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Reverse Migrationof the Wood Pigeons and electromagnetic emissions, before the Mw 3.7 earthquake occurred in Visso-Macerata, Central Italyon October 18, 2021

Authors: Daniele Cataldi[1]; Enrico Cavina[2];

Gabriele Cataldi[1]; Valentino Straser[3]

1 – Radio Emissions Project, Lariano, Rome (I); 2 – Club Italiano del Colombaccio (I); 3 – Department of Science and Environment UPKL, Brussels (B).

E-mail: daniele77c@gmail.com[1]; ecavinaster@gmail.com[2];valentino.straser@gmail.com[3]

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ABSTRACT

On October 18, 2021, an earthquake of magnitude Mw 3.7 occurred at 12:54:17 (UTC) 2 km East from Visso, Macerata, Italy, with geographical coordinates (lat, lon) 42.929, 13.113 and at one depth of 10 km.

This earthquake had been preceded a few days by a series of electromagnetic signals coming from the seismic epicenter and its immediate vicinity.

In the same temporal context, an anomalous behavior of the Wood Pigeons was observed, which were not able to orient themselves autonomously to proceed in the S-SW direction towards the wintering areas mainly Corsica, Sardinia, the Iberian Peninsula, North Africa, after/ during the crossing of the Italian peninsula.

Also in this case the anomalous behavior of these birds occurred a few days before the earthquake. In this study, the group of researchers verified all the data relating to the natural electromagnetic variation to understand if there is a clear relationship between the anomalous behavior of these migratory birds and the electromagnetic pre-seismic phenomenon.

***Keywords**: Wood Pigeons, Earthquake Prevision, Reverse Migration, Seismic Precursors, RDF.*

1 –PREMISE

Some scientific studies [**1**] [**2**] [**3**] [**4**]highlighted the possibility that birds can also orient themselves by means of geomagnetic fields of natural origin, which permeate the natural environment. This orientation mechanism possessed by them, manages to make them orient even at a long distance.

2 - METHOD AND DATA

The data considered in this study examines the data from the Italian RDF network and the behavior of the Wood Pigeons, observed a few days before the seismic event that occurred in Visso, Macerata, Italy, of magnitude Mw 3.7. In this case, we will first consider the electromagnetic monitoring data and then the behavioral data of the Wood Pigeons.

2.1 – RADIO DIRECTION FINDING DATA

The RDF (Radio Direction Finding) type electromagnetic monitoring system is a technology based on the use of a mathematical algorithm (therefore it is necessary to use a computer) through

which it is possible to establish which is the azimuth direction (of origin) of an electromagnetic signal when this is picked up by two aligned loop antennas orthogonally to each other. By using two or more monitoring stations equipped with this technology it is possible to "triangulate" a determined electromagnetic source and understand in which geographical area it is located. The authors, since 2017, have created in Italy the first electromagnetic monitoring network of the RDF type dedicated to pre-seismic radiofrequency.

A few days before the Mw 3.7 magnitude earthquake, which occurred in central Italy in Visso, Macerata, at 12:54:17 UTC on October 18, 2021, and more precisely from October 16, 2021, the RDF monitoring network recorded signals interesting to come from the seismic hypocenter before the earthquake occurred. These data are extremely interesting given that the electromagnetic monitoring carried out with the RDF - Radio Direction Finding network developed by the Radio Emissions Project since 2017 [**5**], allows to highlight the electromagnetic variations that precede earthquakes. Studies in this area have been carried out in this research area since 2017 [**5**] [**6**] [**7**]. As regards the case in question, the main data were recorded by our RDF network starting from 16 October 2021, from the Ripa-Fagnano station, L'Aquila, Italy (around 15:00 LT to 20:00 LT), to record the same signals from the RDF station in Lariano, Rome, Italy starting from 16 October 2021 (around 12:30 LT - 16:00 LT). Further signals were recorded from the Pontedera station. Pisa, Italy (starting at 00:00 LT on October 18, 2021). Below I attach part of the dynamic spectrograms in which the signals correlated with the seismic epicenter are observed (**Fig. 1**, **3** and **4**).

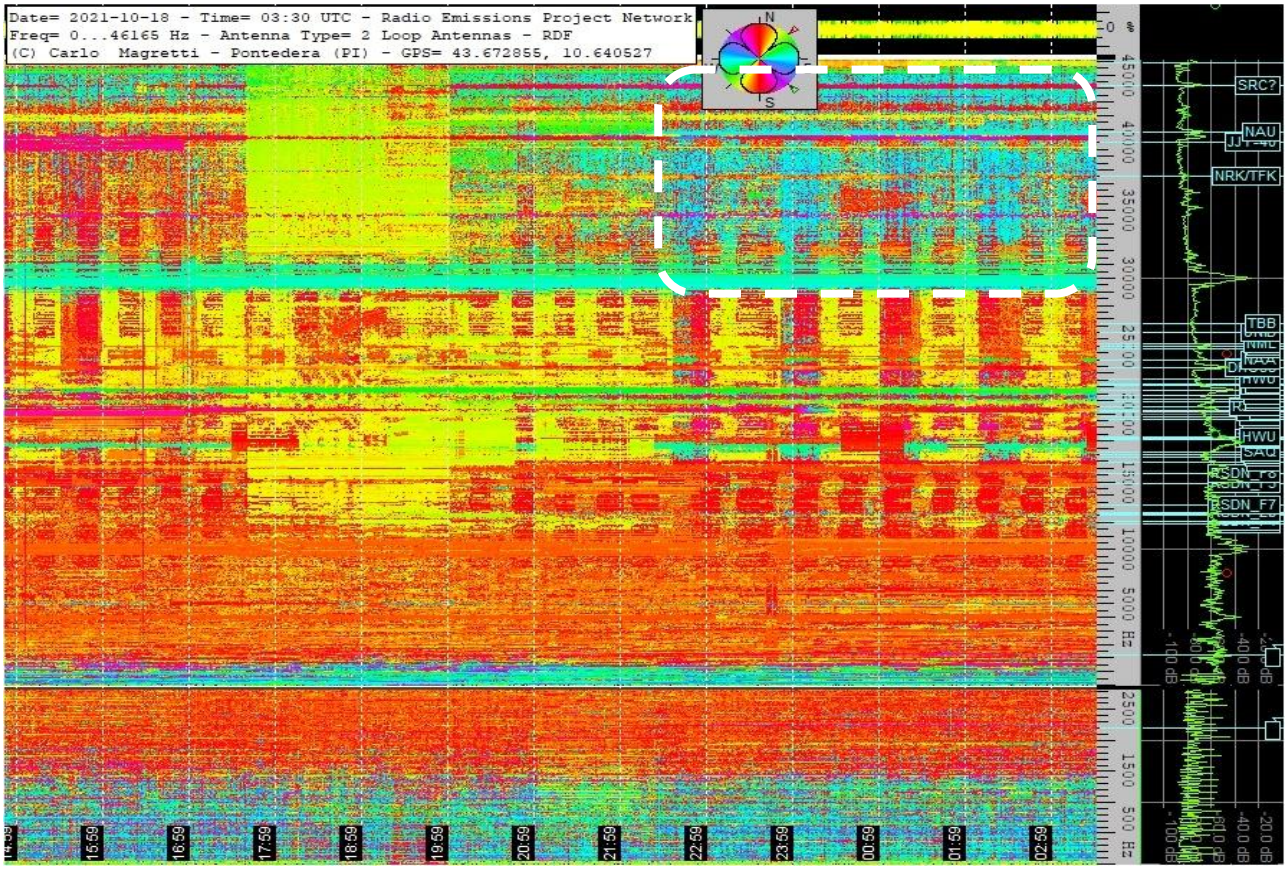

Fig. 1 - Dynamic spectrogram recorded by the RDF station of Pontedera, Pisa, Italy, managed by Mr. Carlo Magretti. The signals correlated with the seismic epicenter are those of a turquoise-blue color. On the Cartesian axis of the ordinates we have the electromagnetic frequency in Hz of the received signals, while on the abscissa axis we have the UTC time.Credits: Radio Emissions Project.

