role in Lublin (Southern-East Poland) region. The concentration of *Alternaria* airborne spores in this area was worth examining for medical and phytopathological aspects.

The continuous sampling of *Alternaria* airborne spores were carried out in Lublin throughout two years 2002 and 2003. The investigation was based on volumetric method with use of Lanzoni VPPS 2000 spore trap, operating on about 16 metres above ground level. The comparison of concentration values in 2002 and 2003 was made. The obtained data were elaborated statistically. To estimate the relationship between *Alternaria* spore concentration and weather variables the mean correlation and regression analyses were used. Six weather parameters were taken under consideration: temperature, relative humidity, wind speed, wind direction, precipitation and cloudiness.

Airborne fungal spore concentrations inside and outside homes in the Fresno (CA) Asthmatic Children's Environment Study (FACES)

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Exposure to airborne fungal spores has been implicated as a causative factor for acute exacerbation of asthma, mainly in young adults. This investigation on indoor and outdoor concentrations of fungal spores is a part of the Fresno Asthmatic Children's Environmental Study (FACES), which is designed to characterize the health effects of air pollution on asthmatic children living in Fresno County of California, USA.

From March 2002 to February 2003, 498 daily pairs of indoor/outdoor samples were collected at 83 homes. During the one-year period, 18 of the residences were sampled during two different seasons. The samples were collected with the Burkard Continuous Recording Air Sampler (Model 9100) continuously for 24 hours in the family room and outside each home at the height of 1.5 m on 5 days during a two-week period. Homes were selected by geographic location (e.g., near highway or central area of the city) and household characteristics (e.g., pets, the number of people, and combustion source). Simultaneous fungal spore sampling was conducted with three Hirst-type Burkard Seven-day Recording Spore traps, one at 11 meters height on the U.S. Environmental Protection Agency's Supersite monitoring station located in central Fresno, two others (at 4.5 meters height each) on trailers located at different school yards in the Fresno area.

Cladosporium spp. were the most common species found indoors, followed by fungi connected to the agricultural environment (species of *Exserohilum*, *Epicoccum*, *Oidium*, *Erysiphe*, *Puccinia*, *Ustilago*, smuts and rusts), and *Alternaria* spp. The indoor concentrations of *Alternaria* spp. were very close to the outdoor concentrations. In a number of homes, *Aspergillus/Penicillium* spp. were found in high concentrations (average 2 h concentration up to 2000 spores m^{-3}) during the times for breakfast, lunch and dinner. Generally the night (8 pm–6 am) concentrations were <100 spores m^{-3}, suggesting that *Aspergillus/Penicillium* ssp. spores in these homes were liberated from surfaces because of indoor activity. The agricultural fungi showed clear seasonal and spatial variation.

Depending on the season, the indoor fungal spore concentration ranged from 4%–20% of the outdoor concentration if the windows were kept closed during the sampling period. If the windows were kept open during the whole sampling period, the indoor fungal spore concentration was 50–90% of the outdoor concentration. Keeping the windows open more than 30 minutes in the early morning (6–9 am) did not increase the total indoor spore concentration as much as having them open in the afternoon (12–6 pm) or night (8 pm–6 am). The ownership of cats or dogs did not increase the indoor spore concentration.

There was no significant difference in the total fungal spore concentrations between the 11 m and 4.5 m heights, whereas the sampling at 1.5 meters height resulted in an ~30% higher total spore counts. The biggest difference was between concentrations of *Alternaria* spp., the counts being higher at the lower sampling level.

The relationships between indoor and outdoor concentrations of fungal spores and airborne endotoxin, PM10, and PM2.5 are discussed

Aerobiological survey of basidiospores in the atmosphere of Seville

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Basidiomycetes produce a large amount of spores that are wind dispersed to long distances, some species can release billions spores in a day, many of those spores are important fungi aeroalergens that are involved in asthma and allergic rhinitis. In a survey carried out, using a Burkard spore trap, in the city of Seville during two consecutive years, we have found out that basidiospores make up the second more frequent spore group in the atmosphere of this city, with a 9% of the total fungi spores sampled. They are present throughout the year showing a certain seasonal distribution; the month with a higher concentration is November with an average concentration of 23.586 basidiospores/m^3. A total amount of 18 different types of basidiospores were identified, being *Coprinus* apd *Ustilago* the most frequent, followed by *Agaricus*, *Phylacteria*, *Boletaceae*, *Ganoderma*, *Cortinarius*, *Calvatia*, *Agrocybe*, *Bovista* and *Puccinia* with much more lower concentration; the rest appeared in concentrations below 1% of total basidiospores.

