the river Altaelva is apparently intact, even after 15 years with regulation and the regulation and/or other impacts have not affected the species choice of habitat. The small lithophilous species that not have been found at the river banks are probably still there and/or in some of the tributaries.

5. Conservation recommendations

Thus, at present the banks and bars along Altaelva inhabit a fairly large amount of rare and/or vulnerable species. Ten of the 27 riparian species collected at Altaelva are red-listed in Norway. Among the species not found in this survey, three other species are also red-listed. In addition, *Bembidion mckinelyi scandicum* is one of four Norwegian responsibility species of beetles on a European level (DN 1999). Due to its habitat requirements, *C. maritima* is probably one of the most threatened riparian carabid beetles on a Scandinavian basis (Andersen and Hanssen 2004). Norway has a special responsibility to protect this riparian fauna.

I would then stress the importance of preserving this fauna as the long-term survival of the riparian species depends on future management decisions. To maintain the river banks, their habitats, and fauna, the following recommendations are essential:

- Keep the flow regime as it is at present.
- Avoid construction of bridges, roads/infrastructure and flood prevention walls. If construction of roads/infrastructure or flood preventing walls are necessary, endeavor to positioning the construction as far back as possible to preserve as much as possible of the river banks and fluvial forest. It is also desirable to remove superfluous flood prevention walls and other encroachments.
- The winter flow should not exceed the level as it is operated today. This will preserve the species with hibernating larvae.
- There must not be removal of sand and silt from the river banks, especially in the vicinity of the *C. maritima* populations.
- To preserve the *C. maritima* populations, leisure activity and passage of cattle must be reduced at a minimum at Øren, Fjellborg and Aronnes. Additionally collection of adults should be avoided.

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Appendix 1

List of the none-riparian beetles found in this study. Eu = euryoecious (F+O, W+D); Li = lithophilous; Si/Sa = confined to sites with silt fine sand; O = open habitats; OD = open, dry habitats; OW = open, wet habitats; F = forest.

Species	Number of specimens	Ecological group
CARABIDAE		
Leistus terminatus	14	F
Nebria rufescens	6	Eu
Pelophila borealis	31	OW
Loricera pilicornis	13	F
Elaphrus cupreus	3	OW
Elaphrus riparius	64	OW
Clivina fossor	39	Eu
Dyschirius globosus	3	Eu
Miscodera arctica	1	OD
Patrobus assimilis	11	F
Trechus rubens	2	Eu
Bembidion bipunctatum	182	O
Bembidion fellmani	2	OW
Bembidion virens	32	Li
Bembidion bruxellense	5	OD/W
Bembidion femoratum	10	OD
Bembidion saxatile	33	Li
Bembidion quadrimaculatum	1	OD
Pterostichus oblongopunctatus	3	F
Pterostichus adstrictus	28	OD
Calathus melanocephalus	74	OD
Agonum fuliginosum	7	Si/Sa
Amara erratica	1	OD
Amara interstitialis	1	OD
Amara quenseli	23	OD
Amara torrida	3	OD
Amara hyperborea	1	OD
Dicheirotrichus cognatus	2	OD
LEIODIDAE		
Hydnobius septentrionalis(?)	2	O

Species	Number of specimens	Ecological group
SILPHIDAE		
Thanatophilus dispar	52	Eu
STAPHYLINIDAE		
Anthophagus caraboides	9	F
Tachinus rufipes	1	Dung and decayed material
Tachinus laticollis	5	Dung and decayed material
Aleochara bilineata	53	Dung and decayed material
Hydrosmecta longula	8	Li/Sa
SCARABAEIDAE		
Aegialia sabuleti	33	O
Aphodius fimetarius	1	Dung
CANTHARIDAE		
Rhagonycha limbata	12	Eu
ELATERIDAE		
Negastrius arenicola	162	Si/Sa
Zorochros minimus	129	Si/Sa
Hypnoidus riparius	9	O
Hypnoidus rivularius	6	Eu
Eanus costalis	1	?
CHRYSOMELIDAE		
Phratora vitellinae	4	Salix spp.
APIONIDAE		
Apion frumentarium	1	Rumex spp., e.g. R.acetosa
Apion brundini	3	Astragalus spp.
CURCULIONIDAE		
Othiorhynchus nodosus	1	Polyfag at rots
Sitona lineellus	1	Leguminosae
Grypus equiseti	3	Equisetum spp.
Notaris aethiops	3	Equisetum spp.
Curculio crux	1	Salix spp.
Phytobius quadrituberculatus	1	Glaux maritima, Polygonaceae
Rhinoncus castor	1	Rumex acetosella
Total	1097	