The electromagnetic signals highlighted by the RDF network highlighted (in triangulation) the geographical area within which the earthquake would then occur, in this case the signals are as follows:

- Yellow signs from Lariano RDF station, Rome, Italy.
- Violet signals from the Ripa-Fagnano RDF station, L'Aquila, Italy.
- Turquoise and blue signals, from the RDF station of Pontedera, Pisa, Italy.

The signals, as shown in **Fig. 2**, were received by the three RDF stations present on Italian soil, from which, as is evident, they were received on the basis of a specific reception angle (azimuth). If we consider the azimuth of the signals, recorded by the Italian RDF stations, they all converge towards the geographical area of the future si-smic epicenter.

The evidence is clear and indicates that there were, starting from October 16, 2021, earthquake preparation phenomena capable of generating significant electromagnetic emissions, recorded over a long distance:

- 218 km from Pontedera station, Pisa, Italy.
- 135 km from Lariano station, Rome, Italy.
- 81.2 km from Ripa-Fagnano station, Italy.

In relation to the reception distance of general radio signals at the crustal level, it can be deduced that these emissions had an important intensity in kW.

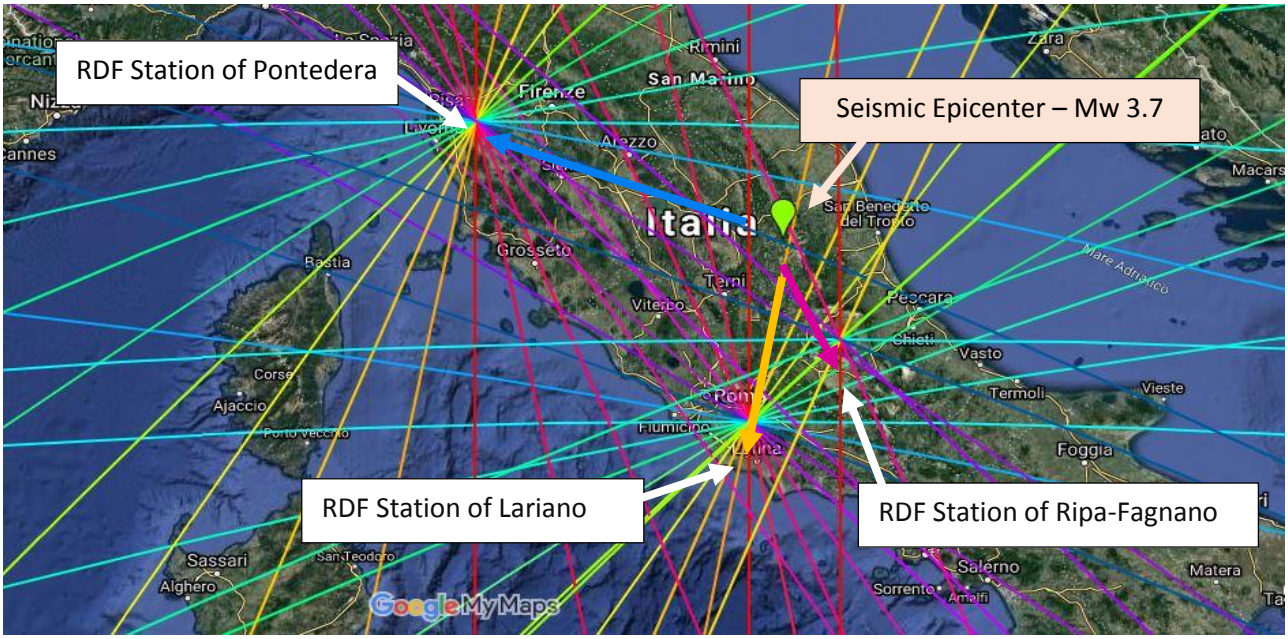

Fig. 2 - Map of the Italian RDF network, developed by the Radio Emissions Project, it highlights the seismic epicenter of the earthquake occurred in central Italy and objects of this study, and the related colored azimuths within which the electromagnetic signals were detected. Credits: Radio Emissions Project.

2.1.1 – GENESIS OF PRE-SEISMIC RADIO SIGNALS

The pre-seismic radio signals are generated by a series of mechanisms that occur at the level of the lithosphere (earth's crust) which have been well known and studied for years. They are mainly emitted by the micro-fractures that are generated on the seismic fault plane when the level of mechanical stress (pressure) reaches such levels as to start breaking up the rocks.Microfractures are small cracks in the rock which, from a geological point of view, generally have a length of a few millimeters (or less) and a width of less than 0.1mm and are formed in the phases preceding the macrofractures [**10**]. Since the size of a microfracture substantially depends on the homogeneity of the rock subjected to tectonic stress, it is evident that fractures of much more varied dimensions have also been observed [**10**].

The first microfractures were observed in 1850 through transmitted light microscopy (TL), while only in 1960 it was possible to observe them through scanning electron microscopy (SEM) [**10**].

The creation of experimentally induced microfractures was demonstrated for the first time through triaxial compression tests [**11**] and currently the study of microfractures produced in the laboratory has allowed us to provide important information on rock breaking processes and a better understanding of faults and formation of microfractures in nature [**12**]. Since the faults do not have a planar morphology but are irregular, they can be described graphically as a fractal [**13**] [**14**]. This condition means that when tectonic stress accumulates, the geometric irregularities of the fault influence each other leading to the formation of additional microfractures in the surrounding rock that have a different orientation than the main ones [**15**] [**16**] [**17**]. It is therefore evident that the volume of the Earth's crust involved in the creation of microfractures is larger than the area defined as the "earthquake preparation zone": according to some estimates [**18**] this volume could be between 24 and 520 times larger than the earthquake preparation area.The locally generated pre-seismic radiofrequency is an electromagnetic phenomenon caused by the tectonic stress that deforms and creates microfractures and macrofractures in the rocks present in the earthquake preparation area through the phenomenon of piezoelectricity [**19**] (**Image. 1**). The amplitude of the electromagnetic signals caused by the formation of microfractures of the rocks subjected to tectonic stress in the earthquake preparation area mainly depends on the density of the microfractures and their size; the morphology of the electromagnetic field depends on the orientation of the microfractures; on the other hand, the period of oscillation of the electromagnetic field (temporal modulation) depends on the geological characteristics of the fault and on the characteristics of the tectonic stress that determine a growth of the microfractures that does not proceed linearly. This explains why the pre-seismic radiofrequency produced through the creation of microfractures can be considered "inconsistent" [**20**].

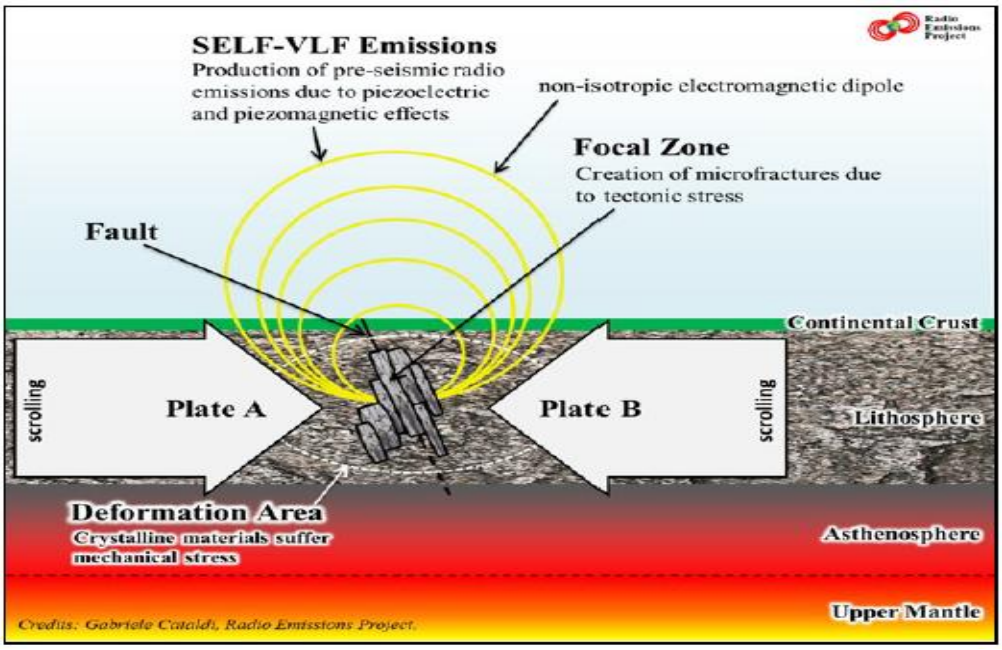

Image 1 – Pre-seismic radiofrequency generated through the phenomenon of piezoelectricity. In the image above the geodynamic mechanism responsible for the pre-seismic radiofrequency emission has been represented. Credits: Gabriele Cataldi, Radio Emissions Project.