The statistic analysis showed that the influence of the different meteorological parameters varies according to the researched type. A temperature increase involves an increase of the greater part of basidiospores, except for *Agaricus* and *Agrocybe* type negatively affected. In general a rainfall increase does not involve a concentration decrease except for *Ganoderma*, *Uredospora* and *Ustilago*, however, on the contrary, concentrations of *Agaricus*, *Agrocybe* and *Coprinus* rise with that rainfall increase. A relative humidity increase is associated to a concentration increase of basidiospores, though concentrations of *Ustilago* and *Uredospora* decrease when relative humidity is high. At the same time as insolation increases basidiospores air concentration decreases, though concentration levels of some types as *Ganoderma*, *Uredospora* and *Ustilago* increase. Eventually as wind is concerned, basidiospores are more frequent on days with a calm weather.

Poster session c3

FORECASTING POLLEN

The influence of meteorological parameters and bioclimatic indices in the atmospheric pollen content of Cupressaceae in Ponferrada (León)

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The forecasting of the atmosphere pollen content is a topic of permanent investigation in the Aerobiology. In previous studies it was suggested that bioclimatic indices could be used in polinic forecastings of herbaceous taxa (FERNÁNDEZ-GONZÁLEZ et al., 2000; VALENCIA-BARRERA et al., 2000). Here, we test the two methodologies for routine pollen forecasting by comparing correlation coefficients using Cupressaceae airborne pollen, family which includes scrubs or trees, as the dependent variable and meteorological parameters and bioclimatic indices as independent variables.

Pollen grains were sampled by using a volumetric collector type Hirst seven–day-recording trap, from 1996 to 2002 in the atmosphere of the city of Ponferrada (León, N. W. Spain). Regarding the methodology and sample preparation it has been followed the proposal of the REA (DOMÍNGUEZ et al., 1991) and Andersen (1981) to determine main pollination period (MPP). In this study we have worked with the Spearman correlation analysis. For this statistical analysis we have used the MPP, the three months before the MPP and the MPP with the three months before this period. The meteorological parameters that we used in this study were: temperature (maximum, minimum and mean), rainfall, relative humidity, wind speed, calms and direction (NE, SE, SW, NW), and the bioclimatic indices were: continental index modified (CI), thermicity index modified (TI) and ombrothermic index modified (OI).

The parameters bearing the greatest positive influence on the occurrence of Cupressaceae pollen grains are: wind direction (NE, SE and NW) and wind speed; negative parameters are: temperature (minimum and mean), rainfall, calms and bioclimatic indices. The most important correlation coefficients were obtained with the bioclimatic indices for the three months before MPP, which seems to indicate that they could be more important for pre-season pollen forecasting.

DOMÍNGUEZ, E.; GALÁN, C.; VILLAMANDOS, F. & INFANTE, F. 1991. Manejo y evaluación de los datos obtenidos en los muestreos aerobiológicos. **REA**. 1:1-8

FERNÁNDEZ-GONZÁLEZ, D; COMTOIS, P. & VALENCIA-BARRERA, R.M.. 2000. On the use of bioclimatic indices in airborne pollen forecasting. **Abstracts of the X International Palynological Congress (I.P.C.)** Nanjing, China.

VALENCIA-BARRERA, R.M.; COMTOIS, P & FERNÁNDEZ-GONZÁLEZ, D. 2002. Bioclimatic indices as a tool in pollen forecasting. **Int J Biometeorol.** 46: 171-175.

VALENCIA-BARRERA, R.M.; VEGA-MARAY, A.; COMTOIS, P. & FERNÁNDEZ-GONZÁLEZ, D. 2000. El uso de índices bioclimáticos en las previsiones polínicas: Plantaginaceae. **Abstracts of the XIII (A.P.L.E.)**, Cartagena, España.

