The Mercantour/Alpi Marittime All Taxa Biodiversity Inventory (ATBI): achievements and prospects

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ABSTRACT
This paper summarizes the main results from taxonomic inventories drawn up as part of the ATBI of the Mercantour/Alpi Marittime parks in the French and Italian Alps. It compares the data on different groups of the invertebrate fauna published in the *Zoosystema* issues devoted to the ATBI with those recorded in the EDIT (European Distributed Institute of Taxonomy) and INPN (Inventaire national du Patrimoine naturel) ATBI databases. It also highlights the contribution of the ATBI inventory to a better knowledge of the biology and ecology of various animal taxa, as well as to the use of the data in conservation management. Overall, 927 animal taxa and 38 host plants are documented in the two special issues, of which 904 are recorded from both parks and 400 are new for one or both parks. Twelve species (ten terrestrial and two aquatic) and one genus (aquatic) are described as new for science, this increases to 30 the number of new invertebrate taxa described since 2006 from the Mercantour/Alpi Marittime parks. However, due to taxonomic uncertainty about material sorted to morphospecies and delays in species descriptions, these represent only a fraction of the taxa recognized as new during the ATBI. This faunal inventory, which includes 88% insect taxa, greatly enhances knowledge of Mercantour/Alpi Marittime biodiversity, notably for several poorly studied taxonomic groups. It also confirms the importance of the area as a European biodiversity hotspot, especially for arthropods and the groundwater fauna, by highlighting the remarkable percentage of endemic species, some of which are rare and poorly documented in the literature.

KEY WORDS
All Taxa Biodiversity Inventory,
Mercantour,
Alpi Marittime, Alps,
National Park,
Natural Park,
arthropods,
groundwater fauna,
terrestrial fauna,
databases.

RÉSUMÉ
L'inventaire biologique généralisé (ATBI) Mercantour/Alpi Marittime : bilan et perspectives.
Cet article résume les principaux résultats obtenus à partir des inventaires taxonomiques entrepris dans le cadre de l'ATBI mis en œuvre dans les parcs Mercantour/Alpi Marittime des Alpes franco-italiennes. Il synthétise les données publiées sur différents groupes d'invertébrés dans les deux fascicules consacrés par *Zoosystem*a à cet ATBI et les compare aux données d'inventaire issues de l'ATBI et enregistrées dans les bases EDIT (European Distributed Institute of Taxonomy) et INPN (Inventaire national du Patrimoine naturel). Ce texte met aussi en évidence le rôle de l'ATBI dans l'acquisition de connaissances sur la biologie et l'écologie de divers taxons animaux et leur utilisation dans la gestion de la conservation. Dans l'ensemble, 927 taxons animaux et 38 plantes hôtes sont cités dans les deux fascicules de *Zoosystema*, parmi lesquels 904 sont répertoriés de l'ensemble des deux parcs, et 400 sont nouveaux pour l'un ou l'autre parc. Douze espèces (dix terrestres et deux d'eau douce) et un genre (d'eau douce), nouveaux pour la science, sont également décrits, portant à 30 le nombre de nouveaux taxons d'invertébrés décrits depuis 2006 des parcs Mercantour/Alpi Marittime. Ces taxons récemment décrits ne représentent toutefois qu'une fraction des taxons collectés lors de cette ATBI et susceptibles d'être nouveaux pour la science, sachant qu'une grande partie du matériel n'a été identifiée qu'à la morpho-espèce (données taxonomiquement incertaines) et que la description d'espèces nouvelles prend souvent beaucoup de temps. Cet inventaire, qui traite à 88 % d'insectes, fait progresser de façon notable les connaissances sur la biodiversité des parcs Mercantour/Alpi Marittime, surtout pour quelques groupes taxonomiques peu étudiés. Il confirme également que cette région est un point chaud de biodiversité en Europe, pour les arthropodes et la faune des eaux souterraines en particulier, du fait notamment du fort pourcentage d'espèces endémiques, y compris des endémiques rares dont la distribution est mal connue.

MOTS CLÉS
Inventaire biologique généralisé,
Mercantour,
Alpi Marittime,
Alpes,
parc national,
parc naturel régional,
arthropodes,
faune des eaux souterraines,
faune terrestre,
bases de données.

INTRODUCTION

Since 2007, knowledge of the natural heritage of the Mercantour National Park (MNP) and the Alpi Marittime Natural Park (AMNP) has been greatly enhanced through the first large-scale biodiversity inventory of the region, the Mercantour-Alpi Marittime ATBI project.

This project focused on lesser-known taxa, such as invertebrates and the non-vascular flora, but without neglecting other, better studied, groups, such as vertebrates and the vascular flora. Between 2007 and 2010, over 250 experts have observed, collected or recorded species in the two parks (Anonymous 2011). The cumulated data provide 8264 species records (6402 in MNP and 3969 in AMNP) on the EDIT website (http://www.atbi.eu/mercantour-marittime/?q=node/481). Moreover, 39 883 georeferenced data concerning 9 583 recorded taxa (species/subspecies) are available through the GBIF (http://doi.org/10.15468/4z4hto) and the INPN/ATBI databases (http://inpn.mnhn.fr/espece/inventaire/I221) (see Material and Methods for acronyms). Data gathered after 2010 are

not accessible to the public, but the Mercantour National Park can make them available to qualified scientists in the context of studies or inventories, provided that the request is accompanied by an explanation of the project and that a data exchange agreement is signed (Deharveng *et al.* 2015a). New taxonomic results will then be made available through the INPN/ATBI database.