Size of earthquake preparation zone (*r*) and precursor region (*R*) for $4.0 \leq M \leq 7.0$		
Magnitude	**Radius (*r*) in Km**	**Radius (*R*) in Km**
4	0,1	52
5	2,5	141
6	6,0	380
7	41,3	1023

Image. 2 – Earthquake preparation area and Electromagnetic Seismic Precursors (ESPs) emission zone in comparison. In the table above the dimensions (radius in km) of the earthquake preparation zone and that which contributes to the production of pre-seismic radiofrequency (ESPs) have been compared. Credits: V. Sgrigna, A. Buzzi, L. Conti. Seismo-induced effects inthe near-earth space [36].

According to a study carried out in 2007 [**18**], the volume of the Earth's crust concerned issue pre-seismic electromagnetic due to the accumulation of tectonic stress, it has a much larger size than the volume of the affected Earth's crust solely on the production of micro-fractures (focal area of the earthquake). Taking as reference an earthquake of magnitude 6 and considering the volumes involved, this ratio is>200:1 (**Image 2**).

Subtracting the energy released by the seismic waves by the energy that theoretically is accumulated as a result of tectonic stress within the earthquake preparation zones, the result is that only a small part of the energy contained in the earthquake focal zone is converted into seismic waves.

According to T. Lay and T. C. Wallace [**25**], only 1-10% of the energy and seismic moment contained in earthquake zones preparation is converted into seismic waves.

It is therefore conceivable that the 90% (or more) of this energy, or part of it, can be converted to radiofrequency.

Taking as a reference an earthquake of magnitude 5, this has an energy and a seismic moment between 1012 and 1018 Nm [**25**].

If we wanted to convert this mechanical moment (kg · m2 · s-2) in energy supplied in 1 second (W/s), the result would be equal to:

1.000.000.000 – 1.000.000.000.000.000 kW/s (1 kW/s = 1000 W/s)

that is:

109 – 1015 kW/s o kJ (1 Ws = 1 J)

Considering that it is not possible to quantify the energy losses of the system in terms of thermodynamic efficiency and the efficiency of energy conversion tectonic in other forms of energy, we assume that only 50% of the energy residual theorized by T. Lay and T. C. Wallace can be converted to radiofrequency. The result is as follows:

500.000 – 500.000.000.000 MW/s o MJ

(1 MW = 106 W; 1 MJ = 106 J)

These values represent the amount of energy that can be converted into radio frequency in one second. Converting it in W/h, we obtain as a result the amount of energy that can be supplied in the form of radiofrequency 1h:

138,9 – 138.888.888,9 MW/h

It is an enormous amount of energy (between ~ 139 MW/h and ~ 138,889 GW/h), then if it were converted into radiofrequency would be able to propagate within the Earth's crust and reach up to the surface.

Laboratory experiments conducted on a few cubic centimeters of rock have found that during the creation of fractures in rocks, as a result of mechanical stress, it emitted a significant amount of radio waves (G. Hammer et al., 1985) through the phenomenon of piezoelectricity.

This phenomenon is observed when crystals is applied on some of the mechanical stress in certain crystallographic directions: the opposite sides of the crystals we load instantly [**24**]. Studies confirming the production of radio frequency emitted by rocks placed under mechanical stress have also been conducted in recent years thanks to the funds allocated NASA (National Aeronautics and Space Administration)[**21-**

23].The existence of pre-seismic radio signals (defined by the authors as "Electromagnetic Seismic Precursors" or ESPs) is now an indisputable fact from the scientific point of view because these natural radio signals were detected through countless times of various radio detection stations type: the first literary work in which a description of these radio signals appears dates back to 1890 [**26**]; nevertheless, in the next century (at least in the good half of the twentieth century) research on these unclaimed signals much success, until in the 90s the international scientific community has begun to reconsider positively these radio signals [**27**] [**28**]. Many authors have got to ensure that the bandwidth of these radio emissions is very wide: it extends from the lower limit of the known radio frequency (SELF band) to the VHF band; while, the intensity is greater at lower frequencies, reaching a maximum intensity between the SELF band and the first half of the ELF band (0 <f≤15 Hz) [**29-34**]. This radio frequency can be easily monitored in order to understand the characteristics and the temporal evolution in relation to seismic activity, and because it is emitted from the focal zone of an earthquake and/or in the neighboring areas of the Earth's crust subject to deformation due to tectonic stress, it is evident that through the use of an electromagnetic detection technology type radiogoniometric or RDF (Radio Direction Finding) is possible to obtain an indication of azimuthal seismic epicenter with respect to the electromagnetic detection station.

The authors have experienced this type of technology from 2017 obtained very encouraging results.