Chilling and heat requirements for the prediction of the flowering of *Alnus glutinosa* (L.) Gaertner in Ponferrada (León)

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Trees which flower in winter, like alder, can survive periods of adverse climatic conditions, entering into a period of "dormancy" at the last days of summer. The end of the dormancy state and the start of the flowering, require a period of low temperatures followed by another of warm temperatures.

Chilling and heat requirements of Alnus glutinosa (L.) Gaertner was studied in Ponferrada during a period of eight years (from 1995 to 2002 inclusive).

In order to determinate the chilling and heat requirements we used a thermal time model, this model was proposed by ARON (1973), based on the accumulation of chilling hours (CH) between 0 °C and 7.2 °C. It considers the maximum and minimum temperatures and the length of the chilling period. Taking into account the day when the mean temperature decreased below the threshold and a change in temperature trend.

Once chilling requirements are attained, the accumulation of heat begins. This was calculated as a function of the sum of the daily mean temperatures after deducting different base temperatures from the end of the chilling period to the beginning of the pollen season (RING et al.., 1983), and expressed as growth degree days (GDD), in °C.

Different threshold temperatures were used for chilling and heat requirements, the lowest variation coefficient was selected as the best threshold temperatures.

The accumulation of chilling in this period takes place from the last days of October to the first fortnight of December or at the beginning of January.

The chilling requirements are obtained with a 7.5 °C threshold temperature, this threshold showed the smallest value for the coefficient of standard deviation, obtaining an average of 1023 CH.

The heat accumulation takes place in a few days,and fluctuates between two and fifteen days. The smallest standard deviation was found with a threshold temperature of 4.5 °C, an average of 26 GDD.

ARON, R. 1983. Availability of chilling temperatures in California. –**Agric. Meteor**. 28: 351-363.

RING, D. R.; HARRIS, M.K K.; JACKMAN, J. A. & HENSON, J. L. 1983. **A fortran computer program for determining start date and base temperature for degree-day models.**The Texas Agricultural Experiment Station Bull MP-1537, The Texas University System, College Station, Texas.

The impact of meteorological factors on *Poaceae* pollen season in Gdańsk (Northern Poland)

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Apart from the individual rhythm of plants pollination, weather conditions are considered the most important factors determining the dispersion and content of tree and herb pollen in the air. The aim of this study was to analyze a relationship between the meteorological conditions and different aspects of pollen season of Poaceae, which is known to be an important aeroallergen in Europe. The influence of particular meteorological factors on a given pollen season feature was evaluated by means of statistical analysis. Furthermore, the factors of the highest influence were used to derive the statistical models of these relationships. The analysis was based on pollen data obtained in Gdańsk (Poland) during nine consecutive years (1994 – 2002) with a volumetric pollen trap.

The linear stepwise multiple regression technique was applied to determine the statistical models of the following parameters of the *Poaceae* pollen season: the length of the season, the annual sum and the starting date. The length of *Poaceae* pollen season varies from 78 to 115 days and it gets longer along with the number of rainy days during the season. Meteorological conditions before and during the season impact the annual sum and the starting date. The annual sum, which changes from 977 to 3258 $P.m^3$/day, is positively correlated with thermal conditions during the season and negatively correlated with number of days in March and April with $T<0°C$. The starting date of the season depends on the mean temperature in April and the number of days with $T<6°C$ between 1st of March and the starting date.

Correlations between pollen concentration and meteorological factors

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The evaluation of pollen concentration in the air and its seasonal variation is important for health and agronomic aspects. Meteorological factors determine intensity of pollen production and influence the trend of its daily concentration during the pollination period.

The aim of the present study was to find relations between pollen emission and meteorological data in Rome, to propose a forecasting model.

Pollen monitoring was carried out by means of a Hirst volumetric spore trap according to the IAA standard method (Mandrioli 1994), during the months of April, May and June from 2001 to 2003, in two different sites of Rome: Tor Vergata University and Central Office of Crop Ecology (UCEA).
Meteorological data were collected from meteorological observatory of UCEA.

Total pollen concentration and three pollen types (Gramineae, *Quercus*, *Olea*) were considered for the model, and their data were correlated with the following meteorological variables: mean daily temperature, total daily rainfall, bright sunshine hours, mean daily wind speed and direction.