In addition to ATBI data, INPN/ATBI database includes records from published literature as well as from unpublished sources referring to these areas. It currently includes 119 064 records of 12 473 taxa (11 688 in MNP and 2765 in AMNP), of which 13% are fungi, 18% plants and 65% terrestrial and freshwater animals (Table 1). The overwhelming majority of the recorded animals (99%) are invertebrates, and 88% are insects (Tables 1, 2). This last percentage is slightly higher than that (81%) obtained from TAXREF data (http://inpn.mnhn.fr/programme/referentiel-taxonomique-taxref; Gargominy *et al.* 2014) for the whole French terrestrial and freshwater animal biodiversity (Tables 1, 2). This is in line with the global biodiversity counts available through the Catalogue of Life (http://www.catalogueoflife.org/) and GBIF (http://www.gbif.org/), in which insects represent about 79% of the world's terrestrial and freshwater animal species. To place these figure in perspective, the animal kingdom accounts for 1.55 million described species (Zhang *et al.* 2011), including about 230 000 marine species (total from World Register of Marine Species; http://www.marinespecies.org/).

The ATBI inventory considerably increased our knowledge of the invertebrate fauna of the two national parks; in six years of prospection, the number of species listed in the databases at least tripled, even though a number of families have not yet been studied (De Biaggi *et al.* 2013; Deharveng *et al.* 2015a). However, most of these records still need to be formally published and updated in the INPN/ATBI database. Updating INPN/ATBI inventory to improve accuracy and making it available to the public will be major tasks in the coming years.

Within the framework of the ATBI project, one genus, 28 species and one subspecies new for science have already been formally described from the MNP/AMNP (Table 3). These include two species and one genus of annelid, one tardigrade, six spider, four mite, two centipede, two springtail and eleven insect species, as well as one coleopteran subspecies. Four of these taxa were recorded from AMNP and three were found in both parks, while the others came from MNP only (Table 3). These new species increase to 388 the number of new taxa described from France since 2006 (INPN 2015), i.e. by almost 7%. However, new taxa already formally described from MNP/AMNP are only a fraction of the invertebrate taxa recognized as new from this inventory, due to taxonomic uncertainty about material sorted to morphospecies and delays in species descriptions. For the terrestrial invertebrates collected in MPN by the Terrestrial Invertebrate Module (TIM), 37 species were considered as new and 45 as potentially new to science (Deharveng *et al.* 2015a). Of these, ten species are described in the *Zoosystema* issues devoted to the ATBI (Table 3). Another example is the Aquatic Subterranean Invertebrate Module, which collected in MNP five new species of groundwater annelids, two of which are described (Martin *et al.* 2015, this issue), and at least nine species of crustaceans that are probably new to science (Olivier *et al.* 2015, this issue) (Table 5).

Here we summarize the main results of the ATBI obtained so far, taking into consideration the different databases involved, the results published in the two issues of *Zoosystema* devoted to the project and other published sources. This allows us to draw some general conclusions concerning the value and effectiveness of the ATBI approach in assessing the biodiversity of the region. Information concerning the context of the ATBI and the methods used for the terrestrial invertebrate component can be found in Deharveng *et al.* (2015a) and Leccia & De Biaggi (2015a).

MATERIAL AND METHODS

Sampling methodologies, specimen sorting and preparation, databasing and site locations are described in Deharveng *et al.* (2015a). The taxonomy follows that used by GBIF.

Abbreviations, acronyms and websites

AMNP	Alpi Marittime Natural Park (Parco naturale Alpi Marittime), Italy [http://en.parcoalpimarittime.it/];
ATBI	All Taxa Biodiversity Inventory [http://www.atbi.eu/mercantour-marittime/];
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora [https://www.cites.org/];
EDIT	European Distributed Institute of Taxonomy [http://www.e-taxonomy.eu/];
GBIF	Global Biodiversity Information Facility (an international open data infrastructure) [http://www.gbif.fr/]
INPN	Inventaire national du Patrimoine naturel, France [http://www.inpn,.mnhn.fr];
MNP	Mercantour National Park (Parc national du Mercantour), France [http://*www.mercantour.eu*/];
TIM	Terrestrial Invertebrate Module of the French part of the ATBI.
MNHN	Muséum national d'Histoire naturelle [http://www.mnhn.fr/fr].

SUMMARY OF THE CONTRIBUTIONS PUBLISHED IN THE TWO ISSUES OF *ZOOSYSTEMA* DEVOTED TO THE ATBI

The dominance of new records of invertebrate obtained during the MNP/AMNP Biodiversity Inventory is particularly obvious in the two special issues of *Zoosystema* dealing with the ATBI. All papers of this collection are open access, thus complying with EDIT priorities for open access to species information and descriptions.

The first issue (*Zoosystema* 2015, 37 (1): 1-280) includes 12 papers, in addition to the foreword (Leccia & De Biaggi 2015a). The first paper (Deharveng *et al.* 2015a) presents the objectives, organization and progress of the multi-taxon inventory of terrestrial invertebrates conducted from 2009 to 2012 by the TIM. Seven inventory papers describe the diversity of various arthropod taxa: spiders (Isaia *et al.* 2015a)

TABLE 1. — Number of taxa (species/subspecies) recorded in the ATBI inventory according to the different databases: Mercantour (MNP, France), Alpi Marittime (AMNP, Italy), both parks combined (MNP+AMNP), as listed in the INPN or EDIT ATBI databases, and the number of taxa recorded in France according to the TAXREF database (Gargominy *et al.* 2014). Lines in grey are totals for kingdoms.

