The European *Vitis* Database (www.eu-vitis.de) – a technical innovation through an online uploading and interactive modification system

E. Maul[1]*, K. N. Sudharma[1], S. Kecke[2], G. Marx[2], C. Müller[2], L. Audeguin[3], M. Boselli[4]*,
J. M. Boursiquot[5], B. Bucchetti[6], F. Cabello[7], R. Carraro[8], M. Crespan[8], M. T. de Andrés[7], J. Eiras Dias[9]*,
J. Ekhvaia[10], L. Gaforio[7], M. Gardiman[8], S. Grando[11]*, D. Gyropoulos[12], O. Jandurova[13],
E. Kiss[14], J. Kontic[15], P. Kozma[16], T. Lacombe[5], V. Laucou[5], D. Legrand[3], D. Maghradze[17],
D. Marinoni[18], E. Maletic[15], F. Moreira[11], G. Muñoz-Organero[7]*, G. Nakhutsrishvili[10], I. Pejic[15]*, E. Peterlunger[6], D. Pitsoli[12], D. Pospisilova[19], D. Preiner[15], S. Raimondi[18], F. Regner[20], G. Savin[21],
S. Savvides[22], A. Schneider[18]*, C. Sereno[3], S Simon[15], M. Staraz[4], L. Zulini[11], R. Bacilieri[5]*
and P. This[5]*

[1] JKI - Julius Kühn-Institut, Bundesforschungsinstitut für Kulturpflanzen, Institut für Rebenzüchtung Geilweilerhof, Siebeldingen, Germany
[2] Julius Kühn-Institut, Zentrale Datenverarbeitung, Quedlinburg, Germany
[3] Institut Français de la Vigne et du Vin (IFV), Pôle National Matériel Végétal, Le Grau-du-Roi, France
[4] Department of Biotechnology, University of Verone, San Floriano, Italy
[5] INRA – SupAgro Montpellier, UMR DIAPC, Équipe Génétique Vigne, Montpellier, France
[6] Department of Agricultural and Environmental Sciences, University of Udine, Udine, Italy
[7] Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario (IMIDRA), Alcalá de Henares, Spain
[8] Consiglio per la Ricerca e la sperimentazione in Agricoltura, Centro di ricerca per la Viticoltura (CRA-VIT), Conegliano, Italy
[9] Estação Vitivinicola Nacional (EVN-INIAP), Dois Portos, Portugal
[10] Institute of Botany, Georgian Academy of Sciences, Tbilisi, Georgia
[11] Istituto Agrario di San Michele all' Adige (IASMA), San Michele all' Adige, Italy
[12] National Agricultural Research Foundation (NAGREF), Maroussi, Athens, Greece
[13] Research Institution of Crop Production (RICP), Prague, Czech Republic
[14] Szent István University, Institute of Genetics and Biotechnology, Gödöllő, Hungary
[15] Faculty of Agriculture, University of Zagreb, Department of Viticulture and Enology, Zagreb, Croatia
[16] FVM Szőlészeti és Borászati Kutatóintézete, Pécs, Hungary
[17] Research Institute of Horticulture, Viticulture and Oenology (IHVO), Tbilisi, Georgia
[18] CNR - Plant Virology Institute, Unit of Grugliasco, Grugliasco, Italy
[19] Research and Breeding Station for Viticulture; Modra, Slovakia
[20] Höhere Bundeslehranstalt und Bundesamt für Wein- und Obstbau (HBLAuBA), Klosterneuburg, Austria
[21] National Institute for Viticulture and Oenology (INVV), Chisinau, Moldova
[22] Agricultural Research Institute (ARI), Nicosia, Cyprus

Summary

The objective of the European *Vitis* Database is to safeguard and enhance germplasm by monitoring its preservation. Two issues are strongly related to that purpose: (1) participation of collections covering almost all grape biodiversity and (2) assessment of accessions trueness to type. In the scope of the European project GrapeGen06 efforts have been made towards both objectives. The 35 participating grape germplasm repositories are found between the Iberian Peninsula and Transcaucasia, thus covering a broad range of grape diversity. Altogether they maintain 32,410 accessions. However with respect to biodiversity, gaps are still evident and further collections need to be included and trueness to type assessment absolutely needs to be pursued to organize duplication of endangered genotypes. Within the GrapeGen06 project focus was laid on the establishment of a database conferring the collection holders a high degree of responsibility and independence. Hence for the first time in a European Central Crop Database an on-line uploading application and an interactive modification system for data administration was implemented. These innovations disburden the database manager and offer the curators of collections more flexibility. Prerequisites for data import, descriptors applied, access levels, database contents, uploading, export and search functions are described.

