

BeneFruits 2025 (14 - 18 September, Wageningen)

Calibration, verification and application of the *Halyomorpha halys* forecasting model HHAL-S in Emilia-Romagna Region to support control strategies.

M. G. Tommasini¹, G. Vaccari², S. Caruso², L. Fagioli³, F. Manucci³, D. Mirandola³, M. Preti⁴, M. Landi⁵, S. Pesolillo⁶

¹RI.NOVA; ²Conorzio Fitosanitario Provinciale di Modena; ³Conorzio Agrario di Ravenna; ⁴Independent Integrated Pest Management Consultant and Researcher; ⁵ASTRA Innovazione e Sviluppo; ⁶Consultant for RI.NOVA
E-mail: mgtommasini@rinova.eu

INTRODUCTION

The **HHAL-S** is a multivoltine population model that simulates the development of the life cycle stages of *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae) as a function of the weather conditions occurring in the field. The mathematical structure of the model is based on the theory of Time-Varying Distributed Delay Models (TVD) (Manetsch, 1976; Vansickle, 1977). The specific bioclimatic parameters of *H. halys* and the reproductive module equations (used for the eggs production) are found in the literature (Baek et al., 2017). The HHAL-S model simulates the daily developmental dynamics of adults, eggs, and five nymphal stages, starting from the 1st of January (Figure 1). Each block in the figure represents the simulator for a specific developmental stage, and the arrows indicate the daily output from each respective stage (adults, eggs, nymphs).

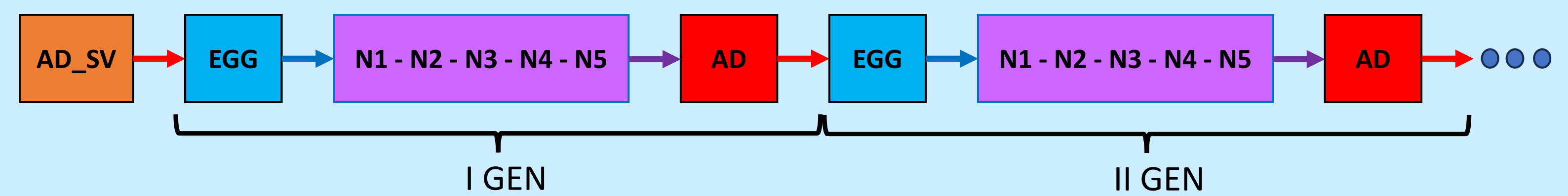


Figure 1. HHAL-S model structure: the first block simulates the emergence of overwintering adults (SV_AD), followed by the reproduction module (EGG), the five nymphal stages (N1, N2, N3, N4, N5), and adult development (AD). A new generation is possible by connecting a new reproductive module and following the same structure as the first generation.

MATERIALS AND METHODS

The **calibration** of the model's bioclimatic parameters is based on a comparison between simulation results and field monitoring data of *H. halys* nymphs and adults. These data were collected at eight points near Gargallo (Modena, Emilia-Romagna Region, Northern Italy) from 2020 to 2022 and are available on the open-access website:

<https://big.csr.unibo.it/projects/cimice/monitoring.php>

The strong agreement observed during the calibration phase is illustrated in Figure 2, where the dotted lines represent the averaged field-collected data (red for adults, purple for nymphs) and the solid lines correspond to the simulation results (dark red for adults, dark purple for nymphs).

The calibrated HHAL-S model was applied and **verified** in a real-time simulation for 2 further areas, Bondeno (Ferrara) and Pieve di Cesato (Ravenna), in 2023 and 2024. A good correspondence was obtained between simulated and average field-collected data in different years and areas (Figure 3).