Main group	Phylum	INPN/ATBI			EDIT/ATBI	TAXREF
		MNP	AMNP	MNP+AMNP	MNP+AMNP	France
Algae		256	171	396	240	2276
	Charophyta	159	14	159	0	1021
	Chlorophyta	24	0	24	0	46
	Ochrophyta	70	157	210	237	1190
	Rhodophyta	3	0	3	1	19
Animals		7539	2127	8131	6102	48189
	Annelida	21	0	21	17	367
	Arthropoda	7271	2061	7835	5884	44515
	Chordata	77	19	85	65	1063
	Mollusca	167	47	187	135	775
	Nematoda	1	0	1	1	460
	Platyhelminthes	1	0	1	0	508
	Tardigrada	1	0	1	0	66
Bacteria		64	1	64	0	62
	Cyanobacteria	64	1	64	0	64
Fungi		1650	60	1655	565	15402
	Ascomycota	1406	60	1411	367	5299
	Basidiomycota	244	0	244	198	10103
	Oomycota	0	0	0	2	0
Plants		2170	406	2218	1339	10660
	Magnoliophyta	1490	203	1529	684	9308
	Bryophyta	512	153	517	506	803
	Lycopodiophyta	3	0	3	1	18
	Marcantiophyta	115	40	118	121	234
	Pinophyta	10	3	10	8	95
	Pteridophyta	33	6	34	17	202
Protozoa		9	0	9	20	0
All Taxa		11688	2765	12473	8264	76589

TABLE 2. — Number of arthropod taxa from Mercantour (MNP, France), Alpi Marittime (AMNP, Italy), both parks combined (MNP+AMNP), as listed in the INPN or EDIT ATBI databases and number of taxa recorded in France according to the TAXREF database (Gargominy *et al.* 2014).

Class	Order	INPN/ATBI			EDIT/ATBI	TAXREF
		MNP	AMNP	MNP+AMNP	MNP+AMNP	France
Arachnida		410	198	477	319	3218
Chilopoda		33	0	33	28	138
Diplopoda		12	0	12	0	281
Branchiopoda		1	0	1	0	153
Malacostraca		22	1	22	2	455
Entognatha		148	0	148	79	824
Insecta		6645	1862	7142	5456	39107
Insecta by order	Coleoptera	1824	594	2012	1461	11387
	Diptera	620	60	645	345	8543
	Hemiptera	539	53	555	405	3491
	Hymenoptera	1024	131	1063	729	8337
	Lepidoptera	2233	956	2452	2232	5415
	Others	405	68	415	284	1934
Totals		7271	2061	7835	5884	44176

and butterflies (Bonelli *et al.* 2015b) of AMNP, as well as centipedes (Iorio *et al.* 2015), ladybirds (Coutanceau 2015), psyllids (Ouvrard *et al.* 2015) and cynipoid parasitoids (Ferrer-Suay *et al.* 2015, Mata-Casanova *et al.* 2015) of MNP; new taxa are described in several papers (see Table 3). Two papers focus on the descriptions of new species from MNP (Deharveng *et al.* 2015b) or AMNP (Degma & Schill 2015). Finally, three papers give new biological and taxonomical information on emblematic or remarkable species present in MNP/AMNP: the Southern swallowtail *Papilio alexanor* Esper [1800] (Bonelli *et al.* 2015a), the spiders *Cybaeus vignai* Brignoli, 1977 and *Dysdera cribrata* Simon, 1882 (Isaia & Charle 2015), and the rare tenebrionid *Gerandryus aetnensis* (Rottenberg, 1871) (Bouyon *et al.* 2015).

This second issue (*Zoosystema* 2015, 37 (4): 525-694) includes nine papers, in addition to the present contribution, and a postface (Leccia & De Biaggi 2015b). One paper describes two new dance fly species from MNP (Daugeron & Lefebvre 2015, this issue), while seven others are annotated inventories: round fungus beetles from AMNP (Latella 2015, this issue), geometrid moth larvae and their host plants from AMNP (King & González-Estébanez 2015, this issue) snakeflies and neuropterans from MNP (Tillier 2015, this issue), snail-killing flies from MNP (Vala & Williams 2015, this issue), harvestmen from MNP (Delfosse & Iorio 2015, this issue) and the groundwater fauna from MNP (Olivier *et al.* 2015, this issue; Martin *et al.* 2015, this issue); new taxa are described in the latter two papers (Table 3). Finally, the contribution of La Morgia *et al.* (2015, this issue) investigates whether the abundance of rodents in subalpine grasslands of the Alps is related to the intensity of livestock grazing.

ANALYSIS BY MAIN TAXONOMIC GROUPS

In total, 965 taxa (927 species or subspecies of animals and 38 host plants) are documented in the two issues of *Zoosystema*. Out of these, 904 are recorded from the MNP/AMNP, representing more than 7% and 10% respectively of the taxa recorded from Mercantour/Alpi Marittime parks in EDIT and INPN ATBI database. A total of 400 taxa are reported for the first time from MNP and/or AMNP (Tables 4, 5 and supplementary data). At the national levels, the ATBI has added 59 species to the French fauna and seven to the Italian fauna (Table 4, 5). The most diverse group inventoried in these issues is Arthropoda, with 810 terrestrial or aquatic species representing 90% (45% insects, 36% arachnids, 4.5% crustaceans and 4.5% millipedes) of the MNP/AMNP taxa mentioned in all papers.