Introduction

In the 1970s it became evident that human activities had caused the disappearance or were severely threatening the wild grapevine and innumerable numbers of grape cultivars (Alleweldt 1983). Consequently in various countries measures to safeguard the grapevine genetic resources were initiated (Costacurta 1991, Boursiquot 1998, Maigre *et al.* 1999) and are continued today in almost all grape growing nations (Boursiquot *et al.* 2009, Gago *et al.* 2009, Jung 2004, Jung 2008, Torello Marinoni *et al.* 2009). It has been recommended to organise a network of grape-

vine collections and to establish an international database registering the cultivars, breeding lines and wild species maintained therein (Alleweldt 1983). As a result the *Vitis* International Variety Catalogue (VIVC: www.vivc.de) was established as a leading example for an inventory of the genetic resources of a crop species and its wild relatives. Subsequently, in the scope of the two European projects Genres081 (runtime 1997-2002) and GrapeGen06 (runtime 2007-2011) the European *Vitis* Database has been created. Main emphasis of the VIVC is on the compilation of the worldwide existing cultivars, while in contrast the European *Vitis* Database is focusing on the registration of accessions preserved in the European grapevine repositories.

A core objective of the second European project, GrapeGen06, was the establishment of a database remaining vital, even after termination of the project (Bacilieri *et al.* 2010). This led to a fundamental change of the database organisation and in 2007 the restructuring of the European *Vitis* Database started.

To date 58 Central Crop Databases (CCDBs) are maintained by institutes from various countries. They were initiated together with the European Cooperative Program for Plant Genetic Resources (ECPGR). In the past, data upload and data modification was done by ECCDB managers in all 58 ECCDBs. The European *Vitis* Database is the first CCDB enabling curators to upload and interactively modify their own passport, characterisation, SSR-marker, virus data and photos. As a consequence, the European *Vitis* Database manager is disburdened, curators of collections have more flexibility with respect to data maintenance and a continuous follow up option, even after the termination of the project funding.

Objectives of GrapeGen06: GrapeGen06 main activities aimed to (1) implement a comprehensive inventory of the European grapevine collections, including Eastern European countries, (2) coordinate the long-term preservation of grapevine genetic resources, (3) assess the trueness to type via SSR-markers to sort out synonymy, homonymy and misnaming, which is an ongoing challenge in many grapevine collections, and (4) carry out standardised description of rare but historically unique genotypes. Having survived in grapevine collections or as a relict in old vineyards, today historical cultivars contribute to our understanding of grapevine migration, the origin and parentage of varieties. Other activities included an inventory of still existing populations of the ancestor of the cultivated grape *Vitis vinifera* subsp. s*ylvestris* (C. C. Gmel.) Hegi, threatened with extinction and the on-farm maintenance and evaluation of old cultivars and their clones. All data generated during GrapeGen06 have been incorporated into the European *Vitis* Database.

Material and Methods

Partners: Twenty-five partners from 17 countries are involved in GrapeGen06. Three partners from the previous project Genres081 (Maul *et al.* 2008) did not participate in GrapeGen06, but data were kept. Eight collections from the Black Sea project (Maghradze *et al.* 2009) were included. Thus the countries being involved are Armenia, Austria, Azerbaijan, Bulgaria, Croatia, Cyprus, Czech Republic, France, Germany, Georgia, Greece, Hungary, Italy, Morocco, Moldavia, Portugal, Russia, Slovakia, Slovenia, Spain, Switzerland and Ukraine.

Technical infrastructure: For the development of the European *Vitis* Database the following tools were applied: (1) the relational database management system MySQL, (2) the internet programming language PHP, (3) JavaScript, (4) Cascading Style Sheets (CSS), (5) PEAR-Spreadsheet, (6) FPDF (a PHP class to generate PDF files), (7) Ajax, (8) the operating system LINUX and (9) the web server APACHE. To prevent data loss database dumps are used for backing up the data. Dump files are maintained at least one year.