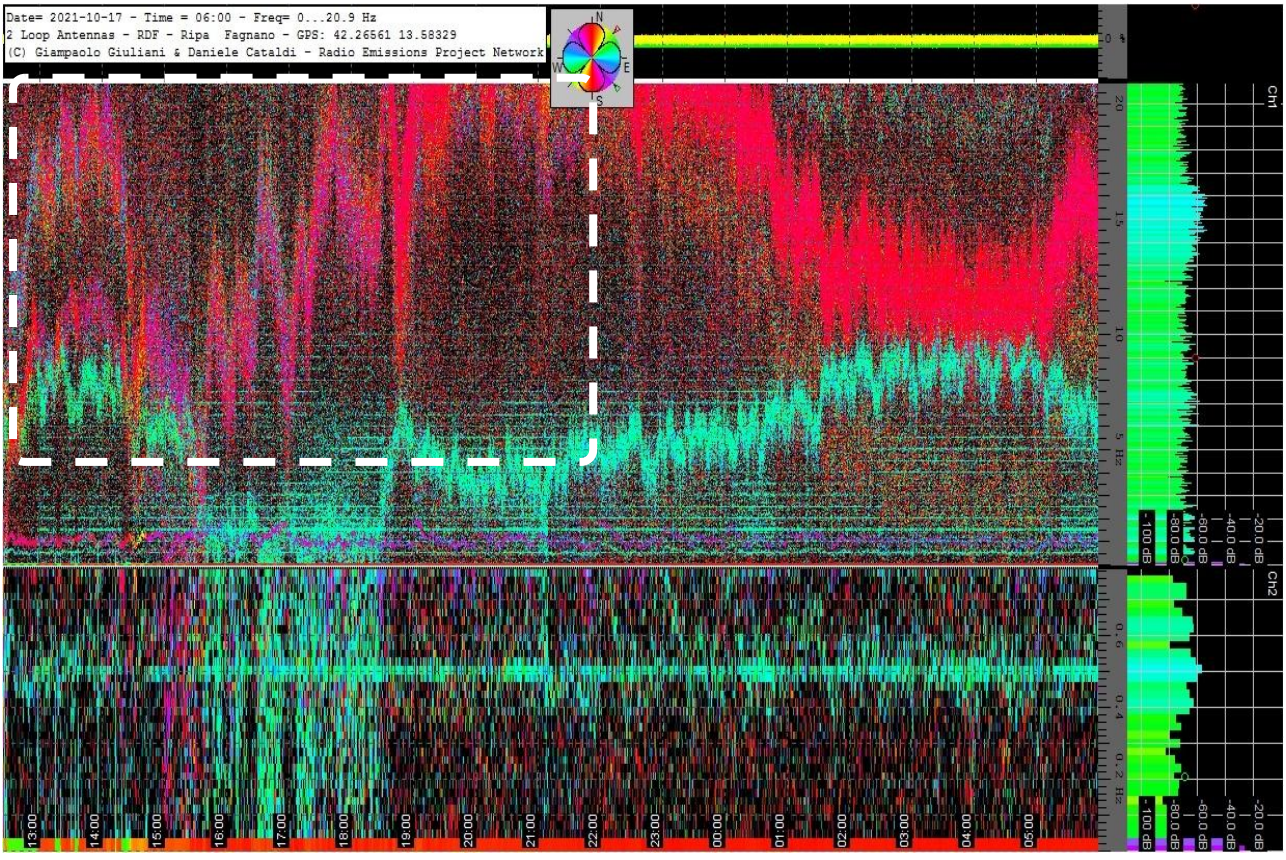

Fig.3 - Dynamic spectrogram recorded by the Ripa-Fagnano RDF station, L'Aquila, Italy. The signals correlated with the seismic epicenter are those of a purplish color. On the Cartesian axis of the ordinates we have the electromagnetic frequency in Hz of the received signals, while on the abscissa axis we have the UTC time.Credits: Radio Emissions Project.

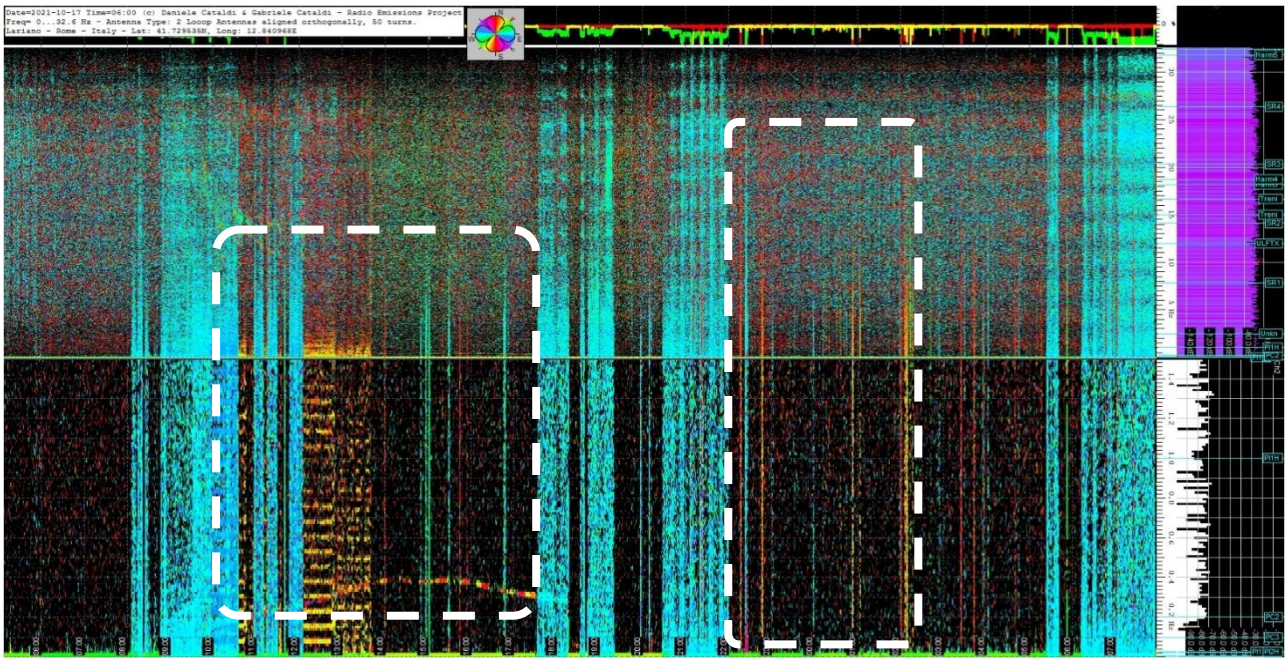

Fig.4 - Dynamic spectrogram recorded from Lariano station, Rome, Italy. The signals correlated with the seismic epicenter are those of yellow color. On the Cartesian axis of the ordinates we have the electromagnetic frequency in Hz of the received signals, while on the abscissa axis we have the UTC time.Credits: Radio Emissions Project.

2.2 - DATA ON THE BEHAVIOR OF COLUMBA PALUMBUS

The autumnal migration of the Wood Pigeon (*Columba palumbus*) in Italy takes place annually in various temporal waves in the month of October and the first fortnight of November. Scandinavia) and eastern Russia and cross all of Eastern and Central-Eastern Europe and the Balkans to then cross the Italian Peninsula (with food stops) heading towards the wintering areas prevalent in the Iberian Peninsula and North Africa but also in more nears (Southern France, Corsica, Sardinia and more recently also in peninsular Italy).

The migration from N / NE to S / SW takes in Europe on two main routes, the first north-European so-called Baltica (above the Alps), the second south of the so-called Alps “Mediterranean”: these routes are fragmented into various Directions / Corridors conditioned by the orography but all oriented (genetic imprinting linked to the theories of the Drift of Continents) from N / NE to S / SW.

The European population is estimated at over 50-60 million wood pigeons and in the last 5-6 years it has increased by 200-300%, and this also applies to the populations that migrate to Italy.

Today the monitoring system makes use of an APP (MCL) which makes it possible to follow the progress of the migration in real time and for 6 geographical ranges of migration flows.

All the Signalers record their observations on a daily basis, making use of great experience of what happens in the context of their hunting site, not least the orientation of the migrating flights, all in terms of "sensitive migratory ecology.

"The flight of migrating flocks is always very precise in migratory orientation and changes (in the various territories) also as a function of the solar azimuth during the period of daylight, but also lunar if the migration becomes nocturnal with lunar surface more than 60% illuminated.

All the studies on orientation and biological compass affirm that migratory birds actually "see" the geo-magnetic field on which they orient themselves during migration, even with the integration with other senses (sight, smell, barometric sense in the organ Vitali's Para-Tympanic) precisely framed as "ecology-sensitive-migratory".

The migration of Wood pigeons (*Columba palumbus*) is characterized by groups of birds that are numerically not large which by now or almost reached the wintering areas find territories with scarce food resources (mostly acorns and other berries) then retrace (also from the islands) on the contrary, the path that has just ended, orienting itself, mostly with the sense of smell, on reassuring areas for nutrition or at least not crowded [**8**] [**9**] [**35**].

The phenomenon, also characterized by large wanderings of hundreds of thousands of Wood Pigeons (*Columba palumbus*), is much studied in the Iberian Peninsula and in particular in the Pyrenees and based on a peculiarity of Species defined as "migratory flexibility".

In the two events of reverse migration, one observed in 2016 (and not treated in this study) and that of October 2021 (considered here), the observations took place in a limited time frame (2-3 days) and in a period of "full" migration when the populations had not yet fully reached the wintering areas.

This means that the "return flights" observed in this event are really the expression of a temporary problem of the pigeon orientation system (sensitive-migratory ecology).

The monitoring system (live) in real time, of the Italian Wood Pigeon Club (*Columba palumbus*), makes use of about 150 active observers (over 500 members) distributed over 6 migratory bands / corridors and in "real time" at the end of the day a complete view of the "migrant mass" that crosses the Italian Peninsula.

The list of reports relating to the phenomenon of "reverse migration" reported between 17 and 18 October 2021, prior to the earthquake that occurred in Visso, Macerata, Italy is visible in **Fig. 5**, where among other things it is to be confirmed that the he observation that took place in Sanseverino Marche, is the one closest to the seismic epicenter of the Mw 3.7 earthquake, where a large herd of wood pigeons (*Columba palumbus*) was observed on the morning of 18 October 2021.