Many other groups, such as algae, vascular plants, lichens, fungi, molluscs and vertebrates, were inventoried during the course of the ATBI project (Table 1) but they are generally not covered in these issues. These groups have been the subject of scientific reports, but as yet only some of them have been formally published, as is the case for Ochrophyta (diatoms) (Falasco *et al.* 2012), Ascomycota (Van Vooren 2010), Bryophyta (Saatkamp *et al.* 2011), Mollusca (Gargominy & Ripke 2006; Gargominy *et al.* 2011) and Amphibia (Morand & Bovero 2013).

Insects

Of the insects dealt with in *Zoosystema* issues, the best inventoried order is Lepidoptera, with about 191 butterfly species recorded (47% of insect taxa), but only one new for both the parks (Bonelli *et al.* 2015b) (Table 4).

The predominance of insects, particularly Lepidoptera, among the inventoried animals of MNP/AMNP has already been mentioned in the fourth ATBI+M newsletter (Anonymous 2011). Arthropods represent 96% of all animal taxa in both the INPN and EDIT's ATBI databases, with insects accounting for 88 and 89% respectively, while Lepidoptera form 34 and 41%, respectively, of all insect taxa in the two databases. The 2452 moth and butterfly taxa recorded from the two parks in the INPN/ATBI database (Table 2) represent about 40% of the Lepidoptera listed in Fauna Europaea (www.faunaeur.org) for France and Italy. Considering that the two parks cover only 0.1% of France and Italy's national territories, a minimum value of 40% species representation can be considered a very significant result (Anonymous 2011). A moth inventory has also been performed in MNP by G. and P. Leraut (unpublished data). *Ectoedemia* species (Lepidoptera: Nepticulidae) have been collected during the course of the ATBI project and used for molecular studies with the intention of distinguishing cryptic species (Van Nieukerken *et al.* 2012) and providing phylogenetic information to investigate whether host shifts and allopatry have been instrumental in the speciation of these leaf-mining insects (Doorenweerd *et al.* 2015).

Coleoptera, with 2012 species recorded from the two parks (Table 2) represent 28% of all insect taxa listed in the INPN/ATBI database, which is in line with the Fauna Europaea data for the whole Europe (De Jong *et al.* 2014). However, as for Lepidoptera, few new data are provided for this order by the *Zoosystema* special issues or others publications. Of the 42 MNP ladybird species recorded during the course of the TIM work (Coutanceau 2015), only 10 were not previously listed in the INPN database, to which must be added the three leiodid species new for the AMNP (Latella 2015, this issue) and the tenebrionid *Gerandryus aetnensis* new for the MNP (Bouyon *et al.* 2015).

Diptera are also poorly documented in this issue, just as they are in the INPN/ATBI database (Table 2), in which they account for 9% of the insect taxon records. This is despite the fact that, in Europe, they represent 20% of insects in terms of number of described species (De Jong *et al.* 2014). The only Diptera studied are the two new Empididae species (Daugeron & Lefebvre 2015, this issue), and the nine species of Sciomyzidae, including six new to MNP (Vala & Williams 2015, this issue). However, a recent work (Ssymank & Lair 2015) undertaken within the framework of the ATBI also provided important data on hoverflies, with 240 species recorded in MNP, representing 45% of all the species of Syrphidae known from France. One of the species is new to Europe and another is new to France (Ssymank & Lair 2015).

Hymenoptera are, after Coleoptera, the second most diverse insect order in Europe; they represent 25% of all insect taxa recorded in Fauna Europaea (De Jong *et al.* 2014) but less than 15% in the INPN/ATBI database. They have mainly been studied by Schmid-Egger (2011), who published an inventory of 472 species of Aculeata from MNP/AMNP, including three as yet undescribed species. The Hymenoptera species listed in the *Zoosystema* special issues are all parasitoids; 39 Figitidae are new for MNP, including 26 new for France and five are new for science (Ferrer-Suay *et al.* 2015; Mata-Casanova *et al.* 2015; Tables 3, 4). Two other Hymenoptera (Braconidae) are mentioned as parasitoids of geometrid larvae (King & González-Estébanez 2015, this issue); both of them are cited for the first time in AMNP

TABLE 3. New invertebrate taxa described since 2006 in the Mercantour/Alpi Marittime parks (MNP/ANMP) (2015 references are all from the special issues of *Zoosystema*, except the one marked with an asterisk).