Descriptors: With respect to passport data, the FAO / IPGRI Multi-Crop Passport Descriptor (MCPD) format (Alercia 2001) used by EURISCO, including MLS Status and Aegis Status, even though *Vitis* is not an Annex 1 crop of the Multilateral System of the International Treaty on Plant Genetic Resources (http://www.planttreaty.org/training/annex1_en.htm), was adopted. Thirteen *Vitis* specific passport descriptors were appended in order to (1) better describe the accession, added descriptors were "berry color", "country of origin of the variety", "year of crossing" and (2) include criteria related to trueness to type by adding descriptors "trueness to type", "variety name", "variety number", "confirmation of the accessions identity by ampelography", "confirmation of the accessions identity by SSR-markers", "confirmation of the accessions identity by bibliography", "bibliography (volume)", "bibliography (page)", "confirmation by others", "remarks to the accession name", resulting in a total of 49 descriptors.

For the characterisation and evaluation of accessions 48 descriptors of the OIV descriptor list for grapevine varieties and species (OIV 2009) have been chosen, e.g. Young leaf: colour of upper side of blade (4th leaf) (OIV 051), Mature leaf: number of lobes (OIV 068), Berry: shape (OIV 223), Time of bud burst (OIV 301), Bunch: density (OIV 204), Bunch: single bunch weight (OIV 502). For all descriptors applied see http://www.eu-vitis.de/docs/descriptors/mcpd/WP2-DESCRIPTORS-v4.pdf. For SSR-marker analysis 6 loci of Genres081 (VVS2, VVMD5, VVMD7, VVMD27, VrZAG62 and VrZAG79) recommended as a standard set for grapevine genotyping (This *et al.* 2004), plus 3 further most common and polymorphic loci (VVMD25 VVMD28, VVMD32) (Bowers *et al.* 1999) were selected. To investigate the virus status of accessions, four viruses were analysed: Grapevine Fanleaf Virus, Arabis Mosaic Virus, Leaf Roll Virus type1 and Leaf Roll Virus type 3. Photos mainly of shoot tips, leaves and bunches were collected. The photos had to be uploaded in original size and the file name had to match with the required format "accenumb_accename_category of plant organ(_additional text).jpg". Specific descriptors were designed to evaluate on-farm maintained neglected varieties, encompassing the general description of the cultivar, the vineyard, morphology, agronomic and oenological features and results from public wine tastings. For the inventory of

populations and plants of *Vitis vinifera* subsp. *sylvestris* the FAO / IPGRI MCPDs were adopted.

MCPD and OIV descriptors and excel file formats for all categories can be downloaded from the European *Vitis* Database homepage via "Descriptors / file formats".

Institute codes, assigned by the World Information and Early Warning System (WIEWS) (http://apps3.fao.org/wiews/wiews.jsp) on Plant Genetic Resources, with respective contact data of grapevine collections can be retrieved via "Institute codes". They are needed for the standardized entry of MCPDs like holding institution, donor and breeder in the database.

Standardisation of terms: A prerequisite for databases is the standardisation of vocabulary. Adoption of taxonomic terms, language and specific expressions is fundamental. Hence in agreement with the partners of GrapeGen06, terminology has been defined for a series of MCPDs like berry colour (green, rose, red, grey, in total 16 combinations are accepted), trueness-to-type (yes, no, uncertain, no reference, not checked), crop use (wine grape, table grape, raisin grape, rootstock, ornamental grape, wild grape) and *Vitis* species spelling. As an example the white berry colour of an accession needs to be entered as "green". "White", "yellow", "blanc", "belyi" "G", "B", etc. are not accepted. In addition data entry had to follow fixed format rules, e.g. for descriptors where the date had to be entered, the year had to be mentioned first, followed by the month and by the day, for example: 20020623. In the same context the use of an institute code instead of distinct spellings of institute names is a must.

Access levels: Three access levels have been created: public access, all partner access and partner specific access. All levels have the same search options, except SSR-marker data that are confidential and reserved for partners of GrapeGen06 and for people having registered for SSR marker data admission *via* public success. Partner specific usernames and passwords authorise the partners to upload their own data and photos on the partner specific access level. On the same level, MCPD data can interactively be modified and in all categories data sets can be deleted. From the both partner-access-levels (*i.e.* "all partner access" and "partner specific access") export options for MCPD, characterisation, SSR-marker, virus data, on-farm evaluation and *Vitis vinifera* subsp. s*ylvestris* (C. C. Gmel.) Hegi germplasm have been implemented.