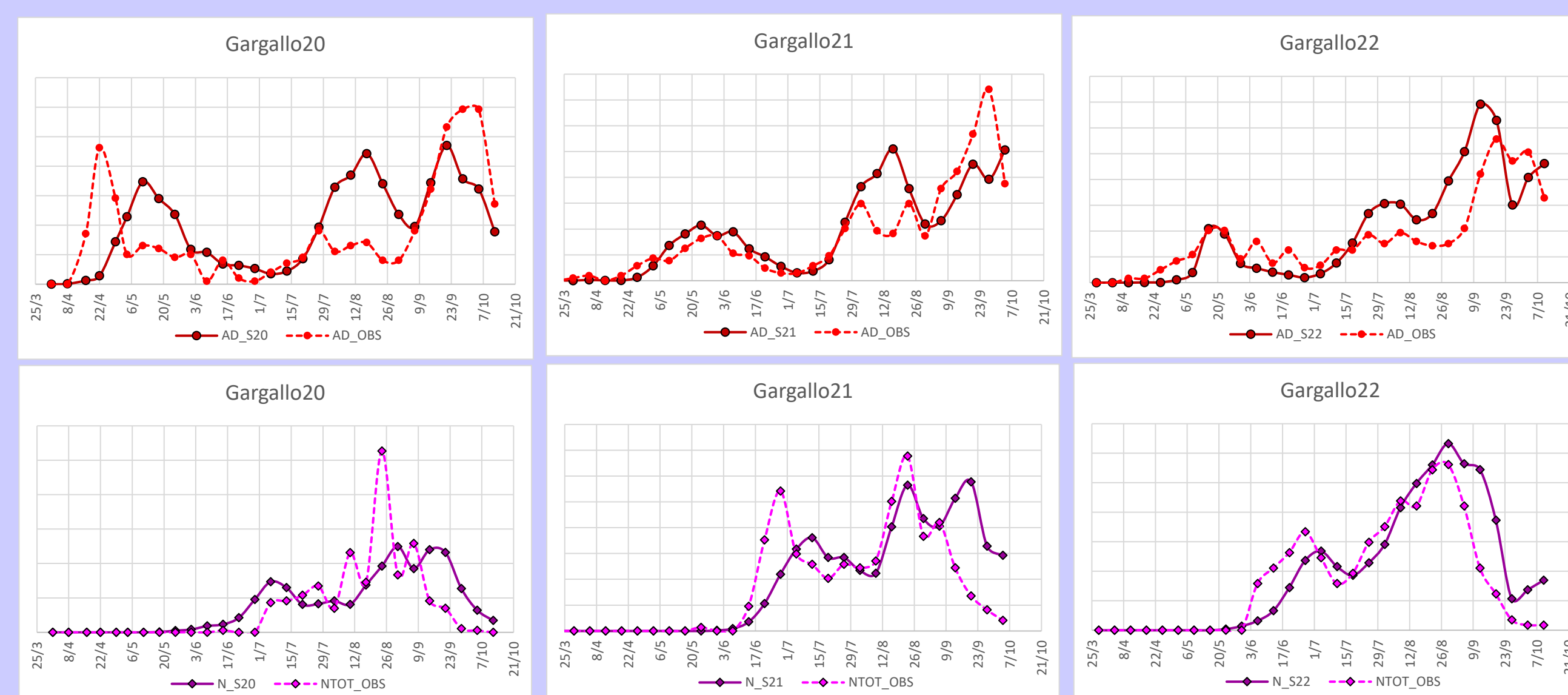
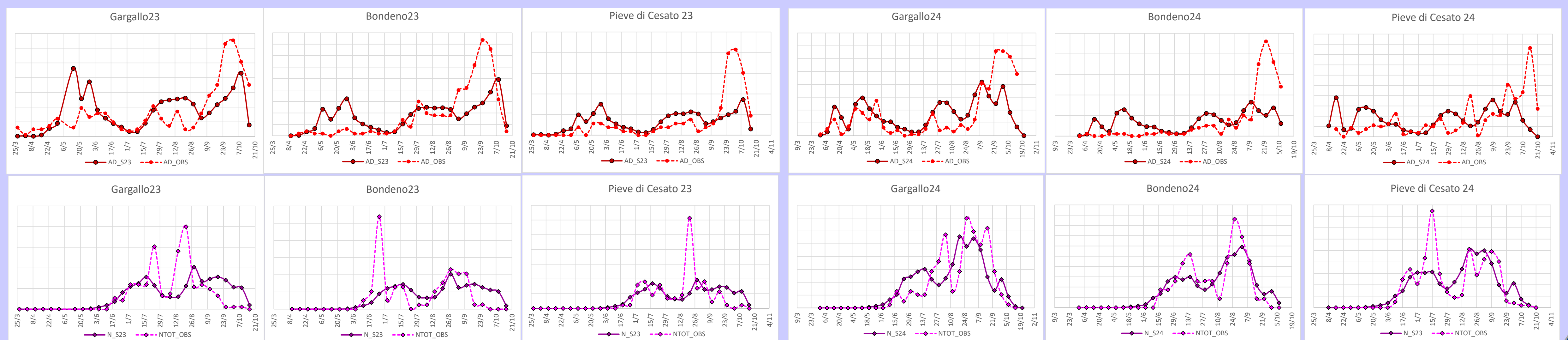


Figure 2. Calibration results: comparison between HHAL-S model results (solid lines) and average field data (dotted lines) for Gargallo 2020–2022. Adults are shown in red and nymphs in purple.

Figure 3. Verification results: comparison between HHAL-S model results (solid lines) and average field data (dotted lines) for Gargallo, Bondeno and Pieve di Cesato 2023–2024. Adults are shown in red and nymphs in purple.



RESULTS AND CONCLUSIONS

To improve the real-time **application** of the model, forecasted meteorological data were introduced into HHAL-S allowing to predict the development of *H. halys*.

The resulting information is described in weekly bulletins and, starting from 2025, will be integrated into the open-access on-line platform (as shown in the figure on the left, blue rectangle).

The results obtained with the calibration, verification and application of HHAL-S make this model a useful support tool for sustainable control strategies against *H. halys* development in the Emilia-Romagna Region.

References

- Baek S., Hwang A., Kim H., Lee H. and Lee J.-H. 2017: Temperature-dependent development and oviposition models of *Halyomorpha halys* (Hemiptera: Pentatomidae). *J. of Asia-Pacific Entomology*, 20: 367-375.
- Manetsch T. J., 1976: Time-varying distributed delay models and their use in aggregative models of large systems. *IEEE Trans. Syst. Man Cybern.*, 6: 547-553.
- Vansickle J., 1977: Attrition in distributed delay models. *IEEE Trans. Syst. Man Cybern.*, 7: 635-638.

ACKNOWLEDGMENTS

This study was funded by the Emilia-Romagna region within Reg. Law 17 del 27/10/2022. Type of operation "Urgent interventions to support the agricultural, agri-food, fishing and reclamation sectors" Art. 1 "Interventions for innovation in the agricultural and agri-food sector" – Project "INTEGR.HALYS - Integrazione di tecniche innovative per la gestione sostenibile della cimice asiatica"