Main group	Order	Family	Species	Records	References
Annelids	Enchytraeida	Enchytraeidae	*Marionina sambugarae* Schmelz, 2015	MNP	Martin *et al.* (2015)
	Haplotaxida	Naididae	*Aberrantidrilus stephaniae* Martin, 2015 (new genus)	MNP	
Tardigrades	Echiniscoidea	Echiniscidae	*Echiniscus pardalis* Degma & Schill, 2015	AMNP	Degma & Schill (2015)
Spiders	Araneae	Agelenidae	*Tegenaria mercanturensis* Bolzern & Hervé, 2010	MNP	Bolzern & Hervé (2010)
		Gnaphosidae	*Drassodex drescoi* Hervé, Robert & Murphy, 2009	MNP/ANMP	Hervé *et al.* (2009)
			Drassodex simoni Hervé, Robert & Murphy, 2009	MNP/ANMP	Hervé *et al.* (2009)
			Drassodes thaleri Hervé & Rollard, 2009	MNP/ANMP	Hervé & Rollard (2009)
		Linyphiidae	*Diplocephalus guidoi* Frick & Isaia, 2012	AMNP	Frick & Isaia (2012)
		Agelenidae	*Histopona leonardoi* Bolzern, Pantini & Isaia, 2013	AMNP	Bolzern *et al.* (2013)
Mites	Trombidiformes	Rhagidiidae	*Troglocheles lanai* Zacharda, 2015	AMNP	Zacharda, *et al.* (2011)
		Tetranychidae	*Bryobia mercantourensis* Auger & Migeon, 2014	MNP	Auger & Migeon (2014)
			Bryobia cinereae Auger & Migeon, 2014	MNP	
			Eotetranychus quercicola Auger & Migeon, 2014	MNP	
Centipedes	Geophilomorpha	Geophilidae	*Clinopodes vesubiensis* Bonato, Iorio & Minelli, 2011	MNP	Bonato, *et al.* (2011)
	Lithobiomorpha	Lithobiidae	*Lithobius lemairei* Iorio, Zapparoli, Ponel & Geoffroy, 2015		Iorio *et al.* (2015)
Springtails	Collembola	Hypogastruridae	*Orogastrura tetrophthalma* Deharveng, Bedos & Duran, 2015	MNP	Deharveng *et al.* (2015)
		Neanuridae	*Deutonura jeromoltoi* Deharveng, Bedos & Duran, 2015	MNP	
Insects	Coleoptera	Carabidae	*Duvalius magdelaini tordjmani* Lemaire & Raffaldi, 2011	MNP	Lemaire & Raffaldi (2011)
	Diptera	Empididae	*Empis fusca* Daugeron & Lefebvre, 2015	MNP	Daugeron & Lefebvre (2015)
			Rhamphomyia brevis Daugeron & Lefebvre, 2015	MNP	
		Tachinidae	*Isochaeta incisor* Tschorsnig, 2011	MNP	Tschorsnig (2011)
	Hemiptera	Rhyparochromidae	*Plinthisus heteroclitus* Matocq & Pluot-Sigwald 2013	MNP	Matocq *et al.* (2013)
	Hymenoptera	Anacharitinae	*Xyalaspis pseudolaevigata* Mata-Casanova & Pujade-Villar, 2015	MNP	Mata-Casanova *et al.* (2015)
		Charipinae	*Alloxysta alpina* Ferrer-Suay & Pujade-Villar, 2015	MNP	Ferrer-Suay *et al.* (2015)
			Alloxysta franca Ferrer-Suay & Pujade-Villar, 2015	MNP	
			Alloxysta pilae Ferrer-Suay & Pujade-Villar, 2015	MNP	
	Lepidoptera	Adelidae	*Nematopogon argentellus* Leraut & Leraut, 2015	MNP	Leraut & Leraut (2015)*
		Gelechiidae	*Caryocolum dauphini* Grange & Nel, 2012	MNP	Grange & Nel (2012)
		Geometridae	*Dyscia royaria* Tautel & Billi, 2006	MNP	Tautel & Billi (2006)

and one of them, *Aleiodes crassipes* (Thomson, 1892), seems to have previously been unknown from Italy, according to the Taxapad database (Yu *et al.* 2011).

Hemiptera, mainly bugs and leafhoppers, represent about 6% and 8% respectively of the insect taxa in the ATBI databases of INPN and EDIT. The list of Psylloidea published by Ouvrard *et al.* (2015) comprises 68 species, all new to MNP, including seven new to France (Table 4); none of these species had yet been recorded from France in the TAXREF database. Moreover, 20 families and 240 species of true bugs have been recorded from MNP/AMNP by Korn (2013), while a new apterous species of *Plinthisus* (Rhyparochromidae) was described from MNP by Matocq & Pluot-Sigwald (2013) (see Table 3).

Although 12 of the 36 species of Neuropterida observed in MNP are new for the park (Tillier 2015, this issue), all are recorded from France in the TAXREF database. Pettavino (2015) listed 15 species of dragonflies in AMNP, which all are recorded in the INPN/ATBI database.

OTHER ARTHROPODS

Arachnida is the second best inventoried class, with 477 taxa (6% of arthropods) recorded in the INPN/ATBI database (Table 2), including 400 species of spiders (i.e. 8% of the Araneae listed in Fauna Europaea). Of the 295 spiders from AMNP listed by Isaia *et al.* (2015a), 156 are new for AMNP (182 when excluding the newly annexed areas of the Site of Community Importance and Special Area of Conservation "Alpi Marittime") and five are new for Italy (Table 4). The study of Isaia & Chiarle (2015) also recorded two *Cybaeus* species new for MNP, among which *C. intermedius* Maurer, 1992 was new for France, while *Dysdera cribrata* was newly recorded from Italy. Finally, the 49 harvestmen recorded in MNP by Delfosse & Iorio (2015, this issue) include 13 species that are new for the park.

Iorio *et al.* (2015) reported 70 centipede species from the south-east of France, including 38 from MNP, of which seven are new for the park and one is new to science. Currently, only 45 species of Myriapoda, including 33 centipedes, are recorded in the INPN/ATBI database (Table 2).

Overall, 772 taxa of terrestrial arthropods and one tardigrade species are reported from MNP/AMNP in these two *Zoosystema* issues. Out of these, 156 are new for MNP and 42 are new for the French fauna, while 163 are new for AMNP (in its broad sense) and seven are new for Italy (Table 4 and S1 in supplementary data).