Pollen concentrations were analysed considering 10 day running means to describe seasonal scale fluctuations and daily deviations from the mean to single out important anomalies.
The time behaviour of the mean concentration values was studied in reference to the degree/day parameter (starting from the first day of April and assuming the mean April temperature as reference) and other meteorological variables like wind, rainfall and bright sunshine hours.

The long term fluctuation of mean concentrations are characterised by an increasing trend reaching the maximum when the total of 100 degree/day (on the threshold of 13,1°C) is passed. Thereafter mean pollen concentrations are gradually decreasing. The intensity of the said maximum appears to be related to the frequency of rainfall events.

The occasional large daily anomalies are clearly dependent on the synoptic scale low level circulation: peak positive daily deviations are associated to winds blowing from the sector N-E, that is to say when air trajectories develop over land. Negative anomalies, on the other hand, do occur when air goes through a long sea path.

According to the described preliminary results, to be confirmed by a longer experimentation, the availability of meteorological prognostic fields such as those provided by the European Centre for Medium Range Weather Forecasting (ECMWF) or by the U.S. National Centre for Environmental Prediction, offer useful elements to build up an objective methodology for pollen prediction in the range of a few days.

Modelling and forecasting *Olea europaea* L. airborne pollen concentrations in Granada (Southern Spain) using Soft Computing

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Forecasting concentrations of different airborne pollen types is one of the main goals of Aerobiology. This interest comes from its immediate clinical use, allowing for the allergic population to adjust their prophylactic treatment. This also justifies that most of the studies carried out so far are devoted to the most allergenic pollen types that reach high concentrations in the atmosphere. In Granada, *Olea* pollen is the main contributor in the annual pollen spectrum, being as well one of the main aeroallergens, as occurs in the whole Mediterranean area.

The aim of this work is to apply forecasting models based on Soft Computing to the problem of airborne *Olea* pollen concentrations. Soft Computing comprises a number of techniques of Modern Artificial Intelligence and entails to develop reasoning models which can represent and use imprecise and uncertain knowledge, modelling human reasoning. Fuzzy Logic and Artificial Neural Networks are two of the most popular paradigms, and were chosen here considering that have been applied before to the modelling of several types of time series. The models used were a neuro-fuzzy model, ANFIS (Jang, 93), which combines the advantages of both paradigms, and an artificial neural network based on generalised regression, GRNN (Specht, 92).

The dataset studied in this work comprises daily pollen concentrations measured during 11 years by means of a Seven Days Spore Trap (Burkard Ltd.). Preparation of samples and microscope counting was done accordingly to the metodology proposed by the REA (spanish aerobiology network) (Domínguez et al., 1991).

Contrary to the traditional approach, which tries to find relationships between the pollen concentrations and the associated meteorological variables, in this study we have tried to predict the future pollen concentration by using just past values of the time series, ignoring the information provided by the exogenous variables. The experimental design carried out was based on the autocorrelation study of the series, which indicated that the stronger correlation with pollen concentration in time t was held by concentrations in time $t-1$ and $t-3$. These two delay steps determinated, hence, the two input variables that the models took. Regarding the output of the models, we have calculated forecasting errors for three concentration intervals based on the aerobiological criteria.

The results obtained allow us to state that Soft Computing is an appropriate tool to analyze airborne pollen concentrations. Precisely, in the central interval (50-200gr/m^3), we have obtained forecasting errors of 56 gr/m^3 using the ANFIS model and 66 gr/m^3 using the GRNN model, which in both cases is better than the result obtained by linear regression (73 gr/m^3). In the first interval (0-50 gr/m^3) the two advanced models perform better than the linear regression, but, as is the case for the third interval (>200 gr/m^3), results are similar for the three models. We can conclude, hence, that the neuro-fuzzy approach is the most precise, which adds up to its interpretability in terms of linguistic rules. As well, it is noticeable that all the models used trend to perform worse when predicting higher concentrations (third interval), which is probably caused by the differences between those concentrations through the years, which are either dry or very rainy.

The possibility of including exogenous variables (meteorological parameters and bioclimatic indices) to the studied models opens an interesting path which may lead to better results.