Another important testimony was reported near of the same seismic epicenter, in Città di Castello, where in the locality of Lerchi, various Woodpigeons (especially in small flocks of 12 to 15 specimens) have been noticed passing at medium height in a direction practically opposite to the pace commonly observed in that area, that is, they headed from from North to South.

These testimonies indicate a clear phenomenon of reverse migration caused by the bird's inability to orient itself autonomously and normally, along a route that it normally knows very well.

All valid reports mainly confirm the morning time between 17 and 18 October 2021, according to these reports, no other reverse migrations were observed after 18 October. All observations are valid for flights (more than three for each observation site) with typical characteristics of "migration" and not of "wandering". Wood pigeons total observations were 662,856 between 16 and 18 October 2021.

OBSERVATION PLACES	REPORTERS/OBSERVERS
• Alto Mugello, • Arcevia, • Boncio Siligate, • Campiglia Marittima, • Castelvecchio, • Città di Castello, • Giano dell'Umbria, • Grutti, • Gualdo Cattaneo, • Massa Martana, • Mazzolla, • Montecchio, • Mugello. • Radicandoli, • Sacinelle, • SanSeverino Marche, • Santerno, • Savena, • Val di Lamone, • Valfabbrica, • Volterra, The phenomenon of reverse migration has been observed and / or reported as, single, sequential, repeated, superimposed in the following locations of the Central Apennines.	Andrea Campigli, Andrea Pieri, Filippo Della Martera, Giacomo Secciani, Giancarlo Fiammelli, Marco Stefanini, Massimiliano Piersimoni, Massimiliano Profidia, Michele Baroni Renato Bianchi, Riccardo Rossi, Rino Meotti,

Fig.5 - Table relating to the reports of the phenomenon of "reverse migration", carried out in the days preceding the system which took place in Visso, Macerata, Italy. The data contend not only for the locality but also for the name of the reporter. Credits: Club Italiano del Colombaccio (*Columba palumbus*) - https://www.ilcolombaccio.it/CMS/author/enrcavilcolombaccio/.

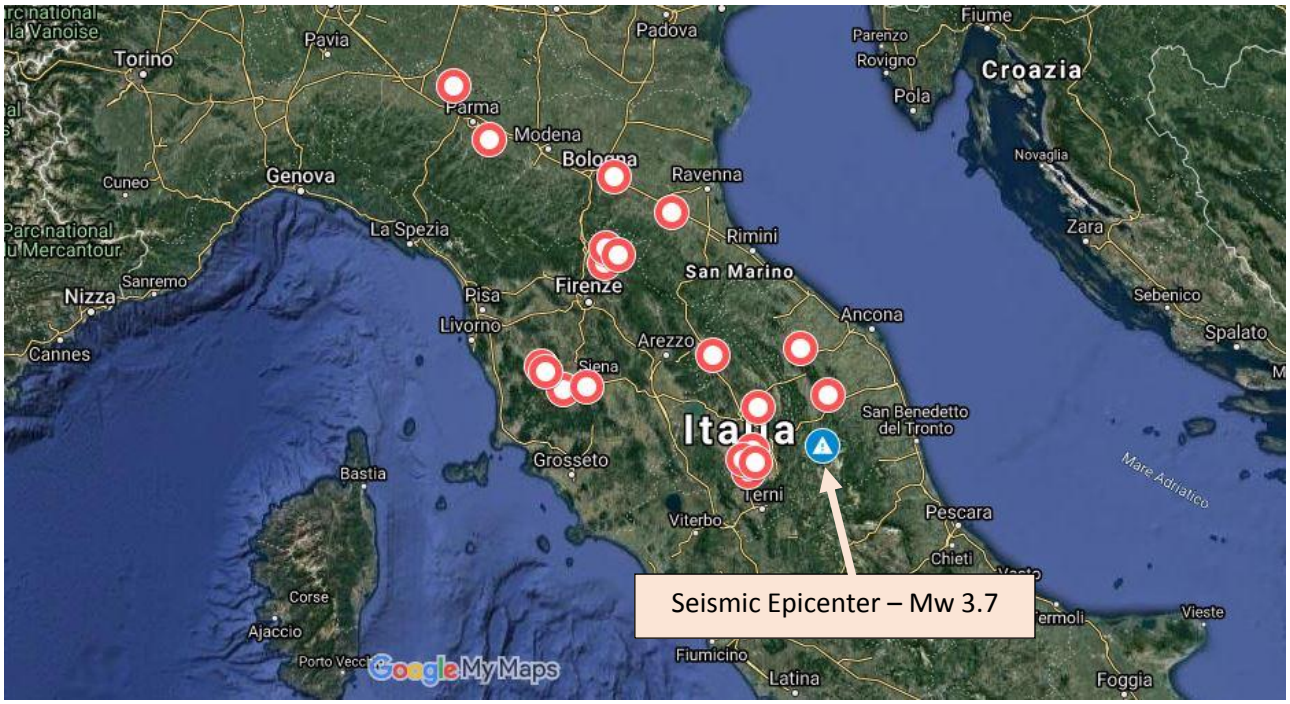

Fig. 6 - Italian map in which the observations of the phenomenon of "reverse migration" and the position relative to the seismic epicenter are highlighted in red (Visso seism, Macerata, Italy (Mw 3.7). Credits: Radio Emissions Project, Club Italiano del Colombaccio (*Columba palumbus*) - https://www.ilcolombaccio.it/CMS/author/enrcavilcolombaccio/, INGV.

The map visible in **Fig. 6**, indicates the position of the observations made on the birds that presented the inverse migration, and the blue, the seismic epicenter.

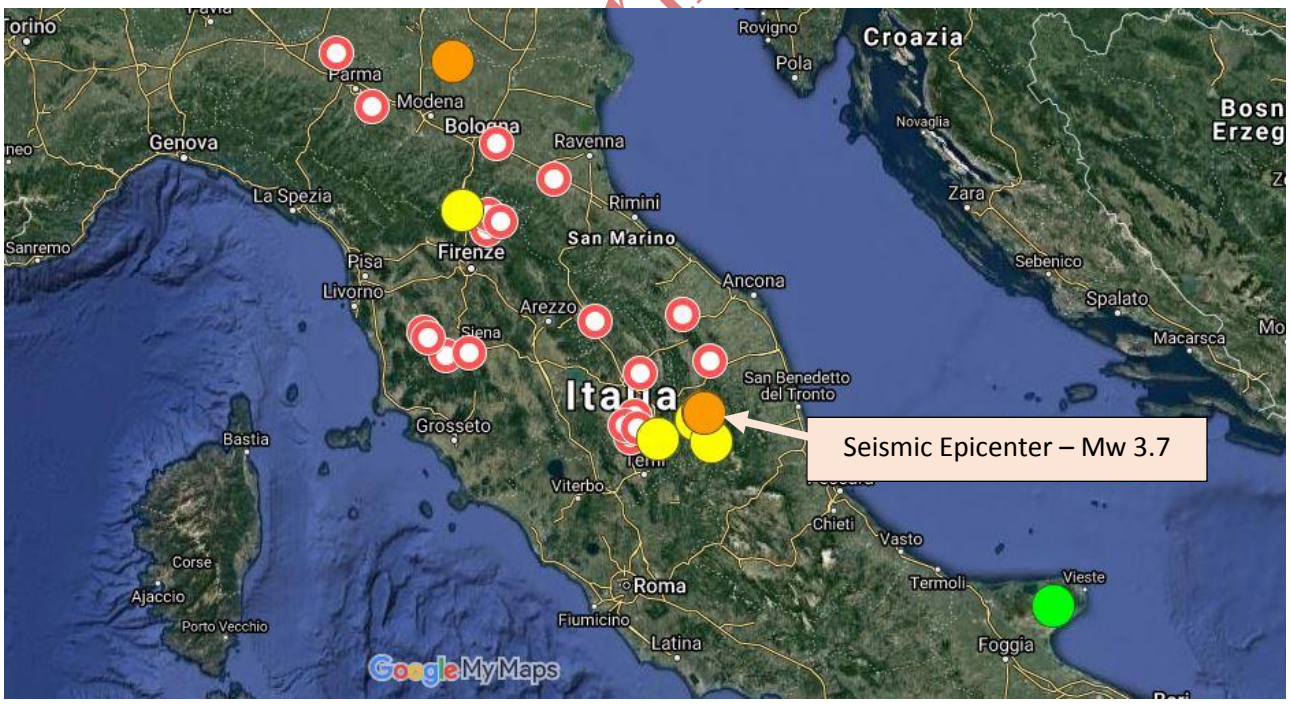

Fig. 7 - Italian map in which the observations of the phenomenon of "reverse migration" and the position at the seismic epicenters of the earthquakes that occurred between 16 and 18 October 2021 are highlighted in red, M2+. Credits: Radio Emissions Project, Club Italiano del Colombaccio (*Columba palumbus*) - https://www.ilcolombaccio.it/CMS/author/enrcavilcolombaccio/, INGV.