Aquatic fauna

The contribution of the groundwater fauna to new species records for the MNP is even more remarkable (Table 5 and S2 in supplementary data). In total, 87 species (2 Acari, 48 Annelida and 37 Crustacea) have been recorded in the six major valleys of MNP. Among them only one, the isopod *Proasellus rouchi* Henry, 1980, was already known from the park. Two annelid species and one genus are new to science (Martin *et al.* 2015, this issue), while at least three other annelids and nine new crustacean species await description (Martin *et al.* 2015, this issue; Olivier *et al.* 2015, this issue). These results greatly improve the INPN inventories, which previously included only a small number of records of non-arthropod invertebrates (Table 1).

BEYOND THE INVENTORY: CONSERVATION AND ECOLOGY

The MNP and AMNP are protected at the national and Europeans levels, both being Natura2000 Special Protection Areas (SPAs). However, in order to ensure the effective management and conservation of biodiversity within the parks, it is important to know which species are present and to have information on their distribution and habitat preferences.

Faunal inventories are the first step in the study of biodiversity and can provide a basis for various types of ecological studies. They are also instrumental for conservation and management decisions. The ATBI faunal lists greatly enhance knowledge of MNP/AMNP biodiversity, notably for poorly studied taxonomic groups, such as Figitidae and Psyllidae (100% new records in this issue) or groundwater annelids and crustaceans (99% new records). Several papers in this issue also clearly demonstrate the importance of the area as a European biodiversity hotspot, especially for arthropods and the groundwater fauna, by revealing the remarkable percentage of endemic species including, in addition to newly described taxa, rare endemics that are poorly documented in the literature.

MNP/AMNP is thus home to viable populations of four globally threatened butterfly species, all listed in Annex IV of the Habitats Directive and in Appendix 2 of the Bern Convention: *Parnassius apollo* (Linnaeus, 1758) (also included in the CITES Appendix 1), *P. mnemosyne* (Linnaeus, 1758), *Papilio alexanor* Esper, [1800] and *Maculinea arion* (Linnaeus, 1758). Populations of *P. apollo* and *P. mnemosyne*, in particular, benefit from extensive breeding sites in this area and accordingly have very high population densities, while *P. alexanor* has its most robustly established population within the Italian part of this region. Several other interesting species, from a conservation point of view, are also firmly established, such as *Thymelicus acteon* (Rottemburg, 1775) (mainly Mediterranean), *Glaucopsyche alexis* (Poda, 1761) and *Boloria titania* (Esper, [1789]) (mainly montane species) (Bonelli *et al.* 2015b).

Similarly, the tenebrionid *Gerandryus aetnensis* is a saproxylic species present in France only in mid-altitude mixed forests of the Southern Alps. This species is of high scientific value because of its restricted and disjunct distribution (French Maritime Alps and Italy/Sicily), a unique example, as far as we are aware, for European beetles. Its presence in the Mercantour National Park and its periphery adds to the already considerable biological value of this area (Bouyon *et al.* 2015). It is also noteworthy that the 15 dragonflies found in AMNP by Pettavino (2015) are all considered endangered in the IUCN Red List (International Union for the Conservation of Nature 2015).

As regards the Hymenoptera, only two subfamilies of figitid parasitoids have been thoroughly inventoried in this issue: the Charipinae, which are hyperparasitoids of aphids, and the Anacharitinae, whose few known hosts are neuropteran species. Their study in MNP led to the addition of 26 species to the French fauna (Ferrer-Suay *et al.* 2015; Mata-Casanova *et al.* 2015). However, these groups are currently too poorly known in terms of their biology and distribution to allow a reliable assessment of their conservation value. On the other hand, the inventory performed by Schmid-Egger (2011) on MNP/AMNP aculeate Hymenoptera (256 bee species and 216 wasp species) greatly enhanced our knowledge of the local biodiversity of this group, including numerous species playing an important role as pollinators or parasitoids. This inventory includes 19 rare montane and Mediterranean species, in five families, that deserve further attention as priority target species for nature conservation management.

However, Hymenoptera are not the only pollinators among insects, since dipteran groups such as hoverflies and dance flies also are involved in plant pollination. The extensive hoverfly inventory in MNP led Ssymank & Lair (2015) to discuss the possible consequences on their fauna of intense grazing within the park boundaries and give recommendations for nature conservation and site management. The role of empidine dance flies has been highlighted by a study performed during the course of the ATBI project (Lefebvre *et al.* 2014). About a hundred species of Empidinae were recorded in MNP, of which 23 were observed foraging on flowers. By their diversity and abundance, they formed a major component of the higher-altitude insect fauna. Their pollination impact, which seems to be a key element of the functioning of Alpine ecosystems, is currently under study (Lefebvre *et al.* unpublished data).

The data gathered on other terrestrial groups and the groundwater fauna provide further evidence of the importance of MNP/AMNP as a regional biodiversity hotspot. Among spiders, *Vesubia jugorum* (Simon, 1881), *Troglohyphantes konradi* Brignoli, 1975, *Nesticus morisii* Brignoli, 1975 and *Turinyphia clairi* (Simon, 1884) are the most emblematic species among the eight endemic species recorded in AMNP by Isaia *et al.*

TABLE 4. — Number of terrestrial invertebrate species newly recorded from the ATBI inventory in the Mercantour (MNP, France) and the Alpi Marittime (AMNP, Italy) parks and published in the special issues of *Zoosystema* (Daugeron *et al.* 2015a, b). Grey lines are totals for each class. *, number of spider species recorded as new in the AMNP in its widest sense, corresponding to the Site of Community Importance and Special Area of Conservation "Alpi Marittime" IT1160056. Dashes correspond to unverified data.