DOMÍNGUEZ VILCHES, E.; GALAN, C.; VILLAMANDOS, F. & INFANTE, F. (1991). Manejo y evaluación de los datos obtenidos en los muestreos aerobiológicos. **Monografías REA/EAN**, 1: 1-18

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D.F. SPECHT. (1991). A general regression neural network. **IEEE Transactions on Neural Networks**, 2.

Forecasting the start and severity of pollen season in a Semi-Arid Climate

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Daily and seasonal forecasts for airborne pollen are used in the management of allergic airway disorders. Prediction of the onset and severity of the pollen season has proved to be a valuable tool in the preventive patient care.

In this study pollen data was collected continuously over a seven-year period in Tucson, Arizona, using a 7-day recording volumetric Hirst-type spore trap. Meteorological data available from 7 miles from the pollen monitoring location was studied in the year before and the years during the pollen collection. The pollen data of *Olea* spp., *Ambrosia* spp., Poaceae and *Chenopodium*-Amaranthaceae was included in the study.

Positive correlation between increased rain in February and *Olea* spp. pollen numbers during the following season was found ($p=0.02$), whereas negative correlation was found between the annual *Olea* spp. pollen output ($p=0.02$) and the number of chilling hours from January 15th to February 15th. Negative correlation was also found between the annual *Olea* spp. pollen output ($p=0.02$) and increased solar radiation in February.

Although *Ambrosia* spp. pollen are found through the whole year in Arizona, 95 % of the ragweed pollen grains occur in late February and March (*Ambrosia deltoidea*), a second, although much weaker, peak typically occurs in late September and October. The total *Ambrosia* spp. pollen output correlated strongly with increased precipitation in the preceding two months ($p<0.001$). When the total amount of rain was less than 60 mm during the 60 days prior the flowering of *Ambrosia deltoidea* , the season start was delayed beyond Julian day 64 ($p<0.001$). Also the amount of accumulated solar radiation in the two months before the pollen season negatively correlated with the onset of *Ambrosia* season ($p<0.001$). *A. deltoidea* is a perennial shrub, however, the climate variables in the proceeding year did not correlate with the number of *Ambrosia* pollen grains found during the spring season.

Poaceae pollen in Tucson routinely peaks in March-April and in August-September, the late summer flowering being more prominent than the spring one. There was a positive correlation with the start of the first season and the combination of pre-seasonal rain and accumulated solar radiation ($p=0.002$). The amount of grass pollen released during the second season correlated strongly with monsoonal rainfall ($p=0.001$).

The main flowering season for species from Chenopodiaceae and Amaranthaceae in Tucson is generally from July to October. The result of the multiple regression analysis show that the main flowering onset occurs 1-2 weeks after the start of the monsoon season, and the pollen counts strongly correlate with the amount of monsoonal rain in the same year.

Although the results from seven years continuous pollen measurements are too limited to develop any successful forecasting models for the investigated species, it is proved, that the onset and extend of the season for some allergenic pollen may be predicted by climatic variables in a semi-arid climate.

A new approach to the relationship between the rainfall and pollen discharge: Usind Symbolic Dynamic

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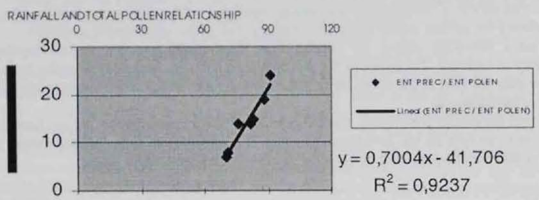
The major objectives for modelling aerobiological systems are to enable the prediction of pollen or spores concentrations and to evaluate the major factors influence these concentrations. The task of modelling aerobiological systems to achieve a predictive capability requires the integration of diverse information regarding the many stages and factors in a given system cycle into a comprehensive descriptive package. The rainfall is an important factor in pollen activity, since decrease the concentrations and the controlling role in plant development processes. However, whereas the first effect is easily relatable, it's more complicated the positive relationship between the rainfall and the posteriors flowering. The pollen samples are identified and recounted using the methodology proposed by the Aerobiological Spanish Network (REA). We used the rainfall and pollen data collected in Cartagena (Spain) between 1993 and 1999.