The map shown in **Fig. 7** shows us how in the period in which the birds showed a reverse migration, earthquakes (M2+) occurred near these areas.

Going instead to evaluate the total number of earthquakes, which occurred between 16 and 18 October 2021, and of magnitude M1+, we can note a clear temporal relationship between the manifestations of reverse migration and the presence of earthquakes located on Italian soil (**Fig. 8** and **9**).

In this context, we are mostly talking about very low intensity earthquakes.

It appears, therefore, that the low intensity earthquakes could not generate electromagnetic emissions such (in their intensity) as to interfere with the orientation system of the birds, while it is possible to hypothesize that in the preparatory phase of the earthquake of Visso, Macerata, Italy (Mw 3.7), the accumulated energy was sufficient to generate an electromagnetic emission capable of interacting with the flight of birds.

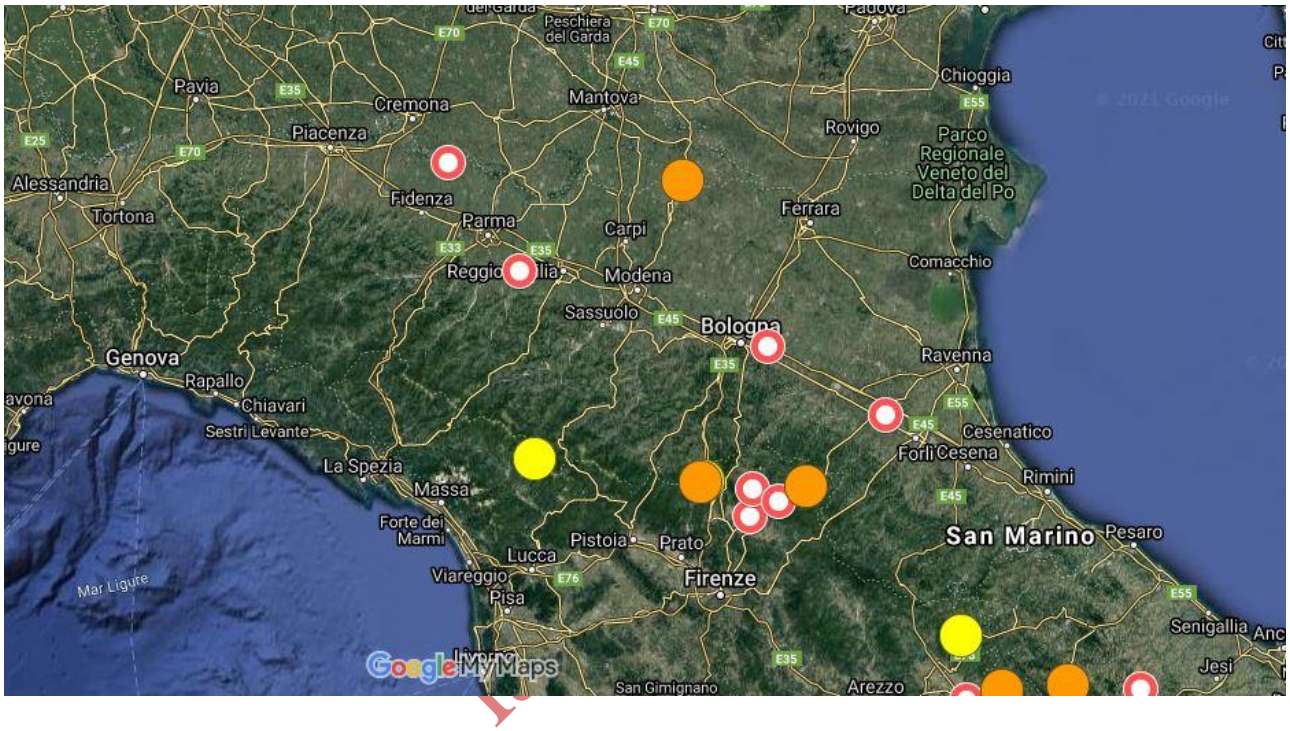

Fig. 8 – Italian map in which the observations of the phenomenon of "reverse migration" and the position at the seismic epicenters of the earthquakes that occurred between 16 and 18 October 2021 are highlighted in red, M1+. Credits: Radio Emissions Project, Club Italiano del Colombaccio (*Columba palumbus*) - https://www.ilcolombaccio.it/CMS/author/enrcavilcolombaccio/, INGV.

This obviously in the hypotheses, given that the study considers not only the strong earthquake in question, but also the weaker ones.

Since the Apennine arc is characterized by continuous telluric movements, it is presumed that the birds are accustomed to a certain level of natural radio emissions of crustal origin, but obviously not to the more intense ones, which precede a certain degree of seismic activity.

The analysis of the seismic data and those relating to the observations of reverse migrations indicates that these were observed more where more earthquakes occurred, this would indicate that there were a greater number of electromagnetic emissions, compared to the areas affected by a lower number of earthquakes, which is why there were a greater number of anomalies in the orientation of birds (Woodpigeons), as visible from **Fig. 8** to **Fig. 10**, where earthquakes with magnitude M1+.