Information about European *Vitis* Database content, search functions and functionality can be found in the handbook available on the top of the homepage.

Results

Database contents: The European *Vitis* Database registered MCPD data collected within the two European projects GrapeGen06 and Genres081 and the Black Sea-project (Maghradze *et al*. 2009). Up to now 32,410 accessions are held in 35 grapevine collections, which are located in 22 countries. Characterisation data are available for 2,132 (6.6 %) accessions of old and rare varieties, 4,323 (13.3 %) accessions have been genotyped by SSR-markers, virus status has been checked at 464 (1.4 %) accessions and 3,678 photographs of shoot tips, leaves and clusters have been imported. For a detailed listing of the institutes involved, the number of accessions preserved and described, see the Table. On farm-evaluation has been carried out on 56 cultivars. With 225 locations a considerable number of *Vitis vinifera* subsp. *sylvestris* sites have been identified, from which 631 plants have been safeguarded and are preserved by 6 countries in 6 repositories.

Data upload: An important prerequisite for automated data upload is the utilization of standard excel file formats, which had been previously designed for the different types of data. With respect to MCPD, the excel file format is strictly in line with the requirements of EURISCO, the European network of *ex situ* National Inventories. To motivate the partners of the European *Vitis* Database to communicate the MCPD data of their grapevine collections to their countries National Inventory Focal Points (http://eurisco.ecpgr.org/static/network_focal_points.html) a respective note was placed on the partner access level as a reminder.

The primary key of the database is the accession number, which is a unique code number assigned to a sample/genotype entering a gene bank. The accession number is part of the MCPD data, which is uploaded first. Before MCPD data are definitely registered in the database, the import program controls if the accession number exists twice or even more frequent. It will reject all accessions with identical accession numbers. Subsequently during importation descriptive data and photos are linked to that unique accession number.

With each upload of a grapevine collections MCPD data, the previous MCPD data are deleted. As a consequence the MCPD data of the entire collection always has to be imported.

In case that an accession with linked data does not figure on the newly imported MCPD data list, a warning message pops up indicating that characterisation, SSR-marker data or photos exist. The respective accession can be maintained and the partner checks his inventory again. Interactive modification of the data set has been implemented. Addition, adjustment and deletion of MCPD entries are possible, according to the agreed rules. Implementation of drop down menus and choice by ticking check boxes also contribute to a standardised data input. In contrast to MCPD data, where in the scope of a new upload the previous MCPD records are all replaced, characterisation, marker and virus data are appended, except if a description of the accession had already been imported before. As a consequence, during characterisation data upload it is checked if data exist for the respective accession numbers and the years of description. If this is the case, data are overwritten. The same procedure is carried out during SSR-marker and virus import. Data are overwritten if records of the same accession number had been uploaded before. In this way records can be revised and completed. Deletion of data records can be carried out as well. In order to generate a variety describing pdf-document, full size photos are imported. Smaller size photos are produced during import for a rapid screen display.

Table

European *Vitis* Database: imported accessions by collections and number of described accessions by categories (status July 2011). The 1st part of the table encompasses collections from partners of GrapeGen06, in the 2nd part of the table are listed the collections of the Black Sea Project (MAGHRADZE *et al.* 2009) and in the 3rd part of the table collections of Genres081(MAUL *et al.* 2008) partners not participating in GrapeGen06 are given