Class/Order	Total	New to MNP	New to AMNP	New to France	New to Italy	New to Science
Tardigrada	1	0	1	0	1	1
Echiniscoidea	1	–	1	–	1	1
Arachnida	169	15	156	1	5	0
Araneae	156	2	156*	2	5	0
Opiliones	13	13	–	0	–	0
Chilopoda	8	8	–	1	–	1
Lithobiomorpha	3	3	–	1	–	1
Geophilomorpha	2	2	–	0	–	0
Scolopendromorpha	3	3	–	0	–	0
Entognatha	2	2	–	2	0	2
Collembola	2	2	–	2	–	2
Insecta	134	131	6	38	1	6
Coleoptera	4	1	3	0	–	0
Diptera	8	8	–	2	–	2
Hemiptera	68	68	–	7	–	0
Hymenoptera	41	41	2	26	1	5
Lepidoptera	1	1	1	0	0	0
Neuropterida	12	12	–	3	–	0
Totals	314	156	163	42	7	10

TABLE 5. — Number of groundwater species/morphospecies newly recorded from the ATBI inventory in the Mercantour National Park (MNP, France) and published in the special issues of *Zoosystema* (Daugeron *et al.* 2015 a, b), compared to the other groundwater species newly recorded for France since 2006, based on the TAXREF database (Gargominy *et al.* 2014). Grey lines are totals for each class. *The number of species new to science includes, in brackets, the number of species already described (this issue).

Class/Order	New to MNP	New to France	New to science*	TAXREF New to France
Clitellata	47	5	5 (2)	19
Enchytraeida	27	1	1 (1)	12
Haplotaxida	14	1	1 (1)	6
Oligochaeta	6	3	3	1
Polychaeta	1	0	0	1
Aciculata	1	0	0	1
Arachnida	2	0	0	2
Actinotrichida (Acari)	2	0	0	2
Maxillopoda	11	2	2	4
Cyclopoida	7	1	1	3
Harpacticoida	4	1	1	1
Ostracoda	6	4	1	1
Podocopida	6	4	1	1
Malacostraca	19	6	6	5
Amphipoda	7	0	0	4
Bathynellacea	4	0	0	0
Isopoda	8	6	6	1
Totals	86	17	14 (2)	32

(2015a). In turn, the species richness of the chilopod fauna in MNP represents more than a quarter of the centipedes identified in France, making it an important biogeographical area for this group. Three of these species are endemic to the Maritime Alps and their immediate vicinity (*Clinopodes vesubiensis* Bonato, Iorio & Minelli 2011, *Lithobius lemairei* Iorio *et al.* 2015 and *Strigamia cottiana* (Verhoeff, 1935)), as well as 22 species and subspecies at the limit (mainly western) of their geographical ranges (Iorio *et al.* 2015). Likewise, with almost 100% of taxa new for the area, including two species and one genus new to science and at least ten further species to be described, the MNP may be considered as a new European hotspot for groundwater biodiversity, in which many additional species probably remain to be discovered (Martin *et al.* 2015, this issue; Olivier *et al.* 2015, this issue).

Other experiments performed in the course of the ATBI project focused on landscape conservation and management. The study of La Morgia *et al.* (2015, this issue) suggested that the abundance of rodents in Alpine grasslands is influenced by livestock grazing history. Even versatile rodents like *Apodemus* spp. were rare in formerly intensively grazed sites, despite their suitable vegetation cover. These preliminary results should encourage natural resource managers to carefully consider and act on the spatial distribution of grazing

pressure. On another hand, a recently published study (Isaia *et al.* 2015b) performed in a protected, pristine beech forest within the AMNP showed that forest maturity benefited the biodiversity by providing positive conditions for arthropod assemblages that play a fundamental role in this ecosystem.

According to the fourth ATBI+M Newsletter (Anonymous 2011), the field activities of the project involved over 250 scientists, who carried out the equivalent of about 2300 days of fieldwork in total, but this synthesis does not mention the considerably greater time spent by taxonomists to identify species. We therefore note that another important point to draw from the papers of the two special issues of *Zoosystema* is the major implication of taxonomists in this project, with fifty scientists contributing to the faunistic studies, eight of whom are non-institutional taxonomists.

A number of major groups present in the material have not yet been significantly recorded in the databases, even though specialists are potentially available. These include many mites, millipedes, terrestrial woodlice and several important insect families (Deharveng *et al.* 2015a). In other cases specialists are lacking or unavailable for a number of insect families, including some that are very diverse, such as the common families Muscidae Latreille, 1802 (houseflies and relatives), Calliphoridae Hough, 1899 (carrionflies) and Sarcophagidae Haliday, 1853 (fleshflies), and various microhymenopteran parasitoid families, such as Diapriidae Haliday, 1833 and Platygastridae Haliday, 1833. These "orphan groups" are now priority targets for completing the inventory.

This project was conceived as an "ATBI+M", where the "M" stood for monitoring, the intention being that the project would include long-term field surveys to monitor biodiversity changes over time. In practice, however, this monitoring does not extend beyond 2011, due to the absence of provisions for funding such activities after the end of the contract. Nevertheless, the data collected during the three-year survey would provide a solid base for future conservation monitoring in the event that other sources of support can be obtained by the parks.