We have studied the relationship of the pollen discharge and the rainfall, by means of the entropy of both variables, calculated by approximation with the symbolic dynamic. The symbolic dynamics technique converts the time series of the biological signals $\{x_t\}$ $(t = 1,2,...N)$ in a sequence of symbols $\{s_j\}$ based on a window of size M, according to the following expression:

$$s_j = \sum_{i=1}^{M-1} \begin{cases} 0 & if \quad \left| x_i^j - x_{i+1}^j \right| \geq a \cdot \sigma_j \\ 1 & if \quad \left| x_i^j - x_{i+1}^j \right| < a \cdot \sigma_j \end{cases}$$

for $j = 1,2,...,N - M + 1$, where σ_j is the standard desviation of the original signal x_t over the j^{th} window and a is a tolerance measure. (Pincus, S.M. *et al*, 1991).

In the figure, the relationship between the rainfall and the total pollen concentration is observed. In this case, it's showed the total pollen concentration entropy in the spring versus the rainfall entropy in the previous autumn.



We showed that the pollen activity is related with the rainfall activity, and it's could be a an application of the chaos theory, that it's in its early stages of introduction in the environmental management (Kakonge, J.O., 2002).

PINCUS, S.M., GLADSTONE, I.M. & EHRENKRANZ, R.A. 1991. A regularity statistic for medical data analysis. In: **Journal of clinical monitoring** 7; 335-345.

KAKONGE, J.O. 2002. Application of chaos teory to solving the problems of social and environmental decline in Lesotho. **Journal of Environmental Management** 65; 63-78.

Airborne Poaceae pollen concentrations in the atmosphere of Bahía Blanca, Argentina and correlation with meteorological data. First prediction models

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Records of grass pollen concentrations and meteorological data from three years of sampling in Bahía Blanca, Argentina (38°44'S; 62°16'W) are used to analyse the behavior of Poaceae pollen in the atmosphere and the correlations with meteorological data. Daily data were obtained using a volumetric impact sampler Rotorod model 40 situated at height of 10 m above ground level on a building located in a residential zone near the downtown. Bahía Blanca city is located within the Pampas phytogeographic province, characterized by the lack of trees and the dominance of herbs of the grass family. Grass (Poaceae) pollen was selected for the analysis due to its being the taxonomic group of highest allergogenic relevance in Bahía Blanca area (Ramón *et al.*, 1995 and Carignano *et al.*, 1998).

Analysis of the results identifies the characteristic of grass pollen series in this period. We consider three pollen seasons for the study: August 2000 - June 2001; June 2001 - May 2002 and May 2002 - June 2003. The three curves are very similar and the total pollen emissions were: 3060 grains in 2000/2001; 2586 grains in 2001/2002; 2416 grains in 2002/2003. The pollen concentration are examined in relation to the main meteorological variables: temperature, relative humidity, accumulated temperature and rainfall, wind velocity and different wind directions. In addition, are used some others variables like accumulated pollen concentration and 3-day running mean of the prior day with a very important results. The concentration of pollen grains from Poaceae were found to be positively correlated with the average temperature (maximum, medium, and minimum) and predominant winds direction of the north and northeast, negatively correlated with relative humidity and predominant winds direction of the east to the south and southwest.

Although grass pollen was always present in the air during the studied period, a significant raise was detected between October and February. The highest relative concentration was reached in November. The beginning of the Spring raise in airborne pollen was detected in October for all the periods. The striking magnitude of the Spring peak can be attributed to the predominance of species of the pooid group (of winter-to-spring growing cycle mainly).

Some models are proposed to predict daily Poaceae pollen counts. These studies represents a very important advance in the development of the Aerobiology in South America because these are the first prediction models that have been carried out.

RAMÓN G.D., BRONFEN S., VILLAMIL C.B., FERRER N., APPHATIE S. & BARZÓN S. 1995. Pólenes relevantes para la rinitis alérgica estacional en la ciudad de Bahía Blanca y zona de influencia. **Archivos Argentinos de Alergia e Inmunología.** 26: 171-178.
CARIGNANO C., IAQUINARDI A., ARAMAYO E., VALLE A., ANDRADA A. & LAMBERTO S. 1998. Polinosis en la Región de Bahía Blanca. **Archivos Argentinos de Alergia e Inmunología** 29 (3): 21-27.