Institute code[1]	Partner	MCPD data	Characteri-sation data	Characteri-sation data	SSR-marker	Virus data	Photos of shoot tips, leaves and bunches
		No. of maintained accessions	No. of described accessions	No. of accessions and repe-titions	No. of genotyped accessions	No. of tested accessions	No. of photos
FRA139	partner00	7,502	194	208	753	71	375
DEU098	partner01	3,622	233	312	529	50	432
AUT024	partner02	940	43	50	261		104
ESP080	partner03	3,402	510	522	187	45	238
GRC010	partner04	807	105	106	18		199
PRT051	partner05	721	104	172	130		399
ITA388	partner06	3,215	118	152	132	29	327
ITA388p	partner06	28	17	17	27	17	
ITA360	partner07	596	130	192	203	87	613
ITA360p	partner07	36	31	31	31	4	
ITA362	partner08	274	97	129	172		105
ITA368	partner09	390	57	57	60	30	220
ITA412	partner10	56					
ITA035	partner29	179			179		
ITA041	partner28	15			15		
CHE019	partner11	327					
HUN045	partner12	1,101	109	109	142		207
HUN005 (no collection)	partner13				76		
CZE041	partner14	124	124	168	82	35	89
FRA274	partner15	1,756			1,011		
CYP001	partner16	92	9	9			76
SVK042	partner17	151	151	151			
SVN019		69					
MDA004	partner18	421					
HRV041	partner20	100	100	100	100	99	238
GEO014	partner23	147					55
MARXX01	partner24	94			94		
		26,805	2,132	2,485	4,323	467	3,678

Institute code[1]	Partner	MCPD data: No. of maintained accessions	Characeri-sation data: No. of described accessions	Characerisation data: No. of accessions and repetitions			Shoot tips, leaves and bunches: No. of photos
UKR050	Black Sea Collections	346					
RUS 02	Black Sea Collections	500					
GEO015	Black Sea Collections	40	25	25			53
GEO017	Black Sea Collections	251					
GEO018	Black Sea Collections	178					
GEO019	Black Sea Collections	251					
AZE007	Black Sea Collections	397					
ARM011	Black Sea Collections	133					
		2,096	25	25			53

Institute code[1]		MCPD data: No. of maintained accessions	Characerisation data: No. of described accessions	Characerisation data: No. of accessions and repetitions			Shoot tips, leaves and bunches: No. of photos
BGR013		1,673					
ESP074		1,577	68	107			
GRC005		259	87	131			205
		3,509	155	238			205

Data export: All registered data can be downloaded as a whole or as a subset according to preselected criteria. In particular with respect to the first MCPD data import, considerable and thus time consuming modifications prior to definite upload are necessary in most cases. Therefore if an update is envisaged it is recommended to use the already standardized MCPD data set by exporting the collection's MCPD data. By doing so, repeated laborious adaptation according to the required terms can be avoided. The accessions characterisation and SSR-marker data of various geographic origins are a valuable source for checking trueness to type in grape germplasm repositories. Through the possibility of data export they are ready to be used for comparison purposes and data processing.

Database search: MCPD data upload follows strict rules. Most field entries are checked if they are in line with the agreed vocabulary and various options or explanations support the selection of the correct term or spelling. As a result a database search finds all accessions corresponding to the chosen criteria.

Various search combinations have been implemented. The most comprehensive search is to be found under "Advanced Search", where 39 of the 49 MCPD descriptors are retrievable, also in combination with characterisation data on the public access level and moreover in combination with SSR-marker data on the partner access level. In doing so, accessions corresponding to specific traits or sharing the same allelic pattern can be selected. For all other categories like "Characterisation data" or "Virus data" either all described / analysed accessions can be listed or a preselection can be made by using the list fields.

The table which is generated encompasses the 11 most important criteria in two aspects: "accession name", "color of berry skin", "holding institution", "accession number", "species", "subtaxa" and "country of origin of the variety" are related to passport attributes, whereas "trueness to type of the variety", "variety name", "variety number VIVC", "remarks to the accession name" target the real identity of an accession and are the outcome of intensive investigations and work which is still underway. The utilisation of the variety code number of the VIVC was agreed by all partners to tag identical accessions. It has been added to support the retrieval of identical accessions, even if they are listed under distinct designations (synonyms). The completion of variety numbers is still going on. Rare grapevine varieties are of particular interest for winegrowers wanting to offer

regional specialties to wine enthusiasts. The description of neglected autochthonous varieties was a focus of Grape-Gen06. One page descriptions of varieties are download-able via pdf-document. The created pdf-document lists the most important features of the variety, including photos of the shoot tip, leaf and bunch. The evaluation results of cul-tivars having been maintained on farm are downloadable as pdf-documents as well.