WHICH TYPE OF BIODIVERSITY INVENTORY?

Large-scale species inventories are an effective way to increase our knowledge of the diversity of life on our planet and in the process they help to raise public awareness of the need to conserve biodiversity. One of their advantages is that they create synergies between the participants and build up an overall picture of the compositions of ecosystems, something that would be impossible to obtain with smaller projects (Leponce *et al.* 2010). It is therefore interesting to compare the ATBI approach with that of other large-scale sampling strategies, such as those performed during major expeditions. The obvious differences between the two approaches are those of time and space: an ATBI is restricted to a predefined area of intensive collecting over an extended period of time (years), whereas expeditions usually seek to obtain extensive collections from as many sites and habitats as possible over a shorter period of time (weeks or months). What they share in common is a goal of maximizing the number of taxa sampled. An advantage of the expedition approach is that it allows more flexibility in the field, since the most promising and most diverse sites can be chosen for sampling. The disadvantages are that some species (or their identifiable stages) might be missed due to periodicity in their development, the chosen sites may not fit the ecological requirements of some taxa, and the logistics of bringing together scientists, technicians and support staff represent a major challenge. Because it extends over a period of years or even decades, an ATBI is more likely to pick up species whose populations fluctuate and it is much easier to get a large number of scientists into the field when the visits can be divided between small groups over several years.

The true costs of the ATBI, like those of most expeditions, are generally underestimated. While the EDIT ATBIs funded travelling and subsistence costs, they initially envisaged that the tasks of sorting and identification would be carried out on a "voluntary" basis (EDIT 2011). One serious problem was the lack of any provision for the work of sorting in the original project. The idea that interested amateurs could be enlisted to help process field samples (EDIT 2011) betrays a lack of understanding of the nature and scale of the task. While amateurs might be willing to sort some particular groups, sorting samples from Malaise traps or Berlese extractions requires an ability to recognize a wide range of taxa in order to be done efficiently. There has been much discussion of the "taxonomic impediment" (Lipscomb *et al.* 2003) – meaning the lack of sufficient taxonomists to identify and describe the enormous number of species – in the last few years, but the experience of the present ATBI highlights another bottleneck for many groups, namely the lack of technical expertise for sorting the material obtained by efficient trapping methods. Deharveng *et al.* (2015a) noted that only slightly over half of all samples obtained by the Terrestrial Arthropods Module of the Mercantour part of the ATBI had been sorted; but because this included independent sampling methods, which were far more often sorted, the proportion is much lower for samples obtained from integrated sampling methods, such as Malaise traps, intercept traps and Berlese extraction, despite the dedicated efforts of two technicians. Even then, the comments of Vala & Williams (2015) on the representation of sciomyzid flies in the material they received suggest that the sorting might not have been uniform. Perhaps the EDIT management reasoned that partner museums would necessarily have technicians capable of carrying out such sorting, but this is not always the case. If governments or the European Union decide to pursue this type of project in future, more consideration should be given to the infrastructure needed to support such work.

Despite these limitations, large scale expeditions and ATBIs play an invaluable role in increasing public awareness of biodiversity and the need for its preservation. The two approaches are largely complementary: expeditions, of any size, are "one shot" sampling events, but they can help identify areas of particular interest in terms of fauna and flora, which could then

be studied more intensively and over a longer period in the form of an ATBI. Obtaining dozens of new species from a single area in countries usually considered to have "well known" faunas, like France and Italy, can make a strong impression on the general public, who often imagine that novelties only remain to be discovered in remote regions of the tropics or the deep seas. Even some zoologists might be surprised to learn that new species continue to be found in the Alps, which have a long history of collecting and biogeographical study. ATBIs can therefore play an important role in raising public awareness of the importance of biodiversity research, which is one of the goals of Aichi biodiversity targets (https://www.cbd.int/sp/targets/) and the Global Taxonomy Initiative (https://www.cbd.int/gti/), instigated by the Convention on Biological Diversity.

PERSPECTIVES

Despite concerted efforts to boost our knowledge of the region, the inventory of all the species living in the Maritime Alps is far from complete, as shown for terrestrial invertebrates by Deharveng *et al.* (2015a). Further studies will no doubt produce many surprises in terms of taxa new to science or previously unknown from France or Italy. Data diffusion is another concern that we are discussing with partners in charge of this task, in order to ensure free access to verified data and publications arising from the MNP/AMNP ATBI, for both the scientific community and the public. The ATBI thus remains an ongoing project, in which the community of taxonomists and naturalists continues to participate. This rewarding human and scientific adventure has helped open the perspective of a possible inclusion of MNP/AMNP in the UNESCO list of World Heritage Sites (Leccia & De Biaggi 2015b, this issue), which would be a fitting acknowledgement of its great natural importance.

SUPPLEMENTARY DATA

Two additionnal tables are available on the website: http://sciencepress.mnhn.fr/fr/periodiques/zoosystema/37/4

Table S1. Terrestrial invertebrate species newly recorded from the Mercantour (MNP, France) and Alpi Marittime (AMNP, Italy) parks, and from France and Italy, published in the ATBI special issues of *Zoosystema* (Daugeron *et al.* 2015a, b).

Table S2. Groundwater invertebrate species newly recorded from the Mercantour (MNP, France) National Park and from France, published in the ATBI special issues of *Zoosystema* (Daugeron *et al.* 2015a, b). Species in bold are recorded as new for science, but only two have been described in these issues.

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