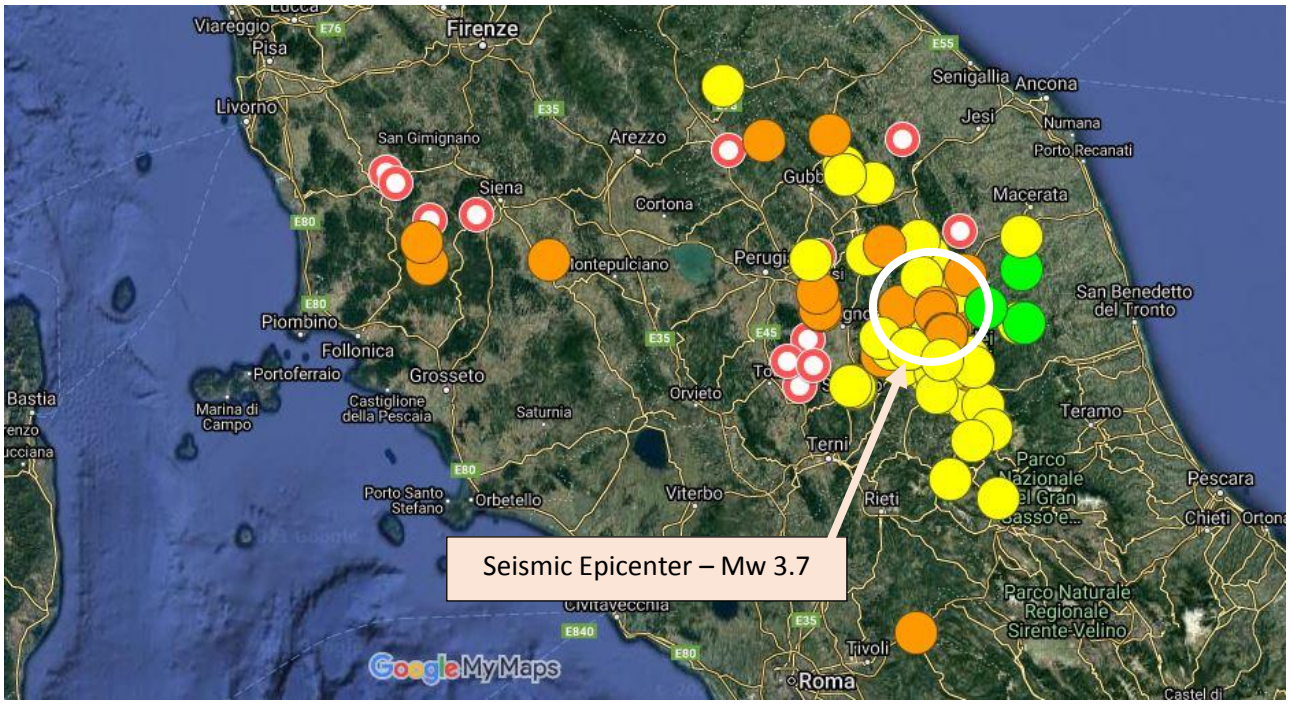

Fig. 9 – Italian map in which the observations of the phenomenon of "reverse migration" and the position at the seismic epicenters of the earthquakes that occurred between 16 and 18 October 2021 are highlighted in red, M1+. Credits: Radio Emissions Project, Club Italiano del Colombaccio (*Columba palumbus*) - https://www.ilcolombaccio.it/CMS/author/enrcavilcolombaccio/, INGV.

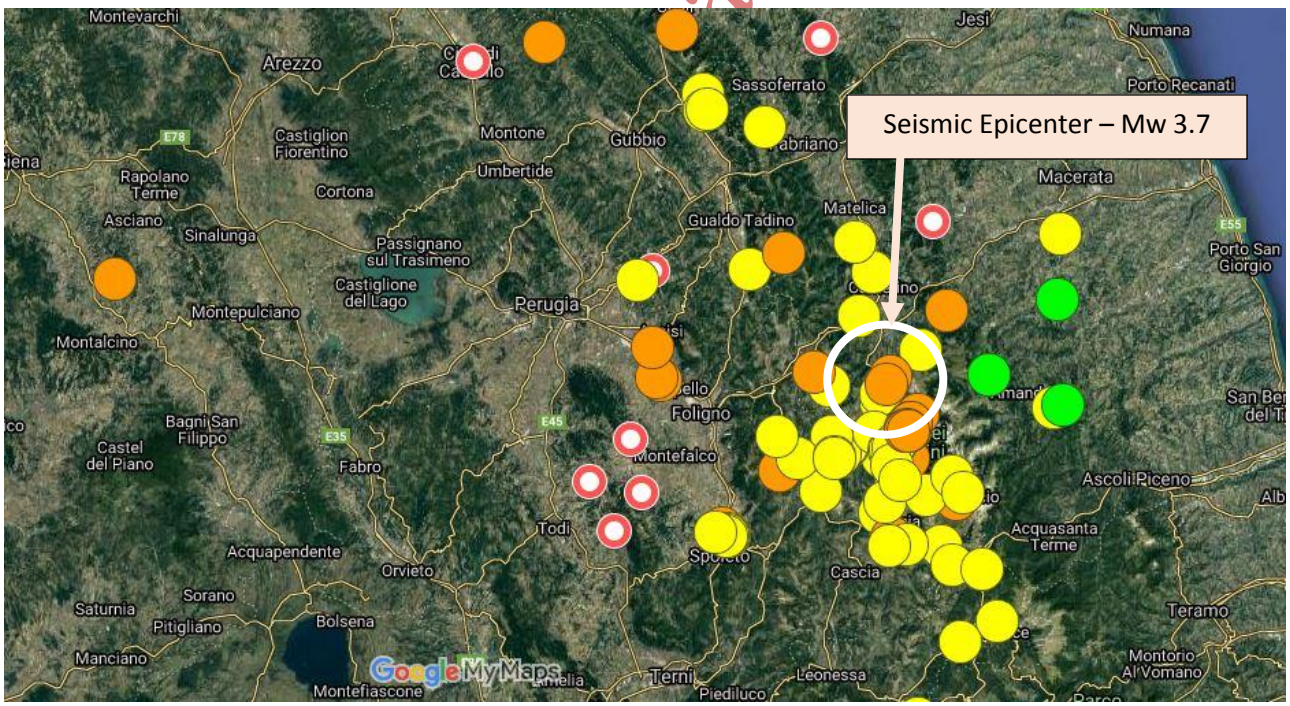

Fig. 10 - Italian map which highlights, in red, the observations of the phenomenon of "reverse migration" and the position at the seismic epicenters of the earthquakes that occurred between 16 and 18 October 2021, M1+. With a greater magnification of the geographical area, the high number of earthquakes that occurred in a few hours in the area where the strongest earthquake then occurred. Credits: Radio Emissions Project, Club Italiano del Colombaccio (*Columba palumbus*) - https://www.ilcolombaccio.it/CMS/author/enrcavilcolombaccio/, INGV.

2.3 – GEOMAGNETIC DATA

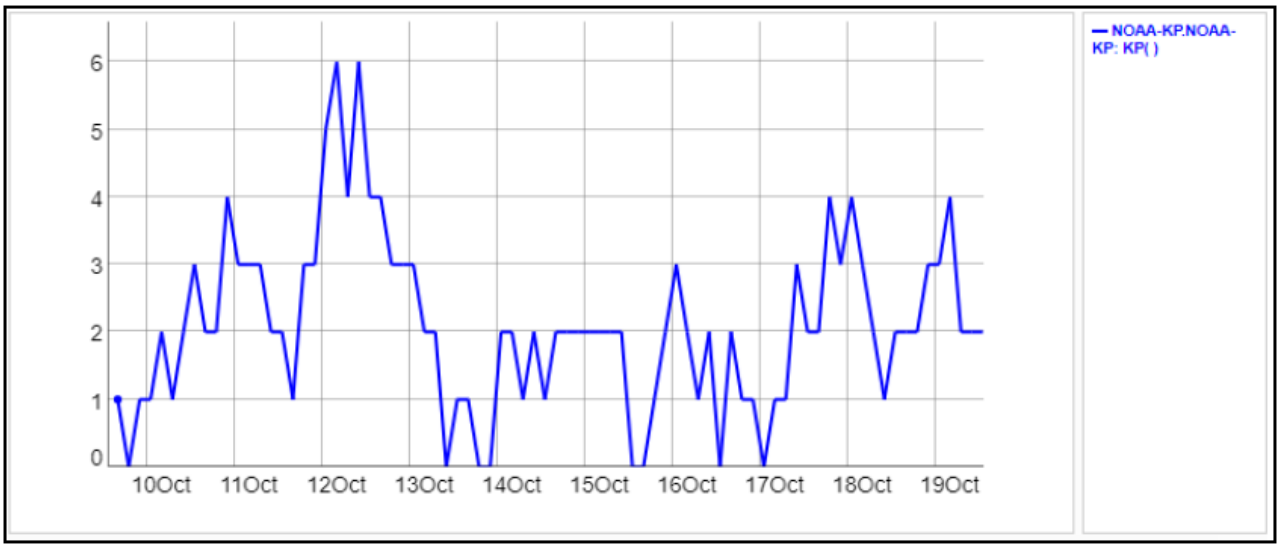

Fig. 11 – Variation of the Kp Index between 9 and 19 October 2021. The graph above shows the variation of the Kp Index recorded between 9 and 19 October 2021. The Planetary Kp Index is derived at the National Oceanic and Atmospheric Administration (NOAA), Space Weather Prediction Center (SWPC) using data from the following ground-based magnetometers: Sitka, Alaska; Meanook, Canada; Ottawa, Canada; Fredericksburg, Virginia; Hartland, UK; Wingst, Germany; Niemegk, Germany; and Canberra, Australia. The K Index, and by extension the Planetary K Index, are used to characterize the magnitude of geomagnetic storms. Kp is an excellent indicator of disturbances in the Earth's magnetic field and is used by SWPC to decide whether geomagnetic alerts and warnings need to be issued for users who are affected by these disturbances. Credits: iSWA.