D a t a b a s e   b e n e f i t s : One of the ultimate goals of a crop database like the European *Vitis* Database is germplasm monitoring, aiming at the long term preserva-tion of the still existing grapevine genetic resources. Here-of the identification of precious endangered genotypes and their safeguarding through duplicate conservation is one of the uttermost tasks. To date the European *Vitis* Database is covers 22 wine growing nations from the Iberian Penin-sula to Transcaucasia, 35 grapevine repositories with alto-gether 32,410 accessions. Via the comparison of genetic fingerprints, notations of morphological descriptions and photos, present in the European *Vitis* Database, duplicates and questionable varieties, like misnomers, have been identified (Schneider *et al.* in prep.). This is a first step. For most participating grapevine collections genotyping is underway or has been completed using at least 6 to 9 of the GrapeGen06 SSR-markers. With this information a comprehensive comparative study of fingerprints becomes realistic, representing an enormous step in the identifica-tion of unique genotypes. In this context the inclusion of further partners, in particular from countries not present in the European *Vitis* Database, is needed to gather the most complete coverage of grapevine diversity.

Besides the description and evaluation of accessions from autochthonous varieties which are maintained in collections a practice oriented evaluation of 56 neglected varieties maintained on farm has been carried out within GrapeGen06 as well. Growers interested in rare historical cultivars will find detailed information about their agro-nomical features, must and wine characteristics. This ac-tivity was carried out to initiate the direct use of genetic resources.

An inventory of *Vitis vinifera* subsp. *sylvestris* popu-lations has been carried out by the 8 countries Austria, France, Georgia, Germany, Italy, Portugal, Slovakia and Spain. As *Vitis vinifera* subsp. *sylvestris* is the ancestor of the cultivated grape (This *et al*. 2006), whose biodiversity with respect to wine quality and other agronomic traits has not yet been investigated, still existing populations need characterisation and protection. The European *Vitis* Data-base provides information about the status of the popula-tions with respect to reproduction and the potential risk of extinction serves to raise public awareness. The European *Vitis* Database may provide a focal point for collecting and distributing *Vitis vinifera* subsp. *sylvestris* information to interested partners.

Conclusion

The innovative aspect of the European *Vitis* Database is that curators are enabled to import and modify their own data in a central database. The database manager not being involved is disburdened from time consuming tasks. Up-dating at any time makes database maintenance by collec-tion holders more flexible. Hence this new uploading and interactive modification system represents real progress. Furthermore, the objective to create an attractive data-base worthwhile to be maintained, even after the end of the GrapeGen06 project, because of high quality data of interest for any question related to grape germplasm was achieved.

Owing to the ease of data import and data administra-tion the inclusion of further collection inventories in the European *Vitis* Database is realistic. This is important, with respect to countries not present in the European *Vitis* Da-tabase, to further gather grapevine diversity information. The final goal is to have registered true to type accessions in the European *Vitis* Database to be used as references and to identify and organize conservation of endangered geno-types.

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Corrigendum

On page 79 one of the author's names (D. Gyropoulos) of the manuscript:

The European *Vitis* Database (www.eu-vitis.de) – a technical innovation through an online up-loading and interactive modification system

E. Maul[1]*, K. N. Sudharma[1], S. Kecke[2], G. Marx[2], C. Müller[2], L. Audeguin[3], M. Boselli[4]*,
J. M. Boursiquot[5], B. Bucchetti[6], F. Cabello[7], R. Carraro[8], M. Crespan[8], M. T. de Andrés[7], J. Eiras Dias[9]*,
J. Ekhvaia[10], L. Gaforio[7], M. Gardiman[8], S. Grando[11]*, D. Gyropoulos[12], O. Jandurova[13],
E. Kiss[14], J. Kontic[15], P. Kozma[16], T. Lacombe[5], V. Laucou[5], D. Legrand[3], D. Maghradze[17],
D. Marinoni[18], E. Maletic[15], F. Moreira[11], G. Muñoz-Organero[7]*, G. Nakhutsrishvili[10], I. Pejic[15]*,
E. Peterlunger[6], D. Pitsoli[12], D. Pospisilova[19], D. Preiner[15], S. Raimondi[18], F. Regner[20], G. Savin[21],
S. Savvides[22], A. Schneider[18]*, C. Sereno[3], S Simon[15], M. Staraz[4], L. Zulini[11], R. Bacilieri[5]*
and P. This[5]*

is incorrectly written. The correct writing is: D. Argyropoulos.

We apologise for this error.