Between 16 and 18 October 2021 a progressive increase in the Kp Index was recorded which reached, between 17 and 18 October 2021, the value of 4. By observing the graph (**Fig. 11**) it is also possible to identify a geomagnetic storm of degree G2 which preceded the time period under consideration (16-18 October 2021): this geomagnetic storm was recorded on 10 October 2021, at 04:30 UTC and at 10:30 UTC. This data indicates that it would explain the greater number of observations of reverse migrations observed in those days, not surprisingly, given that the geomagnetic increases are real precursor phenomena of earthquakes. In this context, these (non-local) variations, equally like the local ones (epicentral radio emissions), could certainly have an influence on the biological orientation system possessed by the Woodpigeons.

3 - DISCUSSION

The data considered in this study show how the seismic events, with magnitude equal to and greater than M1+ that occurred from 16 to 18 October 2021, were all preceded by a series of electromagnetic signals indicated in a particular way. the central Apennines.

This evidence was accompanied by a series of anomalies observed on the flight of birds (Woodpigeons), which presented reverse migration. A significant datum and directly correlated, temporally, with the M1+ seismic events that occurred on the Italian territory a few hours and days after these behaviors of the birds.

In the same period these behavioral anomalies of the birds were followed and accompanied by a series of radio emissions emitted at the crustal level, which came from the seismic epicenter M3.7 which occurred in Visso, Macerata, Italy, on 18 October 2021. More generally, these electromagnetic emissions concerned several areas of the central Apennines, where most of the earthquakes visible in **Figs. 8**, **9** and **10** were then located.We are faced with something that had already happened in 2016, when before the strong earthquake in Amatrice, Rome, Italy, the Italian Club of the Wood pigeon (*Columba palumbus*) had observed the same anomalies (21 locations in Central Appenine) in the orientation of the birds, while the Radio Emissions Prject it had experienced strong geomagnetic and electromagnetic increases before the strong

earthquake.In this study, the M3.7 earthquake in Visso, Macerata, Italy confirmed the initial hypotheses, namely that it was a bird migration problem due to the presence of particularly intense radio emissions capable of influencing the biological orientation system of the birds, since these move along the tenuous lines of the natural geo-magnetic field, these strong emissions can overlap and cover them, effectively determining the momentary disappearance of these natural electromagnetic fields.

4 – CONCLUSIONS

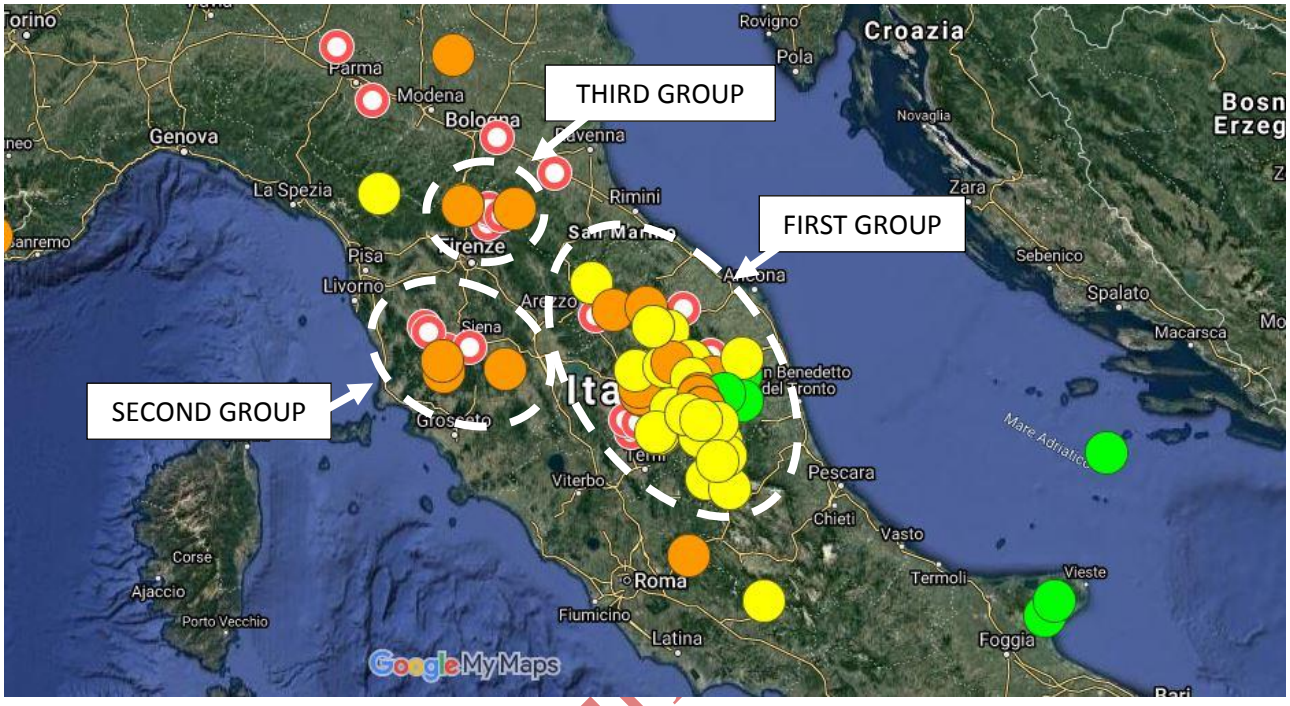

Fig. 12 – Italian map in which the observations of the phenomenon of "reverse migration" and the position at the seismic epicenters of the earthquakes that occurred between 16 and 18 October 2021 are highlighted in red, M1+. Credits: Radio Emissions Project, Club Italiano del Colom-baccio (*Columba palumbus*) - https://www.ilcolombaccio.it/CMS/author/enricavilcolombaccio/, INGV.

We conclude in this studyis that there are potentially recordable phenomena that can forewarn the occurrence of an earthquake, including the behavior of birds and in this case that of migratory birds, such as the Wood pigeon (*Columba palumbus*).

The researchers involved in this study consider this evidence to be extremely important in a particular seismic context such as that of the Italian territory, given that such behaviors can forewarn in the occurrence of earthquakes of a certain magnitude. The behavioral study of these birds, combined with electromagnetic monitoring of the national territory, could be a tool to assess whether there is a real risk of an earthquake occurring.

The data in fact showed that there is a clear relationship between the number of earthquakes, the number of reverse migrations and the appearance of electromagnetic signals of crustal origin, evidence that gives importance to this still pioneering and experimental research. The groupings are mainly three (**Fig. 12**):

A. **First Group -** close to the Central Apennines and in the immediate vicinity of the seismic epicenter M3.7, an area where the greatest number of earthquakes occurred and where the greatest number of observations of reverse migrations are concentrated.
B. **Second Group** - within the Tuscan geographical area. Second zone for number of observed inverse migrations, in close proximity to some seismic epicenters.
C. **Third Group** - Mugello area. Area characterized by a fair number of reverse migrations and earth-motions.

If we consider these facts, we can understand that the time period useful for the warning of an earthquake was 2 days, within which all the phenomena considered in this study occurred. This study highlights an important result relating to animal behavior, a behavior that is affected by the phenomena produced by the interaction between solar activity and the planet Earth. All scientists should understand this, in an area where there are scientists who do not accept the results of such scientific evidence. It is high time that these results were not observed again with taboo and skepticism, since the results of this study are now similar to many other researches, in which the behaviors of the most varied animal species are observed, in relation to the phenomena influenced by the spaceweather. We living beings live in symbiosis with our natural habitat, where we were born and raised and where we have developed senses useful for our survival. It is therefore normal that the behavior of living beings, who live in closer contact with their habitat, are sensitive to the weak changes produced by nature.

We believe that a large natural laboratory and a specific research project should be created in this area of research, capable of studying this reverse migration mechanism, highlighted and considered in this study, in a more exhaustive way. We believe it is important to start analyzing animal behavior, with the new tools that technology makes available to us.

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